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ESCRS

EUROPEAN SOCIETY OF CATARACT & REFRACTIVE SURGEONS

# ESCRS Cataract Guidelines- Draft version

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Concept version

# European Society of Cataract and Refractive Surgeons (ESCRS) Guideline for Cataract Surgery

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# Chapter outline

# List of abbreviations

AAO: American Academy of Ophthalmology
ACD: Anterior chamber depth
AE: Adverse Event
AGREE II: Appraisal of Guidelines for Research and Evaluation II
AK: Arcuate Keratectomy
AL: axial length
AMD: Age-related Macular Degeneration
ANCHOR: Anti-VEGF Antibody for the Treatment of Predominantly Classic Choroidal Neovascularization in AMD
AREDS: Age-Related Eye Disease Study
ASCRS: American Society of Cataract and Refractive Surgery
BCVA: Best-Corrected Visual Acuity
BICAT-NL: Bilateral Cataract Surgery in the Netherlands
BUT: Tear Break-up Time
C: Cortical Cataract
CCC: Continuous Curvilinear Capsulorrhexis
CCS: Conventional Cataract Surgery
CCT: Central Corneal Thickness
CDE: Cumulative Dissipated Energy
CDG: Constituting Guideline Development Group
CDGAS: Cumulative Drusen and Geographic Atrophy Size
CDVA: Corrected Distance Visual Acuity
CFS: Corneal Fluorescein Staining
CI: Confidence Interval
CME: Cystoid Macular Edema
CNV: Choroidal Neovascularization
CROMS: Clinical-Reported Outcome measures
CRT: Central Retinal Thickness
D: Diopter
DCIVA: Distance Corrected Intermediate Visual Acuity
DED: Dry eye disease
DEX: Dexamethasone
DME: Diabetic Macular Edema
DMEK: Descemet Membrane Endothelial Keratoplasty
DSBCS: Delayed Sequential Bilateral Cataract Surgery
EAGLE: Effectiveness in Angle-Closure Glaucoma of Lens Extraction
ECD: Endothelial Cell Density
ECL: Endothelial Cell Loss
EDF: Extended Depth of Focus
ELP: Effective Lens Position
EPT: Effective Phacoemulcification Time

EQ5D: EuroQol-5 Dimension Questionnaire
ERM: Epiretinal Membrane
ESCRS: European Society of Cataract and Refractive Surgeons
ETDRS: Early Treatment Diabetic Retinopathy Study
EUREQUO: European Registry of Quality Outcomes for Cataract and Refractive Surgery
FECD: Fuchs Endothelial Corneal Dystrophy
FLACS: Femtosecond laser assisted cataract surgery
GDG: Guideline Development Group
GRADE: Grading of Recommendations Assessment, Development and Evaluation
HOA Higher Order Aberrations
HUI3: Health Utilities Index Mark 3
IC: Intracameral
IFIS: Intraoperative Floppy Iris Syndrome
IOL: Intraocular lens
IOP: Intraocular pressure
ISBCS: Immediate Sequential Bilateral Cataract Surgery
IVB: Intravitreal Becavizumab
K: Keratometry
LOCS: Lens Opacities Classification System
LRI: Limbal Relaxing Incision
LVC: Laser Vision Correction
MAE: Mean Absolute Error
MARINA: Minimally Classic/Occult Trial of the Anti-VEGF Antibody Ranibizumab in the Treatment of Neovascular AMD
MC: Mean Change
MD: Mean Difference
MGD: Meibomian Gland Dysfunction
MICS: Micro-Insicion Cataract Surgery
MPE: Mean Prediction Error
MT: Macular Thickness
NC: Nuclear Colour
NO: Nuclear Opalescence
NPDR: Non-Proliferative Diabetic Retinopathy
NSAID: Non-steroidal anti-inflammatory drug
NVA: Near Visual Acuity
OCCI: Opposite Clear Corneal Incisions
OCT: Optical Coherence Tomography
OR: Odds Ratio
PBK: Pseudophakic Bullous Keratopathy
PCA: Posterior Corneal Astigmatism
PCME: Pseudophakic Cystoid Mauclar Edema
PCO: Posterior Capsular Opacification
PCR: Posterior Capsule Rupture

PCS: Phacoemulsification Cataract Surgery
PEX: Pseudoexfoliation syndrome
PICO: Population Intervention Comparators Outcome
pIOL: Phakic Intraocular Lens
PKP: Penetrating Keratoplasty
PPC: Precision Pulse Capsulotomy
PREMED: Prevention of Macular Edema after Cataract Surgery
PROMS: Patient-Reported Outcome Measures
PSC: Posterior Subcapsular Cataract
PVD: Posterior Vitreous Detachment
QALY: Quality Adjusted Life-Years
RCT: Randomized controlled Trial
RK: Radial Keratotomy
RR: Risk Ratio
SCH: Suprachoroidal Haemorrhage
SE: Standard Error
SIA: Surigcally Induced Astigmatism
SMD: Standardized Mean Difference
TASS: Toxic Anterior Segment Syndrome
TCA: Triamcinolone Acetonide
TIA: Target Induced Astigmatism
TK: Total Keratometry
TNF: Tumor Necrosis Factor
TTO: Time Trade-Off
UIVA: Uncorrected Intermediate Visual Acuity
UNVA: Uncorrected Near Visual Acuity
VA: Visual Acuity
VF-14: Visual Function Index questionnaire
VF-7: Visual-Functioning 7-item Index
WMD: Weighted Mean Difference
ZD: Zonular Dialysis

# 1. Introduction

This guideline provides explicit, evidence-based recommendations and insights that healthcare providers should follow to deliver high-quality care. This ESCRS Cataract Surgery Guideline is crucial for medical practice, supporting clinical decision-making and promoting better care, transparency, and reduced unwanted practice variation. While they are not prescriptive regulations, healthcare providers may deviate from these recommendations in complex cases where the patient's circumstances differ significantly from the 'average patient.' The physician must exercise their judgment on the suitability of the care provided to a particular patient, considering all the circumstances presented by the patient. However, any deviation should be documented in the patient's record and supported by clear reasoning.

# 2. Definitions

## 2.1 Definition of Cataract

Cataract is a significant cause of blindness, which is only reversible by surgery. Currently no non-surgical therapy exists. As age advances, the prevalence of cataracts tends to increase significantly. The prevalence of cataract ranges from 3.9% among individuals aged 55-64 years to as high as 92.6% among those aged 80 years and older. It is projected that by 2025, the worldwide population of individuals affected by cataract blindness will surge to 40 million.(Fang et al., 2022) Cataract surgery is the most performed surgical procedure worldwide, with 7 million cases each year in Europe, 3.7 million cases in the USA, and 20 million worldwide.(Rossi et al., 2021) The European Registry of Quality Outcomes for Cataract and Refractive Surgery (ESCRS EUREQUO) already contains more than 2.9 million cataract surgery records.(ESCRS and EUREQUO, 2021 [accessed 2.5.23])

Cataract can affect infants, adults and older people but predominantly affects the latter group. Cataracts can result from genetic, metabolic, nutritional, or environmental impacts or secondary to other systemic or ocular comorbidities, such as diabetes, retinal degenerative diseases and trauma, and medication use (e.g., corticosteroids). Ageing is by far the most common cause.(Lee et al., 2019) Treatment options include the correction with glasses only at an early stage, but if the cataract matures enough to interfere with routine activities, cataract extraction (i.e., phacoemulsification with IOL implantation) is advised.(Moshirfar et al., 2022, Chylack, 1993, Yanshole et al., 2019, Lee et al., 2019)

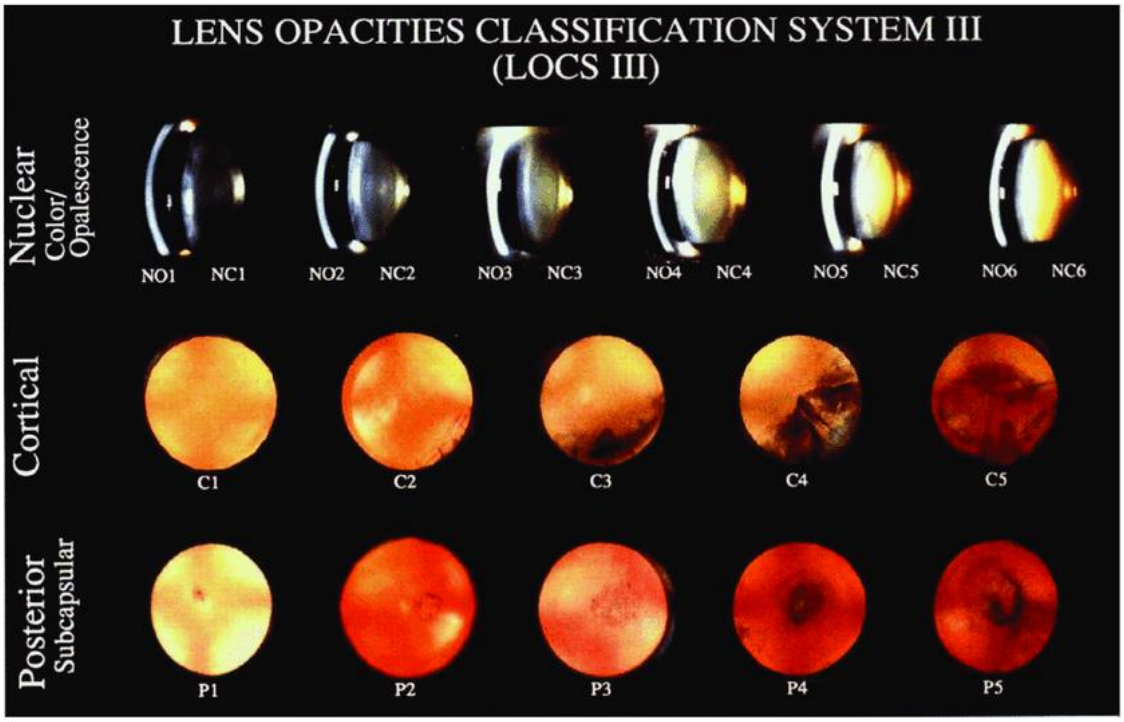
Cataract is a pathology characterized by clouding or opacification of the natural lens or capsule. The passage of light through the lens to the retina becomes obscured, and results in hazy and blurred vision. Colours appear faded, and patients become more sensitive to light. It is important to mention that cataract is not a single disease entity and may result from a diverse range of pathologies. The location of the opacity in the lens, the opaque area's appearance and the opacification rate can vary greatly.(Moshirfar et al., 2022) The lens consists of transparent fibres (modified epithelial cells) enclosed in a membranous structure called the lens capsule. Over time, degenerative processes denature and coagulate lens proteins in the lens fibres, resulting in a loss of transparency. These mechanisms include fibrous metaplasia of the lens epithelium, leading to a subcapsular cataract, hydration of the spaces between the lens fibres causing a cortical cataract, and deposition of pigments resulting in a nuclear cataract. Cataracts can be subcategorized according to different grading schemes (references) which consider the amount of capsular, anterior, and posterior subcapsular, cortical, and nuclear cataracts. A common grading scheme is the Lens Opacities Classification System III (LOCS III), which includes four categories (NO; NC; C; PSC) shown in Table 1. Nuclear opalescence **(NO)** describes the average opalescence when viewing the central nucleus and the peripheral nucleus; Nuclear colour **(NC)** focuses the slitlamp beam on the posterior

capsule to describe the true colour of the lens; Cortical cataract **(C)** describes the cortical changes best seen on retroillumination; while posterior subcapsular cataract **(PSC)** refers to the amount of the posterior subcapsular opacity seen in retro illumination.(Chylack, 1993, Yanshole et al., 2019)

*Table 1. LOCS Grading* (Chylack, 1993)

| | |
|---|---|
| **NO** | Opalescence is averaged between the central nucleus and the peripheral nucleus<br>- Graded from 0.1 to 6.9 (E.g., NO 6.0 – clear peripheral zone is gone) |
| **NC** | Focus on the posterior capsule to capture the actual colour of the lens<br>- 1.0 More white than yellow<br>- 2.0 More yellow than white<br>- 3.0 Lemon yellow<br>- 4.0 Gold<br>- 5.0 Bronze<br>- 6.0 Reddish bronze |
| **C** | Retro illumination - cortical cataracts must be opaque to be graded<br>- Assess the aggregate area of the cortex<br>- Ignore isolated vacuoles or water clefts<br>- The density of the shadow is irrelevant; only the area is assessed |
| **PSC** | The opacity must be visible in the retro illumination view to be graded<br>- Only grade if it lies in the central 3.0 mm zone of the pupil (outside this area, it is a cortical cataract). Estimate the area, not the density. |

*Figure 1. LOCS III Classification* (Chylack, 1993)



## 2.2 Definitions of different intraocular lens targets

Prior to cataract surgery, patients should be consulted regarding the desired target refraction. This guideline covers the following target refraction goal definition:

- Emmetropia: refers to the condition in which there are no refractive errors present. When the eyes are in an emmetropic state, objects located at infinity are sharply focused on the retina in the absence of accommodation. In practice a refraction ranging between +0.25D and -0.25D is defined as emmetropia.(Langenbucher, 2015)
- Minimonovision: refers to the condition where the dominant eye is targeted for emmetropia while the non-dominant eye is targeted slightly myopic ranging between -0.25D and -0.75D in order to increase spectacle independence.(Cochener, 2018)
- Monovision: refers to the condition when one eye is targeted for distance vision while the other eye is targeted for near vision. The range of diopters for monovision correction may vary according to the specific needs of the patient. In practice, monovision ranges from -1.25D to -2.00D.(AAO PPP Cataract and Anterior Segment Panel and Hoskins Center for Quality Eye Care, 2021 [accessed 2.5.23])

## 2.3 Definitions of different types of astigmatism

- Grading
    - Low astigmatism (0.25 to 1.5D)
    - Moderate astigmastism (1.5 to 3.0D)
    - High astigmatism (above 3.0)
    - Myopic / hyperopic / mixed astigmatism (Nunez et al., 2019)

- Regular astigmatism
    - With-the-rule astigmatism: Steep axis of the cylinder is vertical or within 30 degrees of the 90 degrees of vertical meridian (60-120 degrees)
    - Against-the-rule astigmatism: Steep axis of the cylinder is horizontal or within 30 degrees of the horizontal meridian (0-30 or 150-180 degrees)
    - Oblique astigmatism: Steep axis of the cylinder is not within 30 degrees of the horizontal or vertical meridians (31-59 degrees and 121-149 degrees)(Nunez et al., 2019)

- Irregular astigmatism
    - Where the two main axes of astigmatism are not symmetric and/ or do not lie 90 degrees apart (orthogonal)
    - Irregular or pathological astigmatism treatment is beyond the scope of this guidelines (e.g., those caused by corneal dystrophies, traumas, degeneration, ocular surface disease, corneal ectactic diseases such as keratoconus, and prior corneal surgery)(Nunez et al., 2019)

## 2.4 Definitions of different IOLs

Classifying intraocular lens (IOL) technologies is not an easy task, primarily due to the various categories that can be integrated into a classification. Some of these categories represent different characteristics that may be inappropriately combined in an attempt to create a simplified taxonomy, which is not always feasible. Therefore, when defining an IOL, it is crucial to differentiate between various categories and avoid mixing them, to prevent confusion for the user.

### 2.4.1 Optical Technologies

Two main types of optical technologies, diffractive and refractive, have historically been used to classify IOLs, depending on the optical principles utilized for focusing light.(Rampat and Gatinel, 2021) Diffraction and refraction can be achieved through distinct optical structures or optical features.(Davison and Simpson, 2006, Teng S, 2013) Diffraction can be accomplished with small optical apertures and diffractive gratings, while refraction can be achieved by varying the asphericity and radius of an optical surface or through zones and sectors.(Rampat and Gatinel, 2021, Teng S, 2013) However, some designs may combine some of the previously described optical features or mechanisms, thus controversies are likely to occur forcing to assign an IOL to one optical classification.(Kanclerz et al., 2020, Rampat and Gatinel, 2021, SM., 2021)

According to the shape and number of foci, a taxonomy with five categories has been described in the literature: multifocal intraocular lenses (including bifocal, trifocal and panfocal), with the first trifocal lens introduced in 2010,(Sudhir et al., 2019) extended depth of focus lenses (EDF), which emerged in 2014,(Kanclerz et al., 2020, Kohnen and Suryakumar, 2020) monofocal IOLs with enhanced depth of focus (Mono-EDF) for which the first Conformité Européenne (CE) mark was granted in 2019,(Fernández et al., 2023, Mencucci et al., 2020, Rampat and Gatinel, 2021) and conventional monofocal aspherical and finally spherical IOLs.

### 2.4.2 Standard Terms and Definitions

According to the International Organization for Standardization (ISO 11979-7, 2024), there are four main categories of IOLs that are determined by optical design and/or clinical characteristics or performance.(ISO-11979-7:2024., 2024) Monofocal, Toric, Simultaneous Vision Range Lenses (SVL) and Accommodating IOLs. From these, SVL are those non accommodative lenses that provide simultaneous vision at multiple distances and can be subclassified in three types:

- Multifocal (MIOL): emphasize optical and functionally useful acuity levels at far, but when compared to monofocal control lenses, also have improved optical and clinical performances at intermediate (for trifocal IOLs) and near distance.

- Extended Depth of Focus (EDF): emphasize optical and functionally useful acuity levels at far but also from far through intermediate distance.
- Full Visual Range (FVR): emphasize optical and functionally useful acuity levels at far but also from far through intermediate and up to near distance.

Table 2 describes the end-points that should be accomplished for classifying a SVL according to the ISO 11979-7:2024 standard.

*Table 2. Summary of end-points for Standard ISO 11979-7:2024 classification for Multifocal (MIOL), Extended Depth of Focus (EDF) and Full Visual Range lenses (FVR).*

| | MIOL | EDF | FVR |
|---|---|---|---|
| Mesopic (logCS) without Glare | ≤ 0.3[b*] | ≤ 0.3[b*] | ≤0.3[b*] |
| CDVA (logMAR) | ≤ 0.2[a] | ≤ 0.1[b*] | ≤ 0.1[b*] |
| DCIVA at 66 cm (logMAR) | | ≤ 0.2[a] and X[b*] | ≤ 0.2[a] and X[b*] |
| DCNVA at 40 cm (logMAR) | X[b*] | | ≤ 0.2[a] and X[b*] |
| RoF (D) in 0.2 logMAR | | ≥1.5[a] | ≥2.5[a] |
| ∆RoF (D) in 0.2 logMAR | | ≥0.5[b*] | |
| [a] Absolute value;<br>[b*] Relative difference for a stablished value vs. monofocal control group<br>X[b*]: Relative difference for any magnitude X vs. monofocal control group<br>*one-tailed test vs. control (p=0.025)<br>CDVA: Corrected Distance Visual Acuity, DCIVA: Distance Corrected Intermediate Visual Acuity; DCNVA: Distance Corrected Near Visual Acuity, ∆RoF: Relative increase of the range of the depth of field versus the control | | | |

It is important to note, that ISO agrees with the ANSI standard for EDF IOLs in all the end-points described in Table 2, but ISO adds the achievement of a RoF absolute value at a visual acuity level of 0.2 logMAR of 1.5 D.(Z80.35-2018-A.) Conversely, ANSI describes that EDF IOLs should have a monotonous decrease of visual acuity which means that the visual acuity from far to near should have a continuous decrease, and in the it should have an inflexion point, this one should be ≤ 0.04 logMAR.(Z80.35-2018-A.)

### 2.4.3 Evidence-Based Functional Classification

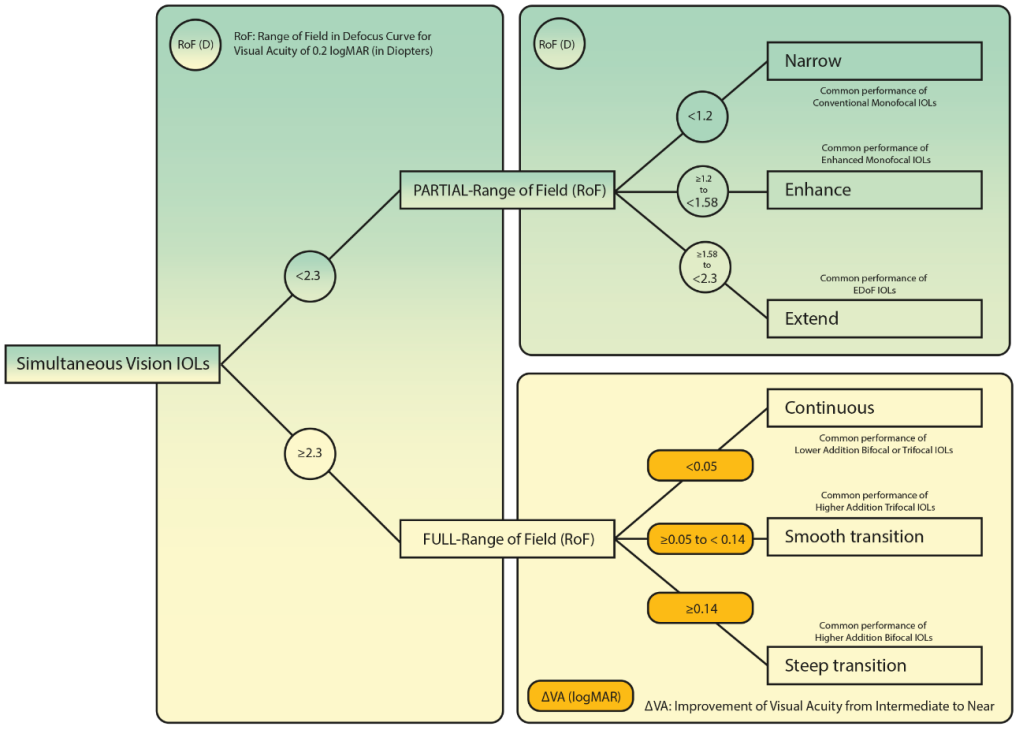
A functional classification has been developed considering the end-points described in the standards,(Fernandez et al., 2024) especially those referring to the RoF measured through monofocal visual acuity defocus curves with the best distance correction. This classification has been qualified as evidence-based because the scientific method (cluster analysis) has been the pillar during the development.

The cluster analysis found that two metrics were enough to classify IOLs:

1. The increase in VA (ΔVA) from intermediate to near in the event of a non-monotonic decrease in visual acuity from far to near and
2. The RoF from CDVA to 0.2 logMAR or 0.3 logMAR cut-offs of visual acuity.

Figure 2 shows that two main categories can be identified depending on the defocus curve RoF at the visual acuity level of 0.2 logMAR and the shape: 1. PARTIAL-RoF, 2. FULL-RoF. In 1. PARTIAL-RoF three subcategories can be described according to the achieved RoF: 1.1. PARTIAL-RoF Narrow, 1.2. PARTIAL-RoF Enhance, and 1.3. PARTIAL-RoF Extend. On the other hand, 2. FULL-RoF IOLs subcategories depend on how steep is the increase in visual acuity from intermediate to near: 2.1. FULL-RoF Continuous for an increase below 0.05 logMAR, 2.2. FULL-RoF Smooth for an increase between 0.05 and below 0.14, and 2.3. FULL-RoF Steep for an increase of 0.14 logMAR or higher.

*Figure 2. Diagram of functional classification depending on: 1. the range of the depth of field (RoF) achieved in the monocular defocus curve with best correction at distance at 0.2 logMAR visual acuity level, and 2. the improvement of visual acuity from intermediate to near ΔVA.*



### 2.4.4 Conclusion

Historical terminologies used for classifying IOLs have been reviewed, and a functional classification has been introduced to enhance understanding, focusing on the visual acuity that patients achieve across the visual range. The importance of separating classification categories is emphasized, as different optical technologies could produce similar functional outcomes. However, there is a recognized relationship between optical terms and functional classification. Therefore, Table 3 summarizes the usual correspondences between optical, standard, and functional classifications, which may help surgeons understand the new concept.

*Table 3. Summary of the usual correspondences between historical, standard, and functional terms.*

| Optical Technologies | Standard Terms | Functional Classification |
|---|---|---|
| Monofocal | Monofocal | PARTIAL-RoF narrow |
| Enhanced Monofocal | - | PARTIAL-RoF enhance |
| EDF | SVL: EDF | PARTIAL-RoF extend |
| MIOL: trifocal / bifocal of low addition | SVL: FVR | FULL-RoF continuous |
| MIOL: trifocal of high addition | SVL: FVR | FULL-RoF smooth |
| MIOL: bifocal of high addition | SVL: MIOL | FULL-RoF steep |

EDF: Extended Depth of Focus
MIOL: Multifocal Intraocular Lenses
SVL: Simultaneous Vision Range Lenses
FVR: Full Visual Range
RoF: Range of Field

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# 3. Methodology

## 3.1 Introduction

The European Society of Cataract and Refractive Surgeons (ESCRS) has developed international guidelines for managing cataracts, using the best available evidence.

This chapter describes the methods and processes used to develop the ESCRS guideline for cataract surgery. The development process includes comprehensive quality criteria as described in the Appraisal of Guidelines for Research and Evaluation II (AGREE II) instrument (Dans and Dans, 2010), primary methodological research, and evaluation by the guideline development group (GDG). The methodology used to create this guideline follows a globally recognized approach to guideline development.

## 3.2 Development Process

### 3.2.1 Phase 1: Setting the Scope

The ESCRS was a stakeholder interested in the guideline topic for the European Guidelines for Cataract Surgery. The Guideline Development Group (GDG) of the ESCRS was asked to establish this European guideline and was supported by a grant from the ESCRS. The guideline development process consisted of face-to-face and online meetings with the GDG. Two PhD candidates (JW, VK) and the methodologist (JK) worked closely with the GDG during the development period.
The first vital issues include the aim of the guidelines, considering the health problems to be addressed, the patient group and the target audience. Cataract, the most important cause of age-related vision loss, is clinically diagnosed. The GDG group decided this guideline must be relevant to all patients with cataracts for whom cataract surgery is considered. In general, the decision to perform cataract surgery is mainly based on the patient's degree of symptoms and the presence or absence of other ocular and systemic co-morbidities. (Mukhija and Nanavaty, 2023)
The purpose of this guideline was to address both diagnostic and therapeutic steps in cataract management. The structure of this guideline is according to the patient pathway, including the following sections: screening and patient selection, preoperative assessment, perioperative procedure, postoperative care, and complication management. The guideline aims to apply to all healthcare workers (e.g., ophthalmologists, residents, general practitioners, nurses, optometrists, and opticians) and patients interested in cataract management.

3.2.2 Phase 2: Invitation of the Guideline Development Group (GDG)

In preparation for the guideline development, a guideline development group (GDG) was composed, including members from 12 different countries (Austria, Belgium, France, Germany, Israel, Italy, the Netherlands, Norway, Portugal, Spain, Sweden and the United Kingdom). These members were invited by the GDG Chairs (OF, RN) to be representative healthcare professionals with extensive knowledge of cataract management. The members of the GDG formulated vital issues which were further developed by the constituting guideline development group (CDG). The CDG included two PhD students (JW, VK) and the supervising methodologist (JK).

In the composition of the GDG, several factors were considered. First, all clinical members should have an affinity with diagnosing and treating cataracts, considering that clinical knowledge on the subject is key. Second, the distribution of geographical differences between GDG members is desired, as the guideline is aimed at an international audience.

The GDG consisted of 18 ophthalmologists (AA, AB, AD, CP, DM, FR, GA, JA, KG, MN, NH, NR, OF, PH, PR, RB, RN, SN), one patient representative (PK), two PhD candidates (JW, VK) and one methodologist (JK) with extensive experience in guideline development. In addition, the GDG members received the assistance of a methodologist's team (staff at Kleijnen Systematic Reviews Ltd) whose work covered input from information specialists, quality assurance, and evidence review and support.

*Table 4. Members of the Guideline Development Group (GDG)*

| **Guideline member** | **Profession** | **Institution** | **Country** |
|---|---|---|---|
| Adi Abulafia (AA) | Ophthalmologist | Shaare Zedek Medical Center, Jeruzalem | Israel |
| Anders Behndig (AB) | Ophthalmologist | Umeå University, Umeå | Sweden |
| Alexander Day (AD) | Ophthalmologist | Moorfields Eye Hospital NHS Trust, London | United Kingdom |
| Catarina Pedrosa (CP) | Ophthalmologist | Hospital Lusiadas Lisboa, Lisbon | Portugal |
| Dominique Monnet (DM) | Ophthalmologist | Paris Descartes University, Paris | France |
| Filomena Ribeiro (FR) | Ophthalmologist | Hospital da Luz - University of Lisbon, Lisbon | Portugal |
| Gerd Auffarth (GA) | Ophthalmologist | University of Heidelberg, Heidelberg | Germany |
| Jorge Alio (JA) | Ophthalmologist | Universidad Miguel Hernandez, Alicante | Spain |
| Kjell Gundersen (KG) | Ophthalmologist | IFocus Eye Clinic AS, Haugesund | Norway |
| Mayank A.Nanavaty (MN) | Ophthalmologist | University Hospitals Sussex NHS Foundation Trust, Brighton | United Kingdom |

| | | | |
|---|---|---|---|
| Nino Hirnschall (NH) | Ophthalmologist | Johannes Kepler University & Kepler University Hospital GmbH, Linz | Austria |
| Nic Reus (NR) | Ophthalmologist | Amphia ziekenhuis, Breda | The Netherlands |
| Oliver Findl (OF) | Ophthalmologist | Vienna Institute for Research in Ocular Surgery (VIROS), Hanusch Hospital, Vienna | Austria |
| Peter Hoffmann (PH) | Ophthalmologist | Augen - und Laserklinik Castrop-Rauxel, Castrop-Rauxel | Germany |
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### 3.2.3 Phase 3: Formulating Review Questions

Three researchers (JK, JW, VK) formulated a set of review questions assessing the key issues listed in the scope. These review questions were formulated according to important patient outcomes in a PICO framework (population, intervention, comparator, and outcome). The PICO framework was used to assess the effectiveness of an intervention and similar frameworks for other types of questions. Table 5 describes the PICO framework, which offers a helpful and structured approach for developing questions about interventions.

*Table 5. PICO Framework, used for formulating the review questions*

| | |
|---|---|
| Population (P) | Which population are we interested in? How best can it be described? Are there subgroups that need to be considered? |
| Intervention (I) | Which intervention, treatment or approach should be used? |

| | |
|---|---|
| Comparators (C) | Are there alternative(s) to the intervention being considered? If so, what are these (e.g., other interventions, standard active comparators, usual care or placebo)? |
| Outcome (O) | Which outcomes should be considered to assess how well the intervention is working? What is important for people using services? Core outcome sets may be used where appropriate; one source is the COMET database. |

A draft scope, including the review questions and a set of outcomes, was discussed with the chairs (OF, RN) of the GDG. The input of the chairs was used to refine the questions and cluster them into five different topics (Patient selection and indication, Special indications; pseudophakic presbyopia correcting IOLs and astigmatism; Diagnostics, IOL formulae, Target refraction; Prophylaxis, Pre- and Postoperative medication; Surgery techniques, Complications). A GDG subgroup discussed every topic with extensive expertise in this area of interest. The questions were discussed during online meetings with every subgroup and finalized according to the comments and feedback of the GDG members. The finalized questions were structured and clustered into chapters according to the patient pathway (i.e., screening, and patient selection, preoperative assessment, perioperative procedure, postoperative care, and complication management). The set of outcomes, which are important and critical for decision-making in the clinical setting, were also discussed with the GDG members and revised. The final set of outcomes, given in Table 6, is crucial for assessing the strength of evidence by applying GRADE. Grading the evidence is essential in formulating appropriate recommendations.

*Table 6. Set of selected outcome parameters*

| **Outcome measures/parameters** | **Importance** |
|---|---|
| Serious adverse events<br>- Complications during surgery<br>o Posterior capsule rupture with/without vitreous loss<br>o Dropped nucleus<br>o Zonular dialysis with vitreous loss<br>o Iris damage with the need for reconstruction<br>o IOL damage during insertion<br>o Suprachoroidal haemorrhage<br>- Complications after surgery<br>o Inflammation (e.g., endophthalmitis, toxic anterior segment syndrome (TASS))<br>o Retinal detachment<br>o Pseudophakic bullous keratopathy<br>o Intraocular lens related complications | Critical outcome |
| Visual acuity<br>- Distance visual acuity<br>- Intermediate visual acuity | Critical outcome |

| | |
|---|---|
| - Near visual acuity | |
| Postoperative refractive outcome<br>- Spherical error<br>- Cylindrical error | Critical outcome |
| Quality of life<br>- Spectacle independence<br>- Optical side effects<br>- Activities of daily living<br>- Satisfaction (Patient satisfaction questionnaire) | Important, but not critical |
| Visual function<br>- Defocus Curve<br>- Contrast sensitivity | Important, but not critical |
| Adverse events<br>- Complications during surgery<br>o Anterior capsule tear<br>o Iris damage<br>o Zonular dialysis without vitreous loss<br>- Complications after surgery<br>o Posterior capsular opacification (PCO)<br>o Capsular contraction syndrome<br>o Elevated intraocular pressure<br>o Inflammation<br>▪ Cystoid macular edema<br>▪ Postoperative anterior uveitis<br>o Corneal edema<br>o Binocular imbalance and double vision<br>o Dry eye symptoms<br>o Refractive surprise and presbyopia induction | Limited importance |

### 3.2.4 Phase 4: Literature Search

Literature searches were conducted on 17 January 2023 to identify relevant systematic reviews and randomized controlled trials on cataract surgery.

The search strategies were developed specifically for each database and the keywords were adapted according to the configuration of each database. Searches were limited by date range to 2005-2023. Searches were not limited by language or publication status.

**Handling of citations**

References identified from the searches were downloaded into EndNote bibliographic management software for further assessment and handling.

*Table 7. Resources searched:*

| Resource | Host | Date Range | Date searched | Records found |
|---|---|---|---|---|
| KSR Evidence | https://ksrevidence.com/ | to 17.1.23 | 17.01.23 | 390 |
| CDSR | Wiley | Iss 1/12, Jan 2023 | 17.01.23 | 155 |
| MEDLINE, Epub, Daily Update & In-Process | Ovid | 1946 to January 13, 2023 | 17.01.23 | 2630 |
| Embase | Ovid | 1974 to 2023 January 13 | 17.01.23 | 3761 |
| CENTRAL | Wiley | Iss 1/12, Jan 2023 | 17.01.23 | 4137 |
| | | | | |
| **TOTAL** | | | | **11073** |
| **TOTAL (after deduplication)** | | | | **5744** |

Full details of all search strategies are presented in Appendix 1.

### 3.2.5 Phase 5: Research evidence reviewing

Dr Joukje Wanten, Dr Victoria Kauer, and the KSR team extracted data from the selected articles supervised by the methodologist (JK) and the GDG. For each question, the selection of evidence focused on available meta-analyses and systematic reviews, supplemented by other studies published in 2005 and onwards. For the systematic reviews, no specific date limit was used.

For grading the evidence, the quality assessment is crucial. The methodologist (JK) and staff critically appraised all the systematic reviews. The critical appraisal was based on the Risk of Bias in Systematic Reviews assessment tool (ROBIS).(Whiting et al., 2016) This tool looks at four domains of a systematic review: study eligibility criteria, identification and selection of studies, data collection and study appraisal, synthesis, and findings. The full ROBIS tool and guidance documents are available from the ROBIS Web site (www.robistool.info) and as Appendices at www.jclinepi.com. The Joanna Briggs Institute Critical Appraisal Checklist was used for assessing the risk of bias in randomized trials.(Joanna Briggs Institute, 2020 [accessed 20.2.23])

### 3.2.6 Phase 6: Developing and formulation of recommendations.

The quality of the relevant evidence was summarized using the GRADE approach (table 8).(Neumann et al., 2014) This approach assessed the quality of the evidence for intervention studies by checking the features of the evidence found for each 'critical' and 'important' outcome. Grading the evidence was only done once the recommendations were advanced.

If needed, we updated high-quality systematic reviews, or their primary studies used, as evidence for informing a new review.

According to the GRADE approach, the evidence is classified as high, moderate, low or very low. These classifications are accompanied by a specific formulation of the

recommendations, using the wording ‘must’, ‘should’, ‘could’, ‘may’, ‘may not’, and ‘can be considered’. Considering high-level evidence, the term ‘must’ was used in the recommendations of this guideline. In the case of moderate evidence, ‘should’ or ‘could’ were used. For low-graded evidence, ‘could’ or ‘may’ are applicable, and lastly, when there was very low evidence implemented in the recommendations, ‘can be considered’ was used.(Whiting et al., 2016, Joanna Briggs Institute, 2020 [accessed 20.2.23], Neumann et al., 2014)

*Table 8. GRADE strategy for evaluating the quality of evidence.*

| **Grade of evidence** | **Definition** | **Specific wording** |
|---|---|---|
| High | Further research is very unlikely to change our confidence in the effect estimate. GRADE ++++ | ‘Must’ |
| Moderate | Further research is likely to impact our confidence in the estimate of effect and may change the estimate. GRADE +++ | ‘Should’ |
| Low | Further research is very likely to impact our confidence in the estimate of effect and is likely to change the estimate. GRADE ++ | ‘Could’ or ‘may’ |
| Very low | Any estimate of the effect is very uncertain. GRADE + | ‘Can be considered’ |

For the evidence review, specific sections were included: the summary of the evidence, evidence statements, full GRADE profiles, evidence tables, and forest plots (on indication).
During the ESCRS congress in Milan 2022, face-to-face meetings were scheduled for each subgroup of the GDG with a specific topic of interest. All review questions were discussed during this meeting, including the selected relevant literature retrieved from KSR Evidence, Embase (Ovid) and MEDLINE (Ovid). This meeting allowed all the GDG members to give feedback and comments on the questions and evidence. According to these comments, the questions were rephrased and optimized. Besides, the evidence found during the general literature search was discussed, and members provided their interpretations. Based on this information, the questions were finalized by the PhD candidates (JW, VK) and the methodologist (JK). According to these adjustments, the literature search was optimized and summarized. The finalized set of questions is given in Table 10.

*Table 10. Final set of review questions for the Cataract Surgery Guideline*

| Phase/Chapter | Questions |
|---|---|
| Screening and patient selection | - What are the indications for cataract surgery?<br>- Will the presence versus absence of (characteristic A) impact efficacy and safety outcomes in patients for whom cataract surgery is considered?<br>- What mental health factors must be considered when preparing for cataract surgery?<br>- What information about surgery, target refraction and complications should be given to the patient before cataract surgery?<br>- In patients needing cataract surgery, what are the effects of immediate bilateral surgery compared with delayed sequential surgery and what is the minimum time between cataract surgery on the first and second eye?<br>- Do pseudophakic presbyopia correcting IOLs have a better postoperative outcome than monofocal IOLs or monofocals with monovision?<br>- Do toric IOLs give a better postoperative outcome than non-toric IOLs in cataract surgery? From which magnitude of corneal astigmatism is a toric IOL indicated?<br>- What type of anaesthesia is indicated for the patient? |
| Preoperative assessment | - What kind of diagnostics and preoperative assessment of the patient should be done? In patients who will undergo cataract surgery, what are the effects of diagnostic A versus no diagnostic A or versus diagnostic B on efficacy and safety outcomes?<br>- What kind of diagnostics and preoperative assessments of patients who previously underwent refractive surgery should be done?<br>- In which patients with an indication for cataract surgery is posterior segment OCT indicated?<br>- In which patients with an indication for cataract surgery is ultrasonography (A- or B-scan) indicated?<br>- What are the indications for specific assessment examinations for patients with corneal comorbidities?<br>- What are the indications for specific assessment examinations for patients with keratoconus?<br>- What preoperative assessment is necessary for presbyopia correcting IOLs?<br>- What preoperative assessment is necessary for toric IOLs?<br>- Which formula(e) for calculating lens power should be considered?<br>- Which formula(e) for calculating lens power in specific conditions should be considered?<br>- Which formula(e) for calculating the intraocular lens in patients who have undergone refractive surgery is/are preferred?<br>- Which target refraction is preferred in patients who will undergo cataract surgery? |

| | |
|---|---|
| Perioperative procedure | - What are the differences between femtosecond assisted laser cataract surgery (FLACS) and conventional phacoemulsification cataract surgery?<br>- What is the role of femtosecond laser in astigmatism control during a cataract surgery?<br>- What are the differences between different marking techniques for patients receiving toric IOLs?)<br>- What prophylaxis should be administered during cataract surgery to minimize the risk of postoperative endophthalmitis?<br>- What prophylaxis should be used in cataract surgery to minimise the risk of postoperative inflammation?<br>  o What is the most effective treatment to reduce postoperative inflammation after cataract surgery and reduce the risk of cystoid macular edema (CME)?<br>  o Is it equally effective to give inflammatory prophylaxis perioperatively ('dropless cataract surgery') so that patients do not have to drip at home?<br>- What is the optimal intra- and postoperative medication regimen for patients with other ocular pathologies who undergo cataract surgery? |
| Postoperative care | - Which precautions does the patient have to consider after the surgery? When should the next follow-up visit take place?<br>- What is the preferred postoperative medication that should be administered for inflammation and CME after cataract surgery?<br>- When is remote care after cataract surgery indicated for patients? |
| Complication management | - What kind of complications can occur during cataract surgery?<br>- What kind of complications can occur after cataract surgery?<br>- What kind of severe complications can occur during cataract surgery?<br>- What kind of severe complications can occur after cataract surgery? |

For each review question, the graded literature was summarized and interpreted, considering the quality of each article. The recommendations were written using specific wording according to the quality of the evidence.
During the face-to-face meeting in Vienna (November 2022), the GDG members discussed the proposed recommendations for the questions and made decisions about the importance and implementation of these recommendations in the guideline. If no specific evidence was found in the literature, the question was answered using an expert opinion or no recommendation was made.

## 3.3 The validation process for the draft guidelines

The draft version of the ESCRS cataract guidelines will be published on the ESCRS website. The ESCRS will inform respondents and ask them to submit any feedback within two months.

3.3.1 Finalizing and publishing the Guideline

The complete development of this guideline took between 12 and [ADD] months (table 11). This (dynamic) guideline will be updated every 5 years, with specific chapters being updated on a two-year basis depending on new scientific research advances. This will keep the guideline up to date by involving searches and assessments of relevant literature to review the current recommendations. The relevant literature should provide a reconsideration for adapting the recommendations.

*Table 11. Schedule of guideline development*

| **Program** | **Period of time** |
|---|---|
| Development guideline protocol | February 2022 |
| Establishing the Guideline Development Group | March 2022 |
| Face-to-face meeting: Introduction | May 2022 (Frankfurt) |
| Development of review questions | May-July 2022 |
| Online meeting: discussing questions in subgroups | July 2022 |
| Literature searches | July-September 2022 |
| Face-to-face meeting: discussing the questions according to the evidence found | September 2022 (Milan) |
| Finalizing literature search and drafting recommendations | September-November 2022 |
| Face-to-face meeting: discussing methodology and recommendations | November 2022 (Vienna) |
| Face-to-face meeting: discussing drafts | March 2023 (Vilamoura) |
| Face-to-face meeting: discussing drafts | April 2023 (Vienna) |
| Finalizing draft guideline | April-July 2023 |
| Validation and checking | September 2023-May 2024 |

## 3.4 Conflict of Interest

All GDG group members completed a conflict-of-interest questionnaire (appendix [X]). ESCRS is the sponsor for this project guideline.

## 3.5 References

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# 4. Screening and patient selection

## 4.1 Indications for cataract surgery

### Output question

What are the indications for cataract surgery?

### Recommendation

A cataract is clinically diagnosed at the slit lamp examination by an ophthalmologist. The patient and ophthalmologist should take the shared decision for cataract surgery, and this should be well documented in the patient's medical records. (GRADE +)

Important aspects to be considered for the indication for cataract surgery are the presence and appearance of cataract, a patient’s visual acuity and function (visual acuity and quality of vision), the subjective disability of the patient and the expected benefits of the cataract surgery. (GRADE +).

Co-morbidities and the surgical risk profile should be considered and discussed with the patient prior to the surgery. Documentation of this process in the patient file is mandatory. It is recommended to use validated patient satisfaction questionnaires and Patient Reported Outcome Measures (PROMs) to evaluate the outcome of cataract surgery. (GRADE +)

### Considerations

Since cataracts are clinically diagnosed, subjective changes in visual function can help identify suitable patients for cataract surgery. The presence or absence of ocular comorbidities, the preoperative visual acuity and other visual function parameters, and the functional disability of the patient are important to take into consideration for decision-making.(Quintana et al., 2010)

A scoring system can be used to clinically predict the increase of visual performance based on preoperative visual function, better-sighted eye, and surgical complexity.(Kuoppala et al., 2012, Perea-Milla et al., 2011)

Preoperative visual acuity is often used as a primary indicator for cataract surgery but is a poor predictor of postoperative visual function. However, it is an efficient way of setting a barrier to patients' eligibility for cataract surgery. Other indications for cataract surgery include facilitating treatment or monitoring of a posterior segment disease, correcting anisometropia, preventing acute narrow angle glaucoma, or treating lens-induced ocular diseases.(Kessel et al., 2016a) Co-morbidities and surgical risk profile should be considered and discussed with the patient prior to the

surgery. Appropriate documentation of this process is recommended. (Expert opinion)

In the cataract pathway, the outcomes of cataract surgery can be evaluated using validated questionnaires such as Catquest-9SF,(Lundstrom and Pesudovs, 2009) and other patient-reported outcome measures (PROMs). By assessing PROMs, a more comprehensive evaluation of the quality of the procedure can be obtained in addition to clinical-reported outcome measures (CROMs). This is because the relationship between PROMs and CROMs is multifactorial and complex and evaluating both can provide deeper insights into the success of the procedure.(Zijlmans et al., 2021)

## Conclusion

Implications for practice

Based on currently available evidence, cataract is clinically diagnosed by slitlamp examination by an ophthalmologist. The decision to perform cataract surgery must be shared consent between the patient and the ophthalmologist. It should be based on the presence and appearance of cataract, a patient's visual acuity and function, the subjective view of patients' disabilities and the expected benefits of cataract surgery.

Knowledge gaps

Further research on the specific indications for cataract surgery in a combination of other ocular and systemic co-morbidities would be useful. Research on the indications for phacoemulsification and intraocular lens exchange might also include aspects of refractive lens exchange, therapeutic lens exchange (e.g., glaucoma), as well as in young patients and those without ocular co-morbidities.

## Identified research evidence

### Findings from Systematic Reviews

One relevant systematic review was identified.

Meta-analyses showed that there was no difference between poor preoperative VA and fair preoperative VA in improving subjective visual function measured with the visual function questionnaire (VF-14) (mean difference [MD] -3.01, 95% Confidence Interval [CI] -10.32 to 4.30, 2 studies, low certainty evidence), or number of patients with an improved VA after cataract surgery (risk ratio [RR] 0.85, 95% CI 0.64 to 1.13, 3 studies, very-low certainty evidence), or several patients with an improved subjective visual function after cataract surgery (RR 1.00, 95% CI 0.94 to 1.06, 2 studies, very-low certainty evidence). One study showed that there was a difference

in favour of fair preoperative VA in terms of the number of patients with postoperative VA of 39 Early Treatment Diabetic Retinopathy Study (ETDRS) Letters score or less (~20/40) at 5 years after surgery (RR 0.30, 95% CI 0.09 to 0.97, low certainty evidence). Another study showed no difference between fair preoperative VA and poor preoperative VA in improving postoperative VA measured with logarithm to the minimal angle of resolution (logMAR) (MD 0.01, 95% CI -0.03 to 0.05, low certainty evidence). (Kessel et al., 2016a) The review was judged to be at a high risk of bias.

## GRADE table

### Poor preop VA compared to fair preop VA for cataract surgery

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2. Rosen PN, Kaplan RM, David K. Measuring outcomes of cataract surgery using the Quality of Well-Being Scale and VF-14 Visual Function Index. J Cataract Refract Surg. Feb 2005;31(2):369-78. doi:10.1016/j.jcrs.2004.04.043

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With fair preop VA | With poor preop VA | | Risk with fair preop VA | Risk difference with poor preop VA |
| **Subjective visual function (assessed with: VF-14 score)** | | | | | | | | | | | |
| 249 (2 observational studies) | serious[a] | serious[b] | not serious | serious[c] | none | ⨁◯◯◯ Very low | 204 | 45 | - | The mean subjective visual function was **0** | MD **3.01 lower** (10.32 lower to 4.3 higher) |

**CI:** confidence interval; **MD:** mean difference

**Explanations**

a. Results from observational studies.
b. Significant heterogeneity detected.
c. Small sample sizes.

## 4.1.1 References

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## 4.2 Patient characteristics and cataract surgery

### Output question

Will the presence versus absence of (characteristic A) impact efficacy and safety outcomes in patients for whom cataract surgery is considered?

**P**: Target group of patients which are suitable for cataract surgery
**I**: In patients (with characteristic A) for whom cataract surgery is considered
**C**: In patients (without characteristic A) for whom cataract surgery is considered
**O**: Visual acuity, visual function, quality of life, (serious) adverse events, postoperative refractive outcome, Quality of life

<u>Characteristics (Permanent conditions)</u>

- Macular degeneration (AMD)
- Glaucoma / Narrow angles prone to closure / Ocular hypertension
- Diabetic Retinopathy / Diabetic macular edema
- Dry eye disease (DED)
- Amblyopia
- Corneal opacities
- Macular pucker / Epiretinal membrane
- Previous refractive surgery
- Shallow anterior chamber
- Pseudoexfoliation syndrome
- White cataract / Brunescent cataract
- Small Pupil / Intraoperative Floppy Iris Syndrome
- Eyes with extreme axial length
- Uveitis
- Herpes keratitis
- Vascular occlusion

### Recommendations

<u>General recommendation</u>

The presence of patient characteristics and comorbidities can have an impact not only on the outcome in vision but also on the risks of surgery and postoperative complications. These should be discussed with the patient so that they are fully informed, and expectations are realistic. (GRADE +)

Significant ocular comorbidities, such as diabetic retinopathy, glaucoma, maculopathies, and uveitis should be identified during the preoperative evaluation since its presence can affect the postoperative visual acuity and function. (GRADE +)

1. Macular degeneration:

Cataract surgery in patients with macular degeneration improves visual function in all severity grades of AMD, at least in the short-term. (GRADE +)

It is recommended to perform cataract surgery in a period of quiescence of neovascular AMD, but timing for cataract surgery must be individualized according to the patient's needs. (GRADE +)

Maculopathies should be identified before cataract surgery. The long-term effects of AMD after cataract surgery are still unclear. (GRADE +)

2. Glaucoma/ Narrow angles prone to closure/ Ocular hypertension:

Intraocular pressure (IOP) should be monitored short-term after cataract surgery in glaucoma patients. (GRADE ++)

3. Diabetic Retinopathy / Diabetic Macular Edema:

The presence of active diabetic retinopathy or diabetic macular edema increases the risks of intraoperative and postoperative complications, such as macular edema. (GRADE +)

Cataract surgery can be considered when the underlying retinal disease is stabilised or when the presence of the cataract impedes with the evaluation and treatment of the retinal disease. (GRADE +)

4. Dry eye disease (DED):

Preoperative dry eye has an impact not only on preoperative examinations but also on postoperative outcomes. DED management should be optimised prior to surgery (see preoperative examinations) and the patients should be informed that DED symptoms often become worse after surgery (although often temporary). (GRADE +)

5. Amblyopia

Preoperative orthoptic examination may be necessary to assess binocular vision and detect possible amblyopia. (GRADE +)

6. Corneal opacities

Patients should be advised on the impact of the opacities on outcomes and the risk of additional medical or surgical management. (GRADE +)

7. Macular pucker / Epiretinal Membrane (ERM):

Compared to eyes without ERM, higher rates of cystoid macular edema and a reduced postoperative gain in visual acuity can be noted. (GRADE +)

8. Previous refractive surgery

In cataract patients who previously underwent refractive surgery, special preoperative examinations such as corneal topography and tomography may be of added value. (GRADE +).

The impact of previous surgery on refractive outcome prediction should be discussed as well as the need for further refractive correction. (GRADE +)

9. Shallow anterior chamber

Patients with a shallow anterior chamber should be informed about the increased risk of peri- and postoperative complications such as iris prolapse and corneal endothelial cell losss. (GRADE +)

10. Pseudoexfoliation syndrome (PEX)

PEX is an important risk factor in phacoemulsification because of complications such as poor pupillary dilatation, zonular weakness inducing intra- or postoperative lens dislocation, vitreous loss, postoperative IOP spikes, capsular phimosis, prolonged inflammation, and postoperative corneal decompensation. Patients should be counselled accordingly. (GRADE +)

11. White cataract/ Brunescent cataract

Surgical adaptions such as using trypan blue for capsular bag staining and decompression/ aspiration, or “milking” of the cortical material should be performed to reduce the risk of capsular tear. (GRADE +)

High cohesive viscoelastics and intravenous mannitol may be used to reduce the risk of tear out. (GRADE +)

Anterior segment ocular tomography (OCT) may be performed to grade lens intumescence. (GRADE +)

12. Small pupil / Intraoperative Floppy Iris Syndrome (IFIS)

The use of pupil expansion strategies should be considered in cases with small pupils that cannot be dilated pharmacologically. (GRADE +).

A staged approach of viscodilation, pupil expansion devices, including rings and iris hooks, should be considered and these devices should be available in the operating room. (GRADE +)

In cases of IFIS a combination of strategies including appropriate phacoemulsification fluidic parameters, pharmacological agents, longer corneal tunnels and dispersive viscoelastics should be considered. (GRADE +)

13. Eyes with extreme axial length

Long eyes can be defined as eyes with an axial length of over 26mm, while short eyes are generally defined as eyes with an axial length of under 22mm.

Patients should be informed about the increased risk of refractive surprise and complications with postoperative refraction being non-coherent with target refraction. (GRADE +)

Intraocular lens calculation must be adapted to axial length. This will be treated in the chapter about IOL calculation (see chapter 6).

14. Uveitis

Patients with uveitis will have visual improvement after cataract surgery but are also at more risk for the development of macular edema and a recurrence of uveitis. (GRADE +)

Active inflammation should be controlled prior to surgery, which means that the inflammation is sufficiently controlled, where possible. (GRADE +)

Pre-exisiting corneal, anterior, and posterior segment pathological changes such as corneal scarring, band keratopathy, iris atrophy, vascular fragility, anterior and posterior synechiae, pupillary and cyclic membrane formation, macular scarring, optic nerve inflammation, ischaemia, atrophy and retinal vascular disease should be considered. (GRADE +)

15. History of herpes keratitis

Antiviral prophylaxis with acyclovir or valacyclovir should be considered. (GRADE +)

16. Vascular occlusions

Patients with preoperative history of central retinal vein occlusions should be informed about the possible limitations on their visual outcomes after cataract surgery compared to other patients without retinal diseases. (GRADE +)

**Considerations**

Pre-existing ocular characteristics can have an impact on the effectiveness and risk assessment of cataract surgery. Appropriate preoperative counselling with the patients regarding these issues is important and expectations should be tailored and managed accordingly. Ocular comorbidities may limit cataract surgery results as long as this procedure may increase the risk for preexisting ocular conditions to progress. Screening for pre-existing ocular conditions with adequate staging and appropriate assessment is the key for complication risk mitigation and enhancing visual results when performing cataract surgery. (Expert opinion)

1. Macular degeneration

AMD and cataract may coexist in various severity levels. Cataract surgery can improve visual acuity and quality of life in most patients, but AMD remains a predictor of poor visual outcome even after cataract surgery. This depends, however, on the type and severity of the underlying degeneration as well as the timing and combination with treatments of active neovascularisation.(Forooghian et al., 2009)

In general, it can be stated that opinions about the role of cataract surgery on the development or progression of AMD differ. Earlier population-based studies showed

that cataract surgery was a statistically significant risk factor for the development of AMD and concluded that the incidence of AMD due to cataract surgery was approximately 50%.(Howard et al., 2013) However, more recent clinical studies have not found any statistically significant association between cataract surgery and the development or progression of AMD.(Casparis et al., 2017, Chandra et al., 2021)

Cataract surgery provides short-term improvement (6 months) in visual acuity in eyes with AMD, but the long-term effects could not be evaluated.(Casparis et al., 2017) It is unclear whether the timing of the surgery is important in patients with dry AMD. In the AREDS study visual acuity showed better improvement in eyes with early AMD compared to eyes with neovascular AMD. (Howard et al., 2013) ANCHOR (Anti-VEGF antibody for treatment of predominantly classic choroidal neovascularization in AMD),(Brown et al., 2009) retrospective analysis as well as MARINA (Minimally Classic/ occult trial of the Anti-VEGF antibody Ranibizumab in the treatment of neovascular AMD) showed an improvement of visual acuity at 3 months following cataract surgery.(Penman et al., 2020 [accessed 8.6.23]) Another review stated that the AMD progression is not affected by cataract surgery.(Chandra et al., 2021) Quality of life and visual acuity increase after cataract surgery shown by the AREDS(Huynh et al., 2014) and AREDS 2(Bhandari et al., 2022) report on patients with AMD who received cataract surgery.

An increased risk of postoperative complications such as posterior capsular rupture and endopthalmitis has been noted in patients with neovascular AMD receving intravitreal therapy undergoing cataract surgery.(Shalchi et al., 2017) Reactivation of quiet neovascular AMD secondary to iatrogenic inflammation has also been reported. It is recommended to perform cataract surgery in eyes with long-term quiescent neovascular AMD, as neovascular AMD then is less likely to reactivate. However, the Fight Retinal Blindness Project reported that the proportion of visits with choroidal neovascularization (CNV) lesions graded as active was similar pre- and post cataract surgery in most patients. It has to be noted that the CNV lesions showed greater expansion after cataract surgery in some patients. The course of neovascular AMD and the frequency of intravitreal injections required is not influenced by cataract surgery.(Kessel et al., 2016c)

In eyes with disciform scars secondary to AMD an improvement of visual acuity has been noted but was not sustained over the longterm.(Arikan Yorgun et al., 2018)

The current evidence regarding the effectiveness and safety of cataract surgery is limited compared to no surgery in eyes with AMD. Therefore, no conclusion can be drawn for the long-term effects (after 12 months). Furthermore, it was found that patients without AMD who underwent cataract surgery are significantly more at risk for developing late AMD, with an adjusted odds ratio of 1.96 (95% CI 1.28 to 3.02). Although it has to be noted that the occurrence of developing late AMD is rare.(Casparis et al., 2017, Howard et al., 2013)

2. Glaucoma

Cataract surgery might lead to an IOP decrease due to the replacement of the natural thickened lens and the implantation of a thinner artificial intraocular lens.(Berdahl, 2009) Studies concluded that the mean IOP, as well as the number of medications used, decreased significantly after cataract surgery especially in patients with angle-closure glaucoma as well as patients with open-angle glaucoma.(Hayashi et al., 2001) The decrease in IOP was proportional to presurgical IOP in eyes with primary open angle glaucoma, with a greater decrease in eyes with high presurgical IOP. IOP remained unchanged in eyes with low IOP preoperatively. In this study IOP reduction at one year remained constant for a follow-up period of 10 years and was similar in all age groups.(Poley et al., 2008)

In patients with preoperative PEX or glaucoma, short-term IOP elevation over 24 hours can occur directly after cataract surgery. The causes of these IOP spikes are multifactorial - surgical trauma, retained lenticular material or ophthalmic viscosurgical devices, preexisting comprise of outflow facilities, the release of iris pigment, hyphema and inflammation might contribute to IOP spikes directly after cataract surgery.(Hildebrand et al., 2003) Installation of carbonic anhydrase drops or topical betablockers might be induced after surgery.(Levkovitch-Verbin et al., 2008)

Clear lens extraction can be considered a therapeutic option in patients with angle-closure glaucoma even in the absence of cataract. An increased lens volume and the anterior positioning can contribute to an increased risk of angle closure. When comparing lens extraction to peripheral iridotomy in patients with angle closure glaucoma, clear lens extraction resulted in a lower IOP. According to the Preferred Practice Pattern from the American Academy of Ophthalmology (AAO), in the case of a primary angle-closure glaucoma, clear lens extraction can lower IOP in up to 30% of the cases.(Chen et al., 2015) This has also been shown by the EAGLE study, showing that refractive lens exchange had a greater efficacy and was more cost-effective than laser peripheral iridotomy.(Tanner et al., 2020) Topical treatment and iridotomy should be considered prior to performing surgery.

3. Diabetic Retinopathy / Diabetic Macular Edema

Patients with diabetic retinopathy are significantly more likely to develop macular edema (OR 5.91, 95% CI 2.72 to 12.84, $p<0.001$) and progressive retinopathy (OR 5.28, 95% CI 3.05 to 9.14, $p<0.001$), compared to patients without diabetic retinopathy, after cataract surgery. In addition, patients with diabetic retinopathy are less likely to have a postoperative visual acuity of 20/40. Hence, identifying diabetic retinopathy before performing cataract surgery is essential to predict postoperative visual acuity and function.(Guo et al., 2017)

Nevertheless, cataract surgery should be considered in patients with diabetic retinopathy. Postoperative treatment as well as an adaption to intraoperative treatment is indicated. The PREMED (Prevention of Macular Edema after cataract surgery) study proposed topical treatment with corticosteroids and anti-inflammatory drugs in combination with subconjunctival injection of triamcinolone at the end of the cataract surgery, which was able to significantly reduce cystoid macular edema compared to patients receving an intravitreal injection of bevacizumab in diabetic patients.(Wielders et al., 2018b) The risk of IOP increase afer treatment with corticosteroids has to be noted, and IOP should be followed up, especially in patients with pre-exisiting increased intraocular pressure.

4. DED

Specific information about DED can be found in chapter 5.5

5. Amblyopia

While there is no specific evidence, the diagnosis of amblyopia is not a contraindication to cataract surgery. Preoperative orthoptic examination may be indicated to assess binocular vision and detect possible amblyopia. (Expert opinion)

6. Corneal opacities

While there is no specific evidence, it is well accepted that reduced surgical visibility has an impact on complications and may require adaptation of the standard technique. Patients should be advised on the impact of the opacities on outcomes and the risk of additional medical or surgical management. (Expert opinion)

7. ERM / Macular Pucker

The incidence of ERM development within the first three years after cataract surgery is 11.2% compared to age-matched control eyes with no cataract surgery. Patients with an ERM who underwent cataract surgery showed improvement in visual acuity during the short-term follow-up (1-3 months).(Fong et al., 2013) The presence of ERM was related to the decrease in odds of achieving a visual acuity improvement of >0.30 logMAR. Moreover, compared to eyes without ERM, there is an increased risk of CME and decreased likelihood to obtain substantial visual improvement.(Chu et al., 2016b, Shakarchi et al., 2023) Eyes with a preoperative visual acuity of 20/40 will benefit more from cataract surgery than those with better preoperative visual acuity.(Hardin et al., 2018)

The characteristics of the retina can predict the risk of development or progression of ERM after cataract surgery. The presence of ERM itself preoperatively does not cause a statistically significant increase in ERM progression. Partial posterior vitreous detachment seemed to be the only risk factor for the development or progression of ERM after cataract surgery. Patients should be informed about the possible need of a combined pars plana vitrectomy in cases with macular traction due to ERM.(Kwon et al., 2021)

8. Previous laser refractive surgery

A customized preoperative examination is key to an excellent visual outcome in patients who previously underwent refractive surgery. Preoperative examination should include an accurate refraction and visual acuity measuring, extended slitlamp and dilated fundus examination, corneal topography, and and biometry. Adequate surgical planning using modern cataract surgical techniques and advanced methods of IOL power calculations is important for patients to regain a high quality of vision.(Alio et al., 2016)

Various systematic reviews showed that cataract patients following a corneal refractive surgery often showed similar preoperative corrected distance visual acuity (CDVA) to those without previous corneal refractive surgery. However, they were younger and presented a higher risk of worse postoperative CDVA, especially if they presented a preoperative CDVA of logMAR 0.0 (20/20) or better. Despite modern technologies and new formulae in IOL calculation, refractive surprise and patient dissatisfaction might occur, highlighting the importance of comprehensive preoperative patient education and counselling.(Alio et al., 2016, Manning et al., 2015)

Further discussion on these aspects is found in chapter 5.2.

9. Shallow anterior chamber

A shallow anterior is defined as one of 2.4 mm or less from the epithelial surface, and not necessarily associated with a narrow angle. While there is no specific evidence, it is known that a shallow chamber poses an increased risk of perioperative and postoperative complications such as iris prolapse and corneal endothelial cell loss. Patients should be informed of this.

10. Pseudoexfoliation syndrome

Pseudoexfoliation (PEX) syndrome is an age-related process associated with glaucoma and is characterized by the deposition of fibrillar material in the anterior

segment of the eye.(Aslan and Oktem, 2020) PEX might lead to the formation of dense nuclear cataracts, with a higher chance of having a nuclear opalescence grade of more than 4. PEX syndrome can also lead to a reduced pupil size of less than 6mm compared to the control groups. PEX can lead to a higher complication rate during cataract surgery, highlighting the importance of preoperatively detecting pseudoexfoliation syndrome. Complications may include poor pupillary dilatation, zonular weakness inducing intra- or postoperative lens dislocation and vitreous loss, postoperative IOP spikes, capsular phimosis, prolonged inflammation, and postoperative corneal decompensation.(Haripriya et al., 2019)

Although some studies have shown no significant differences in postoperative intra-ocular lens dislocation, raised intraocular pressure and corneal decompensation, other studies have shown that PEX has been associated with a higher rate of lens subluxation, zonular dehiscence and vitreous loss along with a higher chance of poor visual outcome, which indicates the need of a customized approach to cataract surgery in order to minimize intra- and postoperative complications.(Thevi and Abas, 2019)

Complication rates during cataract surgery are expected to be higher in the PEX groups than in the control group. Nevertheless, studies showed that one-year postoperative best-corrected visual acuity, one-year postoperative complication rates and average endothelial cell loss, when adjusting to age and nuclear opacity, are comparable. Pseudoexfoliation eyes without a shallow anterior chamber, small pupils, or apparent zonulopathy can be considered as eyes with lower risks for complications. If possible, experienced surgeons should operate on patients with PEX syndrome to minimize the risk for intraoperative complications. (Haripriya et al., 2019)

11. <u>White cataract / Brunescent cataract</u>

Phacoemulsification in patients with a white cataract requires skillful and experienced surgeons, because the capsule is more fragile, and the visibility of the red reflex is obscured.(Z. Chen et al., 2022a) Intraoperative complications include the leakage of liquefied cortical material and capsulorhexis tears tending to extend to the periphery because of high intracapsular pressure. This high intracapsular pressure may result from damage to the iron pump and metabolic barrier, allowing fluids to enter the lens nucleus with cortical hydration.(Kara-Junior et al., 2009)

Surgical adaptations may be necessary such as trypan blue for capsular bag staining and decompression/aspiration or “milking” of cortical material that can reduce the risk of capsular tear. Anterior segment OCT can be useful in preoperative assessment for lens intumescence. The use of high cohesive viscoelastics and intravenous mannitol help reduce the risk of tear out. (Expert opinion)

Additionally, when using a femtosecond laser, an adjustment of the femtosecond laser capsulotomy position should be considered, by increasing the post-anterior distance and reducing the pre-anterior capsule distance, as this might decrease the occurrence of an incomplete capsulotomy.(Z. Chen et al., 2022a)

Dense brown lenses also pose specific peroperative risks, particularly when performing phacoemulsification, due to the increased energy use. This may lead to an increased risk of posterior capsular tear, endothelial decompensation, and zonular instability. Additional surgical procedures may be required, and the patient should be informed on the potential risks. (Expert opinion)

12. Small pupil / Intraoperative Floppy Iris Syndrome (IFIS)

Small pupils can result from ageing, pseudoexfoliation syndrome, diabetes mellitus, uveitis, glaucoma, trauma, the instillation of a miotic agent or previous intraocular procedures and the use of an alpha-1-antagonist. A small pupil may complicate the cataract procedure by hindering the visualization and creating significant difficulties in handling the intraocular instruments.(Chang and Campbell, 2005) As a result, the surgeon may create an incomplete capsulorhexis. Complications such as an increased rate of intraocular bleeding, iris sphincter tear, posterior capsule rupture, vitreous loss and increased endothelial cell loss have been associated with a small pupil.(Tripathy et al., 2017)

Pupil dilation via topical medication mainly consists of cycloplegic (tropicamide 1%) and adrenergic receptor agonists (phenylephrine 2.5%). Also, a combination of phenylephrine (1.0%) and ketorolac injections (0.3%) can be applied. Additionally, preoperative NSAID use can help sustain mydriasis.(Shugar, 2006)

Methods including mechanically stretching small pupils, introducing iris hooks, using iris pupil expansion rings, or creating iris sphincter tears have been described but often lack scientific benefit and might potentially inflict other intraoperative complications. An adhesion between the iris and the anterior lens capsule can usually be gently pulled apart with a spatula or similar instrument. At the same time, pupillary membranes attached to the pupil can be peeled off to release contraction forces applied to the iris and help enlarge the pupil. Studies have compared surgical outcomes performed through a small pupil using minimal iris manipulation with a normal well-dilated pupil, concluding that phacoemulsification through a small pupil may be safe and lead to similar results when performed by an experienced surgeon. (Malyugin, 2018, Yuguchi et al., 1999, Graether, 1996, Chang, 2008, Zhang et al., 2016) Additional adaption of the phacoemulsification machine by decreasing the fluidic parameters is advised to prevent inadvertent aspiration of the iris tissue.(Agarwal et al., 2008, Chang, 2008, Graether, 1996, Malyugin, 2018, Yuguchi et al., 1999)

In cases of IFIS, a combination of strategies including appropriate phacoemulsification fluidic parameters, pharmacological agents, longer corneal tunnels and dispersive viscoelastics can be required. The risk of IFIS is increased in patients with preoperative use of tamsulosine, a systemic sympathetic alpha-1A antagonist medication most frequently prescribed for benign prostatic hypertrophy.(Chang and Campbell, 2005) Patients should be informed of the additional risks when performing phacoemulsification in IFIS preoperatively.

## 13. Long eyes and short eyes

In short eyes, which are defined as eyes with an axial length of less than 22mm the risk of angle closure glaucoma is higher, which implicates that cataract surgery might be done earlier than in patients with a normal axial length (22-26mm).(Zhang et al., 2016) The prediction error of the refractive oucome increases with the amount of hyperopia. Higher IOL powers are needed for emmetropia in eyes with shorter axial length, implicating that any inaccuracy in the effective lens position (ELP) has an exaggerated effect. Also, IOLs with +30.0D of power or higher are less likely to be available in +0.5D increments. Patients need to be informed on the possibility of a refractive surprise.(Day et al., 2018, Eom et al., 2014, Gavin and Hammond, 2008, Hoffer and Savini, 2017)

High myopia has been associated with an increased incidence of cataract. Long eyes, with an axial length of over 25 mm are prone to postoperative refractive error, such as undesired hyperopia. Patients have to be informed about the possibilities of different target refractions and the chance of postoperative refractive error. (Expert opinion)

## 14. Uveitis

Chronic uveitis might lead to cataract formation due to uncontrolled inflammation and the prolonged use of corticosteroids. The incidences in Fuchs heterochromic iridocyclitis ranges from 57% to 78%. Prior to performing cataract surgery in patients with chronic uveitis the clinical course and response to medical therapy, the age of the patient and the etiology of the uveitis have to be considered. Active inflammation has to be sufficiently controlled prior to surgery, where possible. Pre-exisiting corneal, anterior and posterior segment pathological changes such as corneal scarring, band keratopathy, iris atrophy, vascularization, anterior and posterior synechiae, pupillary and cyclic membrane formation, macular scarring, optic nerve inflammation, ischaemia, atrophy and retinal vascular disease have to be considered.(Foster, 1994)

Synechiolysis, membranectomy, pupillary sphincterotomy and the use of iris retractor hooks have to be considered during cataract surgery.(Foster, 1994) If vitrous haze or hemorrhage is present, possible combined pars plana vitrectomy is to be considered.(Foster et al., 1993) Pre-, intra- and postoperative medication, such as anti-inflammatory drugs and corticosteroids need to be administered. The patient has to be informed about the possible limitation in visual outcome.

Patients with uveitis who underwent cataract surgery showed significant improvement in visual acuity of two or more Snellen lines.(Elgohary et al., 2007) In the case of a recurrent uveitis episode, most occur will be within three months after surgery. Risk factors for recurrence include female gender and the presence of synechiae. Finally, these patients were also significantly more likely to develop macular edema.(Elgohary et al., 2007)

15. History of herpes keratitis

Reactivation of herpes keratitis may pose a postoperative complication, due to surgical trauma as well as the modulation of the ocular immune response caused by postoperative application of steroids. Antiviral prophylaxis, such as acyclovir or valacyclovir should be considered. It is important to clearly differentiate between a reactivation of herpetic keratouveitis and an epithelial keratitis.(Gessa-Sorroche et al., 2022)

16. Vascular occlusions

Cataract surgery is associated with a small increase in the risk of retinal vein occlusion postoperatively, though this is not clinically significant.(Bagdasarova et al., 2021) Patients with preoperative history of retinal vein occlusions have to be informed about the possible limitations on visual outcome compared to other patients without retinal diseases. (Expert opinion)

## Conclusions

### Implications for practice

Various characteristics of cataract patients must be considered and evaluated prior to surgery, as some might increase the intra- or postoperative complication risks. In these cases, an experienced surgeon and a thorough preoperative assessment is crucial to ensure a good visual outcome. Typically, eyes with active pathological conditions are more susceptible to complications when performing cataract surgery. Ideally, surgery should be performed during a quiet phase of the disease.

Complication rates during cataract surgery are expected to be higher in patients with PEX and these include lens subluxation, vitreous loss, and a higher chance of a poor visual outcome. In patients who previously underwent refractive surgery, additional preoperative diagnostic measures and a customised IOL power calculation are essential to prevent a refractive surprise and warrant patient satisfaction.

Knowledge gaps

Further research to elaborate on the importance of different diagnostic measures and a comparison of different available phacoemulsification techniques for patients with certain risk factors are warranted. Special attention has to be warranted for patients with PEX syndrome and more research on adapted IOL implantation techniques or the usage of different IOL types is needed. Research for the correct IOL calculation after previous corneal refractive surgery is warranted.

**Identified research evidence**

**Findings from Systematic Reviews**

Three relevant systematic reviews were identified.

Meta-analysis including three studies demonstrated that, cataract surgery compared to observation resulted in improved visual acuity (logMAR) at 6-month or 12-month follow-up (mean difference [MD] -0.13, 95% confidence Interval [CI] -0.17 to -0.09, low certainty evidence). However meta-analysis of three studies demonstrated that there were no differences between cataract surgery and observation groups in progression to exudative age-related macular degeneration (AMD) during 6 to 12 month follow up (risk ratio [RR] 1.33, 95% CI 0.60 to 2.94, very-low certainty evidence). (Kessel et al., 2016c) The review was judged to have a high risk of bias.

The meta-analysis showed that compared with those without diabetic retinopathy, patients with diabetic retinopathy had higher odds of developing macular edema (odds ratio (OR) 5.91, 95% confidence interval (CI) 2.72 to 12.83) and progressive retinopathy (OR 5.28, 95% CI 3.05 to 9.14), and lower odds of visual acuity (OR 0.21, 95% CI 0.12 to 0.38) following cataract surgery. (Guo et al., 2017) The review was judged to have a low risk of bias.

In a systematic review, one study found that the immediate-surgery group showed a greater mean improvement in best-corrected visual acuity (BCVA) measured with the LogMAR scale compared with the delayed-surgery group at six-month follow-up (mean difference (MD) -0.15, 95% confidence interval (CI) -0.28 to -0.02, 56 participants, moderate certainty evidence). The same study (with 56 participants) reported that compared with the delayed-surgery group, the immediate-surgery group

had higher overall mean quality of life scores measured with the Impact of Vision Impairment (IVI) questionnaire at six months (MD 1.60, 95% CI 0.61 to 2.59, low certainty evidence). Another study found no differences between immediate-surgery and delayed-surgery groups in reducing the cumulative drusen and geographic atrophy size (CDGAS) at 12 months (MD 0.76, 95% CI -8.49 to 10.00, 49 participants, low certainty evidence) or development of choroidal neovascularization at 6 months (risk ratio [RR] 3.21, 95% CI 0.14 to 75.68, 56 participants, very-low certainty evidence). (Casparis et al., 2017) The review was judged to be at low risk of bias.

**Key articles**

There was one key article selected.

The purpose of this randomized clinical trial in twelve European study centers was to compare the efficacy of perioperative treatments, in addition to topical bromfenac 0.09% and dexamethasone 0.1%, to lower risks of cystoid macular edema (CME) after routine surgery for cataracts in patients with diabetes. Patients having phacoemulsification cataract surgery were assigned randomly to receive no additional treatment, a subconjunctival injection with 40 mg triamcinolone acetonide, an intravitreal injection with 1.25 mg bevacizumab, or a combination of both. The study consisted of 213 patients. At 6 and 12 weeks postoperatively, the central subfield mean macular thickness was 12.3 μm and 9.7 μm lower, respectively, in patients who had received subconjunctival triamcinolone acetonide than patients who did not (P= .007 and P= .014, respectively). No patient who received subconjunctival triamcinolone acetonide experienced CME. Macular thickness was not affected by Intravitreal bevacizumab. Patients who received a subconjunctival injection with triamcinolone acetonide at the end of cataract surgery had a reduced macular thickness and macular volume at 6 and 12 weeks postoperatively than patients who did not. Intravitreal bevacizumab had no significant effect. (Wielders et al., 2018b)

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## 4.3 Cataract surgery and mental health

### Output question

What mental health factors must be considered when preparing for cataract surgery?

**P:** Adult patients suffering from or at risk of developing mental health conditions which are suitable for cataract surgery
**I:** Cataract surgery
**C:** No surgery, usual care, education
**O:** Depression, dementia, cognitive function, anxiety

### Recommendation

Cataract surgery has a beneficial effect on cognitive and mental health. Cataract extraction can be considered in patients at higher risk for cognitive decline and impaired vision due to cataracts. (GRADE +/++)

The timing of the surgery with regard to the course of the mental illness and the potential application of Immediate Sequential Bilateral Cataract Surgery (ISBCS) may be of benefit for these patients. (GRADE +/++)

### Considerations

Cataract extraction is associated with a lower risk for the development of dementia, including a hazard ratio of 0.71 (95% CI, 0.62-0.83; p<0.01), for patients who underwent cataract surgery compared to patients without cataract surgery.(Lee et al., 2022) In addition, there is evidence that cataract surgery benefits cognitive function and depression in the elderly. The surgery can have a positive effect on the quality of life of these patients. In the case of visual function impairment due to cataracts, cataract surgery is worth considering for improving visual acuity and mental and cognitive health.(Pellegrini et al., 2020)

Although cataract extraction may positively affect mental health, it is less likely to be performed in patients diagnosed with dementia compared to non-dementia patients with cataracts. It is important to make the right decision for each patient according to the potential benefits and risks of the surgery. This patient population should receive sound guidance and appropriate management of their visual impairment due to cataracts.(Pershing et al., 2019) Timing surgeries within a short time interval may be beneficial for patients with mental health problems.(Hou et al., 2021) The choice of anaesthetic should be tailored to the severity of the illness and should also be discussed with an anaesthesiologist. (Expert opinion)

## Conclusion

Implications for practice

Regarding the current evidence, in patients diagnosed with mental health diseases (such as depression or dementia), the decision-making for cataract surgery may be more complex. Although improving the visual acuity by performing cataract extraction significantly, this has positive effects on the mental or cognitive symptoms and quality of life.

Knowledge gaps

Further research into the effects of cataract surgery on dementia and mental health issues is necessary to evaluate the clinical relevance.

## Identified research evidence

### Findings from Systematic Reviews

One relevant systematic review was identified.

A meta-analysis of 14 studies showed that cataract surgery reduced depression using a variety of measurement instruments (standardised mean difference (SMD) = 0.460; 95% confidence interval (CI): 0.223 to 0.697, very-low certainty evidence). Meta-analysis of six studies showed that, compared with controls, cataract surgery might reduce depression (SMD = 0.161; 95% CI: 0.027 to 0.295, low certainty evidence). A meta-analysis of 9 studies showed that cataract surgery slightly improved cognitive function using various tools for measurements (SMD = 0.254; 95% CI: 0.120 to 0.388) compared with prior to surgery. Meta-analysis of four studies showed that compared with controls, surgery might slightly improve cognitive function (SMD = 0.188; 95% CI: 0.002 to 0.374). (Pellegrini et al., 2020) The review was judged to be at a high risk of bias.

## GRADE Table

### Cataract surgery compared to no surgery or standard care for improving mental health

**Bibliography:**

1. Lee, C. S., Gibbons, L. E., Lee, A. Y., et al. 2022. Association between cataract extraction and development of dementia. JAMA Internal Medicine, 182, 134-141.
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| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Study event rates (%) | | | Anticipated absolute effects | |
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | With no surgery or standard care | With cataract surgery | Relative effect (95% CI) | Risk with no surgery or standard care | Risk difference with cataract surgery |
| **Depression** | | | | | | | | | | | |
| 0 (6 RCTs) | very serious[a] | not serious | not serious | not serious | none | ⨁⨁◯◯ Low | | | - | - | SMD **0.161 SD higher** (0.027 higher to 0.295 higher) |
| **Dementia** | | | | | | | | | | | |
| 3038 (1 observational study) | very serious[b] | not serious | serious[c] | not serious | none | ⨁◯◯◯ Very low | 1382/3038 (45.5%) | | **HR 0.71** (0.62 to 0.83) | 455 per 1.000 | **105 fewer per 1.000** (from 141 fewer to 59 fewer) |
| **Cognitive function** | | | | | | | | | | | |
| 0 (4 RCTs) | very serious[a] | not serious | not serious | not serious | none | ⨁⨁◯◯ Low | | | - | - | SMD **0.188 SD higher** (0.002 higher to 0.374 higher) |

**CI:** confidence interval; **HR:** hazard ratio; **SMD:** standardised mean difference

**Explanations**

a. Only one (out of six) studies used randomisation.
b. Results from an observational study
c. Clinical and methodological heterogeneity in terms of population, intervention, comparator and outcome measures.

## 4.3.1 References

Hou, C. H., Chen, K. J., Lee, J. S., et al. 2021. Effect of the time interval between cataract surgery for both eyes on mental health outcome: a cohort study of 585,422 patients. *BMC Ophthalmol,* 21**,** 110.

Lee, C. S., Gibbons, L. E., Lee, A. Y., et al. 2022. Association between cataract extraction and development of dementia. *JAMA Internal Medicine,* 182**,** 134-141.

Pellegrini, M., Bernabei, F., Schiavi, C. & Giannaccare, G. 2020. Impact of cataract surgery on depression and cognitive function: systematic review and meta-analysis. *Clinical and Experimental Ophthalmology,* 48**,** 593-601.

Pershing, S., Henderson, V. W., Bundorf, M. K., et al. 2019. Differences in cataract surgery rates based on dementia status. *J Alzheimers Dis,* 69**,** 423-432.

## 4.4 Preoperative patient information

### Output question

What information about surgery, target refraction and complications should be given to the patient before cataract surgery?

**P**: Target group of patients suitable for cataract surgery which undergoes preoperative patient education
**I**: A detailed explanation
**C**: Various control groups e.g., a less detailed explanation
**O**: Quality of life, satisfaction

### Recommendation

The ophthalmologic surgeon should ensure that the following information is verbally provided to the patient before obtaining informed consent and performing cataract surgery:

- The option of not undergoing surgery
- Purpose and nature of the cataract surgery
- Risk for (serious) complications during and after the surgery
- Patient-specific additional risks
- Surgery on one or both eyes
- Target refraction and expected vision improvement after surgery (see chapter 6.4)
- Treatment options: IOL types (see chapter 6.1)
- The financial implications of the surgical and IOL choices
- In cases of bilateral cataract surgery: delayed sequential or immediate bilateral surgery (see chapter 4.6)
- Type of anaesthesia (see chapter 4.8)
- What to do in emergencies

Targeted interventions improve patients' satisfaction with cataract surgery and the accompanying postoperative care. (GRADE +)

In addition to verbal information, patients undergoing cataract surgery should be provided with written information and, if possible, audiovisual material. It is important to consider national informed consent guidelines and adapt the information provided to local best practices and legal frameworks. (GRADE +)

### Considerations

Patients generally differ in their desire to receive information before cataract surgery.(Elder and Suter, 2004) Audio-visual information and verbal information before cataract surgery can be beneficial in understanding the cataract surgery procedure and decreasing anxiety.(Pager, 2005), (Moseley et al., 2006, Obuchowska and Konopinska, 2021, Panagiotopoulou et al., 2018, Wisely et al., 2020, Zarifsanaiey et al., 2022)

High-quality nursing (i.e., audio-visual education preoperatively, relaxing activities) and preoperative counselling can reduce anxiety and pain during cataract surgery.(Obuchowska and Konopinska, 2021, Panagiotopoulou et al., 2018) Preoperative expectations can also affect the patient's perception of the postoperative outcome. Several factors influence patient satisfaction postoperatively, such as age, costs, level of health literacy, comorbidities, and preoperative spectacle independence. These factors are worth considering during the preoperative counselling process.(Choi and Greenberg, 2018, Panagiotopoulou et al., 2018)

Furthermore, patients who are considering cataract surgery should be made aware of any potential co-payments related to the procedure or the placement of an IOL. It is important to note that the financial implications may vary between countries, and it is essential to adhere to the regulations set forth by the patient's national healthcare system.

## Conclusion

Implications for practice

Regarding the current evidence, information must be provided to every patient before cataract surgery to obtain informed consent. The counselling process is an essential step in identifying patients' expectations. The information can be given verbally, but it is recommended to provide written information and if possible audio-visual material to improve patients' understanding of cataract surgery. When providing information to patients prior to cataract surgery, it is important to consider national informed consent guidelines, and adapt the information to local best practices and legal frameworks.

Knowledge gaps

Additional research is needed to determine the best educational strategies for patients before cataract surgery.

## Identified research evidence

### Findings from Systematic Reviews

One relevant systematic review was identified.

A systematic review evaluated the effectiveness of patient education strategies in improving outcomes such as understanding, postoperative self-care, anxiety, satisfaction, adherence to postoperative self-care, cooperativeness, and adverse events in patients undergoing cataract surgery. Sixteen studies were included in a qualitative synthesis. The review concluded that targeted interventions improved patients' understanding of cataract surgery and postoperative care. However, the quality of evidence was poor for all outcomes.(Choi and Greenberg, 2018) The review was judged to be at a high risk of bias.

## GRADE Tables

### Education compared to standard care in cataract surgery

**Bibliography:** Choi, A. R. & Greenberg, P. B. 2018. Patient education strategies in cataract surgery: a systematic review. J Evid Based Med, 11, 71-82.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With standard care | With education | | Risk with standard care | Risk difference with education |
| **Anxiety (assessed with: STAI)** | | | | | | | | | | | |
| 46 (1 RCT) | serious[a] | not serious | not serious | serious[b] | none | ⨁⨁◯◯ Low | 23 | 23 | - | The mean anxiety was **33.9** | mean **24.8 higher** (0 to 0 ) |

**CI:** confidence interval

**Explanations**
a. Unclear risk of bias for sequence generation and selective reporting.
b. Small sample size.

### Video compared to anatomy in educating patients for cataract surgery

**Bibliography:** Pager, C. K. 2005. Randomised controlled trial of preoperative information to improve satisfaction with cataract surgery. British Journal of Ophthalmology, 89, 10-3.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With anatomy | With video | | Risk with anatomy | Risk difference with video |
| **Satisfaction** | | | | | | | | | | | |
| 141 (1 RCT) | serious[a] | not serious | serious[b] | serious[c] | none | ⨁◯◯◯ Very low | 68 | 73 | - | - | SMD **0.35 higher** (0.02 higher to 0.68 higher) |

**CI:** confidence interval; **SMD:** standardised mean difference

**Explanations**
a. Both sequence generation and allocation concealment judged to be at an unclear risk of bias.
b. No homogeneity in terms of population, intervention, comparator or outcomes
c. Small sample size

### 4.4.1 References


Choi, A. R. & Greenberg, P. B. 2018. Patient education strategies in cataract surgery: a systematic review. *J Evid Based Med,* 11**,** 71-82.

Elder, M. J. & Suter, A. 2004. What patients want to know before they have cataract surgery. *Br J Ophthalmol,* 88**,** 331-2.

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Pager, C. K. 2005. Randomised controlled trial of preoperative information to improve satisfaction with cataract surgery. *British Journal of Ophthalmology,* 89**,** 10-3.

Panagiotopoulou, E. K., Ntonti, P., Vlachou, E., et al. 2018. Patients' expectations in lens extraction surgery: a systematic review. *Acta Medica (Hradec Kralove),* 61**,** 115-24.

Wisely, C. E., Robbins, C. B., Stinnett, S., et al. 2020. Impact of preoperative video education for cataract surgery on patient learning outcomes. *Clinical Ophthalmology,* 14**,** 1365-1371.

Zarifsanaiey, N., Hedayat, M., Mehrabi, M. & Bagheri, Z. 2022. Video-based versus educational booklet training on self-care performance of patients with cataract. *Bangladesh Journal of Medical Science,* 21**,** 601-609.

## 4.5 The time interval between two cataract surgeries

### Output question

In patients needing cataract surgery, what are the effects of immediate bilateral surgery compared with delayed sequential surgery and what is the minimum time between cataract surgery on the first and second eye?

**P:** Adult patients who will undergo cataract surgery
**I:** Immediately sequential bilateral cataract surgery (ISBCS)
**C:** Delayed sequential bilateral cataract surgery (DSBCS)
**O:** Visual acuity, visual function, quality of life, (serious) adverse events (Endophthalmitis, Complications), postoperative refractive outcome

### Recommendation

ISBCS (Immediate Sequential Bilateral Cataract Surgery) is effective and safe, with a high degree of patient satisfaction and can be considered in suitable patients without complication-inducing ocular comorbidities. (GRADE +)

There are comparable clinical outcomes of DSBCS (Delayed Sequential Bilateral Cataract Surgery) and ISBCS. Therefore, either technique can be considered. (GRADE +/+++ (for endophthalmitis))

Bilateral cataract surgery on the same day allows rapid patient rehabilitation and helps avoid suboptimal visual function while waiting for second-eye surgery. However, there was no extra long-term benefit of self-assessed visual function compared with cataract surgery in one eye at a time. (GRADE +)

Specific relative contraindications must be considered if bilateral simultaneous cataract surgery is planned:

- The ISBCS should be reconsidered if there is an increased risk of peri- or postoperative complications.
- If complications occur during surgery of the first eye, these adverse events have to be resolved before proceeding to the second eye and delaying the second eye should be considered.

If bilateral simultaneous cataract surgery is planned, it should be considered and treated as two entirely separate procedures, according to the principal practice guideline for bilateral surgery. (RCO, 2020) The main statements of this guideline include: the instruments go through separate sterilization cycles with indicators; concomitant ocular or periocular disease should be controlled and managed before

surgery; and, any issues with the first eye surgery must be resolved before proceeding with the second eye.

## Considerations

Age-related cataract typically affects both eyes. Surgery on both eyes can be done on different days and this is called delayed sequential bilateral cataract surgery (DSBCS). Alternatively they can both be operated on the same day which is known as immediate sequential bilateral cataract surgery (ISBCS) but they must be performed as two separate procedures.(Kessel et al., 2015a, Spekreijse et al., 2023) When deciding whether a patient should receive DSBCS or ISBCS, the following aspects must be considered: safety, visual and patient-reported outcomes, and logistic issues.(Chandra et al., 2021) These recommendations only apply to patients with cataracts in both eyes intending to be operated on both eyes.

When both eyes are operated on the same day, it is paramount to consider the procedures as two separate surgeries with various logistic considerations. This includes complete aseptic separation of first and second eye surgery and specific protocols to be followed, as described in general principles for Excellence in immediate sequential bilateral cataract surgery 2009. No crossover of drugs or devices can be permitted. Moreover, instruments for the surgery must go through complete separate sterilization cycles.(Malvankar-Mehta et al., 2015, Kessel et al., 2015a, Spekreijse et al., 2023)

The potential advantages of ISBCS include fewer hospital visits for the patient, less home care, faster visual recovery, and increased cost-effectiveness. ISBCS also avoids anisometropia, which may reduce the risk of falls and accidents. Furthermore, ISBCS is a good option for patients undergoing surgery under general anaesthesia, as repeated general anaesthesia is associated with an increased health risk.(Dickman et al., 2022, Spekreijse et al., 2023)

Results comparing the two procedures are highly heterogeneous, and the current evidence is insufficient to draw firm conclusions regarding the benefits and disadvantages of each procedure. Concerning visual (corrected distance visual acuity, CDVA) outcome, the type of surgery (ISBCS or DSBCS) does not make a significant difference (very low-certainty evidence). CDVA did significantly improve after both surgeries and subjective visual function showed similar postoperative results in both patient groups.(Kessel et al., 2015a, Spekreijse et al., 2023)

For the outcome measure refractive outcome (percentage of eyes within predicted target refraction), it can be concluded with reasonable certainty that there is no difference between ISBCS and DSBCS. More specifically, the percentages of eyes that achieved a refraction within 1.0D or 0.5D of target one to three months after

surgery, were similar.(Malvankar-Mehta et al., 2015) There was no difference between ISBCS and DSBCS in postoperative spherical and cylindrical errors.

Regarding potential adverse events, there is no significant difference in risk between ISBCS and DSBCS. Studies concluded that there is no difference in incidence of endophthalmitis when comparing both procedures if similar best practice antibiotic prophylaxis is used. Nevertheless, no firm conclusion can be made due to the rareness of the event. Similarly, no significant differences were found between patients who underwent ISBCS and DSBCS concerning other postoperative adverse events, such as wound leak, iris prolapse, macular edema or corneal edema. The use of intracameral antibiotics at the end of the surgery is strongly recommended.(Spekreijse et al., 2023)

If complications occur during surgery of the first eye, these adverse events have to be resolved before proceeding to the second eye and delaying the second eye should be considered.(Spekreijse et al., 2023)

While refractive surprise may occur rarely after the first eye, this might be corrected or adapted for the second eye in the case of DSBCS. This step is not possible in ISBCS, potentially leading to refractive surprise in both eyes. Nevertheless, different studies conclude that no significant difference in achieving a result within 1.0D or 0.5D of target refraction. The BICAT-NL demonstrated the non-inferiority of ISBCS compared to DSBCS in terms of effectiveness outcomes and comprabele safety. The percentage of second eyes with a postoperative refraction within 1.0D of the target was 97% for the ISBCS group and 98% for the DSBCS group with an adjusted OR of 0.763 (95% CI 0·330–1·762; p=0·526). For postoperative refraction within 0.5D of the target this was 79% for the ISBCS group and 77% for the DSBCS group.(Spekreijse et al., 2023)

PROMS (Patient-Reported Outcomes) showed no significant difference between the two patient groups one to three months after surgery. A significant improvement in postoperative utility score using TTO, EQ5D, HUI3, VF-7, and VF-14 and a non-significant improvement using the Catquest questionnaire was found for both surgeries, therefore reporting a significant improvement in the patient's quality of life and visual acuity in both groups.(Kessel et al., 2015a)

## Conclusion

Implications for practice

Current evidence shows that there may be no significant different between ISBCS and DSBCS concerning the following outcomes: risk of complications, visual outcome one to three months after the surgery, postoperative refraction and PROMS. The

decision on whether to perform ISBCS or DSBCS should be taken in the shared decision-making process, including the surgeon and patient.

Knowledge gaps
Further research with large registrations such as EUREQUO are needed to establish complication frequencies on ISBCS.

**Identified research evidence.**

**Findings from Systematic Reviews**

Three relevant systematic reviews were identified.

Meta-analysis of two studies showed that delayed sequential bilateral cataract surgery, immediate sequential bilateral cataract surgery does not affect postoperative complication rate (including the sensation of dry eyes) (risk ratio [RR] 0.76, 95% confidence interval [CI] 0.55 to 1.07, low certainty evidence) or the number of serious complications (corneal edema, macular edema, wound leak, iris prolapse) (RR 1.63, 95% CI 0.55 to 4.78, very low certainty evidence) and subjective visual function (standardized mean difference [SMD] 0.01, 95% CI -0.47 to 0.48, low certainty evidence). The review was judged to be at a high risk of bias.(Malvankar-Mehta et al., 2015)

Meta-analysis of two (non-randomised) studies showed that compared with delayed sequential bilateral cataract surgery, immediate sequential bilateral cataract surgery reduces the risk of endophthalmitis (risk ratio (RR) 1.97, 95% confidence interval (CI) 0.32 to 12.16, low certainty evidence). Meta-analysis of three (non-randomised) studies showed that compared with delayed sequential bilateral cataract surgery, immediate sequential bilateral cataract surgery has no effect on refraction not within 1.0 dioptres of target 1 to 3 months after surgery (RR 1.02, 95% CI 0.60 to 1.75, low certainty evidence). Meta-analysis of five (non-randomised) studies showed that compared with delayed sequential bilateral cataract surgery, immediate sequential bilateral cataract surgery has no effect on complications rate (RR 1.04, 95% CI 0.47 to 2.29, very-low certainty evidence).(Dickman et al., 2022) The review was judged to be at a low risk of bias.

**Key articles**

There was one key article selected.

This was a multicentre, non-inferiority, randomised controlled trial comparing the safety, effectiveness, and cost-effectiveness of immediate versus delayed sequential bilateral cataract surgery in 865 patients. The primary outcome was the proportion of second eyes with a target refraction of 1.0 diopter or less at 4-weeks post-

intervention. The proportion of second eyes with a target refraction of 1·0 D or less was 97% (404 of 417 patients) in the ISBCS group versus 98% (407 of 417) in the DSBCS group (the percentage difference = –1% (90% CI –3 to 1; p=0·526). Endophthalmitis was not reported in either group. Adverse events were comparable between groups, except disturbing anisometropia (p=0·0001).{Spekreijse, 2023 #13472

## GRADE Table

### Immediate sequential bilateral surgery compared to delayed sequential bilateral surgery for cataracts

**Bibliography:** Dickman MM, Spekreijse LS, Winkens B, Schouten JSAG, Simons RWP, Dirksen CD, Nuijts RMMA. Immediate sequential bilateral surgery versus delayed sequential bilateral surgery for cataracts. Cochrane Database of Systematic Reviews 2022, Issue 4. Art. No.: CD013270.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Study event rates (%) | | | Anticipated absolute effects | |
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | With delayed sequential bilateral surgery | With Immediate sequential bilateral surgery | Relative effect (95% CI) | Risk with delayed sequential bilateral surgery | Risk difference with Immediate sequential bilateral surgery |
| **Endophthalmitis (follow-up: 6 weeks)** | | | | | | | | | | | |
| 0 (2 RCTs) | serious[a] | not serious | not serious | not serious | none | ⨁⨁⨁◯ Moderate | 0 cases of endophthalmitis in both groups (rare event) | | | | |
| **Refraction NOT within 1.0 dioptres of target (follow-up: range 1 months to 3 months)** | | | | | | | | | | | |
| 982 (1 RCT) | serious[a] | not serious | not serious | serious[b] | none | ⨁⨁◯◯ Low | 48/494 (9.7%) | 40/488 (8.2%) | **RR 0.84** (0.57 to 1.26) | 97 per 1,000 | **16 fewer per 1,000** (from 42 fewer to 25 more) |
| **Complications (follow-up: 3 months)** | | | | | | | | | | | |
| 2610 (2 RCTs) | serious[a] | serious[c] | not serious | serious[b] | none | ⨁◯◯◯ Very low | 91/1284 (7.1%) | 91/1326 (6.9%) | **RR 1.33** (0.52 to 3.40) | 71 per 1,000 | **23 more per 1,000** (from 34 fewer to 170 more) |
| **Patient-reported outcome measures (follow-up: range 1 months to 3 months)** | | | | | | | | | | | |
| 1297 (2 RCTs) | very serious[a] | serious[c] | not serious | not serious | none | ⨁◯◯◯ Very low | 637 | 660 | - | - | SMD **0.08 SD lower** (0.19 lower to 0.03 higher) |

**CI:** confidence interval; **RR:** risk ratio; **SMD:** standardised mean difference

**Explanations**
a. High overall risk of bias in both studies
b. Small sample size, results from a single study
c. Significant statistical heterogeneity detected.

## 4.5.1 References


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Kessel, L., Andresen, J., Erngaard, D., et al. 2015a. Immediate sequential bilateral cataract surgery: a systematic review and meta-analysis. *Journal of Ophthalmology,* 2015**,** 912481.
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RCO, R. C. o. O. 2020. Immediate Sequential Bilateral Cataract Surgery (ISBCS) during COVID recovery: RCOphth/UKISCRS rapid advice document.
Spekreijse, L., Simons, R., Winkens, B., et al. 2023. Safety, effectiveness, and cost-effectiveness of immediate versus delayed sequential bilateral cataract surgery in the Netherlands (BICAT-NL study): a multicentre, non-inferiority, randomised controlled trial. *The Lancet,* Epub ahead of print.

## 4.6 Patient selection for correcting presbyopia

### Output question

Do pseudophakic presbyopia correcting IOLs have a better postoperative outcome than monofocal IOLs or monofocals with monovision?

**P:** Adult patients with presbyopia who underwent cataract surgery
**I:** Presbyopia correcting IOLs (bifocal, trifocal, EDF)
**C:** Monofocal IOLs/ Monofocals with monovision
**O:** Visual acuity, visual function, postoperative refractive outcome, Satisfaction

### Recommendation

Detailed patient information must be implemented to choose the correct IOL type for patients undergoing cataract surgery with pseudophakic correcting presbyopia IOLs. (GRADE +)

Multifocal IOLs should be considered in patients who desire a high chance of spectacle independence for far, near and intermediate vision, as multifocal IOLs show better results than standard monofocal IOLs in uncorrected near and intermediate vision. (Low certainty evidence for bifocal vs. trifocal)

Thoughtful use of multifocal IOLs is recommended, as unwanted visual phenomena e.g halos, glare and dysphotopsia are more common in multifocal IOLs than in monofocal IOLs. (GRADE +)

EDF IOLs or pseudophakic monovision can be recommended for patients who desire a good intermediate visual acuity, with significantly less dysphotopsia compared to patients who received multifocal IOLs. (GRADE +)

The implantation of EDF IOLs can be considered an effective method to treat some presbyopia with high rates of spectacle independence and minimal dysphotopsia side-effects with limited reading or near vision spectacle independent performance. (GRADE +)

### Considerations

One of the primary reasons for dissatisfaction following monofocal IOL implantation is the reduction in near and intermediate vision, as these IOLs are designed to primarily address distance vision. Accommodation of the natural lens cannot be perfectly

replicated, but presbyopia correcting IOLs attempt to simulate images of targets at various distances using different optical techniques.

Crucial factors in selecting the appropriate IOL for a patient are a comprehensive understanding of the patient's preoperative examination and the indications for lens surgery, knowledge of the performance characteristics of different IOLs, and consideration of the patient's specific characteristics and expectations. Patients with additional ocular pathologies may not be ideal candidates for pseudophakic presbyopia correcting IOLs. (Expert opinion)

Disadvantages of pseudophakic presbyopia correcting IOLs might include reduced night vision, increased aberrations, problems of neuroadaption and, in most cases, additional costs. Diffractive IOLs can produce a certain amount of dysphotopsias, particularly halo and reduce contrast sensitivity. Especially in multifocal IOLs, daytime clarity can also be reduced. Refractive IOLs may induce starburst and distortion. {Liu, 2019 #420;Jin, 2019 #397}

Concerning multifocal IOLs, research showed discrepancies in outcomes when comparing bifocal and trifocal IOLs. Studies showed a better distance corrected intermediate visual acuity (DCIVA) for trifocal IOLs compared to bifocal IOLs, but no significant difference was shown in CDVA, distance and near visual acuity, contrast sensitivity, quality of vision, residual refractive error, complications, and patient satisfaction.(Jin et al., 2019, Xu et al., 2017, Yang et al., 2018, Zhang et al., 2021)

EDF IOLs are safe and effective for visual correction of aphakia. These IOLs provide superior intermediate and near visual acuity compared to a monofocal IOL. Only a slight reduction in mesopic contrast sensitivity was found for the EDF IOL compared to the monfocal IOL.(Liu et al., 2019, McCabe et al., 2022) The visual disturbance profile of these EDF IOLs is similar compared with an aspheric monofocal IOL.(Bala et al., 2022) (McCabe et al., 2022)

Studies comparing multifocal and EDF IOLs have reported discrepancies in outcomes, including similarities and differences in contrast sensitivity and complaints of dysphotopsias. Trifocals IOLs were associated with more photic phenomena particulary halos. In terms of spectacle independence rates, some studies have shown similar rates between the two IOLs, while others have suggested higher near-distance independence in multifocal IOLs than in EDF IOLs.(Liu et al., 2019, Zhong et al., 2021) It has to be mentioned that it is difficult to make a general statement about near spectacle independence in EDF IOLs, as many different IOLs are available. In general, there is consensus that most EDF IOLs provide less spectacle independence for near than multifocals. (Expert opinion)

Compared to monofocal IOLs, multifocal IOLs show a significantly better intermediate, near vision and spectacle independence.(Khandelwal et al., 2019) With moderate certainty, multifocal IOLs did not show a reduced CDVA than monofocal

IOLs. Newer multifocal IOLs showed better outcomes than older diffractive or refractive lenses in near vision, quality of vision and risk of halos. Multifocal IOLs provided a higher proportion of spectacle independence than standard IOLs used for monovision, hence a higher rate of adverse visual photic phenomena, including glare and halos.(Yoon et al., 2018)

When comparing multifocal IOLs to monovision, no evidence was found for a difference in CDVA, uncorrected near visual acuity (UNVA), and uncorrected intermediate visual acuity (UIVA) between the groups.(Jin et al., 2019, Xu et al., 2017, Yang et al., 2018, Zhang et al., 2021) Monovision provided in most cases, excellent distance visual outcomes. Patients receiving multifocal IOLs showed higher spectacle independence rates than patients receiving monovision, hence a higher risk of glare. Excellent visual outcomes and high patient satisfaction was reported by three studies regarding patients who received monovision, with reduced difficulty during computer work without glasses and better reading ability and improved driving than in patients who received multifocal IOLs. Multifocal IOLs showed a higher rate of dysphotopsia symptoms than pseudophakic monovision.(Labiris et al., 2017)

It must be noted that patients who received multifocal IOLs showed an increased rate of IOL exchange in the first year after surgery.(Yoon et al., 2018)

## Conclusion

Implications for practice

Since there was considerable variety between the different IOL types, results must be interpreted with care. Detailed patient information, evaluation of the patients desired visual outcome and the morphological circumstances are key to choosing the correct IOL type for presbyopic patients. Multifocal IOLs are effective in improving near and intermediate vision compared to monofocal IOLs. However, patients must be informed about the increased risk of adverse visual phenomena, depending on the IOL type used. Motivation to achieve spectacle independence is likely to be the deciding factor to choose for a multifocal IOL. Monovision and EDF IOLs can be considered for patients wanting to achieve a good intermediate visual acuity with less visual side effects but spectacle independence for near vision is less likely than with multifocal IOLs. In such situations, achieving spectacle independence for near vision is less likely than with multifocal IOLs, but clear intermediate vision is typically attainable, and spectacle independence for far vision is almost invariably achieved.

Knowledge gaps

Further research is needed to choose the correct IOL for the corresponding patient. As new IOL types evolve frequently, new studies about the different IOL types from different brands must be up to date with the available IOLs in different facilities.

## Identified research evidence

## Findings from Systematic Reviews

Eleven relevant systematic reviews were identified and one of the highest methodological qualities was selected.

Meta-analysis of eight randomized controlled trials (RCTs) showed that in patients undergoing cataract surgery, compared with monofocal intraocular lens, the multifocal intraocular lens does not affect improving unaided distance visual acuity (VA) worse than 6/6 (risk ratio (RR) 0.96 confidence interval (CI) 0.89 to 1.03, n=682 eyes, moderate certainty evidence), improved unaided near VA (worse than J3/J4 or equivalent) (RR 0.20, 95% CI 0.07 to 0.58, n=782 eyes, low certainty evidence) and reduced dependence on spectacles (any) (RR 0.63, 95% CI 0.55 to 0.73, 10 RCTs, n=1000 eyes, low certainty evidence) at follow-ups ranging from 6 weeks to 18 months. However, a meta-analysis of seven trials showed that in patients undergoing cataract surgery, compared with a multifocal intraocular lens, monofocal intraocular lens reduced glare (participant-reported outcome) (RR 1.41, 95% CI 1.03 to 1.93, 7 RCTs, n=544 eyes, low certainty evidence) and haloes (RR 3.58, 95% CI 1.99 to 6.46, 7 RCTs, n=662 eyes, moderate certainty evidence). (de Silva et al., 2016) The review was judged to be at low risk of bias.

## GRADE Table and Forest plots

### Trifocal compared to bifocal Intraocular Lenses in Presbyopia-Correcting Cataract Surgery

**Bibliography:** Zhang, Z., Jiang, H., Zhou, H. & Zhou, F. 2021. Comparative efficacy between trifocal and bifocal intraocular lens among patients undergoing cataract surgery: a systematic review and meta-analysis. Front Med (Lausanne), 8, 647268.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With bifocal Intraocular Lenses | With trifocal | | Risk with bifocal Intraocular Lenses | Risk difference with trifocal |
| **Mean uncorrected distance visual acuity (follow-up: range 3 months to 12 months)** | | | | | | | | | | | |
| 217 (4 RCTs) | serious[a] | not serious | not serious | serious[b] | none | ⨁⨁◯◯ Low | 115 | 102 | - | The mean mean uncorrected distance visual acuity was **0** | MD **0** (0.04 lower to 0.04 higher) |
| **Mean uncorrected near visual acuity (follow-up: range 3 months to 12 months)** | | | | | | | | | | | |
| 217 (4 RCTs) | serious[a] | not serious | not serious | serious[b] | none | ⨁⨁◯◯ Low | 115 | 102 | - | The mean mean uncorrected near visual acuity was **0** | MD **0.01 higher** (0.04 lower to 0.06 higher) |
| **Mean uncorrected intermediate visual acuity (follow-up: range 3 months to 12 months)** | | | | | | | | | | | |

## Trifocal compared to bifocal Intraocular Lenses in Presbyopia-Correcting Cataract Surgery

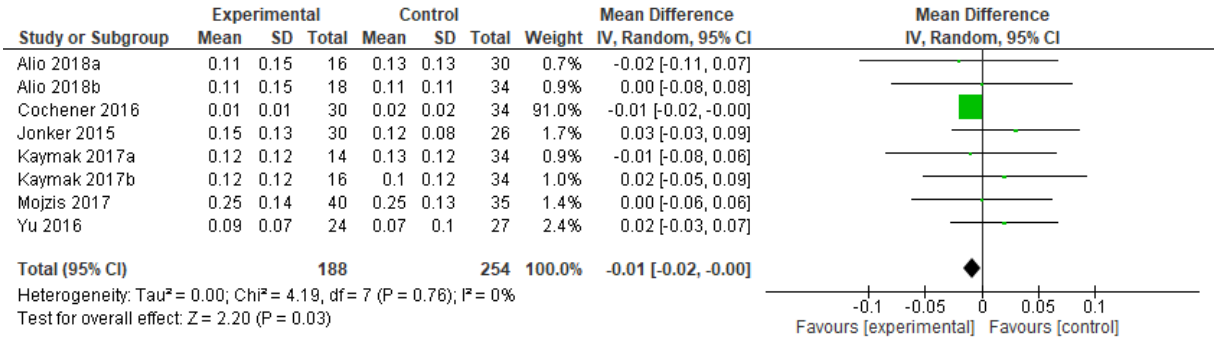
**Bibliography:** Zhang, Z., Jiang, H., Zhou, H. & Zhou, F. 2021. Comparative efficacy between trifocal and bifocal intraocular lens among patients undergoing cataract surgery: a systematic review and meta-analysis. Front Med (Lausanne), 8, 647268.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 217 (4 RCTs) | serious[a] | not serious | not serious | serious[b] | none | ⊕⊕◯◯ Low | 115 | 102 | - | The mean mean uncorrected intermediate visual acuity was **0** | MD **0.16 lower** (0.22 lower to 0.1 lower) |
| **Mean best-corrected distance acuity (follow-up: range 3 months to 12 months)** | | | | | | | | | | | |
| 217 (4 RCTs) | serious[a] | not serious | not serious | serious[b] | none | ⊕⊕◯◯ Low | 115 | 102 | - | The mean mean best-corrected distance acuity was **0** | MD **0** (0.03 lower to 0.04 higher) |
| **Satisfaction** | | | | | | | | | | | |
| 86 (3 RCTs) | serious[a] | not serious | not serious | serious[b] | none | ⊕⊕◯◯ Low | 40/43 (93.0%) | -/43 | **RR 0.97** (0.87 to 1.09) | 930 per 1.000 | **28 fewer per 1.000** (from 121 fewer to 84 more) |

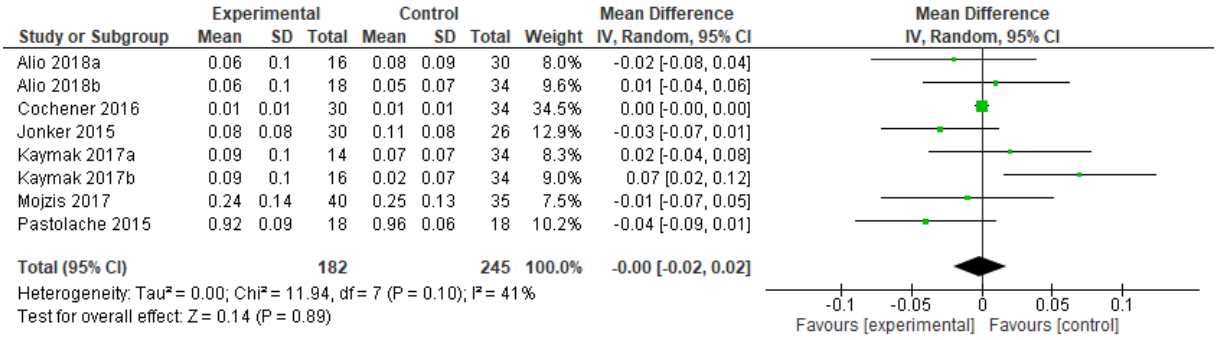
**CI:** confidence interval; **MD:** mean difference; **RR:** risk ratio

**Explanations**
a. Unclear risk of bias of the included studies.
b. Small sample size

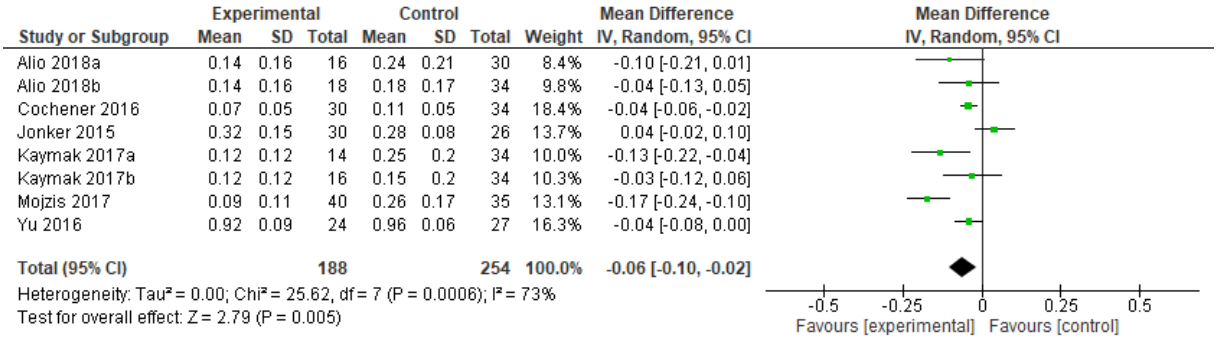
## Forest Plots



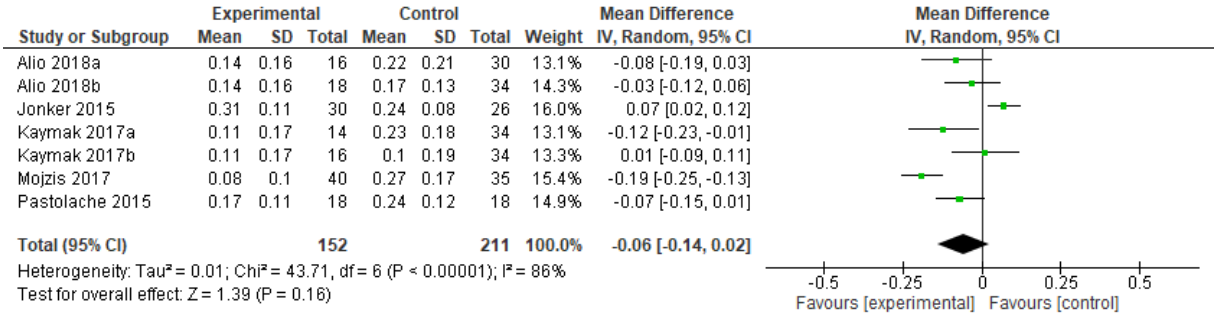

Forest plot of comparison: 1 Trifocal vs bifocal IOL, outcome: 1.1 uncorrected NVA.



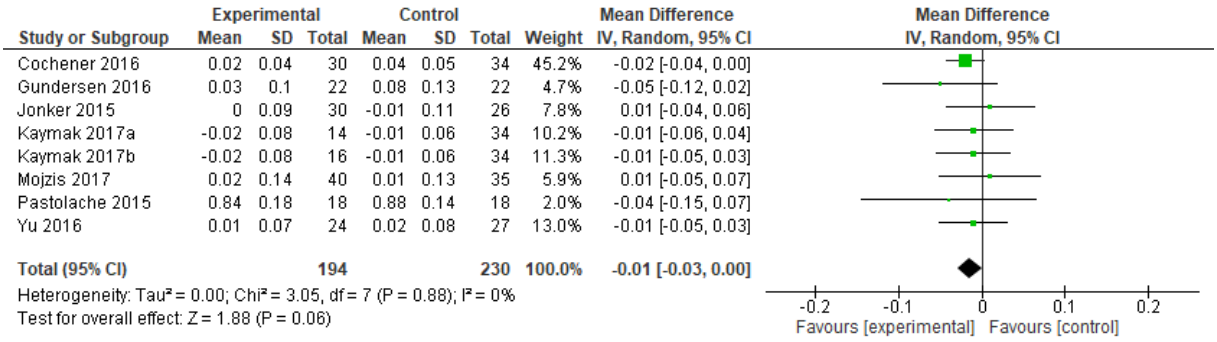

Forest plot of comparison: 1 Trifocal vs bifocal IOL, outcome: 1.2 distance-corrected NVA.



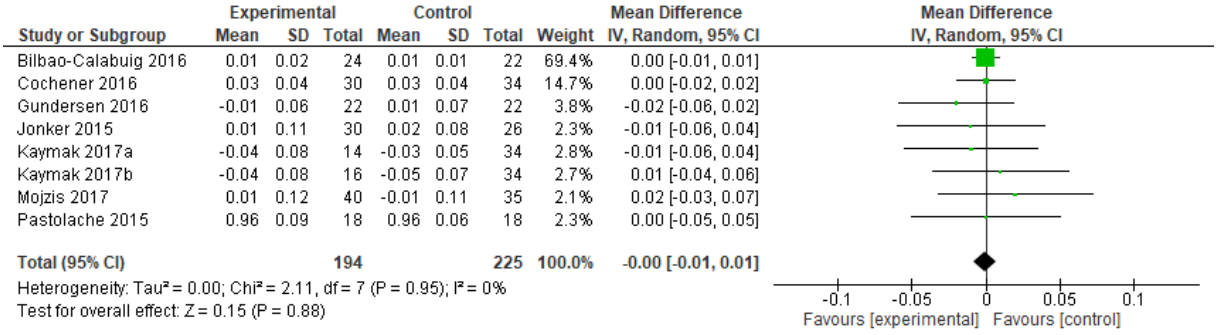

Forest plot of comparison: 1 Trifocal vs bifocal IOL, outcome: 1.3 uncorrected IVA.



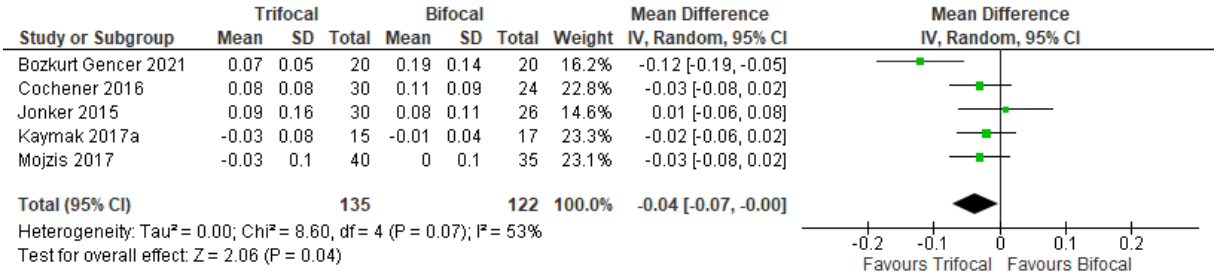

Forest plot of comparison: 1 Trifocal vs bifocal IOL, outcome: 1.4 distant-corrected IVA.



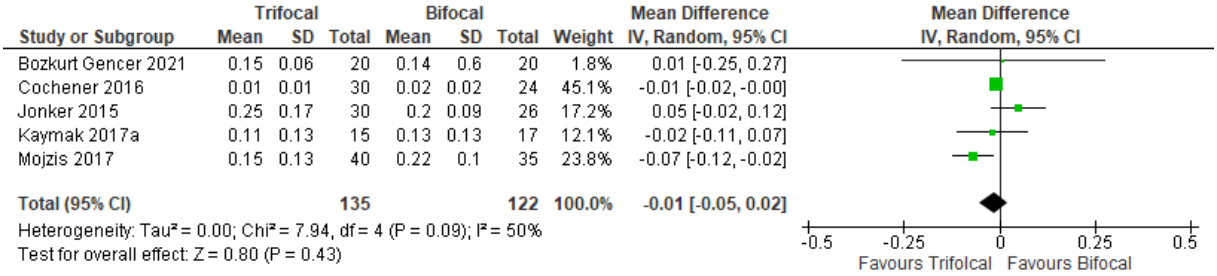

Forest plot of comparison: 1 Trifocal vs bifocal IOL, outcome: 1.5 uncorrected DVA.



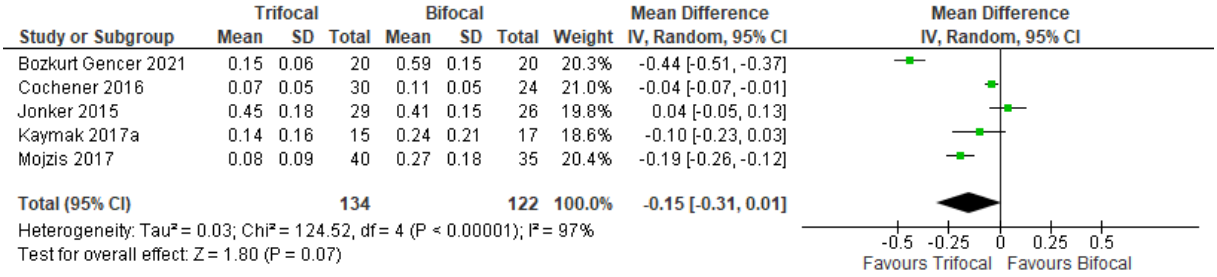

Forest plot of comparison: 1 Trifocal vs bifocal IOL, outcome: 1.6 distant corrected DVA.



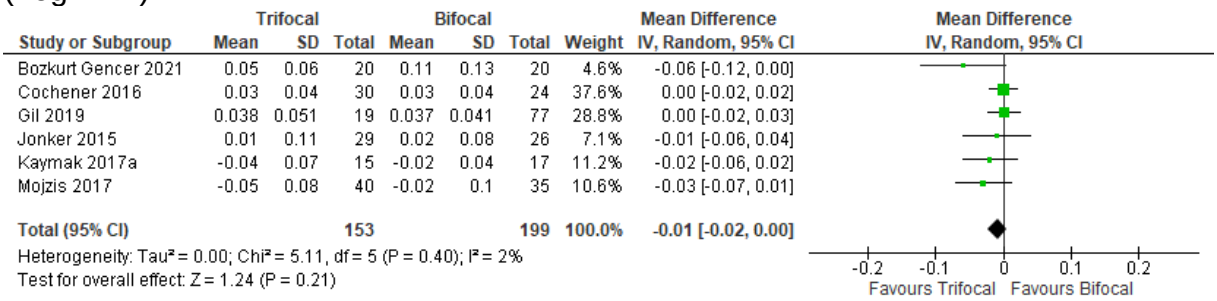

Forest plot of comparison: 1 Trifocal vs bifocal IOL, outcome: 1.7 Mean UDVA (LogMAR).



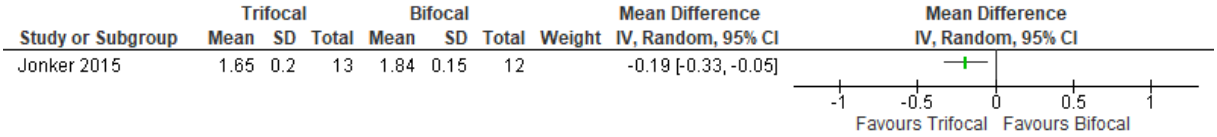

Forest plot of comparison: 1 Trifocal vs bifocal IOL, outcome: 1.8 Mean UNVA (LogMAR).




Forest plot of comparison: 1 Trifocal vs bifocal IOL, outcome: 1.9 Mean UIVA (LogMAR).




Forest plot of comparison: 1 Trifocal vs bifocal IOL, outcome: 1.10 Mean BCDA (LogMAR).




Forest plot of comparison: 1 Trifocal vs bifocal IOL, outcome: 1.11 Mean contrast sensitivity.

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## 4.7 Patient selection for correcting corneal astigmatism

### Output question

Do toric IOLs give a better postoperative outcome than non-toric IOLs in cataract surgery? From which magnitude of corneal astigmatism is a toric IOL indicated?

**P:** Adult patients having (low or high degree) astigmatism who are undergoing cataract surgery
**I:** Toric IOLs
**C:** Non-toric IOLs
**O:** Visual acuity, visual function, postoperative refractive outcome, patients requiring spectacles for distance viewing

### Recommendations

Current recommendations are based on studies performed using anterior keratometry:

In the case of regular corneal astigmatism, toric IOLs may be considered for implementation. (GRADE ++)

Toric IOLs should be considered in eyes with a degree of corneal astigmatism of 1.0D or more, with strong evidence for corneal astigmatism above 2.0D, moderate evidence for corneal astigmatism above 1.5D, and may be beneficial above 1.0D. (GRADE ++)

New insights rely on predictions of postoperative astigmatism, making it imperative to use these predictions as a basis for decision-making in cases with corneal astigmatism.

### Considerations

In the case of regular corneal astigmatism, toric IOLs can offer better uncorrected distance visual acuity (UDVA) outcomes, greater spectacle independence, and lower amounts of residual astigmatism compared with non-toric IOLs. The risk for postoperative residual astigmatism is higher when performing relaxing incisions combined with a non-toric IOL, compared with implantation of a toric IOL.(Kessel et al., 2016b, Bandeira et al., 2018)

The degree of astigmatism must be defined preoperatively to establish the patient's eligibility for implementation of a toric IOL. A toric IOL should be considered in eyes with 1.00D or higher (regular) corneal astigmatism.(Nanavaty et al., 2017)

In cases where toric IOLs are not suitable or where astigmatism is less than or equal to 0.75D, opposite clear corneal incisions (OCCI), or manipulation of the main incision in the positive meridian can be a convenient and a cost-effective manner to decrease postoperative corneal astigmatism. (Expert opinion) The specific incision location selection relies on the surgeon's experience, hence surgically induced astigmatism (SIA) is multifactorial. All incision methods generally result in SIA reduction.(Sheoran et al., 2022, Nikose et al., 2018)

All information above is based on available literature using anterior keratometry. Regarding the latest insights, it is recommended to use the posterior corneal astigmatism (PCA) for decision-making in corneal astigmatism.
In cases of high PCA, toric IOL calculators using measured PCA may provide a potential advantage over predicted PCA in toric IOL calculations using vector summation of the anterior and posterior corneal astigmatism.(Reitblat et al., 2020) It is recommended to use a toric IOL calculator. The ESCRS toric Calculator can be found at: https://iolcalculator.escrs.org/

## Conclusion

Implications for practice
Based on the currently available evidence, it is recommended to consider using a toric IOL in case of predicted postoperative corneal astigmatism above 1.0D. Toric IOLs can provide better UDVA and greater spectacle independence. The choice for toric IOLs or a specific incision location and technique depends on the preoperative magnitude of astigmatism.

Knowledge gaps
Further research into the preferred analysis of surgically induced astigmatism, the required magnitude of astigmatism to consider toric IOLs as well as their cost-effectiveness would be beneficial.

## Identified research evidence

### Findings from Systematic Reviews

One relevant systematic review was identified.

Meta-analysis of 13 studies showed that compared with non-toric intraocular lens (with or without relaxing incision), toric intraocular lens improved postoperative uncorrected distance visual acuity (UDVA) measured with logMAR (mean difference (MD) −0.07, −0.10 to −0.04, low certainty evidence), reduced the risk of not obtaining 20/25 UCDVA (risk ratio (RR) 0.59, 95% confidence interval (CI) 0.50–0.70;, low

certainty evidence), and the need for spectacles for distance viewing (RR 0.51, 95% CI 0.36–0.71, low certainty evidence). Meta-analysis of four studies showed slightly lower rate of postoperative complications (although statistically not significant) in the non-toric intraocular lens (with or without relaxing incision) compared with toric intraocular lens (RR 1.73, 95% CI 0.60–5.04, low certainty evidence).(Kessel et al., 2016b) The review was judged to be at a high risk of bias.

## GRADE Table and Forest Plots

## Toric IOL compared to non-toric for uncorrected distance visual acuity

**Bibliography:** 1.Kessel L., Andresen,J,Tendal,B,et,al.. Toric intraocular lenses in the correction of astigmatism during cataract surgery: a systematic review and meta-analysis.. Ophthalmology; 2016.
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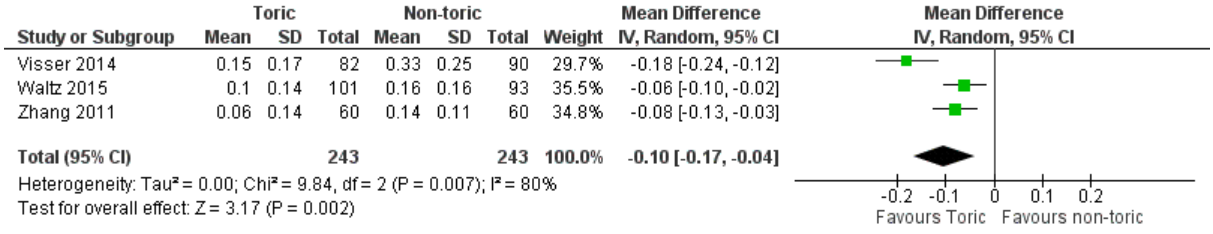
| Certainty assessment | | | | | | | № of patients | | Effect | | Certainty | Importance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| № of studies | Study design | Risk of bias | Inconsistency | Indirectness | Imprecision | Other considerations | Toric IOL | non-toric | Relative (95% CI) | Absolute (95% CI) | | |
| **Uncorrected distance visual acuity** | | | | | | | | | | | | |
| 13 | randomised trials | serious[a] | serious[b] | not serious | not serious | none[2,3,c] | 461 | 462 | - | MD **0.07 lower** (0.1 lower to 0.04 lower) | ⨁⨁◯◯ Low | CRITICAL |
| **20/25 uncorrected distance visual acuity** | | | | | | | | | | | | |
| 5 | randomised trials | serious[c] | not serious | not serious | serious[d] | none[b] | -/335 | 118/335 (35.2%) | **RR 0.59** (0.50 to 0.70) | **144 fewer per 1,000** (from 176 fewer to 106 fewer) | ⨁⨁◯◯ Low[d] | CRITICAL |
| **patients requiring spectacles for distance viewing** | | | | | | | | | | | | |
| 6 | randomised trials | serious[c] | not serious | not serious | serious[d] | none[c,d] | -/431 | 232/436 (53.2%) | **RR 0.51** (0.36 to 0.71) | **261 fewer per 1,000** (from 341 fewer to 154 fewer) | ⨁⨁◯◯ Low | IMPORTANT |

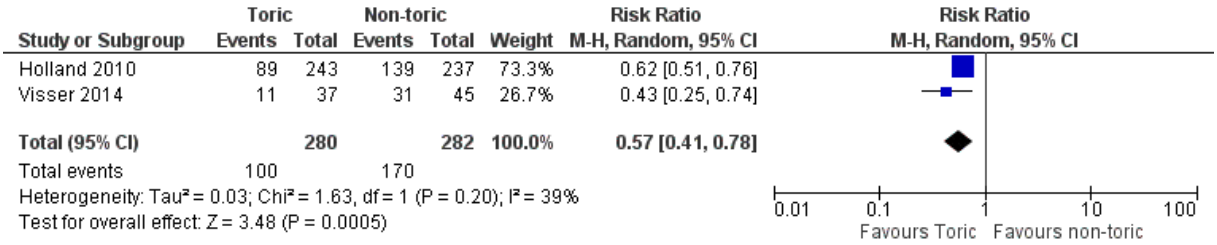
**CI:** confidence interval; **MD:** mean difference; **RR:** risk ratio

**Explanations**
a. Significant statistical heterogeneity detected
b. Unclear or high risk of bias of the included studies.
c. Unclear risk of bias of the included studies.
d. Small total sample size

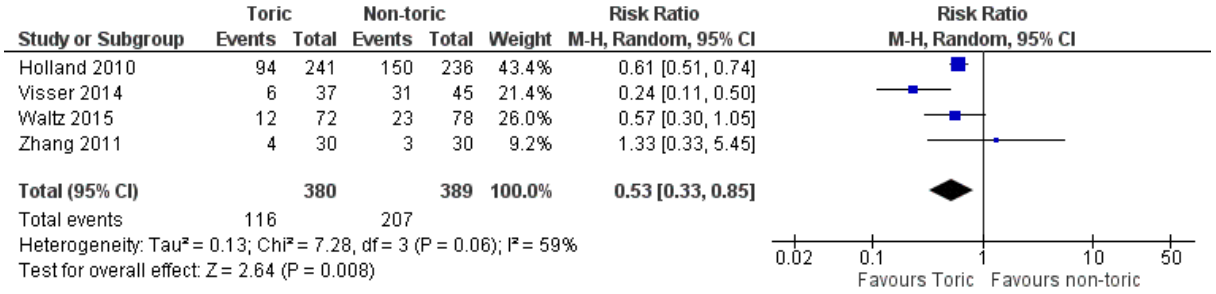
## Forest Plots



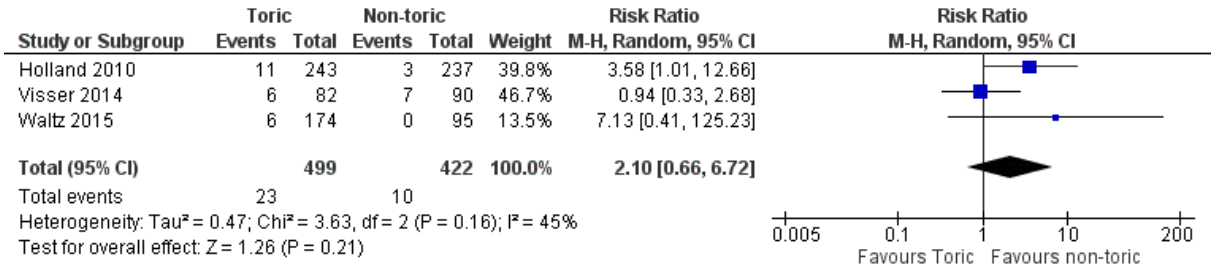

Forest plot of comparison: 2 Toric IOL vs non-toric IOL, outcome: 2.1 UCDVA.



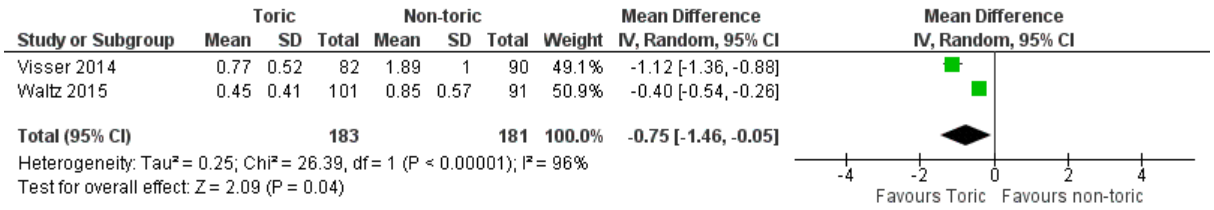

Forest plot of comparison: 2 Toric IOL vs non-toric IOL, outcome: 2.2 Did not achieve 20/25 UCDVA.




Forest plot of comparison: 2 Toric IOL vs non-toric IOL, outcome: 2.3 patients requiring spectacles for distance viewing.




Forest plot of comparison: 2 Toric IOL vs non-toric IOL, outcome: 2.4 postoperative complications.




Forest plot of comparison: 2 Toric IOL vs non-toric IOL, outcome: 2.5 residual astigmatism.

### 4.7.1 References

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Sheoran, K., Arya, S. K., Bansal, R. K., et al. 2022. Surgically induced astigmatism and posterior corneal curvature changes following phacoemulsification. *Indian Journal of Ophthalmology,* 70**,** 406-412.

## 4.8 Anaesthesia techniques

### Output question

What type of anaesthesia is indicated for the patient?

**P**: Adult patients who will undergo cataract surgery
**I:** Surgery being done in topical anaesthesia
**C:** Surgery being done in general anaesthesia
**O**: Visual function, quality of Life, (serious) adverse events, PROM

### Recommendation

There are several accepted and safe anesthesia techniques available for patients who undergo cataract surgery. Topical anesthesia appears to be the most used anesthesia technique during cataract surgery, if suitable for the patient. (GRADE ++/+++)

For further reducing pain during the cataract surgery, an additional intracameral lidocaine injection can be considered. (GRADE ++/+++)

The choice for a specific type of anesthesia during cataract surgery should be made together with surgeon and patient. (GRADE +)

### Considerations

Accepted and safe anaesthesia techniques include topical anaesthesia, general anaesthesia, retro- or peribulbar anaesthesia, and sub-Tenon's anaesthesia.

Topical anaesthesia is not as effective for pain relief when compared to other anaesthesia techniques (including sub-Tenon's, retro- and peribulbar anaesthesia), but its anaesthetic effect is well tolerated during cataract surgery.(Alhassan et al., 2015, Guay and Sales, 2015, Zhao et al., 2012)

Retro- and peribulbar anaesthesia techniques cause more anaesthesia-related complications in comparison with topical anaesthesia. (Segers et al., 2022b) Although, based on EUREQUO registry data, it was found that the use of topical anesthesia for cataract surgey is associated with an increased risk of posterior capsule rupture (PCR) with and without dropped nucleus, and endophthalmitis. (Segers et al., 2022b) Moreover, local anaesthesia in general may cause cognitive disfunction postoperatively compared to topical anaesthesia.(Alhassan et al., 2015)

Anxiety and fear have often been noted during cataract surgery under local anaesthesia. Preoperative education and counselling may reduce these negative feelings.(Obuchowska and Konopinska, 2021)

Further pain reduction can be achieved by the use of additional intracameral lidocaine, oxybuprocaine or bupivacaine injection, although this may lead to significant postoperative cognitive impairment in rare cases (including verbal memory, attention, executive function).(Fathy et al., 2019a, Fathy et al., 2019b, Minakaran et al., 2020)

Routine preoperative fasting is not recommended for preventing the risk of pulmonary aspiration since this is very exceptional.(Popovic et al., 2019) Preoperative fasting should be taken into consideration, as it might be possible that the patient will need intravenous sedation. Additionally, preoperative health tests and blood samples may be necessary in the case of general anaesthesia. (Expert opinion)

## Conclusion

Implication for practice

Regarding current available evidence, the best choice for an anaesthesia technique may vary from surgeon to surgeon based on experience and predilection, and from patient to patient. Topical anaesthesia is the most preferable and frequently used anaesthesia method in cataract surgery, although other techniques have also been accepted and are safe.

Implication for research

Further research is needed to further compare the complication rates between anaesthetic techniques.

## Identified research evidence

### Findings from Systematic Reviews

Three relevant systematic reviews were identified.

In a Cochrane systematic review, meta-analysis of two studies showed that in patients undergoing cataract surgery, compared with peribulbar anaesthesia, retrobulbar has no added benefit on reducing pain scores (mean difference (MD) -0.03 (95% confidence interval (CI) -0.17 to 0.11, n=221, low certainty evidence) or globe akinesia (risk ratio (RR)) 0.98, 95% CI 0.88 to1.09, 4 studies, low certainty evidence)), need for additional injection (RR 1.54, 95% CI 0.91 to 2.60, n=1,029, 4

studies, low certainty evidence). Meta-analysis of two studies showed that, compared with peribulbar anaesthesia, patients under retrobulbar anaesthesia had lower risk of conjunctival chemosis (RR 2.11, 95% CI 1.46 to 3.05, four studies, n=1,042, moderate certainty evidence), and higher risk of lid haematoma (RR 0.36, 95% CI 0.15 to 0.88, n=450, low certainty evidence). (Alhassan et al., 2015) The review was judged to be at a low risk of bias.

In a second Cochrane systematic review, the meta-analysis of six randomised controlled trials (RCTs) showed an increased pain intensity (during surgery) in patients under the topical anaesthesia compared to sub-Tenon's anaesthesia (standard mean difference [SMD] = 0.64, 95% confidence interval [CI] 0.43 to 0.84, low certainty evidence). However, the meta-analysis of two trials showed reduced pain intensity (although statistically not significant) in patients under the topical anaesthesia compared to sub-Tenon's anaesthesia (SMD = -0.20, 95% CI -0.43 to 0.04, 2 RCTs, low certainty evidence). (Guay and Sales, 2015) The review was judged to be at a low risk of bias.

The meta-analysis of eight RCTs showed that compared with topical anaesthesia alone, topical anaesthesia plus intracameral lidocaine reduced intraoperative pain or discomfort measured with analogue rating scales at up to 1 day postoperatively (mean difference [MD] -0.26, 95% confidence interval [CI] −0.39 to −0.13, 1,692 eyes, moderate certainty evidence), but had no effects on postoperative pain or discomfort (MD −0.12, 95% CI −0.29 to 0.05, 751 eyes, low certainty evidence), patient satisfaction (MD 0.1, 95% CI -0.47 to 0.27, very low certainty evidence), the need for additional anaesthesia during surgery (odds ratio [OR] 0.88, 95% CI 0.56 to 1.39, low certainty evidence) or the mean percentage change in pre- to postoperative corneal endothelial cell count (MD 0.89, 95% CI -1.12 to 2.90, moderate certainty evidence). (Minakaran et al., 2020) The review was judged to be at a low risk of bias.

## GRADE Tables

### Peribulbar compared to retrobulbar in cataract surgery

**Bibliography:** Alhassan MB, Kyari F, Ejere HO. Peribulbar versus retrobulbar anaesthesia for cataract surgery. Cochrane Database Syst Rev. 2015 Jul 2;2015(7):CD004083. doi: 10.1002/14651858.CD004083.pub3.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With retrobulbar | With peribulbar | | Risk with retrobulbar | Risk difference with peribulbar |
| **Pain (assessed with: Scale: 0-4)** | | | | | | | | | | | |
| 221 (2 RCTs) | serious[a] | not serious | not serious | serious[b] | none | ⨁⨁◯◯ Low | 111 | 110 | - | The mean pain was **3.7** | MD **0.03 lower** (0.17 lower to 0.11 higher) |
| **Globe akinesia** | | | | | | | | | | | |

## Peribulbar compared to retrobulbar in cataract surgery

**Bibliography:** Alhassan MB, Kyari F, Ejere HO. Peribulbar versus retrobulbar anaesthesia for cataract surgery. Cochrane Database Syst Rev. 2015 Jul 2;2015(7):CD004083. doi: 10.1002/14651858.CD004083.pub3.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1042 (4 RCTs) | serious[a] | serious[c] | not serious | not serious | none | ⨁⨁◯◯ Low | 377/479 (78.7%) | -/563 | **RR 0.98** (0.88 to 1.09) | 787 per 1.000 | **16 fewer per 1.000** (from 94 fewer to 71 more) |
| **Need for additional injection** | | | | | | | | | | | |
| 1029 (4 RCTs) | serious[a] | serious[c] | not serious | not serious | none | ⨁⨁◯◯ Low | 63/498 (12.7%) | -/531 | **RR 1.54** (0.91 to 2.60) | 127 per 1.000 | **68 more per 1.000** (from 11 fewer to 202 more) |
| **Conjuntival chemosis** | | | | | | | | | | | |
| 1042 (4 RCTs) | serious[a] | not serious | not serious | not serious | none | ⨁⨁⨁◯ Moderate | 34/479 (7.1%) | -/563 | **RR 2.11** (1.46 to 3.05) | 71 per 1.000 | **79 more per 1.000** (from 33 more to 146 more) |

**CI:** confidence interval; **MD:** mean difference; **RR:** risk ratio

**Explanations**

a. Unclear or high risk of bias of the included studies.
b. Small sample size; wide confidence intervals around the effect estimate.
c. Significant statistical heterogeneity detected.

## Sub Tenon anaesthesia compared to topical anaesthesia in cataract surgery

**Bibliography:** Guay J, Sales K. Sub-Tenon's anaesthesia versus topical anaesthesia for cataract surgery. Cochrane Database Syst Rev. 2015 Aug 27;2015(8):CD006291. doi: 10.1002/14651858.CD006291.pub3.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With topical anaesthesia | With Sub Tenon anaesthesia | | Risk with topical anaesthesia | Risk difference with Sub Tenon anaesthesia |
| **Pain during surgery** | | | | | | | | | | | |
| 705 (6 RCTs) | very serious[a] | not serious | not serious | not serious | none | ⨁⨁◯◯ Low | 302 | 403 | - | - | SMD **0.64 SD higher** (0.43 higher to 0.84 higher) |
| **Pain during anaesthesia administration** | | | | | | | | | | | |
| 320 (2 RCTs) | very serious[a] | not serious | not serious | not serious | none | ⨁⨁◯◯ Low | 111 | 209 | - | - | SMD **0.2 SD lower** (0.43 lower to 0.04 higher) |
| **Pain at 30 min post-surgery** | | | | | | | | | | | |
| 201 (1 RCT) | not serious | not serious | not serious | serious[b] | none | ⨁⨁⨁◯ Moderate | 65 | 136 | - | - | SMD **0.54 SD higher** (0.24 higher to 0.84 higher) |

**CI:** confidence interval; **SMD:** standardised mean difference

**Explanations**

a. Very high or high risk of bias of the included studies.
b. Small sample size, results from a single study

## Topical anaesthesia with intracameral lidocaine compared to Topical anaesthesia alone in cataract surgery

**Bibliography:** Minakaran N, Ezra DG, Allan BDS. Topical anaesthesia plus intracameral lidocaine versus topical anaesthesia alone for phacoemulsification cataract surgery in adults. Cochrane Database of Systematic Reviews 2020, Issue 7. Art. No.: CD005276. DOI: 10.1002/14651858.CD005276.pub4

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Study event rates (%) | | | Anticipated absolute effects | |
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | With Topical anaesthesia alone | With Topical anaesthesia with intracameral lidocaine | Relative effect (95% CI) | Risk with Topical anaesthesia alone | Risk difference with Topical anaesthesia with intracameral lidocaine |
| **Intraoperative pain or discomfort (follow-up: 1 days; assessed with: VAS; Scale from: 0 to 10)** | | | | | | | | | | | |
| 1692 (8 RCTs) | serious[a] | not serious | not serious | not serious | none | ⊕⊕⊕◯ Moderate | 822 | 870 | - | The mean intraoperative pain or discomfort was **0** | MD **0.26 lower** (0.39 lower to 0.13 lower) |
| **Postoperative pain or discomfort (follow-up: 1 days; assessed with: VAS)** | | | | | | | | | | | |
| 751 (4 RCTs) | serious[a] | not serious | not serious | serious[b] | none | ⊕⊕◯◯ Low | 375 | 376 | - | The mean postoperative pain or discomfort was **0** | MD **0.12 lower** (0.29 lower to 0.05 higher) |
| **Need for additional anaesthesia during surgery** | | | | | | | | | | | |
| 1060 (6 RCTs) | serious[a] | not serious | not serious | serious[b] | none | ⊕⊕◯◯ Low | 41/497 (8.2%) | -/563 | **OR 0.88** (0.56 to 1.39) | 82 per 1.000 | **9 fewer per 1.000** (from 35 fewer to 29 more) |
| **Intraocular toxicity (follow-up: range 1 months to 1 years; assessed with: Mean change in corneal endothelial cell count from pre- to postoperatively)** | | | | | | | | | | | |
| 254 (4 RCTs) | not serious | not serious | not serious | very serious[c] | none | ⊕⊕◯◯ Low | 132 | 122 | - | The mean intraocular toxicity was **0** | MD **0.89 higher** (1.12 lower to 2.9 higher) |

**CI:** confidence interval; **MD:** mean difference; **OR:** odds ratio

**Explanations**
a. High risk of bias of the included studies.
b. Wide confidence intervals around the effect estimate.
c. Small total sample size.

## 4.8.1 References


Alhassan, M. B., Kyari, F. & Ejere, H. O. D. 2015. Peribulbar versus retrobulbar anaesthesia for cataract surgery. *Cochrane Database of Systematic Reviews.*

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Guay, J. & Sales, K. 2015. Sub-Tenon's anaesthesia versus topical anaesthesia for cataract surgery. *Cochrane Database of Systematic Reviews.*

Minakaran, N., Ezra, D. G. & Allan, B. D. S. 2020. Topical anaesthesia plus intracameral lidocaine versus topical anaesthesia alone for phacoemulsification cataract surgery in adults. *Cochrane Database of Systematic Reviews.*

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# 5. Preoperative assessment

## 5.1 General preoperative assessment

### Output question

What kind of diagnostics and preoperative assessment of the patient should be done? In patients who will undergo cataract surgery, what are the effects of diagnostic A versus no diagnostic A or versus diagnostic B on efficacy and safety outcomes?

**P:** Adult patients who will undergo cataract surgery
**I:** Performing diagnostic test A
**C:** Not performing diagnostic A / Performing diagnostic test B
**O:** Adverse events, Cancellation of cataract surgery prior to surgery

### Recommendation

In general, for preoperative assessment prior to cataract surgery the following diagnostic measures are recommended: refraction, visual acuity, slitlamp assessment, biometry and tonometry. (GRADE ++)

Prior to surgery, it is recommended to provide patients with detailed patient information, including: (GRADE ++)

- Surgery process overview
- Potential intra- and postoperative complications
- Target refraction
- Various IOL options
- Postoperative care instructions and medications

In the presence of refractive astigmatism additional measurements with tomography/topography are recommended. (GRADE +)

It is recommended to use cataract-specific checklists adapted to the clinic of practice, since checklist use is associated with improvement of patient safety by reducing surgical morbidity and mortality. (GRADE +)

### Considerations

The current methods to remove a cataract are very reliable but strongly depend on preoperative evaluation of the patient. Specific assessment of the patient prior to cataract surgery is important not only to define whether the patient is eligible for

cataract surgery, in terms of the necessity of a surgery, but also concerning the precise calculation of the IOL, which strongly depends on accurate measurement.

Medical history and symptom assessment as well as an eye examination is required. Special attention has to be taken in patients with systemic diseases for example diabetes mellitus or patients taking anticoagulants as surgery risk is elevated. Routine medical testing prior to cataract surgery is not recommended as it does not provide further safety.(Keay et al., 2019)

Patients who regularly take alpha blockers also present a higher risk during cataract surgery, as alpha blockers might cause changes in the iris structure and iris behaviour during cataract surgery, increasing the risk for an intraoperative floppy iris syndrome (IFIS), consisting of an intraoperative progressive miosis, iris billowing, and iris prolapse. (Jan Teper et al., 2011)

Several measurements are required including:

- **Visual acuity test**. Using a chart or viewing device with progressively smaller letters determines signs of vision impairment. Visual acuity testing is important to evaluate whether symptoms induced by cataract impair a patient in a way that cataract surgery is indicated. (Expert opinion)
- **Refraction.** It is important to define the desired post-op refraction to correctly choose an IOL appropriate for the patient. Target refraction may also depend on a patient's refraction prior to surgery, including the possibility to opt for a good correction for distance, intermediate or near. (Expert opinion)
- **Slitlamp examination**. Structures of the anterior eye, primarily the cornea, iris, lens as well as the anterior chamber of the eye can be seen under magnification by slitlamp. Corneal scars may impair vision and counter the possibility of using presbyopia correcting IOLs. Additionally, only eyes in a non-inflammatory state are suitable for cataract surgery. Eyes with chronic inflammation and cataract may be an exception to this rule. (Expert opinion) PEX, a shallow anterior chamber of the eye as well as other ocular pathologies have to be taken into account when planning a cataract surgery. Pupil dilatation during an eye examination prior to cataract surgery is crucial to correctly classify the amount of cataract as well as to provide an adequate fundus examination.(Gaurisankar et al., 2019) (Expert opinion)
- **Fundus examination**. Fundus examination is imperative as macular changes might induce a worse possible vision outcome. Special attention has to be accounted for diabetic retinopathy, AMD, retinal tears or detachments and papillary changes due to glaucoma. Patients with a wet AMD might receive a simultaneous injection of anti-VEGF during cataract surgery. If fundus examination during slitlamp examination is not sufficient an optical coherence tomography or B-scan is indicated. (See chapter 5.3)

- **Tonometry**. Measuring the intraocular pressure prior to cataract surgery is indicated. Careful evaluation of the IOP has the taken in patients suffering from OHT (ocular hypertension) and glaucoma. (Expert opinion)
- **Biometry**. The refractive power of the eye depends on the power of the cornea, the power and position of the lens as well as the length of the eye. Biometry provides measurement of different anatomical aspects of the eye such as the axial length, anterior chamber depth, lens thickness, corneal radii corneal diameter, central corneal thickness and lens thickness. If an astigmatism of the cornea is present, a toric IOL or corneal incisions may be considered. By knowing these factors, the power of the IOL can be calculated to give the desired refractive outcome. Inaccuracy in either of these measurements may lead to an unpredicted postoperative refractive error.(Gaurisankar et al., 2019) If biometry is not able to accurately capture the axial length, an ultrasonography scan (A-scan) is indicated. (See chapter 5.4)
- **Corneal topography/tomography**. Measurements of the corneal radii of curvature may be achieved by a keratometer, corneal topographer and corneal tomographer. In standard keratometry assumptions are based on a fixed relationship between the front and the back of the corneal surfaces. Corneal tomography can measure both the anterior and posterior radii of the corneal curvature, as well as the corneal thickness. (Expert opinion)

After the biometric measurements of the eye are taken, the power of the IOL can be calculated. However, in addition to diagnostic measurements, providing detailed patient information is crucial. This includes discussing target refraction, potential visual outcomes, and postoperative instructions with the patient. Equally essential is providing a detailed explanation of the surgical process and potential complications. (See chapter 9)

Besides the general preoperative assessment, the use of preoperative checklists is recommended since this improves safety by reducing surgical complications.(de Vries et al., 2010, Kelly et al., 2013, Stolk-Vos et al., 2018, Zamir et al., 2012)

**Conclusion**

Implications for practice

Several tests including visual acuity, refraction, slitlamp examination, fundus examination, tonometry, and biometry are essential prior to cataract surgery. Other examinations including OCT, ultrasonography and tomography are very useful as adjunctis in the presence of different ocular pathologies and specific patient characteristics. (See chapter 4.2) Additionally, a detailed patient information is needed and the use of checklists prior to surgery is recommended.

Knowledge gaps

In order to make preoperative assessment more time and cost-effective further research on the necessity of different diagnostic measurements is needed.

## Identified research evidence

### Findings from Systematic Reviews

Two relevant systematic reviews were identified.

Meta-analysis of 27 studies showed a strong overall correlation between axial length (AL) and refractive error (correlation coefficient r=−0.67, 95% confidence interval (CI) −0.76, −0.56) and a weak correlation between anterior chamber depth (ACD) and refractive error (r=−0.28, 95% CI −0.45, −0.08). There was a moderate correlation between ACD and AL, though with a large variation (r=0.49, 95% CI −0.04, 0.58). There was a very weak correlation between corneal power and refractive error (r=−0.16, 95% CI −0.26, −0.05). The correlation between corneal power and AL was weak (r=−0.29, 95% CI −0.47, −0.09).(Gaurisankar et al., 2019) The review was judged to be at a high risk of bias.

Meta-analysis of three studies showed no difference between routine preoperative medical testing and selective or no preoperative testing in the number of adverse events (AEs) (odds ratio (OR) 1.00, 95% confidence interval (CI) 0.86 to 1.16, n=21,531, low-certainty evidence), intra-operative ocular AEs (OR 0.99, 95% CI 0.71 to 1.38, two trials, n=2281, low-certainty evidence) or postoperative ocular AEs (OR 1.11, 95% CI 0.74 to 1.67, two trials, n=2,281, low-certainty evidence) up to 2 months after surgery. Meta-analysis of two studies showed no difference between routine preoperative medical testing and selective or no preoperative testing in the number of cancellations of cataract surgery (OR 0.97, 95% CI 0.78 to 1.21, two trials, n=20,582, low-certainty evidence). (Keay et al., 2019) The review was judged to be at a low risk of bias.

## GRADE Table

### Routine preoperative medical testing compared to selective or no preoperative medical testing for detecting macular disease before cataract surgery

**Bibliography:** Keay L, Lindsley K, Tielsch J, Katz J, Schein O. Routine preoperative medical testing for cataract surgery. Cochrane Database Syst Rev. 2019 Jan 8;1(1):CD007293. doi: 10.1002/14651858.CD007293.pub4.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Study event rates (%) | | | Anticipated absolute effects | |
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | With selective or no preoperative medical testing | With Routine preoperative medical testing | Relative effect (95% CI) | Risk with selective or no preoperative medical testing | Risk difference with Routine preoperative medical testing |
| **Overall medical adverse events up to 2 months after surgery** | | | | | | | | | | | |
| 21531 (3 RCTs) | very serious[a] | not serious | not serious | not serious | none | ⊕⊕◯◯ Low | 354/10767 (3.3%) | 0/10764 (0.0%) | **OR 1.00** (0.86 to 1.16) | 329 per 10.000 | **0 fewer per 10.000** (from 45 fewer to 51 more) |
| **Intraoperative ocular adverse events up to 2 months after surgery** | | | | | | | | | | | |
| 2280 (2 RCTs) | serious[b] | not serious | not serious | serious[c] | none | ⊕⊕◯◯ Low | 78/1140 (6.8%) | 0/1140 (0.0%) | **OR 0.99** (0.71 to 1.38) | 68 per 1.000 | **1 fewer per 1.000** (from 19 fewer to 24 more) |
| **Postoperative ocular adverse events up to 2 months after surgery** | | | | | | | | | | | |
| 2280 (2 RCTs) | serious[b] | not serious | not serious | serious[c] | none | ⊕⊕◯◯ Low | 54/1140 (4.7%) | 0/1140 (0.0%) | **OR 1.11** (0.74 to 1.67) | 47 per 1.000 | **5 more per 1.000** (from 12 fewer to 29 more) |
| **Cancellation of cataract surgery prior to surgery** | | | | | | | | | | | |
| 20582 (2 RCTs) | very serious[d] | not serious | not serious | not serious | none | ⊕⊕◯◯ Low | 166/10295 (1.6%) | 0/10287 (0.0%) | **OR 0.97** (0.78 to 1.21) | 161 per 10.000 | **5 fewer per 10.000** (from 35 fewer to 33 more) |

**CI:** confidence interval; **OR:** odds ratio

**Explanations**
a. Very high risk of bias in the two (out of three) of the included studies.
b. Very high risk of bias in one of the included studies.
c. Wide confidence intervals around the effect estimate.
d. Very high risk of bias in both of the included studies.

### 5.1.1 References


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## 5.2 Preoperative assessment in patients with previous refractive surgery

**Output question**

What kind of diagnostics and preoperative assessments of patients who previously underwent refractive surgery should be done?

- **P:** Adult patients who previously underwent refractive surgery (including laser refractive surgery, radial keratotomy and phakic IOLs) and will now undergo cataract surgery
- **I:** Performing specific preoperative diagnostics
- **C:** Not performing specific preoperative diagnostics
- **O:** Visual acuity, visual function, (serious) adverse events, postoperative refractive outcome

**Recommendation**

<u>Prevous laser refractive surgery</u>

It is recommended to perform corneal tomography or topography in patients who previously underwent corneal refractive surgery. (GRADE +)

<u>Previous radial keratotomy (RK)</u>

In post-radial keratotomy (RK) eyes a corneal tomography/ topography should be performed for assessment of corneal astigmatism and corneal irregularities. (GRADE +)

A slightly myopic target refraction should be considered. (GRADE +)

Patients should be informed about the possibility of a refractive surprise. (GRADE +)

<u>Previous phakic IOLs (pIOLs)</u>

It is recommended to choose a slightly myopic target refraction in anterior and posterior phakic IOLs. (GRADE +)

An anterior segment OCT may be used for axial length and anterior chamber depth measurements in anterior phakic IOLs. (GRADE +)

Endothelial cell count should be done in patients with anterior phakic IOLs prior to cataract surgery. (GRADE +)

**Considerations**

Currently, limited scientific evidence is available for preoperative diagnostics for patients with previous laser refractive surgery and the general preoperative evaluation and assessment of the corneal topography/tomography before cataract surgery in patients who previously underwent refractive surgery. When available, performing corneal aberrometry should be considered in this patient subgroup. IOL calculation should be performed using customised IOL calculation formulae (see chapter 6). Different approaches to IOL asphericity selection might be needed depending on the type of corneal refractive surgery and its consequences in the corneal optics. In any case, a neutral aspheric monofocal IOL may be an adequate and safe approach for most of these cases. (Alio et al., 2016)

In patients with posterior phakic IOLs, cataract development might be due to age-related cataract or to the phakic IOL touching the anterior lens capsule of the crystalline lens and thereby inducing a cataract. Careful retroillumination to examine for iris defects and the patency of the peripheral iridotomy is indicated in most cases. Even if posterior phakic IOLs are generally very thin, a biometry from before the phakic IOL implantation should be preferably used to define the axial length (when available). (Cakir et al., 2023, Lee et al., 2016, Jonker et al., 2020) It is recommended to target for slight myopia instead of emmetropia in IOL calculation.

In patients with anterior phakic IOLs, cataract development is mostly age-related. As implantation of anterior phakic IOLs requires a large incision, these patients often develop an against-the-rule astigmatism during the healing process. This is not true however for foldable iris fixated phakic IOLs, who require small incisions.
his astigmatism has to be considered in the preoperative assessment. During preoperative assessment, it is recommended to look for iris damage and the patency of the peripheral iridotomy. Corneal endothlelial cell density and morphology should also be assessed, as endotheal cell loss might be present in eyes with anterior chamber phakic IOLs. As anterior phakic IOLs are rather thick it is recommended to perform an optical coherence biometry to measure axial length and anterior chamber depth. A slightly myopic target refraction should be considered. For the surgery techniques of a pIOL explantation combined with cataract surgery, it is recommended to use soft-shell viscoelastic technique to protect the endothelium. After the pIOL is explanted, the phacoemulsification can be performed using the main incision, however separate incisions can be recommended to prevent instability of the anterior chamber during surgery. (Jonker et al., 2020, de Vries et al., 2009, Papa-Vettorazzi et al., 2022, Moshirfar et al., 2010, Gaurisankar et al., 2022)

For eyes that previously underwent RK, it is challenging to perform an accurate IOL calculation. Conventional keratometric assessment of the 4 mm paracentral zone

might lead to an overestimation of the corneal power, hence leading to postoperative hyperopia. Therefore, corneal tomography or corneal topography (eg. with emphasis on the 3.0mm central corneal flattening) should be used for assessment of the corneal power and astigmatism.(Chen et al., 2003) Web-based tools as the ASCRS IOL power calculator for post-refractive eyes can be used for IOL power calculation. IOL power calculation might be affected by refractive instability and irregular astigmatism.(Alio et al., 2016) In some post-RK patients the corneal curvature may continue to change inducing a hyperopic shift with very flat central corneas. Choosing a slightly myopic target refraction between -0.5D and -1.5D is therefore recommended. Patients should also be informed about the risk of opening of the RK incisions, the increased risk of a refractive surprise and the fact that stabilisation of the postoperative refraction may take longer upto several months.(Geggel, 2015) Additionally it is important to avoid interference with the RK incisions during cataract surgery.

**Conclusion**

Implications for practice

The scientific evidence for this question is limited. In patients who previously underwent laser refractive surgery corneal tomography or topography/aberrometry should be performed to obtain the most accurate information about the shape of the cornea.

Knowledge gaps

Additional research into this topic is highly recommended since this question is currently only based on expert opinion.

**Identified research evidence**

**Findings from Systematic Reviews**

No systematic reviews were identified.

### 5.2.1 References

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## 5.3 Indications for posterior segment OCT

### Output question

In which patients with an indication for cataract surgery is posterior segment OCT indicated?

**P:** Adult patients who will undergo cataract surgery with ocular comorbidities
**I:** Performing preoperative OCT with macular scan and/or optic disc
**C:** Not performing OCT
**O:** Visual acuity, visual function, (serious) adverse events, postoperative refractive outcome

### Recommendation

In general, posterior segment OCT in cataract surgery should be used when there is a clinical indication, such as age-related macular degeneration, diabetic retinopathy, glaucoma, or when the visual acuity is worse than expected. (GRADE +)

OCT is more effective in detecting optic nerve or macular pathologies than a regular fundus examination. (GRADE +)

Posterior segment OCT may be used in routine cataract cases and can be considered at least in the following situations: (GRADE +)

- In case of increased risk or medical history of macular abnormalities that could adversely affect the postoperative visual outcome, such as AMD, diabetic retinopathy
- Where the visual acuity is worse than expected and cannot be fully explained by the degree of cataract
- In case of considering presbyopia correction IOLs.

### Considerations

The rapid emergence of OCT has led to the development of many different ophthalmic applications. Spectral domain OCT provides non-invasive, high-resolution in-vivo cross-sectional images of both anterior and posterior segments of the eye. The utility of OCT in cataract surgery continues to broaden including preoperative assessment, intraoperative image-based treatments as well as postoperative care and complication management. Macular changes obscured by a cataract can limit the surgical outcome, emphasizing the importance of preoperative assessment to identify unknown macular disease affecting the final vision.(Nguyen and Chopra, 2013)

The chance of detecting abnormalities in patients is greater with higher age, thus reducing the number to treat and increasing the value of an OCT scan prior to surgery.[124] OCT scans should be performed on indication to predict the risk of reduced visual recovery, especially in cases of retinal pathologies such as pre-existing diabetic retinopathy or age-related macular degeneration. Moreover, performing an OCT scan prior to cataract surgery facilitates preoperative detection of subtle macular and optic nerve pathologies, which may go unnoticed by fundus examination.(Goldberg et al., 2024) Studies have shown that preoperative OCT can reveal macular abnormalities in approximately 5% of patients who appear to have a normal funduscopy. This significantly affected the surgical plan for 0.83% of all patients, particularly those over 70, with hypertension or a smoking history.(Alizadeh et al., 2021) In contrast, another group found 12.8% of the patients attending a preoperative cataract assessment presented with an occult maculopathy only detectable on OCT.(Murphy et al., 2022)

Literature on the use of macular OCT in routine cataract patients is limited. It is suggested that the incorporation of routine macular OCT scans for cataract surgery candidates is beneficial in identifying macular pathologies that could be overlooked or underestimated during standard fundus microscopic examination. This additional information could potentially enhance patient management and improve outcomes.(Weill et al., 2021) Nevertheless, due to the limited amount of research on this topic, further investigation is required to confirm these findings and address the research gap. It is important to consider the additional time investment for the patient as well as the extra costs of this intervention. Moreover, it is worth noting that an OCT unit might not be available for all preoperative visits. (Expert opinion)

## Conclusion

Implications for practice

When considering whether to perform an OCT scan, it is important to consider the arguments for and against. While an OCT scan may be more effective than fundoscopy in detecting macular and optic nerve pathologies, there is limited research on its use in routine cataract patients. Currently, an OCT scan is only indicated in certain cases, such as when visual acuity is worse than expected, in the presence of exudative macular degeneration or diabetic retinopathy, when potential abnormalities on the OCT would impact (post-)operative management, or when considering a pseudophakic presbyopia correcting IOL.

Knowledge gaps

Further research is needed on the possibilities of augmenting the preoperative assessment of routine cataract patients with routine use of posterior OCT technology.

**Identified research evidence**

**Findings from Systematic Reviews**

No relevant systematic reviews were identified.

### 5.3.1 References


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## 5.4 Indications for ultrasonography

### Output question

In which patients planned for cataract surgery is ultrasonography (A- or B-scan) indicated?

**P:** Adult patients who will undergo cataract surgery with ocular comorbidities
**I:** Performing preoperative ultrasonography (A- or B-scan)
**C:** Not performing ultrasonography
**O:** Visual acuity, visual function, (serious) adverse events, postoperative refractive outcome

### Recommendation

Ultrasound biometry (A- and/or B-scan) should be used when there is low visibility of the posterior segment, such as in mature and dense cataracts when optical biometry is not applicable or feasible. (GRADE +)

### Considerations

When comparing optical biometry to ultrasound biometry, it has several advantages since it is non-contact, fast and accurate. In patients where optical biometry is not possible due to mature or dense posterior subcapsular cataracts, ultrasound biometry remains a good alternative.(Joshi et al., 2019)

No significant differences were found between optical and ultrasound biometry (when assessed by an experienced operator) in measuring the axial length or comparing refractive outcomes.(Khan et al., 2019, Naicker et al., 2015)

In the case of silicon-filled eyes, optical biometry seems to be more accurate and reliable for IOL power calculation compared to ultrasound biometry.(Anwar et al., 2022)

### Conclusion

<u>Implications for practice</u>
Regarding the current evidence, the use of ultrasound biometry in preoperative assessment of a cataract patient is recommended when optical biometry is not possible, for instance in the case of mature and dense cataracts. In these cases, ultrasound is very important for performing an adequate lens calculation before surgery and checking whether there are pathologies in the posterior part of the eye.

Knowledge gaps

Further research on the usage of ultrasonography is needed to provide good diagnostic measurements for patients with mature cataracts.

**Identified research evidence**

**Findings from Systematic Reviews**

No relevant systematic reviews were identified.

### 5.4.1 References


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## 5.5 Preoperative assessment in case of corneal comorbidities

### Output question

What are the indications for specific assessment examinations for patients with corneal comorbidities (e.g., dry eye disease, Fuchs endothelial corneal dystrophy (FECD), corneal scars)?

**P:** Adult patients with corneal comorbidities who underwent cataract surgery
**I:** Performing specific preoperative diagnostics
**C:** Not performing specific preoperative diagnostics
**O:** Prevalence of dry eye disease post-surgery

### Recommendation

Consider treatment of the dry eye disease before performing cataract surgery. Patients with pre-existing dry eye disease should be recognized and diagnosed before cataract surgery by testing the tear breakup time, corneal fluorescein staining or Schirmer test. (GRADE +)

The severity of Fuchs' endothelial dystrophy should be evaluated for cataract surgery decision-making, based on the clinical presentation and the visual symptoms. (GRADE +)

Identifying corneal scars or opacities before cataract surgery is important for estimating potential vision gain. If a patient is not a good candidate for corneal transplantation, phacoemulsification can still be safely performed. In addition, cataract surgery can serve as an interim measure while the patient waits for penetrating keratoplasty. (GRADE +)

### Considerations

<u>Dry eye disease (DED)</u>

There are discrepancies in the evidence about the relationship between dry eye disease and cataract surgery. The prevalence of patients with dry eye disease ranges from 6-34% and it can present as different clinical manifestations. Studies show that more than one-third of the patients who underwent cataract surgery develop DED. However, contrasting research shows that cataract surgery does not provoke or exacerbate DED and may only cause reduced tear film stability. This reduced tear film stability combined with the damaged corneal surface may cause

more complaints after cataract surgery in patients with pre-existing dry DED.(Lu et al., 2021, Miura et al., 2022)

Preoperative treatment of dry eye and ocular surface diseases should be considered. These ocular surface problems should be recognized and identified before cataract surgery to minimise the complaints of DED. Particular attention should be paid to high-risk patients diagnosed with, for example, Sjögren syndrome, graft versus host disease, or Stevens-Johnson Syndrome. When patients experience visual disturbance and discomfort, this can be diagnosed as DED when tear film instability is present. The tear breakup time, corneal fluorescein staining or Schirmer I testing can be performed to objectify the existence of the disease.(Chuang et al., 2017)

Fuchs endothelial corneal dystrophy (FECD)

In patients with FECD undergoing cataract surgery, specific preoperative assessments are necessary to evaluate the disease's severity and identify other critical influencing factors. Determining whether cataract surgery alone will improve the patients' visual acuity or whether it should be combined with corneal transplant surgery is a key decision that should be made during the consultation. The severity of the FECD plays a crucial role in making informed decisions regarding cataract surgery, taking into account both clinical presentation and visual symptoms. (Eghrari et al., 2010, Mukhija et al., 2023) Risk scores can be used to predict the progression to descemet membrane endothelial keratoplasy (DMEK) after cataract surgery.(Moshirfar et al., 2022, Seitzman et al., 2005, Matthaei et al., 2019, Patel, 2019)

The corneal curvature and refractive index of the corneal tissue can also be affected by FECD and this can result in a hyperopic shift. Biometry measurements can also be influenced by variations in preoperative corneal guttata and edema. As a result, the potential for a hyperopic refractive shift should be considered when performing IOL calculations.(Moshirfar et al., 2022) In addition,if an endothelial keratoplasty will be considered, targeting slightly more myopic will allow for this post-transplantation shift. (Expert opinion)

Corneal scars and opacities

Patients with corneal opacities should undergo a comprehensive preoperative evaluation to determine the extent of the corneal opacity, the potential for visual recovery with cataract surgery, and the possibility of combining cataract surgery with other procedures such as penetrating keratoplasty (PKP) if needed. Studies have shown that despite having corneal opacities, patients who underwent cataract surgery had significant improvements in visual acuity and contrast sensitivity. Additionally, cataract surgery can be a viable option for improving visual function in

patients with corneal opacities who are not candidates for corneal transplantation. However, each case must be evaluated individually, and the benefits and risks of cataract surgery should be carefully weighed for each patient.(Ho et al., 2018)

## Conclusion

Implications for practice

Regarding the current evidence, pre-existing corneal comorbidities are important to identify before performing cataract surgery. For patients diagnosed with Fuchs endothelial corneal dystrophy, the severity of the disease must be evaluated for decent decision-making; preoperative assessment of the disease is essential before cataract surgery. Preoperative treatment should be considered in case of dry eye or ocular surface disease.

Knowledge gaps

Further investigation is required to determine which diagnostics are most effective in forecasting the risk of corneal decompensation following phacoemulsification in FECD.

## Identified research evidence

### Findings from Systematic Reviews

Two relevant systematic reviews were identified.

Meta-analysis of 22 studies showed that compared with various controls (including within group comparisons) patients with pre-existing meibomian gland dysfunction (MGD) had worse subjective symptoms of dry eye (mean change (MC) 1.31, 95% confidence interval (CI) 0.66 to 1.95, very low certainty evidence), a reduced tear break-up time (TBUT) (MC −2.27, 95% CI −2.66 to −1.88, very low certainty evidence), and a worse corneal fluorescein staining (CFS) score (0.75, 95% CI 0.5 to 1.0, very low certainty evidence) 1 month after phacoemulsification cataract surgery. (Lu et al., 2021) The review was judged to be at a high risk of bias.

Meta-analysis of 9 studies showed a cumulative prevalence of dry eye disease (DED) after cataract surgery of 37.4% (95% confidence interval (CI) 22.6–52.3, very low certainty evidence) at follow-ups ranging from 1 month to more than 1 year. (Miura et al., 2022) The review was judged to be at a high risk of bias.

## GRADE Table

### What is the prevalence of DED after Cataract Surgery

**Bibliography:** Miura M, Inomata T, Nakamura M, Sung J, Nagino K, Midorikawa-Inomata A, Zhu J, Fujimoto K, Okumura Y, Fujio K, Hirosawa K, Akasaki Y, Kuwahara M, Eguchi A, Shokirova H, Murakami A. Prevalence and Characteristics of Dry Eye Disease After Cataract Surgery: A Systematic Review and Meta-Analysis. Ophthalmol Ther. 2022 Aug;11(4):1309-1332. doi: 10.1007/s40123-022-00513-y.

| Certainty assessment | | | | | | | Summary of findings | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With | With DED Prevalence | | Risk with | Risk difference with DED Prevalence |
| **Prevalence of dry eye disease** | | | | | | | | | | | |
| 775 (9 observational studies) | very serious[a] | very serious[b] | not serious | not serious | none | ⊕◯◯◯ Very low | Overall 37.4% (95% CI 22.6–52.3; 206/775) of patients without preexisting DED developed DED after cataract surgery. | | | | |

**CI:** confidence interval

**Explanations**
a. Results from observational studies pooled together with RCT
b. Significant statistical heterogeneity detected.

### 5.5.1 References


Chuang, J., Shih, K. C., Chan, T. C., et al. 2017. Preoperative optimization of ocular surface disease before cataract surgery. *Journal of Cataract and Refractive Surgery,* 43**,** 1596-1607.

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## 5.6 Preoperative assessment in case of keratoconus

### Output question

What are the indications for specific assessment examinations for patients with keratoconus?

**P:** Adult patients with keratoconus who will undergo cataract surgery
**I:** Performing specific preoperative diagnostics
**C:** Not performing specific preoperative diagnostics
**O:** Visual acuity, visual function, (serious) adverse events, postoperative refractive outcome

### Recommendation

In keratoconus patients, stabilizing procedures before cataract surgery should be considered if the patient is at risk of progression. (GRADE +)

When evaluating astigmatism in this patient population, the anterior, posterior and total corneal astigmatism should be assessed to perform the most accurate IOL calculations. (GRADE +)

### Considerations

Evaluation of astigmatism before cataract surgery is essential. When there is corneal thinning present in the patient, the surgeon must be aware of the possible presence of either keratoconus or pellucid marginal degeneration. Usually, keratoconus does not progress in patients older than 50 years, but in the case of pellucid marginal degeneration progression can and does occur. (Expert opinion)
In the case of keratoconus, the preoperative cornea and astigmatism assessment should include anterior-, posterior- and total corneal astigmatism to perform the most accurate IOL calculations. Due to these inaccuracies of optical biometry, obtaining reliable intraocular lens calculations is challenging. In keratoconus patients, there is an additional risk for a postoperative hyperopic biometry error in cases with high keratometry (K) values.(Gupta and Caty, 2018) It is recommended to aim for a slight myopic target in patients with K values up to 55D.(Moshirfar et al., 2018)

While most patients with keratoconus and cataract typically exhibit corneas that are relatively stable, it is important to note that in instances requiring stabilization procedures, options as corneal crosslinking or intrastromal corneal ring segment implantation can be considered. The utilization of these stabilizing techniques can significantly enhance the precision of the IOL calculations, ultimately resulting in improved visual acuity outcomes following cataract surgery.(Moshirfar et al., 2018)

## Conclusion

Implications for practice

Consider stabilizing procedures pre-cataract surgery in keratoconus patients. For accurate IOL calculations, use anterior, posterior, and total corneal astigmatism values. For extensive information about IOL calculation in keratoconus eyes, see chapter 6.2. Keratoconus patients have an increased risk of inaccurate biometry measurements and may need additional treatment after cataract surgery for poor refractive outcomes.

Knowledge gaps
Additional research is needed to further optimize the refractive prediction and postoperative outcomes in keratoconus patients.

## Identified research evidence

### Findings from Systematic Reviews

No systematic reviews were identified.

### 5.6.1 References

Gupta, P. C. & Caty, J. T. 2018. Astigmatism evaluation prior to cataract surgery. *Curr Opin Ophthalmol,* 29**,** 9-13.

Moshirfar, M., Walker, B. D. & Birdsong, O. C. 2018. Cataract surgery in eyes with keratoconus: a review of the current literature. *Curr Opin Ophthalmol,* 29**,** 75-80.

## 5.7 Preoperative assessment for intraocular surgery aiming to improve intermediate and near vision

### Output question

What preoperative assessment is necessary for presbyopia correcting IOLs?

**P:** Adult patients who will undergo cataract/lens surgery with IOLs aiming to increase intermediate and near vision
**I:** Performing preoperative assessments
**C:** Not performing preoperative assessments
**O:** Visual acuity, visual function, quality of life, (serious) adverse events, postoperative refractive outcome

### Recommendation

Patient selection for pseudophakic presbyopia correcting IOLs should be based on the presence of ocular comorbidities, the desire for spectacle independence, and realistic patient expectations. (GRADE +)

For the preoperative assessment before implantation of a presbyopia correcting IOL (including monofocal+, EDF, multifocal IOLs), besides the general mandatory preoperative assessment (see chapter 5.1), additional assessments can be considered including evaluation of dry eye symptoms, stereopsis assessment, corneal topography/tomography, posterior segment OCT, and pupillometry. (GRADE +)

### Considerations

Modern cataract surgery offers the possibility of correcting presbyopia using complex optic IOLs. A more extensive preoperative assessment must be performed to achieve high levels of patient satisfaction after implantation of a presbyopia correcting IOL. The preoperative assessment starts with patient selection, which is key. Different patient factors must be considered: visual expectations and desire for spectacle independence, personality, lifestyle, profession and hobbies. Considering patient personality, patients with unrealistic expectations appear less likely to be happy after receiving a multifocal IOL. In addition, in cases of ocular comorbidities such as macular disease, amblyopia, or glaucoma it must be noted and discussed that these may influence the quality of vision postoperatively. If patients are considering a presbyopia correcting IOL, the postoperative expected outcomes should be discussed. (Expert opinion)

Patients should be informed about their risk for refractive surprise and a need for glasses or additional surgical interventions postoperatively. In extremely long or short eyes, the risk for a refractive surprise is higher when compared to eyes within the normal range of axial length. When choosing a monovision approach with a presbyopia correcting IOL, the eye dominance should be assessed. (Expert opinion)

The assessments for presbyopia correcting IOL may differ according to the optical IOL technology used. Consider the following:

Evaluation of dry eye symptoms

Patients with pre-existing DED should be diagnosed and treated before performing cataract surgery with a pseudophakic presbyopia correcting IOL. Dry eye or ocular surface symptoms may affect both the preoperative examination and IOL calculation, and postoperative visual acuity. In case of ocular surface problems before cataract surgery, preoperative and, if applicable, postoperative treatment should be considered. This leads to a significant improvement of patient satisfaction postoperatively.(Chuang et al., 2017, Starr et al., 2019) For additional dry eye disease information, see chapter 5.5.

Corneal topography/tomography

Evaluation of the cornea is important and can influence the performance of complex optics so consider using corneal topography/tomography to identify cases with irregular corneas, forme fruste keratoconus, or decentered ablation after refractive laser surgery procedures. (Expert opinion) Additional information about correcting corneal astigmatism by cataract surgery can be found in chapter 7.2. Surgeons should also be aware of the corneal aberrometry of the eye in order to perform a good patient selection. In cases of increased higher order aberrations (HOA), above 0.5 microns, the use of a pseudophakic presbyopia correcting IOL should be reconsidered. (Expert opinion) (Goto and Maeda, 2021)

Posterior segment Optical Coherence Tomography

Since the performance of a presbyopia correcting IOL might be affected by retinal disease, fundus examination is required and a posterior segment OCT before implantation can be considered. The current evidence shows that OCT is more effective in detecting retinal abnormalities compared to funduscopy. Therefor, performing a posterior segment OCT should be considered during the preoperative assessment before presbyopia correcting IOL implantation.(Nguyen and Chopra, 2013, Tognetto et al., 2019, Abdelmassih et al., 2018, Copete et al., 2019) Additional information about posterior OCT can be found in chapter 5.3.

Pupillometry

Pupillometry when planning multifocal IOL implantation can be of benefit, since the performance of the IOL optic can be pupil size dependent. If the light energy distributions on the IOL optic vary with pupil size, the pupil diameter becomes even more relevant.(Fernandez et al., 2020)

The angle kappa value, which is characterized as the angle between the visual and pupillary axes, does not exhibit a discernible predictive influence on postoperative visual outcomes in the context of presbyopia correcting IOLs. Consequently, this variable cannot serve as a reliable criterion for assessing eligibility for presbyopia correcting IOL implantation.(Wallerstein et al., 2023)

## Conclusion

Implications for practice
When implanting a presbyopia correcting IOL, additional preoperative assessments such as evaluation of dry eyes, corneal tomography/topography, posterior optical coherence tomography, pupillometry or aberrometry should be considered to secure the planned postoperative outcome. Patients requesting a presbyopia correcting IOL implantation may have higher expectations concerning postoperative visual function which should be managed preoperatively.

Knowledge gaps
There is limited evidence about the optimal preoperative assessment for presbyopia correcting IOL implantation. Further research into additional assessments in particular including pupillometry and aberrometry before implanting a specific IOL should be performed.

## Identified research evidence

### Findings from Systematic Reviews

No relevant systematic reviews were identified.

## 5.7.1 References

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Tognetto, D., Pastore, M. R., De Giacinto, C., et al. 2019. Swept-source optical coherence tomography biometer as screening strategy for macular disease in patients scheduled for cataract surgery. *Scientific Reports,* 9**,** 9912.
Wallerstein, A., Ridgway, C., Gatinel, D., et al. 2023. Angle Kappa Influence on Multifocal IOL Outcomes. *J Refract Surg,* 39**,** 840-849.

## 5.8 Preoperative assessment for toric IOLs

### Output question

What is a special preoperative assessment necessary for toric IOLs?

**P:** Adult patients who will undergo cataract surgery with implantation of toric IOLs
**I:** Performing preoperative assessments
**C:** Not performing preoperative assessments
**O:** Visual acuity, visual function, quality of life, (serious) adverse events, postoperative refractive outcome

### Recommendation

In the case of implantation of a toric IOL the preoperative assessment should encompass not only general mandatory evaluations but also corneal topography and/or tomography. (GRADE +)

Methods which include measurements of factors such as the additional posterior corneal astigmatism and effective lens position are preferred for toric IOL calculation. (GRADE +)

### Considerations

In addition to the general preoperative assessments for cataract surgery defined in chapter 5.1 (including visual acuity measurements, slitlamp, funduscopic examination, IOP measurement and biometry), corneal topography and/or tomography should be performed when planning a toric IOL to establish the type, axis and amount of astigmatism. (Expert opinion)

For the IOL power calculation of a toric IOL, the use of methods which include measurements of the posterior corneal astigmatism and effective lens position are preferred to use when performing the calculation. The postoperative residual cylinder is significantly lower when performing IOL calculation that considers posterior corneal astigmatism and effective lens position.(Yeu et al., 2020)

Further information regarding marking techniques can be found in chapter 7.3.

### Conclusion

<u>Implications for practice</u>
Based on the currently available evidence, the preoperative assessment for implantation of a toric IOL should include corneal topography/tomography and a toric IOL calculator.

Implications for research

Additional research might be necessary to substantiate and validate this evidence regarding preoperative assessment in case of a toric IOL implantation. Tilt and decentration analyses are currently not measured by biometry, additional research into this is necessary to further optimize the IOL calculations.

**Identified research evidence**

**Findings from Systematic Reviews**

No relevant systematic reviews were identified.

### 5.8.1 References

Yeu, E., Cheung, A. Y. & Potvin, R. 2020. Clinical outcomes of toric intraocular lenses: differences in expected outcomes when using a calculator that considers effective lens position and the posterior cornea vs one that does not. *Clin Ophthalmol,* 14**,** 815-822.

# 6. IOL power calculation

## 6.1 IOL formulae and calculations

### Output question

Which formula(e) for calculating lens power should be considered?

**P:** Adult patients who will undergo cataract surgery
**I:** Formula A
**C:** Formula B
**O:** Visual acuity, visual function, quality of life, postoperative refractive outcome

Included formulae:
- Traditional formulae: Hoffer Q, SRK/T, Haigis, Holladay 1
- Newer-generation formulae: Barret Universal II, Cooke K6, EVO, Hill-RBF, Hoffer QST, Kane, Olsen, PEARL-DGS, Hollady 2, Castrop.

### Recommendation

There is a tendency towards improved outcomes with newer-generation formulae as they show less trend error, meaning that they appear more consistent along the range of axial lengths. Traditional formulae can still be considered an acceptable option where newer formulae are not available. (GRADE +)

### Considerations

There are many different IOL formulae available to calculate IOL power for patients undergoing cataract surgery. For many decades, the well-known third generation formulae including the Haigis, Hoffer Q, Holladay 1 and 2 and SRK/T formulae have been mostly used. Recently newer generation formulae for IOL power calculation have been introduced with the aim to reduce trend errors and to improve the refractive outcome after lenticular surgery.(L. Wang et al., 2019) (Eom et al., 2014) Newer generation formulae include the Barrett Universal II, Cooke K6, EVO, Hill-RBF, Hoffer QST, Kane, Olsen, and PEARL-DGS formula.(Rong et al., 2019).(Raufi et al., 2020) Most of the new formulae are unpublished and their algorithms are not known, but clinical studies comparing the different formulae have been published. The Castrop formula, for example, is fully published and provides an integrated toric calculator (device independent). (Langenbucher et al., 2021a, Langenbucher et al., 2021b, Wendelstein et al., 2022b) Similar results have been reported for most of the new generation studies, with more accurate results reported in new generation formulae.(Melles et al., 2018, Savini et al., 2020)

The ESCRS online IOL calculatorcludes most of the new-generation formulae listed above, with the exception of the Olsen formula. This calculator can be found at: https://iolcalculator.escrs.org/

Numerous studies have compared different IOL formulae, but it is important to note that most of these studies evaluate the formulae for specific IOL types. Therefore, when examining the aforementioned formulae, it is crucial to consider the IOL types included and compare them with those used in the hospital or clinic. Furthermore, it is important to take into account the optical biometry device used in different studies, as the accuracy of the measurements can vary depending on the device used. By considering these factors, practitioners can make informed decisions about which IOL formula to offer to their patients. (Expert opinion)

**Conclusion**

Implications for practice

Regarding the current evidence, many new-generation formulae are applicable for performing IOL calculations in patients undergoing cataract surgery. Differences between the new-generation formulae are small and formulae can be chosen based on the surgeons' preferences. Third generation formulae including SRK/T, Hoffer Q, Holiday 1 and 2, Barrett and Haigis can still be used, but newer formulae are preferred due to the reduction of the trend error. Older formulae including SRK-II, SRK, Binkhorst and Hoffer should not be used. Caution needs to be used if it is necessary to transpose biometric data into an online IOL power calculator since errors may occur.

Knowledge gaps

Available research is often of low quality, with low case numbers and heterogeneous study samples: e.g., mixing IOL models, various biometric devices, non-optimized IOL constants, mixed refraction lanes and undefined refraction techniques. Additional studies including uniform study methodology should be conducted.

**Identified research evidence**

**Findings from Systematic Reviews**

No relevant systematic reviews were identified.

### 6.1.1 References

*ESCRS IOL Calculator* [Online]. Available: https://iolcalculator.escrs.org/ [Accessed 04-05-2023].
Eom, Y., Kang, S. Y., Song, J. S., et al. 2014. Comparison of Hoffer Q and Haigis formulae for intraocular lens power calculation according to the anterior chamber depth in short eyes. *Am J Ophthalmol,* 157**,** 818-824 e2.
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Rong, X., He, W., Zhu, Q., et al. 2019. Intraocular lens power calculation in eyes with extreme myopia: comparison of Barrett Universal II, Haigis, and Olsen formulas. *J Cataract Refract Surg,* 45**,** 732-737.
Savini, G., Taroni, L. & Hoffer, K. J. 2020. Recent developments in intraocular lens power calculation methods - update 2020. *Ann Transl Med,* 8**,** 1553.
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Wendelstein, J., Hoffmann, P., Hirnschall, N., et al. 2022b. Project hyperopic power prediction: accuracy of 13 different concepts for intraocular lens calculation in short eyes. *British Journal of Ophthalmology,* 106**,** 795-801.

## 6.2 IOL formulae and calculations for special indications

### Output question

Which formula(e) for calculating lens power in specific conditions should be considered?

Conditions to be considered

- Long eyes (AL >26 mm)
- Short eyes (AL <22 mm)
- Flat/ steep corneas
- Unusual anterior chamber depths (ACD)
- Keratoconus

**P:** Adult patients who will undergo cataract surgery
**I:** Formula A
**C:** Formula B
**O:** Visual acuity, visual function, quality of life, postoperative refractive outcome

### Recommendation

Specific IOL formulae are recommended for eyes with certain conditions to ensure accurate outcomes. In extreme long and short eyes new-generation formulae are recommended. (GRADE +)

In eyes with keratoconus all formulae tend to result in a hyperopic surprise. It is recommended to avoid traditional formulae other than SRK/T and to use keratoconus-specific formulae for more accurate outcomes. It is suggested that the Barrett True-K and Kane formulae for keratoconus have more accurate results, especially in more advanced stages of keratoconus. (GRADE +)

In patients with steep corneas (>46D) or very flat corneas (<38D), the Barrett Universal II (TK) and EVO (TK) formulae may be considered. (GRADE +)

The Haigis formula should be considered for patients with an ACD >3.5mm, while the Hoffer Q formula is suggested for a shallow anterior chamber (ACD <2.5mm). (GRADE +)

MICS (micro-incision cataract surgery) followed by the implantation of toric IOLs can be considered a safe and effective procedure for keratoconus patients regarding keratometric stability, visual and refractive results. (GRADE +)

## Considerations

When planning cataract surgery, one of the most crucial steps is to choose the right IOL power for the correct patient. IOL selection depends on the anatomical parameters of the eye. The three main sources of error in IOL power calculation are the axial length, keratometry and the predicted IOL position. AL and keratometry measurements have increased in accuracy due to enhancements in biometry, but predicted IOL position largely depends on the IOL formula used.(Fayette and Cakiner-Egilmez, 2015)

The mean axial length of the eye is 22-25 mm, with a mean refractive power of -25.0±1.0D and a mean anterior chamber depth in an adult emmetropic eye of 3-4 mm. An AL below 22 mm is considered a short eye, while an eye with an AL 26 mm or longer is considered a long eye. It must be noted that the AL assessments by most devices show the AL measurements adjusted to the ultrasonography biometry.(Bhardwaj and Rajeshbhai, 2013)

Considering third generation formulae, different formulae are reported to be more precise in patients with longer or shorter eyes. The most frequently used formulae tend to provide reliable results for long eyes, while they may not be as effective for short eyes. However, some IOL formulae can be considered in both type of eyes, such as the Holladay I and SRKT/T formulae. These formulae can be considered in short and normal eyes and are also appropriate in long eyes after a correction with the Wang-Koch (W-K) AL adjustment. Newer generation formulae such as the Olsen, EVO, Kane, Hill-RBF, and Barrett II are considered to be accurate in all eyes. (Wang et al., 2011)

In short eyes with a shallow anterior chamber depth (ACD) of <2.5mm, some formulae might underestimate effective lens position (ELP). The Hoffer Q formula may be preffered over other formulae in these cases. In long eyes with an AL >24.5mm and an increased ACD >3.5mm the Haigis formula has shown more precise results.(Yang et al., 2017)

Adjusting IOL formulae for patients with extreme keratometry readings is warranted. In patients with steep corneas (>46D) or flat corneas (<38D), studies have shown that BU-II (TK) and EVO (TK) formulae resulted in the least trend error.(Qin et al., 2023) For steep corneas, SRK/T and Hill RBF formulae tended towards a myopic error, while Olsen C constant and Haigis led to hyperopic errors. In comparison, for very flat corneas, myopic errors have been reported using Haigis, Hill-RBF, Hoffer-Q and Olsen C formulae, while the SRK/T formula led to a hyperopic error. (Reitblat et al., 2017)

IOL power calculation in keratoconus eyes is difficult as determining the most appropriate keratometric reading remains a challenge. Total corneal refractive power

measurement in keratoconus eyes may differ from standard keratometry as these assume that the ratio of the anterior and posterior curvatures of the cornea are constant.(Kamiya et al., 2018) Corneal tomography may improve keratometric readings in patients with keratoconus.(K. M. Wang et al., 2020)

In eyes with keratoconus most standard formulae tend to result in a postoperative refractive error. SRK/T has been shown to have a slightly decreased tendency towards hyperopia compared to other third and new generation IOL formulae.(Garzón et al., 2020) Results show worse postoperative refractive error in severe keratoconus cases.(Savini et al., 2019) It is recommended to avoid third-generation formulae other than SRK/T for keratoconus eyes.(Heath et al., 2023) Some formulae provide a special variation for keratoconus patients using total keratometry by taking the predicted posterior corneal power into account. The mean absolute errors (MAE) of different newer IOL formulae vary only slightly. Studies showed that the Barrett-True K formula has demonstrated greater accuracy compared to both the Barrett Universal II and Kane's new-generation IOL formulae and have a slight advantage over the SRK/T formula (Barrett-True K predicted), while exhibiting comparable accuracy to the Kane keratoconus formula. (Ton et al., 2021, Vandevenne et al., 2023) These findings suggest that the Barrett True-K and Kane keratoconus formulae may be a reliable option for surgeons seeking to optimize the outcomes of IOL implantation in keratoconic eyes.(Ton et al., 2021, Vandevenne et al., 2023) Furthermore, the study results indicate that the severity of keratoconic disease has an impact on the accuracy of IOL prediction, as reflected in the metrics of MAE, MPE (mean prediction error), and median absolute prediction error. Various classification systems are used to assess keratoconus severity, considering corneal morphology, disease progression, optical and visual function, and corneal shape descriptors (index-based systems). Commonly, the Amsler-Krumeich classification evaluates morphology and disease, while the Alio-Shabayek classification or Belin ABCD grading system assess optical and visual function. Index-based instruments are also employed to differentiate between healthy and keratoconic (suspect) corneas using specific cut-off values. (Santodomingo-Rubido et al., 2022) Specifically, the accuracy of IOL prediction tends to decrease as the disease progresses to more advanced stages. For moderate keratoconus eyes the accuracy of the new-generation formulae such as the EVO 2.0 formula using TK has been improved. In more advanced cases, formulae tended to exhibit more myopic MPE. It is recommended to use the keratoconus specific formulae including the Barret True K and Kane Keratoconus formulae in more advanced stages of keratoconus. Alternative formulae may be needed for patients with advanced keratoconus.(Heath et al., 2023, Vandevenne et al., 2023)

In patients with keratoconus, MICS (micro-incision cataract surgery) followed by implantation of toric IOLs, using corneal topography data and standard formulas for the calculation of the IOL power is a safe and effective procedure considering

keratometric stability, visual and refractive results. Efficacy and safety indexes were 1.38 ±0.58 and 1.17±0.66, respectively. (Alió et al., 2014)

Toric IOL may be considered for the regular component of the corneal astigmatism as long as the keratoconus is known to be stable. Consideration should be given to patients who are planning to wear rigid gas permeable contact lenses postoperatively concerning the potential use of toric IOL, as those would be contraindicated in this situation. (Expert opinion)

## Conclusion

Implications for practice

New-generation formulae show more accurate results across a wider range of biometry parameters considering reaching the predicted refraction than traditional formulae. No consistent difference was found in pairwise comparisons between new generation formulae. Standard IOL formulae show a tendency towards a hyperopic postoperative refractive error in keratoconus patients, therefore it is recommended to use keratoconus specific IOL formulae.

Knowledge gaps

Further large-scale studies are warranted to ascertain the superior performance of distinct new generation formulae, enabling clinicians to make informed decisions for patients with short or long eyes, or those afflicted with keratoconus. These studies would provide valuable clinical guidance, and ultimately enhance the accuracy and efficacy of IOL power calculation in these patient groups.

## Identified research evidence

### Findings from Systematic Reviews

Three systematic reviews were identified.

Four systematic reviews were identified.

The overall mean absolute errors (MAE) of Barrett Universal II, Haigis, Holladay 2, SRK/T, Hoffer Q and Holladay 1 were 0.314D (82.1%), 0.346D (76.1%), 0.351D (69.1%), 0.389D (71.3%), 0.409D (63.3%) and 0.409D (62.0%), respectively. No significant difference was observed between the Barrett Universal II and Haigis in MAE (weighted mean difference [WMD] = -0.04D, 95% confidence interval [CI] -0.08D to 0.01D; 3 studies). Meta-analysis of the included studies reported a significantly smaller MAE with Barrett Universal II when compared to Holladay 2 (WMD = -0.04D, 95% CI −0.07D to −0.02D; 4 studies), SRK/T (WMD = -0.05D, 95%

CI −0.07D to −0.03D; 5 studies), Hoffer Q (WMD = -0.07D, 95% CI −0.10D to −0.05D; 4 studies) and Holladay 1 (WMD = -0.07D, 95% CI −0.09D to −0.05D; 4 studies). Summary estimates from included studies reported a lower percentage of eyes within ±0.50D of prediction error with Haigis when compared to the Barrett Universal II (odds ratio [OR] = 0.78, 95% CI 0.65 to 0.93; 2 studies) and the higher percentage of eyes within ±0.50D of prediction error with Haigis when compared to SRK/T (OR = 1.36, 95% CI 0.98 to 1.90; 5 studies), Holladay 2 (OR = 1.43, 95% CI 1.05 to 1.94; 5 studies), Hoffer Q (OR = 1.84, 95% CI 1.12 to 3.03; 6 studies) and Holladay 1 (OR = 1.97, 95% CI 0.99 to 3.93; 4 studies).(Wang et al., 2018b) The review was judged to be at a high risk of bias.

The MAE and standard error of all the formulae included in the analysis showed the lowest value for Barrett Universal II. It performed equally well as Haigis, Hoffer Q, and SRK/T with WMD and 95% CI of −0.00 (−0.04, 0.03) for the three pairs. The WMD and 95% CI of Barrett Universal II with Hill-RBF, Holladay 1, and Holladay 2 were 0.02 (−0.01, 0.06); 0.02 (−0.01, 0.06), and 0.03 (−0.01, 0.06), respectively. Although the MAE of Barrett Universal II was found to be the lowest, there was no statistically significant difference in any of the comparisons. Concerning the percentage of eyes with PE within ±0.50 D of target refraction of all the formulae included in the analysis, Holladay 1 had the highest percentage of eyes. In the meta-analyses, the OR and 95% CI of Holladay 1 as compared with Barrett Universal II, Haigis, Hill-RBF, Hoffer Q, Holladay 2, and SRK/T formulae were 0.91 (0.68,1.21), 0.95 (0.73, 1.25), 0.94 (0.63, 1.40), 0.85 (0.72, 1.02), 1.10 (0.77, 1.57), 1.19 (0.99, 1.43), respectively. None of the comparisons showed statistically significant results. (Shrivastava et al., 2022) The review was judged to be at a high risk of bias.

The overall mean absolute errors (MAE) for each formula are Holladay 2: 0.496D, 512 with Haigis: 0.498D, 1161 with Hoffer Q: 0.510D, 986 with Holladay 1: 0.513D, 1071 with SRK/T: 0.555D and 84 with SRK II: 1.146D. The comparison between Haigis and the other formulas reported smaller MAE to the eyes than Hoffer Q (mean difference [MD] -0.07D, 95% confidence interval [CI] -0.12D to -0.02D), SRK/T and (MD -0.07D, 95% CI, -0.13D to -0.02D), SRK II (MD -0.41D, 95% CI, -0.73D to -0.09D). A significant mean difference was observed in Holladay 2 and SRK II (MD -1.20, 95% CI, -1.74 to 0.66).(Wang et al., 2018a) The review was judged to be at a unclear risk of bias.

Of the 13 formulae, Pearl-DGS had the highest percentage within ± 0.25D. In the ± 0.5D range, and it was significantly higher than Barrett Universal II (P = 0.001), Haigis (P = 0.02), Hoffer Q (P = 0.0003), Holladay1 (P = 0.01), Holladay2 (P = 0.007) and Olsen (P = 0.05). In the ± 1.0D range, Okulix possessed the highest percentage, and it was significantly higher than Barrett Universal II (P = 0.0005), Castrop (P = 0.03), Hoffer Q (P = 0.003) and Holladay2 (P = 0.02).(Luo et al., 2022) The review was judged to be at a unclear risk of bias.

# GRADE Tables

## Barrett Universal compared to Haigis for evaluating the accuracy of intraocular lens power calculation formulae in short eyes

**Bibliography:** Shrivastava AK, Nayak S, Mahobia A, Anto M, Pandey P. Accuracy of intraocular lens power calculation formulae in short eyes: A systematic review and meta-analysis. Indian J Ophthalmol. 2022 Mar;70(3):740-748.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With Haigis | With Barrett Universal | | Risk with Haigis | Risk difference with Barrett Universal |
| **mean absolute error** | | | | | | | | | | | |
| 2198 (5 observational studies) | very serious[a] | not serious | not serious | not serious[b] | none | ⊕◯◯◯ Very low | 1099 | 1099 | - | The mean mean absolute error was **0.48** | MD **0** (0.04 lower to 0.03 higher) |
| **percentage of eyes within ±0.50 D** | | | | | | | | | | | |
| 666 (4 observational studies) | very serious[a] | not serious | not serious | extremely serious[b] | none | ⊕◯◯◯ Very low | 211/333 (63.4%) | -/333 | **OR 1.05** (0.77 to 1.44) | 634 per 1.000 | **11 more per 1.000** (from 63 fewer to 80 more) |

**CI:** confidence interval; **MD:** mean difference; **OR:** odds ratio

**Explanations**

a. Four out of five studies had a high risk of bias for reference standard

b. Small sample size,

## Barrett Universal compared to Haigis for evaluating the accuracy of intraocular lens power calculation formulae in long eyes

**Bibliography:** Wang Q, Jiang W, Lin T, Zhu Y, Chen C, Lin H, Chen W. Accuracy of intraocular lens power calculation formulae in long eyes: a systematic review and meta-analysis. Clin Exp Ophthalmol. 2018 Sep;46(7):738-749.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With Haigis | With Barrett Universal | | Risk with Haigis | Risk difference with Barrett Universal |
| **mean absolute error** | | | | | | | | | | | |
| 4104 (3 observational studies) | not serious | serious[a] | not serious | not serious | none | ⊕◯◯◯ Very low | 2052 | 2052 | - | The mean mean absolute error was **0.31** | MD **0.04 lower** (0.08 lower to 0.01 higher) |
| **percentage of eyes within ±0.50** | | | | | | | | | | | |
| 3206 (2 observational studies) | not serious | serious[b] | not serious | not serious | none | ⊕◯◯◯ Very low | 1252/1603 (78.1%) | -/1603 | **OR 0.78** (0.65 to 0.93) | 781 per 1.000 | **45 fewer per 1.000** (from 82 fewer to 13 fewer) |

**CI:** confidence interval; **MD:** mean difference; **OR:** odds ratio

**Explanations**

a. Significant statistical heterogeneity detected.

b. Moderate statistical heterogeneity detected.

## Haigis compared to Holladay 2 for intraocular lens power calculation formulas in short eyes

**Bibliography:** Wang Q, Jiang W, Lin T, Wu X, Lin H, Chen W. Meta-analysis of accuracy of intraocular lens power calculation formulas in short eyes. Clin Exp Ophthalmol. 2018 May;46(4):356-363

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With Holladay 2 | With Haigis | | Risk with Holladay 2 | Risk difference with Haigis |
| **Mean absolute errors** | | | | | | | | | | | |
| 436 (4 observational studies) | very serious[a] | not serious | not serious | serious[b] | none | ⨁◯◯◯ Very low | 218 | 218 | - | The mean mean absolute errors was **0** | MD **0.01 lower** (0.08 lower to 0.06 higher) |

**CI:** confidence interval; **MD:** mean difference

**Explanations**
a. Results from observational studies
b. Small sample size.

## Hill RBF compared to Barrett Universal for evaluating the accuracy of intraocular lens power calculation formulae in short eyes

**Bibliography:** Shrivastava AK, Nayak S, Mahobia A, Anto M, Pandey P. Accuracy of intraocular lens power calculation formulae in short eyes: A systematic review and meta-analysis. Indian J Ophthalmol. 2022 Mar;70(3):740-748.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With Barrett Universal | With Hill RBF | | Risk with Barrett Universal | Risk difference with Hill RBF |
| **mean absolute error** | | | | | | | | | | | |
| 2210 (5 observational studies) | very serious[a] | not serious | not serious | not serious | none | ⨁◯◯◯ Very low | 1105 | 1105 | - | The mean mean absolute error was **0.49** | MD **0.02 higher** (0.01 lower to 0.06 higher) |
| **percentage of eyes within ±0.50 D** | | | | | | | | | | | |
| 678 (4 observational studies) | very serious[a] | not serious | not serious | serious[b] | none | ⨁◯◯◯ Very low | 227/339 (67.0%) | -/339 | **OR 0.92** (0.67 to 1.27) | 670 per 1.000 | **19 fewer per 1.000** (from 94 fewer to 51 more) |

**CI:** confidence interval; **MD:** mean difference; **OR:** odds ratio

**Explanations**
a. Most studies had a high risk of bias for reference standard
b. Small sample size

## Holladay 1 compared to Barrett Universal for evaluating the accuracy of intraocular lens power calculation formulae in short eyes

**Bibliography:** Shrivastava AK, Nayak S, Mahobia A, Anto M, Pandey P. Accuracy of intraocular lens power calculation formulae in short eyes: A systematic review and meta-analysis. Indian J Ophthalmol. 2022 Mar;70(3):740-748.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With Barrett Universal | With Holladay 1 | | Risk with Barrett Universal | Risk difference with Holladay 1 |
| **mean absolute error** | | | | | | | | | | | |

## Holladay 1 compared to Barrett Universal for evaluating the accuracy of intraocular lens power calculation formulae in short eyes

**Bibliography:** Shrivastava AK, Nayak S, Mahobia A, Anto M, Pandey P. Accuracy of intraocular lens power calculation formulae in short eyes: A systematic review and meta-analysis. Indian J Ophthalmol. 2022 Mar;70(3):740-748.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2372 (5 observational studies) | very serious[a] | not serious | not serious | not serious | none | ⊕◯◯◯ Very low | 1186 | 1186 | - | The mean mean absolute error was **0.49** | MD **0.02 higher** (0.01 lower to 0.06 higher) |
| **percentage of eyes within ±0.50 D** | | | | | | | | | | | |
| 840 (4 observational studies) | very serious[a] | not serious | not serious | not serious | none | ⊕◯◯◯ Very low | 275/420 (65.5%) | -/420 | **OR 0.91** (0.68 to 1.21) | 655 per 1.000 | **22 fewer per 1.000** (from 92 fewer to 42 more) |

**CI:** confidence interval; **MD:** mean difference; **OR:** odds ratio

**Explanations**
a. Most studies had a high risk of bias for reference standard

## Pearl DGS compared to Barrett Universal II for evaluating the accuracy of intraocular lens power calculation formulae in short eyes

**Bibliography:** Luo Y, Li H, Gao L, Du J, Chen W, Gao Y, Ye Z, Li Z. Comparing the accuracy of new intraocular lens power calculation formulae in short eyes after cataract surgery: a systematic review and meta-analysis. Int Ophthalmol. 2022 Jun;42(6):1939-1956.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With Barrett Universal II | With Pearl DGS | | Risk with Barrett Universal II | Risk difference with Pearl DGS |
| **percentage of eyes within ±0.50 D** | | | | | | | | | | | |
| 300 (1 observational study) | serious[a] | not serious | not serious | very serious[b] | none | ⊕◯◯◯ Very low | 94/150 (62.7%) | -/150 | **OR 0.42** (0.25 to 0.71) | 627 per 1.000 | **213 fewer per 1.000** (from 331 fewer to 83 fewer) |

**CI:** confidence interval; **OR:** odds ratio

**Explanations**
a. The study had a high risk of bias for reference standard
b. Very small sample size

## 6.2.1 References


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## 6.3 IOL formulae and calculations after refractive surgery (mostly including laser vision correction (LVC))

### Output question

Which formula(e) for calculating the intraocular lens in patients who have undergone refractive surgery is/are preferred?

**P:** Adult patients who have previously undergone refractive surgery, and now will undergo cataract surgery
**I:** Formula A
**C:** Formula B
**O:** Visual acuity, visual function, quality of life, postoperative refractive outcome

### Recommendation

When performing IOL calculations in patients who have undergone refractive surgery, designated formulas/methods should be used such as the American Society of Cataract and Refractive Surgery (ASCRS) post-refractive calculator. (GRADE +)

### Considerations

Calculating the IOL power for patients who have undergone refractive surgeries such as Laser-Assisted In Situ Keratomileusis (LASIK) or Photorefractive Keratectomy (PRK) presents a considerable challenge due to the complex nature of the problem. Studies showed extremely wide ranges of prediction accuracies within ±0.50D for such patients, with values ranging from 0 to 85% for post-myopic LASIK/PRK and 38.1% to 71.9% for post-hyperopic LASIK/PRK cases. Several factors contribute to prediction errors, including instruments, formulae, and refractive index errors. Post-laser refractive surgery eyes can be identified in the presurgical examination process with the use of tomographic or topographic devices. (Wang and Koch, 2022) (Wang and Koch, 2021)

An important issue that must be considered is the flattened (myopic LVC) or steepened (hyperopic LVC) central cornea after keratorefractive surgery, leading to a low or high central corneal power. Formulae that use corneal curvature as part of the effective lens position (ELP) algorithm, will assume that the IOL following cataract surgery will be ending up sitting closer to (myopic LVC) or further from (hyperopic LVC) the cornea than normal and will therefore suggest less or more lens power. Unless a correction is made, an underestimation (myopic LVC) or overestimation (hyperopic LVC) of the effective lens position will occur, which leads to a sub-optimal postoperative refractive outcome following keratorefractive surgery. Conventional formulae that do not take the altered cornea into account, should therefore not be

used. Also most standard formulas solemnly use the anterior corneal-based keratometry measurements, not assessing the total corneal power..(Wang and Koch, 2022) (Wang and Koch, 2021)

Various formulae have been proposed to enhance IOL calculation accuracy after refractive surgery, employing different approaches. Some rely solely on historical data to estimate the corneal power, while others combine historical data with current measurements, and still others exclusively use current data. Studies reported that when automated keratometry was used with theoretical formulae designed for eyes without previous laser vision correction, mean prediction error after myopic LVC often turned out hyperopic and a low percentage of eyes (8-40%) resulted within 0.5D of target spherical equivalent. Formulae based on both pre-refractive surgery keratometry and manifest refraction, as well as formulae using no historical data resulted in 26-44% and 30%-68% of the eyes within 0.5D of target spherical equivalent respectively. Therefore, methods requiring historical data are no longer the gold standard for post-refractive IOL calculation. Conclusions are limited by the small sample sizes of current studies.(Pantanelli et al., 2021) Another approach is to use ray tracing for IOL calculation to further improve the accuracy of IOL calculation in patients who previously underwent refractive surgery. (Expert opinion)

The ASCRS calculator includes various input values that can be used to choose an appropriate formula. It calculates the minimum, maximum and average IOL power. Study results will inevitably differ by how much additive information and/or history data is available and which IOLs will be proposed. The ASCRS calculator simplifies the process by providing results from multiple IOL formulae, offering a comprehensive summary of outcomes, including average and extreme values. The ASCRS calculator can be found at: https://iolcalc.ascrs.org/wbfrmCalculator.aspx.(Abulafia et al., 2017)

In summary, refractive outcomes of cataract surgery in patients who previously received laser refractive surgery are less accurate than in eyes with no prior history. Patients should be advised that refractive accuracy might be limited. (Pantanelli et al., 2021), (Abulafia et al., 2017, Wang and Koch, 2021) Therefore, in this population, clinicians must be cautious when considering the use of presbyopia-correcting IOLs.

## Conclusion

Implications for practice

Regarding the current evidence, several new generation formulae can be used to improve IOL calculations in patients with a prior history of LVC. There is insufficient evidence to recommend one formula over the others. In practice, it is crucial to identify post-LVC patients and inform these patients about the higher risk for

postoperative refractive errors when performing the IOL calculation. Patients should be aware of this, and align their expectations with the anticipated outcome.

Knowledge gaps

Available research is often of low quality, including low case numbers and inhomogeneous study samples, mixed refraction lanes and in multifocal IOLs undefined refraction techniques. This condition makes systematic reviews troublesome. Additional research on this topic is warranted.

**Identified research evidence**

**Findings from Systematic Reviews**

No relevant systematic reviews were identified.

### 6.3.1 References


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## 6.4 Target refraction

### Output question

Which target refraction is preferred in patients who will undergo cataract surgery?

**P:** Adult patients who will undergo cataract surgery
**I:** Target refraction A
**C:** Target refraction B
**O:** Visual acuity, visual function, quality of life, postoperative refractive outcome

Included target options:

- Emmetropia
- Full monovision
- Mini-monovision
- Myopic target

### Recommendation

The selection of a specific target refraction highly depends on the selected IOL, expectations and preferences of the patient. The patient and ophthalmologist should take the shared decision for IOL target selection. (GRADE ++)

### Considerations

Discussing the target refraction with patients planned for cataract surgery is essential. Several IOL target options are available nowadays. Proper patient selection is essential in determining the best target refraction for the most successful outcomes according to the patient's expectations.

Full monovision appears to be an effective method for presbyopia correction after cataract surgery, with a high degree of spectacle independence and low dysphotopsia side effects. However, in patients who desire a high chance of spectacle independence, multifocal IOLs show better results than standard monofocal IOLs in uncorrected near and intermediate vision.(Yoon et al., 2018) When considering EDF IOL implantation, it is advised to discuss and aim for a mini-monovision target in order to increase spectacle independence. For the definitions of different IOL targets, see chapter 2.2.

### Conclusion

Implications for practice

The selection of a specific target refraction highly depends on the selected IOL, expectations and preferences of the patient. Shared decision-making is essential.

Knowledge gaps

Evidence, including comparison studies, on IOL target refraction, is limited. Additional research is necessary to investigate further how to determine the optimal target refraction in a cataract patient.

## Identified research evidence

### Findings from Systematic Reviews

Two relevant systematic reviews were identified.

In most comparative studies pseudophakic monovision technique was compared with the implantation of multifocal intraocular lenses (IOLs) (9 studies). Studies demonstrated that monovision could provide very good (1 study) to excellent (3 studies) distance visual outcomes. Three studies indicated no statistically significant difference in UNVA between monovision, multifocal, or accommodating groups. Two studies on pseudophakic monovision indicated that contrast sensitivity was decreased at high frequencies but remained in the normal range. One study indicated that patients in the monovision group had significantly better contrast sensitivity than multifocal patients. One study reported that all patients achieved good distance and intermediate visual acuities (logMAR 0 and 0.10, respectively), while a remarkable reduction of near vision was also described (63.33% had logMAR 0.30). A study reported patients who underwent successful monovision presented the reversal threshold only at low decreasing contrast. Excellent visual outcomes and high satisfaction for patients were also reported in three more studies. Regarding spectacle independence, pseudophakic monovision could reduce spectacle use postoperatively (eight studies). However, some studies showed significant superiority of the multifocal technique (3 studies). The effect of pseudophakic monovision in daily activities was examined in four studies. Accordingly, less difficulty during computer work without glasses (2 studies), better reading ability than multifocal patients (1 study) and improved driving (1 study) were reported. One study reported that more patients in the multifocal group had dysphotopsia symptoms than in monovision ($P<0.01$ and $P=0.024$). (Labiris et al., 2017) The review was judged to be at a high risk of bias.

A study compared monovision versus multifocality for presbyopia and reported inferiority of pseudophakic monovision as compared to Isert (relative risk (RR) 0.49, 95% confidence interval (CI) 0.28 to 0.80) and Tecnis diffractive multifocal IOL (RR

0.36, 95% CI 0.25 to 0.52) in cataract patients. One study reported that outcomes of LASIK were comparable to refractive lens exchange using Tecnis (RR 0.93, 0.78 to 1.10) in terms of spectacle independence. In the network analysis (6 trials, 14 arms), pseudophakic monovision was found inferior to Tecnis diffractive multifocal IOL. Indirect comparisons also suggest the inferiority of pseudophakic monovision in cataract patients (ReZoom refractive, TwinSet diffractive) or tend to be inferior (Array refractive) to other multifocal IOLs. However, monovision by LASIK appears as successful in refractive surgery in younger patients as Tecnis multifocal IOL based on one direct comparison and the network analysis. The indirect comparison also suggests no difference in ReZoom and Arrays MFIOLs compared with TwinSet multifocal IOL. One trial reported less glare/dazzle with pseudophakic monovision compared with Tecnis in cataract patients.(Kelava et al., 2017) The review was judged to be at a high risk of bias.

## GRADE tables

### Monovision (SN60WF IOL) compared to multifocal IOL for cataract surgery

**Bibliography:** 1. Labiris G, Giarmoukakis A, Patsiamanidi M, Papadopoulos Z, Kozobolis VP. Mini-monovision versus multifocal intraocular lens implantation. J Cataract Refract Surg. 2015;41:53–7. 2. Kelava L, Baric H, Busic M, Cima I, Trkulja V. Monovision versus multifocality for presbyopia: systematic review and meta-analysis of randomized controlled trials. Adv Ther. 2017;34(8):1815-39.

| Certainty assessment | | | | | | | № of patients | | Effect | | Certainty | Importance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| № of studies | Study design | Risk of bias | Inconsistency | Indirectness | Imprecision | Other considerations | Monovision (SN60WF IOL) | multifocal IOL | Relative (95% CI) | Absolute (95% CI) | | |
| **Complete post-procedural spectacle independence** | | | | | | | | | | | | |
| 1 | randomised trials | serious[a] | not serious | not serious | very serious[b] | none | -/38 | 24/37 (64.9%) | **RR 0.49** (0.28 to 0.80) | **33 fewer per 100** (from 47 fewer to 13 fewer) | ⊕◯◯◯ Very low | CRITICAL |
| **UDVA** | | | | | | | | | | | | |
| 1 | randomised trials | serious[a] | not serious | not serious | very serious[b] | none | 38 | 37 | - | MD **0.03 higher** (0.19 lower to 0.25 higher) | ⊕◯◯◯ Very low | CRITICAL |
| **UNVA** | | | | | | | | | | | | |
| 1 | randomised trials | serious[a] | not serious | not serious | very serious[b] | none | | | - | MD **0.74 higher** (1.15 lower to 2.63 higher) | ⊕◯◯◯ Very low | CRITICAL |

**CI:** confidence interval; **MD:** mean difference; **RR:** risk ratio

**Explanations**
a. Unclear risk of bias of the included study (Labiris 2015)
b. Small sample size, results from a single study

## Monovision (Akreos) compared to multifocal IOL (Tecnis) for cataract surgery

**Bibliography:** 1.Kelava L, Baric H,Busic M,Cima I,Trkulja V.. Monovision versus multifocality for presbyopia: systematic review and meta-analysis of randomized controlled trials.. Adv Ther.; 2017.
2.Wilkins MR, Allan,BD,Rubin,GS,et,al.. Randomized trial of multifocal intraocular lenses versus monovision after bilateral cataract surgery.. Ophthalmology.; 2013.

| Certainty assessment | | | | | | | № of patients | | Effect | | Certainty | Importance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| № of studies | Study design | Risk of bias | Inconsistency | Indirectness | Imprecision | Other considerations | Monovision (Akreos) | multifocal IOL (Tecnis) | Relative (95% CI) | Absolute (95% CI) | | |
| **Complete post-procedural spectacle independence** | | | | | | | | | | | | |
| 1 | randomised trials | serious[a] | not serious | not serious | serious[b] | none | -/105 | 24/105 (22.9%) | **RR 0.36** (0.25 to 0.52) | **146 fewer per 1,000** (from 171 fewer to 110 fewer) | ⊕⊕◯◯ Low | CRITICAL |
| **UDVA Distance uncorrected visual acuity** | | | | | | | | | | | | |
| 1 | randomised trials | serious[a] | not serious | not serious | serious[b] | none | 92 | 94 | - | MD **0.02 lower** (0.41 lower to 0.37 higher) | ⊕⊕◯◯ Low | CRITICAL |
| **UIVA Intermediate uncorrected visual acuity** | | | | | | | | | | | | |
| 1 | randomised trials | serious[a] | not serious | not serious | serious[b] | none | 91 | 90 | - | MD **0.07 lower** (0.4 lower to 0.26 higher) | ⊕⊕◯◯ Low | CRITICAL |
| **UNVA Near uncorrected visual acuity** | | | | | | | | | | | | |
| 1 | randomised trials | serious[a] | not serious | not serious | serious[b] | none | 92 | 94 | - | MD **0.04 higher** (0.31 lower to 0.39 higher) | ⊕⊕◯◯ Low | CRITICAL |

**CI:** confidence interval; **MD:** mean difference; **RR:** risk ratio

**Explanations**
a. High risk of bias of the included study (Wilkins 2013)
b. Small sample size, results from a single study

### 6.4.1 References


Kelava, L., Baric, H., Busic, M., et al. 2017. Monovision versus multifocality for presbyopia: systematic review and meta-analysis of randomized controlled trials. *Advances in Therapeutics,* 34**,** 1815-39.

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# 7. Perioperative procedure

## 7.1 Cataract Surgery Techniques

**Output question**

What are the differences between femtosecond assisted laser cataract surgery (FLACS) and conventional phacoemulsification cataract surgery?

**P:** Adult patients who will undergo cataract surgery
**I:** Femtosecond laser cataract surgery
**C:** Conventional cataract surgery (CCS)
**O:** Visual acuity, visual function, (serious) adverse events, postoperative refractive outcomes.

**Recommendation**

Both conventional cataract surgery (CCS) and femtosecond laser assisted cataract surgery (FLACS) can be used as:

- They are both safe and effective procedures. (GRADE +/++)
- Visual acuity and refractive outcomes are comparable. (GRADE +/++)
- Overall intraoperative and postoperative complication rates are low and appear similar for both conventional phacoemulsification and femtosecond laser assisted cataract surgery (GRADE +/++)

FLACS may be considered in patients with dense cataract or low endothelial cell count as it is a more effective method for reducing endothelial cell loss and postoperative central corneal thickening. Nonetheless, at 6 months postoperatively no significant differences were found between conventional cataract surgery and FLACS regarding endothelial cell loss. (GRADE +/++)

**Considerations**

Conventional ultrasound phacoemulsification has been the predominant surgical technique for decades. Femtosecond laser cataract surgery (FLACS) was developed with the aim of achieving more accurate results. FLACS can accurately and reproducibly perform various steps in cataract surgery including corneal incisions, anterior capsulotomy and lens fragmentation. In comparsion with precision pulse capsulotomy (PPC) and manual continuous curvilinear capsulorrhexis (CCC), FLACS is generally considered to be more precise and reproducible. Despite this, current clinical evidence has not demonstrated significant differences in terms of

visual or refractive outcomes between FLACS and manual capsulorrhexis techniques.(Reddy et al., 2021)

Overall, the literature suggests that FLACS and conventional cataract surgery (CCS) have comparable safety profiles.(Xu et al., 2022) However, some discrepancies have been reported when comparing FLACS to CCS. In terms of complication rates, both techniques have low rates. No differences were reported in terms of anterior capsule tears between the two techniques, but there was a lower posterior capsule rupture rate in FLACS. (Narayan et al., 2023) (very low certainty evidence) Incomplete capsulotomy and anterior capsulotomy tags are complictions unique to FLACS.(Kolb et al., 2020)
The evidence regarding both postoperative cystoid macular edema and elevated intraocular pressures is inconclusive, with low certainty evidence.(Day et al., 2016, Kolb et al., 2020) On the other hand, research suggests that FLACS is safer and more effective in reducing endothelial cell loss and postoperative central corneal thickening at 1 week, 1 month, and 3 months after surgery, making it a good option for patients with dense cataracts or reduced endothelial cells prior to cataract surgery.(Chen et al., 2016, Kolb et al., 2020) However, at 6 months postoperatively, no significant differences were found in endothelial cell loss.(Kolb et al., 2020) In addition, there were no significant differences in postoperative surgically induced astigmatism (SIA) or CDVA between FLACS and CCS.(Chen et al., 2016)

Only limited evidence was found in difference in postoperative visual acuity between FLACS and CCS. A small advantage of CDVA at six months could be found, however with a clinically insignificant mean difference of -0.03 LogMAR. (Day et al., 2016) Patient-reported outcomes (PROMSs) were not statistically different between FLACS and CCS at one month postoperatively.(Stanojcic et al., 2021)

In FLACS, total and effective phacoemulsification times were shorter, cumulative dissipated energy was less, and capsulotomy circularity was more accurate. No difference between FLACS and CCS in terms of diameter of the capsulotomy was reported. (Kolb et al., 2020, J. Wang et al., 2019)

## Conclusion

Implications for practice
Both FLACS and CCS are safe and effective. FLACS required less ultrasound energy and power and led to a more precise treatment and a higher quality of the circularity of capsulorhexis. However, there are no significant clinical differences in terms of postoperative visual acuity and refraction between both methods. Results should be regarded with caution as results may vary across laser platforms.

Knowledge gaps
Studies with larger and different patient populations and standardized reporting of

outcomes are required to determine where this technology is best placed in the future.

## Identified research evidence

### Findings from Systematic Reviews

Four relevant systematic reviews were identified.

A total of 16 studies were included in the synthesis. There were four anterior capsule tears and one posterior capsule tear in 1,076 eyes reported in ten studies (two anterior capsule tears in laser arms, two anterior capsule tears and one posterior capsule tear in standard phacoemulsification arms). The pooled analysis reported no significant difference between laser-assisted cataract surgery and standard ultrasound phacoemulsification cataract surgery groups in the postoperative cystoid macular edema (odds ratio (OR) 0.58, 95% confidence interval (CI) 0.20 to 1.68, nine studies, n=957 eyes) and elevated postoperative intraocular pressures up to one day (OR 0.88, 95% CI 0.29 to 2.66, nine studies, n=1,022 eyes) and one day to one week after surgery (OR 0.57, 95% CI 0.11 to 2.86, eight studies, n=903 eyes) and total duration of procedure (mean difference (MD) 0.1 minutes, 95% CI -0.02 to 0.21, three studies, n=274 eyes). There were no significant differences between laser-assisted cataract surgery and standard ultrasound phacoemulsification cataract surgery groups in corrected distance visual acuity (CDVA) at one week (MD -0.05, 95% CI -0.10 to 0.01, three studies, n=204 eyes) and CDVA at 1-3 months (MD -0.00, 95% CI -0.03 to 0.02, five studies, n=412 eyes). However, there was a small advantage for laser-assisted cataract surgery at six months in CDVA (MD -0.03 log MAR, 95% CI -0.05 to -0.00, three studies, n=224 eyes). No studies reported patient-reported outcome measures such as visual function. Laser-assisted cataract surgery was like standard ultrasound phacoemulsification cataract surgery in uncorrected distance visual acuity (UDVA) at one week (MD -0.03, 95% CI -0.19 to 0.14, two studies, n=150 eyes) and UDVA at 1-3 months (MD -0.03, 95% CI -0.21 to 0.15, two studies, n=150 eyes) and UDVA at six months (MD -0.06 log MAR, 95% CI -0.26 to 0.14, two studies, n=150 eyes). There was a difference in mean absolute errors between the procedures (MD -0.18D for the laser arm, 95% CI -0.27 to -0.09, three studies, n=278 eyes). There was no data reported on costs or resource use. (Day et al., 2016) The review was judged to be at a high risk of bias.

Pooled analysis reported a significantly lower endothelial cell loss percentage at one week (weighted mean difference [WMD] = -2.93, 95% confidential interval [CI] -5.63 to -0.24, n = 222 eyes, 2 studies), one month (WMD = -2.07, 95% CI -2.94 to -1.19, n = 1002 eyes, 4 studies), and three months (WMD = -4.67, 95% CI -7.81 to -1.54, n = 240 eyes, 2 studies) postoperatively with femtosecond laser-assisted cataract

surgery (FLACS) compared with conventional phacoemulsification surgery (CPS) in patients with decreased visual acuity secondary to cataracts. (Chen et al., 2016) Similarly, significant lower thickness of the central cornea was observed at one day (WMD = -16.63, 95% CI -23.40 to -9.86, n = 842 eyes, 3 studies), one month (WMD = -8.69, 95% CI -15.58 to -1.80, n = 696 eyes, 2 studies), and three to six months (WMD = -6.00, 95% CI -11.41 to -0.60, n = 840 eyes, 3 studies) postoperatively with FLACS compared to CPS. The analysis demonstrated significant differences in terms of corrected distant visual acuity (CDVA) at one week postoperatively (WMD = -0.03, 95% CI -0.06 to -0.01, n = 220 eyes, 2 studies) and uncorrected distant visual acuity at the end of the follow-up period (WMD = -0.07, 95% CI -0.14 to 0.00, n = 1265 eyes, 3 studies) with FLACS compared to CPS, whereas no significant difference with regards to CDVA at one month postoperatively (WMD = -0.01, 95% CI -0.04 to 0.02, n = 220 eyes, 2 studies) and at the end of the follow-up period (WMD = -0.01, 95% CI -0.01 to 0.00, n = 1424 eyes, 5 studies). Significant lower phacoemulsification time (WMD = -2.13, 95% CI -2.60 to -1.66, n = 1174 eyes, 10 studies), and power (WMD = -6.57, 95% CI -7.08 to -6.05, n = 1289 eyes, 5 studies), mean absolute error of refraction (WMD = -0.03, 95% CI -0.06 to -0.01, n = 1696 eyes, 6 studies),and higher quality of circularity of capsulorhexis (WMD = 0.06, 95% CI 0.03 to 0.09, n = 371 eyes, 4 studies) were observed with FLACS compared with CPS. However, no significant difference was observed in surgically induced astigmatism between FLACS and CPS (WMD: 0.05, 95% CI: -0.03 to 0.12, n = 100 eyes, 2 studies). (Chen et al., 2016) The review was judged to be at a high risk of bias.

In a meta-analysis, there were no significant differences for uncorrected distance visual acuity (UDVA) after one week (weighted mean difference (WMD) -0.04, 95% confidence interval (CI) -0.12 to 0.03) and at the final visit (WMD -0.04, 95% CI -0.11 to 0.03). Similarly, no significant difference for spherical equivalent (SE) after one week (WMD -0.03, 95% CI -0.10 to 0.04) and six months or more (WMD -0.11, 95% CI -0.23 to 0.01) was reported. (Kolb et al., 2020) Corrected distance visual acuity (CDVA) was comparable after one week (WMD -0.03, 95% CI -0.06 to 0.00). At the medium term, the difference in UDVA (WMD -0.02, 95% CI -0.04 to -0.00), CDVA (WMD -0.01, 95% CI -0.02 to -0.00) and SE (WMD -0.05, 95% CI -0.08 to -0.01) was in favor of femtosecond laser-assisted cataract surgery (FLACs). Moreover, with FLACS, mean absolute refractive prediction error (MAE) improved at the 1-week follow-up (WMD -0.10, 95% CI -0.19 to -0.02) but no significant difference was reported at later follow-ups (one month to three months: WMD -0.04, 95% CI -0.10 to 0.01) and six months or more: WMD 0.00, 95% CI -0.13 to 0.14). No difference was reported in astigmatism induced by both procedures (WMD -0.04, 95% CI -0.12 to 0.05). Total phacoemulsification time (WMD -10.36, 95% CI -14.49 to -6.22) and effective phacoemulsification time (EPT) (WMD -1.88, 95% CI -2.21 to -1.55) of laser procedure were significantly shorter than those of the manual cataract surgery. Additionally, cumulative dissipated energy (CDE) was less in the FLACS group (WMD -1.95, 95% CI -2.48 to -1.42). Anterior capsular rapture occurred in 0.20% of

eyes treated with CCS (odds ratio (OR) 4.80, 95% CI 2.86 to 8.05) and 0.97% of eyes treated with FLACs. Posterior capsular rapture occurred in 0.42% of eyes treated with FLACs versus 0.27% of eyes treated with CCS. There was no significant difference in the number of incidences with increased IOP within the first 24 hours postoperatively (OR 0.86, 95% CI 0.30 to 2.50) and the occurrence of CME (OR 1.24, 95% CI 0.74 to 2.08). In addition, the incidence of central corneal edema after approximately one month (OR 1.51, 95% CI 0.95 to 2.39) and 6 months or more (OR 1.65, 95% CI 0.72 to 3.79) was comparable for the two groups. At three to six weeks postoperatively, corneal edema was reported in 1.8% after the laser procedure and 1.9% after manual surgery. Central corneal thickness (CCT) was significantly higher at one day (WMD -16.49, 95% CI -22.78 to -10.20) and one to three months (WMD -9.33, 95% CI -15.64 to -3.02) after manual cataract surgery. Endothelial Cell Loss (ECL) at intermediate term after 3 to 6 weeks (WMD -2.58, 95% CI -4.18 to -0.97) and three months (WMD -4.83, 95% CI -6.94 to -2.73) was significantly less after FLACS. However, differences were not significant at the 1-week follow-up (WMD -3.89, 95% CI -8.15 to 0.37) or at six months (WMD -0.52, 95% CI 2.74 to 1.71) (Kolb et al., 2020) The review was judged to be at a high risk of bias.

In the meta-analysis, postoperative CDVA of the FLACS group was better than that of the CPCS group (95% confidenceinterval (CI) -0.06 to -0.01), while no statistically significant difference in CDVA was found between the two groups at onemonth (95% CI -0.01 to 0.01), three months (95% CI -0.04 to 0.01) and six months (95% CI -0.03 to 0.01) after surgery.Meanwhile, the differences in postoperative UDVA were not statistically significant at one week (95% CI -0.16 to 0.08), onemonth (95% CI -0.06 to 0.06) and three to six months (95% CI -0.12 to 0.09). For central corneal thickness (CCT): postoperative CCT was significantly lower in the FLACS group compared to the conventional phacoemulsification cataract surgery (CPCS) group at one day (95% CI -23.02 to-6.86) and one week (95% CI -25.23 to -7.75). However, it was not statistically significant at four to six weeks and threemonths. FLACS cases had better postoperative ECC at one week (95% CI 131.94 to 239.99) and four to six weeks (95% CI186.09 to 282.22), while it was not statistically significant between FLACS group and CPCS group at one day, and three tosix months. FLACS also reduced the postoperative ECL compared to CPCS at one week (95% CI -149.19 to -11.05), four tosix weeks (95% CI -139.33 to -21.34) and three months (95% CI -135.81 to -8.08), but not at six months. No significantdifference was observed with respect to macular edema, capsular complication excluding posterior capsular tears andintraocular pressure change between CDVA of the FLACS group. (Chen et al., 2021) The review was judged to be at a high risk of bias.

# GRADE Tables

## Femtosecond compared to phacoemulsification for cataract surgery

**Bibliography:** Day AC, Burr JM, Bennett K, Bunce C, Doré CJ, Rubin GS, Nanavaty MA, Balaggan KS, Wilkins MR; FACT group. Femtosecond Laser-Assisted Cataract Surgery Versus Phacoemulsification Cataract Surgery (FACT): A Randomized Noninferiority Trial. Ophthalmology. 2020 Aug;127(8):1012-1019.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Study event rates (%) | | | Anticipated absolute effects | |
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | With phacoemulsification | With Femtosecond | Relative effect (95% CI) | Risk with phacoemulsification | Risk difference with Femtosecond |
| **intraoperative complications** | | | | | | | | | | | |
| 780 (1 RCT) | not serious | not serious | serious[a] | serious[b] | none | ⨁⨁◯◯ Low | 5/389 (1.3%) | 11/391 (2.8%) | **RR 2.19** (0.77 to 6.24) | 13 per 1.000 | **15 more per 1.000** (from 3 fewer to 67 more) |
| **anterior capsular tear** | | | | | | | | | | | |
| 780 (1 RCT) | not serious | not serious | serious[a] | serious[b] | none | ⨁⨁◯◯ Low | 2/389 (0.5%) | 3/391 (0.8%) | **RR 1.49** (0.25 to 8.88) | 5 per 1.000 | **3 more per 1.000** (from 4 fewer to 41 more) |
| **posterior capsular tear** | | | | | | | | | | | |
| 780 (1 RCT) | not serious | not serious | serious[a] | serious[b] | none | ⨁⨁◯◯ Low | 2/389 (0.5%) | 0/391 (0.0%) | **RR 0.20** (0.01 to 4.13) | 5 per 1.000 | **4 fewer per 1.000** (from 5 fewer to 16 more) |
| **zonular dialysis** | | | | | | | | | | | |
| 780 (1 RCT) | not serious | not serious | serious[a] | serious[b] | none | ⨁⨁◯◯ Low | 0/389 (0.0%) | 1/391 (0.3%) | **RR 2.98** (0.12 to 73.04) | 0 per 1.000 | **0 fewer per 1.000** (from 0 fewer to 0 fewer) |
| **Intraoperative pupil constriction** | | | | | | | | | | | |
| 780 (1 RCT) | not serious | not serious | serious[a] | serious[b] | none | ⨁⨁◯◯ Low | 1/389 (0.3%) | 3/391 (0.8%) | **RR 2.98** (0.31 to 28.57) | 3 per 1.000 | **5 more per 1.000** (from 2 fewer to 71 more) |

**CI:** confidence interval; **RR:** risk ratio

**Explanations**

a. Clinical and methodological heterogeneity in terms of population, intervention, comparator and outcome measures.

b. Wide confidence intervals around the effect estimate.

## FLACS compared to CCS for cataract surgery

**Bibliography:** Kolb CM, Shajari M, Mathys L, Herrmann E, Petermann K, Mayer WJ, et al. Comparison of femtosecond laser-assisted cataract surgery and conventional cataract surgery: a meta-analysis and systematic review. J Cataract Refract Surg 2020;46(8):1075-85

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Study event rates (%) | | | Anticipated absolute effects | |
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | With CCS | With FLACS | Relative effect (95% CI) | Risk with CCS | Risk difference with FLACS |
| **Intraoperative complications (anterior capsular rupture) - Observational studies** | | | | | | | | | | | |
| 15973 (1 observational study) | very serious[a] | not serious | not serious | not serious | strong association | ⨁◯◯◯ Very low | 16/7951 (0.2%) | 78/8022 (1.0%) | **RR 4.83** (2.82 to 8.27) | 2 per 1.000 | **8 more per 1.000** (from 4 more to 15 more) |
| **Intraoperative complications (anterior capsular rupture) - Randomised studies** | | | | | | | | | | | |
| 2248 (1 RCT) | very serious[b] | not serious | not serious | serious[c] | none | ⨁◯◯◯ Very low | 5/1131 (0.4%) | 21/1117 (1.9%) | **RR 4.25** (1.61 to 11.24) | 4 per 1.000 | **14 more per 1.000** (from 3 more to 45 more) |
| **Intraoperative complications (posterior capsular rupture) - Observational evidence** | | | | | | | | | | | |
| 14293 (1 observational study) | very serious[a] | not serious | not serious | not serious | strong association | ⨁◯◯◯ Very low | 19/7102 (0.3%) | 30/7191 (0.4%) | **RR 1.56** (0.88 to 2.77) | 3 per 1.000 | **1 more per 1.000** (from 0 fewer to 5 more) |
| **Intraoperative complications (posterior capsular rupture) - Randomised studies** | | | | | | | | | | | |
| 2230 (1 RCT) | very serious[b] | not serious | not serious | serious[c] | none | ⨁◯◯◯ Very low | 390/1140 (34.2%) | 420/1090 (38.5%) | **RR 1.13** (1.01 to 1.26) | 342 per 1.000 | **44 more per 1.000** (from 3 more to 89 more) |

**CI:** confidence interval; **RR:** risk ratio

**Explanations**

a. 21 studies had a high risk of bias for comparability

b. Almost all studies had serious concerns with regard to performance bias; majority had serious concerns with regard to detection bias; all were judged at an unclear risk of bias for selective reporting.
c. Wide confidence intervals around the effect estimate.

## FLACS compared to CCS for cataract surgery (postop)

**Bibliography:** Kolb CM, Shajari M, Mathys L, Herrmann E, Petermann K, Mayer WJ, et al. Comparison of femtosecond laser-assisted cataract surgery and conventional cataract surgery: a meta-analysis and systematic review. J Cataract Refract Surg 2020;46(8):1075-85

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With CCS | With FLACS | | Risk with CCS | Risk difference with FLACS |
| **Postoperative complications (elevated intraocular pressure) - Observational evidence** | | | | | | | | | | | |
| 804 (1 observational study) | very serious[a] | not serious | not serious | not serious | strong association | ⨁◯◯◯ Very low | 7/390 (1.8%) | 6/414 (1.4%) | **OR 0.80** (0.27 to 2.42) | 18 per 1.000 | **4 fewer per 1.000** (from 13 fewer to 24 more) |
| **Postoperative complications (elevated intraocular pressure) - Randomised studies** | | | | | | | | | | | |
| 628 (1 RCT) | very serious[b] | not serious | not serious | serious[c] | none | ⨁◯◯◯ Very low | 16/314 (5.1%) | 38/314 (12.1%) | **OR 2.56** (1.40 to 4.70) | 51 per 1.000 | **70 more per 1.000** (from 19 more to 151 more) |
| **Central corneal oedema - Observational evidence** | | | | | | | | | | | |
| 1453 (1 observational study) | very serious[a] | not serious | not serious | not serious | none | ⨁◯◯◯ Very low | 647 | 806 | - | The mean central corneal oedema - Observational evidence was **556** | MD **9.33 lower** (15.64 lower to 3.02 lower) |
| **Central corneal oedema - Randomised studies** | | | | | | | | | | | |
| 454 (1 RCT) | very serious[b] | not serious | not serious | serious[c] | none | ⨁◯◯◯ Very low | -/229 | -/225 | **RR 2.07** (0.40 to 3.74) | 0 per 1.000 | **2 fewer per 1.000** (from 4 fewer to 0 fewer) |
| **Surgically induced astigmatism** | | | | | | | | | | | |
| 748 (1 RCT) | very serious[b] | not serious | not serious | serious[c] | none | ⨁◯◯◯ Very low | -/378 | -/370 | **RR 0.93** (0.83 to 1.05) | 0 per 1.000 | **1 fewer per 1.000** (from 1 fewer to 1 fewer) |
| **Endothelial cell loss - at 1-3 days** | | | | | | | | | | | |
| 353 (1 RCT) | very serious[b] | not serious | not serious | serious[c] | none | ⨁◯◯◯ Very low | -/177 | -/176 | **RR 0.08** (0.01 to 0.82) | 0 per 1.000 | **0 fewer per 1.000** (from 1 fewer to 0 fewer) |
| **Endothelial cell loss - at 1 week** | | | | | | | | | | | |
| 222 (1 RCT) | very serious[b] | not serious | not serious | serious[c] | none | ⨁◯◯◯ Very low | -/111 | -/111 | **RR 0.04** (0.00 to 0.59) | 0 per 1.000 | **0 fewer per 1.000** (from 1 fewer to --) |
| **Endothelial cell loss - at 3-6 weeks** | | | | | | | | | | | |
| 991 (1 RCT) | very serious[b] | not serious | not serious | serious[c] | none | ⨁◯◯◯ Very low | -/498 | -/493 | **RR 0.10** (0.01 to 0.89) | 0 per 1.000 | **0 fewer per 1.000** (from 1 fewer to 0 fewer) |
| **Endothelial cell loss - at 3 months** | | | | | | | | | | | |
| 331 (1 RCT) | very serious[b] | not serious | not serious | serious[c] | none | ⨁◯◯◯ Very low | -/168 | -/163 | **RR 0.02** (0.00 to 0.35) | 0 per 1.000 | **0 fewer per 1.000** (from 0 fewer to --) |
| **Endothelial cell loss - at 6 months** | | | | | | | | | | | |
| 205 (1 RCT) | very serious[b] | not serious | not serious | serious[c] | none | ⨁◯◯◯ Very low | -/103 | -/102 | **RR 0.12** (0.00 to 3.16) | 0 per 1.000 | **0 fewer per 1.000** (from 3 fewer to --) |

**CI:** confidence interval; **MD:** mean difference; **OR:** odds ratio; **RR:** risk ratio

**Explanations**
a. 21 studies had a high risk of bias for comparability

b. Almost all studies had serious concerns with regard to performance bias; majority had serious concerns with regard to detection bias; all were judged at an unclear risk of bias for selective reporting
c. Wide confidence intervals around the effect estimate

## Laser-assisted cataract surgery compared to standard ultrasound phacoemulsification for cataract surgery

**Bibliography:** Day, A. C., Gore, D. M., Bunce, C. & Evans, J. R. 2016. Laser-assisted cataract surgery versus standard ultrasound phacoemulsification cataract surgery. Cochrane Database of Systematic Reviews.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Study event rates (%) | | | Anticipated absolute effects | |
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | With standard ultrasound phacoemulsification | With Laser-assisted cataract surgery | Relative effect (95% CI) | Risk with standard ultrasound phacoemulsification | Risk difference with Laser-assisted cataract surgery |
| **Intraoperative complications: anterior capsule tear or posterior capsule tear** | | | | | | | | | | | |
| 273 (10 RCTs) | serious[a] | serious[b] | not serious | serious[c] | none | ⨁◯◯◯ Very low | Only 4 anterior capsule tears, 2 in each group for; and Only 1 posterior capsule tear in standard group | | | | |
| **Corrected distance visual acuity at 1-3 months (assessed with: logMAR acuity chart )** | | | | | | | | | | | |
| 412 (5 RCTs) | very serious[d] | serious[e] | not serious | serious[f] | none | ⨁◯◯◯ Very low | 183 | 229 | - | The mean corrected distance visual acuity at 1-3 months was **0.02** | MD **0** (0.03 lower to 0.02 higher) |
| **Corrected distance visual acuity 6 months or more** | | | | | | | | | | | |
| 224 (3 RCTs) | very serious[d] | not serious | not serious | serious[f] | none | ⨁◯◯◯ Very low | 97 | 127 | - | The mean corrected distance visual acuity 6 months or more was **0.04** | MD **0.03 lower** (0.05 lower to 0 ) |
| **Postoperative complications: cystoid macular oedema** | | | | | | | | | | | |
| 957 (9 RCTs) | very serious[d] | not serious | not serious | not serious | none | ⨁⨁◯◯ Low | 9/484 (1.9%) | -/473 | **OR 0.58** (0.20 to 1.68) | 19 per 1.000 | **8 fewer per 1.000** (from 15 fewer to 12 more) |
| **Postoperative complications: elevated intraocular pressure (follow-up: range 1 days to 1 weeks)** | | | | | | | | | | | |
| 903 (8 RCTs) | very serious[d] | not serious | not serious | not serious | none | ⨁⨁◯◯ Low | 2/455 (0.4%) | -/448 | **OR 0.57** (0.11 to 2.86) | 4 per 1.000 | **2 fewer per 1.000** (from 4 fewer to 8 more) |
| **Refractive outcomes - mean absolute error** | | | | | | | | | | | |
| 278 (3 RCTs) | very serious[d] | serious[g] | not serious | serious[f] | none | ⨁◯◯◯ Very low | 116 | 162 | - | The mean refractive outcomes - mean absolute error was **0.5** | MD **0.18 lower** (0.27 lower to 0.09 lower) |

**CI:** confidence interval; **MD:** mean difference; **OR:** odds ratio

**Explanations**
a. Unclear or high risk of bias of the included studies
b. Inconsistent results
c. Very small number of events
d. Very high risk of bias of the included studies
e. Moderate amount of statistical heterogeneity detected.
f. Small sample size
g. Significant statistical heterogeneity detected.

### 7.1.1 References


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## 7.2 Cataract Surgery Techniques for Astigmatism

### Output question

What is the role of femtosecond laser in astigmatism control during a cataract surgery?

**P:** Adult patients with astigmatism who will undergo cataract surgery
**I:** Femtosecond laser cataract surgery (FLACS)
**C:** Conventional cataract surgery (CCS)
**O:** Visual acuity, visual function, quality of life, (serious) adverse events, postoperative refractive outcome

### Recommendation

Femtosecond-laser assisted (FLACS) as well as manual corneal incisions (eg. opposite clear corneal incisions, limbal relaxing incisions and astigmatic keratotomies) are safe and effective options for astigmatism control during cataract surgery. (GRADE +)

FLACS incisions for the main surgical incision are less effective than relaxing incisions in terms of effectivity and variability and should therefore only be considered in selected patients. (GRADE +)

Femtosecond laser can be used to perform corneal incisions specifically designed to correct corneal astigmatism (eg. intrastromal and penetrating femtosecond laser astigmatism keratotomies). These are more precisely performed than when done by hand. (GRADE +)

### Considerations

Effective management of corneal astigmatism is an important element in cataract surgery to improve visual acuity and decrease reliance on spectacles post-surgery. Current treatments for astigmatism include toric intraocular lens implants (IOL) and non-toric IOLs with incision-based interventions such as astigmatic keratectomy, limbal relaxing incision (LRI) and steep axis incision.

Steep-axis incision is a simple and cost-effective method to correct low levels (0.5-1.5D) of astigmatism during cataract surgery, but its long-term stability and predictability vary.(Liu et al., 2021) Although studies show heterogeneous results, experts recommend limbal incisions only for low astigmatism up to 0.75D. Comparisons of manually performed corneal relaxing incisions and those made with

femtosecond lasers have demonstrated the safety and effectiveness of both techniques, with similar visual and refractive outcomes. Hence femtosecond lasers offer greater precision and predictability, but visual and refractive outcomes of both procedures are similar. Refractive stability was achieved after three months for both procedures.(Gonzalez-Cruces et al., 2022)

Studies showed that steep-axis corneal incision were less effective in astigmatism control when compared with toric IOL implantation for cataract patients with low to moderate corneal astigmatism (1.0-2.0D). (Liu et al., 2021)

## Conclusion

Implications for practice

Corneal incisions in astigmatism control during cataract surgery are a cost effective and time saving method. Long term stability and predictability show heterogeneous results, and corneal incisions appear to show reduced efficacy in astigmatism control compared to toric IOLS.

Knowledge gaps

Further research and large case studies are warranted to determine the optimal approach in treating astigmatism whether that be at the corneal or lenticular plane.

## Identified research evidence

### Findings from Systematic Reviews

We identified one relevant systematic review.

Manual corneal relaxing incisions in 1025 eyes from 946 patients were evaluated. The type of corneal incision used to correct the pre-existing corneal astigmatism were as follows: limbal relaxing incision (LRI) was used in 13 articles (65%), opposite clear corneal incision (OCCI) was used in five (25%), and arcuate keratectomy (AK) was used in two (10%) articles. All OCCIs were penetrating incisions, while the LRIs were non-penetrating, with an incision depth of 80–90% of the peripheral corneal pachymetry or up to 600 microns. The correction index in all the studies evaluated resulted in a correction index ≤ 1.0 (undercorrection). The average correction index value was 0.77 ± 0.18 (range 0.39 to 1.0), suggesting that the target induced astigmatism (TIA) was greater than the surgically induced astigmatism (SIA) in these studies. The correction index was 0.82 ± 0.13 and 0.69 ± 0.22 for studies using the LRI and opposite clear corneal incision (OCCI), respectively (P = 0.17). There was no statistically significant difference between the different nomograms used in the limbal relaxing incision (LRI studies (p = 0.75). The mean (uncorrected distance visual acuity) UDVA pre- and post-surgery was 0.70 ± 0.28 and 0.19 ± 0.12 logMAR (p < 0.01), and the mean (corrected distance visual acuity) CDVA was 0.33 ± 0.19

and 0.16 ± 0.07 logMAR (P < 0.01), respectively. The mean keratometric astigmatism was reduced from 1.86 ± 0.53 D to 1.04 ± 0.48 D post-surgery (P < 0.01), and the mean refractive astigmatism was reduced from 1.96 ± 0.62 D to 0.98 ± 0.36 D (P < 0.01). 2. Femtosecond assisted corneal relaxing incision: A total of 1905 eyes from 1483 patients were evaluated. The type of incision used in almost all the studies was an arcuate keratotomy (AK) paired opposite incision between 7.5 and 9 mm in diameter. An OCCI was performed in only one study. The main platform femtosecond laser used was Catalys Laser System (Abbott Medical Optics, Inc.) 11 studies (55%), followed by LenSx® (Alcon, Fort Worth, Texas, USA) five studies (25%), IntraLase iFS (Abbott Medical Optics, Inc.) two studies (10%), TechnolasVictus SW 2.7 (Bausch & Lomb Inc, Dornach, Germany) one study (5%), and finally LDV Z8 (Ziemer Ophthalmic Systems, Port, Switzerland) one study (5%). An acceptable UDVA/CDVA was found at the end of the postoperative period. For all the studies reporting visual data, the mean UDVA post-operation was 0.15 ± 0.05 logMAR and the mean CDVA was 0.03 ± 0.05 logMAR. There was a reduction in corneal astigmatism from 1.16 ± 0.26 D to 0.64 ± 0.21 D (P < 0.01) after surgery. Refractive astigmatism decreased from 1.41 ± 0.17 D to 0.57 ± 0.22 D (P < 0.01). The mean magnitude of the TIA was 1.16 ± 0.24 D, while the mean SIA was 0.94 ± 0.31 D. In most studies, an under-correction result with a mean CI of 0.79 ± 0.17 (range 0.53 to 1.0) was obtained. In studies in which intrastromal incisions were made, the average CI was 0.72 ± 0.06, while it was 0.86 ± 0.06 for the articles in which penetrating incisions were made, with no significant differences between the groups (P = 0.13). The mean index of success reported was 0.60 ± 0.19 (range 0.20–0.93). (Gonzalez-Cruces et al., 2022) The review was judged to be at a high risk of bias.

## GRADE Table

### FLACS compared to phacoemulsification in patients with in astigmatism undergoing cataract surgery

**Bibliography:** Chlasta-Twardzik E, Nowińska A, Wylęgała E. Comparison of the selected parameters of the anterior segment of the eye between femtosecond laser-assisted cataract surgery, microincision cataract surgery, and conventional phacoemulsification: A case-control study. Medicine (Baltimore). 2019 Dec;98(52):e18340. doi: 10.1097/MD.0000000000018340.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With phacoemulsification | With FLACS | | Risk with phacoemulsification | Risk difference with FLACS |
| **anterior astigmatism (follow-up: 6 months)** | | | | | | | | | | | |
| 56 (1 RCT) | serious[a] | not serious | serious[b] | serious[c] | none | ⊕◯◯◯ Very low | 30 | 26 | - | The mean anterior astigmatism was **1.07** | MD **0.23 higher** (0.2 lower to 0.66 higher) |
| **posterior astigmatism (follow-up: 6 months)** | | | | | | | | | | | |
| 56 (1 RCT) | serious[a] | not serious | serious[b] | serious[c] | none | ⊕◯◯◯ Very low | 30 | 26 | - | The mean posterior astigmatism was **0.36** | MD **0.05 higher** (0.05 lower to 0.15 higher) |

## FLACS compared to phacoemulsification in patients with in astigmatism undergoing cataract surgery

**Bibliography:** Chlasta-Twardzik E, Nowińska A, Wylęgała E. Comparison of the selected parameters of the anterior segment of the eye between femtosecond laser-assisted cataract surgery, microincision cataract surgery, and conventional phacoemulsification: A case-control study. Medicine (Baltimore). 2019 Dec;98(52):e18340. doi: 10.1097/MD.0000000000018340.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **BCVA (follow-up: 6 months)** | | | | | | | | | | | |
| 56 (1 RCT) | serious[a] | not serious | serious[b] | serious[c] | none | ⊕◯◯◯ Very low | 30 | 26 | - | The mean BCVA was **0.95** | MD **0.03 lower** (0.1 lower to 0.04 higher) |
| **central corneal thickness (follow-up: 6 months)** | | | | | | | | | | | |
| 56 (1 RCT) | serious[a] | not serious | serious[b] | serious[c] | none | ⊕◯◯◯ Very low | 30 | 26 | - | The mean central corneal thickness was **549.6** | MD **0.12 lower** (0.65 lower to 0.4 higher) |

**CI:** confidence interval; **MD:** mean difference

**Explanations**
a. Unclear or high risk of bias for sequence generation, allocation concealment and blinding.
b. Clinical and methodological heterogeneity in terms of population, intervention, comparator and outcome measures.
c. Small sample size; wide confidence intervals around the effect estimate.

### 7.2.1 References


Gonzalez-Cruces, T., Cano-Ortiz, A., Sanchez-Gonzalez, M. C. & Sanchez-Gonzalez, J. M. 2022. Cataract surgery astigmatism incisional management. Manual relaxing incision versus femtosecond laser-assisted arcuate keratotomy. A systematic review. *Graefes Arch Clin Exp Ophthalmol,* 260**,** 3437-52.

Liu, Z., Zhou, R., Xu, K., et al. 2021. Efficacy comparison between toric intraocular lens and aspheric intraocular lens plus steep-axis incision in cataract patients with low corneal astigmatism. *Annals of Palliative Medicine,* 10**,** 2610-2619.

## 7.3 Marking Techniques for Toric IOLs

### Output question

What are the differences between different marking techniques for patients receiving toric IOLs?

**P:** Adult patients who will undergo cataract surgery with toric IOLs
**I:** Performing preoperative marking
**C:** Not performing preoperative marking or a comparator marking technqiue
**O:** Visual acuity, visual function, quality of life, (serious) adverse events, postoperative refractive outcome

### Recommendation

Image-guided marking may result in less axis misalignment, a smaller difference vector and less postoperative astigmatism than manual marking, but there are no clinically significant differences in visual and refractive outcomes between the two techniques. (GRADE +)

### Considerations

One of the most effective ways to reduce the amount of residual astigmatism during cataract surgery is the implementation of a toric IOL. In order to obtain a precise correction for astigmatism, the positioning of the toric IOL on the correct axis is crucial which strongly relies on the correct corneal marking. Other factors that have to be considered are postoperative rotation depending on lens material, size and design as well as toric IOL calculation. Deviations from the correct axis mostly are due to misplacement of the lens or lens rotation.(Potvin et al., 2016)

The percentage of eyes with a lens orientation ≥5° off the intended axis is very low in general. (Chlasta-Twardzik et al., 2019) However, for every degree that the orientation of a toric lens deviates from the calculated axis, there is an approximate 3.3% decrease in its effectiveness at reducing astigmatism. If a toric lens is 30° away from its ideal orientation, the magnitude of the preexisting astigmatism of the eye is not changed, though the axis of that astigmatism changes.(Potvin et al., 2016)

Marking techniques include manual marking of the peripheral cornea at the horizontal (0-180°) or vertical (90-270°) axis while the patient is in a seated position to avoid the effects of cyclotorsion when the patient lies prone. Some femtosecond lasers with image guidance can also be used for corneal marking for toric lens alignment.(Zhou et al., 2019)

Manual marking can be done by horizontal slit beam marking, subjective direct visual marking on the table or marking with a pendulum attached marker. Manual marking, however, is subject to human error in comparison with image- guided system that provide non-touch corneal marking.(Zhou et al., 2019) Digital marking systems are based on preoperative imaging.(Zhou et al., 2019)

Studies showed that guided marking was superior to manual marking as it resulted in less axis misalignment, a smaller difference vector and less postoperative astigmatism than the manual marking group. Nevertheless, postoperative UDVA and residual refractive astigmatism showed no significant difference.(Zhou et al., 2019, Webers et al., 2017) Another study showed that at 3 months postoperatively, no significant differences could be found between the two marking techniques concerning UDVA, CDVA, degree of misalignment of the toric IOL or deviation from the target induced astigmatism.(Kose and Erdogan, 2020) Thereby concluding that image-guided marking systems are as effective as manual marking. When comparing different image-guided systems with each other no significant difference could be found.(Kose and Erdogan, 2020, Panagiotopoulou et al., 2019)

## Conclusion

Implications for practice

The image-guided marking system was found to be at least as effective as manual marking in the positioning of toric IOLs, with some studies presenting higher precision in the image-guided group. Results have to be treated with care as different toric IOL types, surgeon experience and IOL calculation may also affect the postoperative residual astigmatism. Additionally, manual marking includes different techniques and not in all cases the same image-guided systems were used. Heterogeneity was present in between the results.

Knowledge gaps

Further research is needed on different marking techniques. With the evolution of image-guided marking techniques, more studies about the proposed improved exactness, outcomes and cost-benefit of image-guided vs. open-hand marking techniques are warranted.

## Identified research evidence

### Findings from Systematic Reviews

One relevant systematic review was identified.

In the pooled analysis, the image-guided marking group had smaller toric IOL axis misalignment (weighted mean difference (WMD) -0.33 degrees, 95% confidence interval (CI) -1.88 to -0.79 degrees, less postoperative astigmatism (WMD -0.14 degrees, 95% CI -0.24 to -0.05 degrees), and a smaller difference vector (WMD -0.10 degrees, 95% CI -0.14 to -0.06 degrees) than the manual marking group. Comparisons on postoperative uncorrected distance visual acuity (UDVA) and corneal cylinder were not statistically significant.(Zhou et al., 2019) The review was judged to be at a high risk of bias.

## GRADE Table

### Image-Guided System compared to Manual Marking Technique for Toric Intraocular Lens Alignment in cataract surgery

**Bibliography:** Zhou F, Jiang W, Lin Z,et al. Comparative meta-analysis of toric intraocular lens alignment accuracy in cataract patients: image-guided system versus manual marking. Journal of Cataract & Refractive Surgery, 2019.

| Certainty assessment | | | | | | | № of patients | | Effect | | Certainty | Importance |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| № of studies | Study design | Risk of bias | Inconsistency | Indirectness | Imprecision | Other considerations | Image-Guided System | Manual Marking Technique | Relative (95% CI) | Absolute (95% CI) | | |
| **Postoperative UDVA (logMAR) (follow-up: range 3 weeks to 3 months)** | | | | | | | | | | | | |
| 3 | randomised trials | serious[a,b,c] | not serious | not serious | not serious | none | 116 | 115 | - | MD **0.02 UDVA (logMAR) lower** (0.04 lower to 0) | ⊕⊕⊕◯ Moderate | CRITICAL |
| **Toric IOL axis misalignment (follow-up: range 3 weeks to 3 months)** | | | | | | | | | | | | |
| 3 | randomised trials | serious[a,b,d] | not serious | not serious | not serious | none | 142 | 141 | - | MD **1.33 degree lower** (1.88 lower to 0.79 lower) | ⊕⊕⊕◯ Moderate | IMPORTANT |
| **Postoperative astigmatism (follow-up: range 3 weeks to 3 months)** | | | | | | | | | | | | |
| 2 | randomised trials | serious[a,b,e] | not serious | not serious | not serious | none | 87 | 87 | - | MD **0.14 cylinder (D) lower** (0.24 lower to 0.05 lower) | ⊕⊕⊕◯ Moderate | CRITICAL |
| **Difference vector (follow-up: range 3 weeks to 3 months)** | | | | | | | | | | | | |
| 3 | randomised trials | serious[a,b] | not serious | not serious | not serious | none | 76 | 75 | - | MD **0.1 D lower** (0.14 lower to 0.06 lower) | ⊕⊕⊕◯ Moderate | IMPORTANT |

**CI:** confidence interval; **MD:** mean difference

**Explanations**
a. Concern about selection bias
b. Concern about measurement bias
c. There were 3 RCTs and one prospective controlled study
d. There were 3 RCTs and one prospective controlled study and one retrospective controlled study
e. There were 2 RCTs and one prospective controlled study

### 7.3.1 References

Chlasta-Twardzik, E., Nowinska, A. & Wylegala, E. 2019. Comparison of the selected parameters of the anterior segment of the eye between femtosecond laser-assisted cataract surgery, microincision cataract surgery, and conventional phacoemulsification: a case-control study. *Medicine,* 98**,** e18340.

Kose, B. & Erdogan, H. 2020. Comparison of toric intraocular lens alignment using image guided system vs manual marking technique. *Beyoglu Eye Journal,* 5**,** 108-13.

Panagiotopoulou, E. K., Ntonti, P., Gkika, M., et al. 2019. Image-guided lens extraction surgery: a systematic review. *Int J Ophthalmol,* 12**,** 135-51.

Potvin, R., Kramer, B. A., Hardten, D. R. & Berdahl, J. P. 2016. Toric intraocular lens orientation and residual refractive astigmatism: an analysis. *Clin Ophthalmol,* 10**,** 1829-1836.

Webers, V. S. C., Bauer, N. J. C., Visser, N., et al. 2017. Image-guided system versus manual marking for toric intraocular lens alignment in cataract surgery. *Journal of Cataract & Refractive Surgery,* 43**,** 781-788.

Zhou, F., Jiang, W., Lin, Z., et al. 2019. Comparative meta-analysis of toric intraocular lens alignment accuracy in cataract patients: image-guided system versus manual marking. *J Cataract Refract Surg,* 45**,** 1340-5.

## 7.4 Endophthalmitis prophylaxis

### Output question

What prophylaxis should be administered during cataract surgery to minimize the risk of postoperative endophthalmitis?

**P:** Adult patients who undergo cataract surgery
**I:** Intracameral antibiotics
**C:** No treatment
**O:** (Serious) adverse events (Endophthalmitis)

**P:** Adult patients who undergo cataract surgery
**I:** Antiseptic agents
**C:** No use of antiseptic agents
**O:** (Serious) adverse events (Endophthalmitis)

<u>The prophylaxis regimes include:</u>

- Intracameral antibiotics
- Antiseptic agents (povidone-iodine or chlorhexidine)

### Recommendation

Intracameral antibiotic therapy should be used because it is effective and safe for preventing endophthalmitis after cataract surgery. The use of intracameral antibiotics significantly reduces the risk of endophthalmitis. (GRADE +)

An intracameral injection should be used (e.g. cefuroxime 1 mg in 0.1 ml.) at the end of the cataract surgery to lower the risk for postoperative endophthalmitis. (GRADE +++)

Adequate antisepsis can be achieved by applying povidone-iodine 5-10% drops 3 minutes before commencing cataract surgery or by continuously applying 0.25% povidone-iodine drops to wash the ocular surface every 20-30 seconds during the procedure. In cases of povidone-iodine allergy, chlorhexidine (0.02%) can be used as an alternative. (GRADE +)

### Considerations

Endophthalmitis is a rare but one of the most severe complications after cataract surgery. Evidence proves that intracameral antibiotics significantly reduce the risk of

endophthalmitis compared to non-intracameral antibiotics. When intracameral (IC) antibiotics are not used during cataract surgery, there is a significantly higher relative risk (RR) of 2.94 for development of endophthalmitis.(Rana et al., 2021) Sufficient evidence for the use of topical antibiotic therapy was not found.

Using an intracameral antibiotic directly at the end of cataract surgery has no additional burden for the patient, if patients are not known to be allergic to the drug. In cases with a higher risk for endophthalmitis, such as cataract surgery with an intraoperative complication, intracameral antibiotics must be especially considered.

Different intracameral antibiotics have been suggested to prevent endophthalmitis, including cefuroxime, moxifloxacin, or vancomycin.(Bowen et al., 2018, Gower et al., 2017, Huang et al., 2016, Kessel et al., 2015d, Rana et al., 2021, Shi et al., 2022, X. L. Wang et al., 2020) Currently, cefuroxime is the only antibiotic approved for intracameral use. To prevent the development of resistance, its use should be reserved for situations in which other antimicrobials do not achieve sufficient results or in cases of allergy to cefuroxim. The odds ratios (OR) for prevention of endophthalmitis range from 0.29-0.30 for cefuroxime and 0.26-0.29 for moxifloxacin.(Bowen et al., 2018, X. L. Wang et al., 2020) The use of vancomycin has been associated with hemorrhagic occlusive retinal vasculitis.(Bowen et al., 2018)

When comparing intracameral antibiotics alone to combination therapy (intracameral and topical antibiotics), the literature shows high heterogeneity in the results and discrepancies. While some studies suggest that intracameral antibiotics in combination with antibiotic eye drops seem to lower the chance of endophthalmitis, other studies suggest that the combination therapy might be as effective as inttracameral antibiotics alone. (Bowen et al., 2018, Gower et al., 2017) There is a lack of evidence to support the use of topical antibiotics postoperatively when intracameral antibiotics are used. (Bowen et al., 2018, Gower et al., 2017) In terms of comparing topical antibiotic therapy alone to intracameral antibiotic injections alone for preventing endophthalmitis, the injections appear to pose a reduced risk of endophthalmitis. (Gower et al., 2017) The current evidence does not prove topical antibiotic therapy as a preventive strategy for endophthalmitis and is therefore not recommended. (Gower et al., 2017, Huang et al., 2016, Rana et al., 2021) In addition, preoperative topical antibiotics should not be used prior to cataract surgery.

Preoperative application of povidone-iodine is a well-established method for preventing infection during cataract surgery. However, using intracameral antibiotics in addition to povidone-iodine can further reduce the risk of endophthalmitis.(Endophthalmitis Study Group and European Society of Cataract and Refractive Surgeons, 2007) The ESCRS recommends the use of 5-10% povidone-iodine drops applied to the cornea, conjunctival fornices, and periocular skin at least three minutes before cataract surgery to ensure adequate

antisepsis.(Endophthalmitis Study Group and European Society of Cataract and Refractive Surgeons, 2007, Koerner et al., 2018) Alternatively, the literature also suggests that repeatedly washing the ocular surface with povidone-iodine 0.25% every 20-30 seconds throughout the surgery can be an effective preventive measure against endophthalmitis.(Shimada and Nakashizuka, 2021) There is currently no evidence to suggest that switching from povidone-iodine to another antiseptic, such as chlorhexidine, would provide additional benefits. However, in the event of poor tolerance or an allergy to povidone-iodine, a lower concentration can be used, or chlorhexidine at a concentration of 0.05%-0.1% can be used as an alternative. It must be noted that the optimal concentration and dosing regimen for chlorhexidine still requires further investigation.(Kanclerz and Myers, 2022)

## Conclusion

Implications for practice

Based on current evidence, a combination of preoperative povidone-iodine and peroperative intracameral cefuroxime is the preferred regimen for preventing endophthalmitis after cataract surgery.

Knowledge gaps

Additional evidence is needed for the use of currently non-approved intracameral antibiotics. There appears to be a lack of evidence for the effectiveness of postoperative topical antibiotics in preventing postoperative endophthalmitis.

## Identified research evidence

### Findings from Systematic Reviews

Eight relevant systematic reviews were identified.

In one meta-analysis, eyes not receiving intracameral (IC) antibiotics had a 2.94 (95% confidence interval (CI) 1.07 to 8.12) higher risk ratio (RR) of postoperative endophthalmitis compared to eyes that did use IC antibiotics. The posterior capsule rupture (PCR) rates were similar in the groups receiving and not receiving IC antibiotics (8,542, 1.18% vs 9046, 1.23%). On meta-regression, the use of topical antibiotics was not correlated with endophthalmitis incidence (coefficient 0.0002, SE 0.004, P=.97). The pooled incidence rate of endophthalmitis was 0.0690% (95% CI 0.0406% to 0.1050%) in the non-sutured group and 0 cases (0.00%) of endophthalmitis in the sutured group.(Rana et al., 2021) The review was judged to be at a high risk of bias.

In another meta-analysis, anterior chamber injection of moxifloxacin could prevent the incidence of endophthalmitis after cataract surgery (odds ratio (OR) 0.29, 95%

confidence interval (CI) 0.15, 0.56). However, no significant differences were observed between the moxifloxacin injection and non-moxafloxacin injection in terms of uncorrected visual acuity (UDVA) (standardised mean difference (SMD −0.27, 95% CI −1.28, 0.74), intraocular pressure (IOP) (SMD −0.04, 95% CI −0.02, 0.01), Corneal Edema (OR 1.03, 95% CI 0.23, 4.69), central corneal thickness (CCT) (SMD −0.01, 95% CI −0.07, 0.05) and corneal endothelial cell density (ECD) (SMD 0.00, 95% CI −0.06, 0.07).(X. L. Wang et al., 2020) The review was judged to be at a high risk of bias.

A pooled analysis of 17 studies, including 900,000 eyes, favored the use of IC antibiotics at the end of phacoemulsification cataract surgery (odds ratio [OR] 0.20, 95% confidence interval [CI] 0.13 to 0.32). Similarly, a significantly lower incidence of endophthalmitis was reported with IC cefuroxime (OR 0.26, 95% CI 0.15 to 0.45, 9 studies), IC moxifloxacin (OR 0.30, 95% CI 0.13 to 0.67, 6 studies) and IC vancomycin (OR 0.09, 95% CI 0.02 to 0.42, 5 studies), respectively, when compared to the control group. The summary estimate of studies found no statistically significant difference in terms of postoperative endophthalmitis rates between patients treated with IC antibiotics plus topical antibiotics and patients treated with IC antibiotics alone within the cefuroxime (OR 0.26, 95% CI 0.10 to 0.68, 5 studies), vancomycin (OR 0.10, 95% CI 0.02 to 0.59, 4 studies) and moxifloxacin groups (OR 0.38, 95% CI 0.14 to 1.04, 4 studies), respectively. In addition, in the cefuroxime group, 14% of eyes were reported with toxic effects from the antibiotic and 23 had corneal edema (3 studies), 6 had endothelial cell death (1 study), 17 developed toxic anterior segment syndrome (1 study), 14 had elevated intraocular pressure (IOP) (2 studies), 18 had macular edema (3 studies) and 15 had poor visual acuity (3 studies). Similarly, six studies comparing vancomycin with control groups found any significant changes in IOP, endothelial cell density, anterior chamber inflammation, corneal edema, or macular edema. However, a case series reported 36 eyes with vancomycin-associated hemorrhagic occlusive retinal vasculitis resulting in worse visual acuity.(Bowen et al., 2018) The review was judged to be at a high risk of bias.

Two studies reported no significant difference between perioperative prophylaxis and no prophylaxis. One study compared irrigation with antibiotics in a balanced salt solution (BSS) with BSS but was not powered sufficiently to detect statistical differences. One study found a reduced risk of endophthalmitis after treatment with intracameral cefuroxime and topical levofloxacin (risk ratio (RR) 0.14, 95% confidence interval (CI) 0.03 to 0.63, n=8,106 participants; high-certainty evidence) or treatment with intracameral cefuroxime alone (RR 0.21, 95% CI 0.06 to 0.74; n=8,110 participants; high-certainty evidence). Two studies reported that a reduced risk of endophthalmitis was observed when combining chloramphenicol-sulfadimidine drops with periocular penicillin compared with topical antibiotics alone (periocular penicillin and topical chloramphenicol-sulfadimidine: RR 0.33, 95% CI 0.12 to 0.92, n=6,618 participants; moderate-certainty evidence) and (intracameral cefuroxime and topical levofloxacin: RR 0.20, 95% CI 0.04 to 0.91; n=8,101

participants; high-certainty evidence). Two studies reported data for visual acuity. One study compared fixed combination with separate instillation of gatifloxacin and prednisolone, which reported that mean visual acuity was the same for both groups at 20 days post-operation. Another study reported no difference in the proportion of eyes with final visual acuity greater than 20/40 following endophthalmitis between groups receiving intracameral cefuroxime with or without topical levofloxacin compared with no intracameral cefuroxime (RR 0.69, 95% CI 0.22 to 2.11; 29 participants; moderate-certainty evidence). None of the studies reported quality of life or economic outcomes in either of the intervention groups.(Gower et al., 2017) The review was judged to be at a low risk of bias.

In a pooled analysis, compared to no intervention group, the rate of postoperative endophthalmitis was lower in the intracameral vancomycin/moxifloxacin group (odds ratio (OR) 0.20, 95% confidence interval CI 0.10,0.42). No difference was observed between subconjunctival injection of antibiotics with the use of other drug administration routes (risk ratio (RR) 1.67, 95% CI 0.55, 5.05). Topical antibiotics significantly reduced the rate of endophthalmitis as compared to no intervention groups (RR 0.65, 95% CI 0.43, 0.99). However, no statistically significant difference was found in microbial isolation rates (RR 0.77, 95% CI 0.34, 1.75). Compared to short-term use of topical antibiotics, long-term use before surgery resulted in a lower risk of microbial isolation rates (RR 0.57, 95% CI 0.44, 0.74).(Huang et al., 2016) The review was judged to be at a high risk of bias.

Finally, a review reported that the prevalence of endophthalmitis differed across continents, neighboring countries and even within the same country. The pooled estimate of 22 studies reported that the use of intracameral antibiotics significantly reduced the endophthalmitis rate when compared to no use of intracameral antibiotic prophylaxis (risk ratio (RR) 0.12, 95% confidence interval (CI) 0.08 to 0.18, n=91,893 participants). For non-randomized controlled trials, the risk of endophthalmitis was significantly reduced to: 0.10 (0.06 to 0.17, 3 studies, n=93,757 participants) in patients receiving cefazolin, 0.09 (0.05 to 0.15, 10 studies, n=944,173 participants) in patients receiving cefuroxime, 0.22 (0.10 to 0.50, 5 studies, n=116,149 participants) in patients receiving moxifloxacin and no significant difference was observed with vancomycin (RR 0.30, 95% 0.02 to 3.90, 3 studies, n = 918893 participants) when compared to no intracameral antibiotic prophylaxis. There was no significant difference in terms of occurrence of endophthalmitis between prophylactic topical antibiotic therapy and no intracameral antibiotic prophylaxis (RR 0.84, 95% CI 0.44 to 1.59, 2 studies, n=31,465 participants).(Kessel et al., 2015d) The review was judged to be at a high risk of bias.

The pooled estimated incidence of endophthalmitis was 0.107% (95% confidence interval (CI) 0.097% to 0.116%). The estimate after sensitivity analysis was 0.092% (95% CI 0.083% to 0.101%). The incidence appeared to decrease with time (before 2000: 0.097%, 95% CI 0.060% to 0.135%; 2000 to 2010: 0.089%, 95% CI 0.076% to

0.101%; after 2010: 0.063%, 95% CI 0.050% to 0.077%). The incidence of endophthalmitis in patients who received typical povidone-iodine solution was (0.178%, 95% CI 0.071% to 0.285%) and antibiotics subconjunctival injections (0.047%, 95% CI 0.001% to 0.095%). Lower incidence of endophthalmitis was observed among those who received intramural antibiotics (0.045%, 95% CI 0.034% to 0.055%, risk ratio (RR) 7.942, 95% CI 4.510 to 13.985).(Shi et al., 2022) The review was judged to be at a high risk of bias.

A meta-analysis of five studies showed that compared with intracameral without cefuroxime injection, intracameral cefuroxime injection reduced the incidence of endophthalmitis after cataract surgery (odds ratio (OR) 0.11, 95% confidenceinterval (CI) 0.07 to 0. 18). The quality of the included studies was high (median of 6 out of 9 on the Newcastle-OttawaScale). (Wu and Jiang, 2015) The review was judged to be at a high risk of bias.

**Key articles**

There was one key article selected.

This was a prospective randomized multicentre trial consisting of 16603 patients undergoing cataract surgery aimed to identify risk factors and to describe the effects of antibiotic prophylaxis on the incidence of postoperative endophthalmitis after cataract surgery. There were 29 patients diagnosed with endophthalmitis, 20 of which had proven infective endophthalmitis. Undergoing cataract surgery without a prophylactic intracameral injection of cefuroxime at 1 mg in 0.1 mL, normal saline had a 4.92-fold increase (95% CI, 1.87-12.9) in the total risk for endophthalmitis postoperatively. The use of clear corneal incisions resulted in a 5.88-fold increase in risk (95% CI, 1.34-25.9) compared to scleral tunnels. Using silicone-based intraocular lenses resulted in a 3.13-fold increase in risk (95% CI, 1.47-6.67) compared to acrylic-based lenses. In the event of surgical complications, the total risk for endophthalmitis increased 4.95-fold (95% CI, 1.68-14.6). The risk for proven infective endophthalmitis was significantly higher in the absence of cefuroxime and silicone optic material use.(Endophthalmitis Study Group and European Society of Cataract and Refractive Surgeons, 2007)

# GRADE Tables

## Cefazolin compared to no intervention for prevention of endophthalmitis after cataract surgery

**Bibliography:** Kessel L, Flesner P, Andresen J, Erngaard D, Tendal B, Hjortdal J. Antibiotic prevention of postcataract endophthalmitis: a systematic review and meta-analysis. Acta Ophthalmol. 2015 Jun;93(4):303-17.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With no intervention | With cefazolin | | Risk with no intervention | Risk difference with cefazolin |
| **incidence of endopthalmitis** | | | | | | | | | | | |
| 93757 (3 observational studies) | serious[a] | not serious | not serious | not serious | none | ⨁◯◯◯ Very low | 120/47165 (0.3%) | 15/46592 (0.0%) | **RR 0.10** (0.06 to 0.17) | 254 per 100,000 | **229 fewer per 100,000** (from 239 fewer to 211 fewer) |

**CI:** confidence interval; **RR:** risk ratio

**Explanations**

a. high risk of bias of the observational included studies.

## Cefuroxime injection compared to placebo for prevention of endophthalmitis after cataract surgery

**Bibliography:** Endophthalmitis Study Group, European Society of Cataract & Refractive Surgeons. Prophylaxis of postoperative endophthalmitis following cataract surgery: results of the ESCRS multicenter study and identification of risk factors. J Cataract Refract Surg. 2007 Jun;33(6):978-88.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With placebo | With cefuroxime injection | | Risk with placebo | Risk difference with cefuroxime injection |
| **incidence of endophtalmitis** | | | | | | | | | | | |
| 16211 (1 RCT) | not serious | not serious | not serious | very serious[a] | none | ⨁⨁◯◯ Low | 24/8103 (0.3%) | 5/8108 (0.1%) | **OR 0.21** (0.08 to 0.54) | 3 per 1,000 | **2 fewer per 1,000** (from 3 fewer to 1 fewer) |

**CI:** confidence interval; **OR:** odds ratio

**Explanations**

a. Results from a single study

## Cefuroxime compared to no cefuroxime for prevention of endophtalmitis after cataract surgery

**Bibliography:** Bowen RC, Zhou AX, Bondalapati S, Lawyer TW, Snow KB, Evans PR, Bardsley T, McFarland M, Kliethermes M, Shi D, Mamalis CA, Greene T, Rudnisky CJ, Ambati BK. Comparative analysis of the safety and efficacy of intracameral cefuroxime, moxifloxacin and vancomycin at the end of cataract surgery: a meta-analysis. Br J Ophthalmol. 2018 Sep;102(9):1268-1276.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With no cefuroxime | With cefuroxime | | Risk with no cefuroxime | Risk difference with cefuroxime |
| **Incidence of endothalmitis** | | | | | | | | | | | |
| 474870 (9 observational studies) | serious[a] | serious[b] | not serious | not serious | none | ⨁◯◯◯ Very low | 312/317386 (0.1%) | 50/157484 (0.0%) | **OR 0.26** (0.15 to 0.45) | 983 per 1,000,000 | **727 fewer per 1,000,000** (from 835 fewer to 540 fewer) |

**CI:** confidence interval; **OR:** odds ratio

**Explanations**
a. High risk of bias of the observational included studies.
b. Significant statistical heterogeneity detected.

## Levofloxacin compared to placebo for prevention of endophtalmitis after cataract surgery

**Bibliography:** Endophthalmitis Study Group, European Society of Cataract & Refractive Surgeons. Prophylaxis of postoperative endophthalmitis following cataract surgery: results of the ESCRS multicenter study and identification of risk factors. J Cataract Refract Surg. 2007 Jun;33(6):978-88.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With placebo | With levofloxacin | | Risk with placebo | Risk difference with levofloxacin |
| **endopthalmitis** | | | | | | | | | | | |
| 16182 (1 RCT) | not serious | not serious | not serious | serious[a] | none | ⨁⨁⨁◯ Moderate | 17/8093 (0.2%) | 12/8089 (0.1%) | **RR 0.71** (0.34 to 1.48) | 2 per 1,000 | **1 fewer per 1,000** (from 1 fewer to 1 more) |

**CI:** confidence interval; **RR:** risk ratio

**Explanations**
a. results from a single study

## Moxifloxacin Injection compared to controls or no intervention for prevention of endophtalmitis after cataract surgery

**Bibliography:** Wang XL, Huang XY, Wang Z, Sun W. The Anterior Chamber Injection of Moxifloxacin Injection to Prevent Endophthalmitis after Cataract Surgery: A Meta-analysis. J Ophthalmol. 2020 Aug 25;2020:7242969.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With controls or no intervention | With Moxifloxacin Injection | | Risk with controls or no intervention | Risk difference with Moxifloxacin Injection |
| **incidence of endophthalmitis** | | | | | | | | | | | |
| 123559 (5 observational studies) | serious[a] | not serious | serious[b] | not serious | none | ⨁◯◯◯ Very low | 41/64607 (0.1%) | 11/58952 (0.0%) | **OR 0.29** (0.15 to 0.56) | 63 per 100,000 | **45 fewer per 100,000** (from 54 fewer to 28 fewer) |

## Moxifloxacin Injection compared to controls or no intervention for prevention of endophthalmitis after cataract surgery

**Bibliography:** Wang XL, Huang XY, Wang Z, Sun W. The Anterior Chamber Injection of Moxifloxacin Injection to Prevent Endophthalmitis after Cataract Surgery: A Meta-analysis. J Ophthalmol. 2020 Aug 25;2020:7242969.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **UCVA** | | | | | | | | | | | |
| 195 (2 observational studies) | serious[a] | serious[c] | serious[b] | serious[d] | none | ⊕◯◯◯ Very low | 100 | 95 | - | - | SMD **0.13 SD lower** (0.62 lower to 0.35 higher) |
| **BCVA** | | | | | | | | | | | |
| 203 (2 observational studies) | serious[a] | serious[c] | not serious | serious[d] | none | ⊕◯◯◯ Very low | 101 | 102 | - | - | SMD **0.27 SD lower** (1.28 lower to 0.74 higher) |
| **IOP** | | | | | | | | | | | |
| 3900 (4 observational studies) | serious[a] | not serious | serious[b] | not serious | none | ⊕◯◯◯ Very low | 1954 | 1946 | - | - | SMD **0.04 SD higher** (0.02 lower to 0.1 higher) |
| **Corneal edema** | | | | | | | | | | | |
| 122 (2 observational studies) | serious[a] | not serious | serious[b] | serious[d] | none | ⊕◯◯◯ Very low | 3/63 (4.8%) | 3/59 (5.1%) | **OR 1.03** (0.23 to 4.69) | 48 per 1,000 | **1 more per 1,000** (from 36 fewer to 142 more) |
| **Corneal centre thickness** | | | | | | | | | | | |
| 3835 (3 observational studies) | serious[a] | not serious | serious[b] | not serious | none | ⊕◯◯◯ Very low | 1922 | 1913 | - | - | SMD **0.01 SD lower** (0.07 lower to 0.05 higher) |
| **Endothelial cell density** | | | | | | | | | | | |
| 3835 (3 observational studies) | serious[a] | not serious | serious[b] | not serious | none | ⊕◯◯◯ Very low | 1922 | 1913 | - | - | SMD **0 SD** (0.06 lower to 0.07 higher) |

**CI:** confidence interval; **OR:** odds ratio; **SMD:** standardised mean difference

**Explanations**
a. High risk of bias of the included observational studies.
b. Results from observational studies pooled together with RCTs
c. Significant statistical heterogeneity detected.
d. Small sample size

## Vancomycin compared to no vancomycin for prevention of endophthalmitis after cataract surgery

**Bibliography:** Bowen RC, Zhou AX, Bondalapati S, Lawyer TW, Snow KB, Evans PR, Bardsley T, McFarland M, Kliethermes M, Shi D, Mamalis CA, Greene T, Rudnisky CJ, Ambati BK. Comparative analysis of the safety and efficacy of intracameral cefuroxime, moxifloxacin and vancomycin at the end of cataract surgery: a meta-analysis. Br J Ophthalmol. 2018 Sep;102(9):1268-1276.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With no vanomycin | With vonomycin | | Risk with no vanomycin | Risk difference with vonomycin |
| **Incidence of endophthalmitis** | | | | | | | | | | | |
| 154699 (5 observational studies) | serious[a] | serious[b] | not serious | not serious | none | ⊕◯◯◯ Very low | 58/88805 (0.1%) | 7/65894 (0.0%) | **OR 0.09** (0.02 to 0.42) | 653 per 1,000,000 | **594 fewer per 1,000,000** (from 640 fewer to 379 fewer) |

**CI:** confidence interval; **OR:** odds ratio

**Explanations**
a. High risk of bias of the observational included studies.
b. Significant statistical heterogeneity detected.

## Intracameral antibiotics compared to no treatment for prevention of post-cataract endophthalmitis

**Bibliography:** Kessel, L., Flesner, P., Andresen, J., et al. 2015d. Antibiotic prevention of postcataract endophthalmitis: a systematic review and meta-analysis. Acta Ophthalmol, 93, 303-17.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With no treatment | With intracameral antibiotics | | Risk with no treatment | Risk difference with intracameral antibiotics |
| **Endophthalmitis** | | | | | | | | | | | |
| 1262183 (22 RCTs) | serious[a] | serious[b] | not serious | not serious | strong association | ⊕⊕⊕◯ Moderate | 421/245796 (0.2%) | 4/1016387 (0.0%) | **RR 0.12** (0.08 to 0.18) | 1,713 per 1,000,000 | **1,507 fewer per 1,000,000** (from 1,576 fewer to 1,404 fewer) |

**CI:** confidence interval; **RR:** risk ratio

**Explanations**
a. Results from observational studies pooled together with RCTs
b. High amount of statistical heterogeneity detected.

### 7.4.1 References


Bowen, R. C., Zhou, A. X., Bondalapati, S., et al. 2018. Comparative analysis of the safety and efficacy of intracameral cefuroxime, moxifloxacin and vancomycin at the end of cataract surgery: a meta-analysis. *Br J Ophthalmol,* 102**,** 1268-76.

Endophthalmitis Study Group & European Society of Cataract and Refractive Surgeons 2007. Prophylaxis of postoperative endophthalmitis following cataract surgery: results of the ESCRS multicenter study and identification of risk factors. *Journal of Cataract & Refractive Surgery,* 33**,** 978-88.

Gower, E. W., Lindsley, K., Tulenko, S. E., et al. 2017. Perioperative antibiotics for prevention of acute endophthalmitis after cataract surgery. *Cochrane Database of Systematic Reviews.*

Huang, J., Wang, X., Chen, X., et al. 2016. Perioperative antibiotics to prevent acute endophthalmitis after ophthalmic surgery: a systematic review and meta-analysis. *PLoS One,* 11**,** e0166141.

Kanclerz, P. & Myers, W. G. 2022. Chlorhexidine and other alternatives for povidone-iodine in ophthalmic surgery: review of comparative studies. *J Cataract Refract Surg,* 48**,** 363-369.

Kessel, L., Flesner, P., Andresen, J., et al. 2015d. Antibiotic prevention of postcataract endophthalmitis: a systematic review and meta-analysis. *Acta Ophthalmol,* 93**,** 303-17.

Koerner, J. C., George, M. J., Meyer, D. R., et al. 2018. Povidone-iodine concentration and dosing in cataract surgery. *Surv Ophthalmol,* 63**,** 862-868.

Rana, K., Bahrami, B., van Zyl, L., et al. 2021. Efficacy of intracameral antibiotics following manual small incision cataract surgery in reducing the rates of endophthalmitis: a meta-analysis. *Clin Exp Ophthalmol,* 49**,** 25-37.
Shi, S. L., Yu, X. N., Cui, Y. L., et al. 2022. Incidence of endophthalmitis after phacoemulsification cataract surgery: a meta-analysis. *Int J Ophthalmol,* 15**,** 327-35.
Shimada, H. & Nakashizuka, H. 2021. Cataract surgery by intraoperative surface irrigation with 0.25% povidone-iodine. *J Clin Med,* 10.
Wang, X. L., Huang, X. Y., Wang, Z. & Sun, W. 2020. The anterior chamber injection of moxifloxacin injection to prevent endophthalmitis after cataract surgery: a meta-analysis. *J Ophthalmol***,** 7242969.
Wu, X. Y. & Jiang, L. Z. 2015. [Effects of intracameral cefuroxime injection on the prophylaxis of endophthalmitis after cataract surgeries: a meta-analysis]. *Int Eye Sci,* 15**,** 1753-56.

## 7.5 Inflammation prophylaxis in routine cataract surgery

What prophylaxis should be used in cataract surgery to minimise the risk of postoperative inflammation?

What is the most effective treatment to reduce postoperative inflammation after cataract surgery and reduce the risk of cystoid macular edema (CME)?

> **P:** Adult patients who will undergo routine cataract surgery
> **I:** Treatment regime A
> **C:** Treatment regime B
> **O:** (Serious) adverse events (Inflammation, central retinal thickness (CRT), cystoid macular edema (CME)), visual acuity, quality of vision, quality of life.

Treatment regimens include:

- Steroids
- NSAIDs
- Steroids and NSAIDs

Is it equally effective to give inflammatory prophylaxis perioperatively ('dropless cataract surgery') so that patients do not have to drip at home?

> **P:** Adult patients who will undergo cataract surgery (non-diabetic patients)
> **I:** Topical treatment of steroids, NSAIDs or both
> **C:** Dropless treatment (Intracameral, subconjunctival)
> **O:** (Serious) adverse events (Inflammation, CRT, CME, visual acuity, quality of vision, quality of life.

**Recommendation**

A combination of NSAIDs and corticosteroid eye drops is more effective to use after routine cataract surgery to prevent inflammation and CME compared to monotherapy. (GRADE +/++)

It is currently unclear whether dropless inflammatory prophylaxis is as safe and effective as topical inflammatory prophylaxis to prevent CME and inflammation after cataract surgery. (GRADE +/++)

## Considerations

Treatment to prevent postoperative inflammation and CME after routine cataract surgery

Corticosteroids and non-steroidal anti-inflammatory drugs (NSAIDs) are currently used to reduce the risk of CME and inflammation after cataract surgery. There are several practice regimens available, including the use of NSAIDs or corticosteroids alone, and a combination therapy of NSAIDs and corticosteroids. (Coassin et al., 2019)

Studies have shown that the use of NSAIDs is associated with a lower incidence of CME, compared to corticosteroid drops alone, when measured 1 month after cataract surgery.(Lim et al., 2016, Juthani et al., 2017, Coassin et al., 2019, Wielders et al., 2018a, Ylinen et al., 2018) The number of cells in the anterior chamber did not differ between NSAIDs or corticosteroid use after 1 week, but the use of NSAIDs resulted in significantly less flare after 1 week. (Coassin et al., 2019, Juthani et al., 2017, Ylinen et al., 2018)

In comparison to NSAIDs or corticosteroid monotherapy, the combination therapy of NSAIDS and corticosteroids was associated with a lower incidence of CME 1 month postoperatively.(Wielders et al., 2018a, Ylinen et al., 2018) Additionally, the reported central retinal thickness (CRT) was lower in the combination therapy group when compared to the corticosteroid monotherapy.(Lim et al., 2016) Flare was also less when using the combination therapy compared to corticosteroid monotherapy after 1 week.(Ylinen et al., 2018) However, other studies did not show a superiority of combination therapy with NSAIDs and corticosteroids compared to NSAIDs monotherapy. A sub-tenon injection of 0.5 ml of 4mg/ml showed an increase in CRT as compared to topical therapy.(Erichsen et al., 2021a, Erichsen et al., 2021b) Variability in outcomes between studies has been shown when comparing effects of combination therapy with NSAIDs and corticosteroids vs. NSAIDs monotherapy on CRT.(Erichsen et al., 2021a, Erichsen et al., 2021b)

Dropless cataract surgery

Topical treatments for cataract surgery are only effective if the patient is compliant with the treatment regimen. To overcome this, dropless cataract surgery has emerged as a potential alternative. Various dropless strategies have been compared with conventional postoperative corticosteroid eye drops in studies, including:

- Perioperative subconjunctival injection of betamethasone acetate (5.7mg/mL) compared to dexamethasone 0.1% eye drops (Dieleman et al., 2011)

- Intravitreal 0.2mL injection of triamcinolone acetonide (0.3mg), moxifloxacin (0.2mg) and vancomycin (2.0mg) (Tyson et al., 2017)
- Intra-operative subconjunctival injection of 2mg triamcinolone acetonide compared to prednisolone acetate eye drops alone or in combination with NSAIDs (Shorstein et al., 2015)
- Transzonular injection of 3mg triamcinolone-moxifloxacin compared to polymyxin b/trimethoprim and prednisolone acetate 1% (Singhal et al., 2019)
- Perioperative subconjunctival injection of triamcinolone 20mg compard to dexamethasone eye drops 1mg/ml (Lindholm et al., 2020)
- Sub-tenon triamcinolone injection (40mg/mL) compared to 0.1% dexamethasone eye drops (Khan et al., 2016)
- Subconjunctival injection of 20mg methylprednisolone compared to conventional dexamethasone 1mg/ml eye drops postoperatively.(Merkoudis et al., 2014)

Studies have reported no significant difference in the development of CME between dropless therapy and conventional therapy at 4-6 weeks postoperatively.(Dieleman et al., 2011, Shorstein et al., 2015, Singhal et al., 2019) However, there were discrepancies in the CRT observed between the two treatments at the same time period. Additionally, the studies showed variable results in CRT and CME at one month postoperatively. (Dieleman et al., 2011, Lindholm et al., 2020)

Perioperative injections seemed to be as effective as the conventional medication strategy in terms of flare one month postoperatively.(Dieleman et al., 2011, Shorstein et al., 2015, Singhal et al., 2019, Tyson et al., 2017) In terms of inflammation indicators such as cell presence in the anterior chamber during the initial postoperative period, no statistically significant variance in cell count was observed in any of the studies within the first 1-2 weeks. However, disparities were observed in the incidence of cells in the anterior chamber following both conventional and dropless therapies.(Dieleman et al., 2011, Khan et al., 2016, Lindholm et al., 2020, Merkoudis et al., 2014)

Studies reported no significant difference in flare during the first 2 weeks after surgery or 4-6 weeks after surgery.(Dieleman et al., 2011, Khan et al., 2016, Lindholm et al., 2020) The current literature states that it is still unclear whether a single perioperative injection treatment is equally effective compared to the postoperative corticosteroid eye drops for preventing CME and postoperative retinal thickness. However, a single perioperative corticosteroid injection appears to be equally effective in reducing general inflammation signs, including cells in the anterior chamber and flare, compared to conventional postoperative corticosteroid eye drops. Nevertheless, further research is needed to determine the specific administration methods, medication, and dosage for this approach. The current available literature contains a high degree of variability among the compared strategies. Whether the inflammatory prophylaxis is comparable to traditional topical therapy postoperatively is uncertain. Dropless cataract surgery can be useful in

some cases where the practical advantages (no postoperative topical medication) are deemed to outweigh the possible disadvantages. (Expert opinion)

Periocular injections of depot corticosteroids may result in an increased risk of elevated intraocular pressure (IOP) that lasts longer than the use of topical corticosteroids. Therefore, additional monitoring of the IOP is recommended if an elevated IOP occurs after one month postoperatively.(Merkoudis et al., 2014) Currently, there is insufficient evidence to establish a correlation between the safety and efficacy of the effects and the dose of periocular steroids applied.

## Conclusion

Implications for practice

Based on available evidence it is recommended to use a combination of NSAIDs and corticosteroid eye drops after routine cataract surgery to prevent inflammation and CME. It is still unclear which dropless medication strategy matches topical inflammatory prophylaxis in terms of safety and efficacy. In patients with an anticipated poor compliance, dropless cataract surgery can be considered.

Knowledge gaps

The optimal dropless cataract surgery strategy needs to be defined. The ESCRS Effectiveness of Periocular drug Injection in CATaract surgery (EPICAT) study is designed to provide insights into this knowledge gap.

## Identified research evidence

### Findings from Systematic Reviews

Three relevant systematic reviews were identified.

Pooled analysis showed no difference in mean cell value compared with the participants receiving a corticosteroid (mean difference (MD) -0.60, 95% confidence interval (CI) -2.19 to 0.99; three studies), and five studies showed that the mean flare value was lower in the group receiving non-steroidal anti-inflammatory drugs (NSAIDs) (MD -13.74, 95% CI -21.45 to -6.04). Uncertainty, whether the risk of edema was higher or lower in the group that received NSAIDs, was present in one study reporting on corneal edema at one week postoperatively (risk ratio (RR) 0.77, 95% CI 0.26 to 2.29). Four studies reported that at one month, participants treated with an NSAID alone had a lower risk of developing cystoid macular edema (CME) compared with those treated with a corticosteroid alone (RR 0.26, 95% CI 0.17 to 0.41). One study reported that postoperative treatment did not favour combination treatment with an NSAID plus corticosteroid or with corticosteroid alone (RR 1.07,

95% CI 0.98 to 1.16). Two studies showed that there was a lower risk of CME in the group that received NSAIDs plus corticosteroids (RR 0.17, 95% CI 0.03 to 0.97). Seven studies reported a lower risk of CME in participants receiving an NSAID plus a corticosteroid compared with those receiving a corticosteroid alone (RR 0.50, 95% CI 0.23 to 1.06). The few adverse events reported were due to phacoemulsification rather than the eye drops. (Juthani et al., 2017) The review was judged to be at a high risk of bias.

The pooled analyses reported a lower risk of poor vision due to macular edema with NSAIDs combined with steroids at three months after surgery compared to steroids alone (risk ratio [RR] 0.41, 95% confidence interval [CI] 0.23 to 0.76, 5 trials, n=1360 eyes). (Lim et al., 2016) The pooled analyses reported that a change in macular volume was in favour of the NSAIDs plus steroids compared to the steroids alone (mean difference [MD] -0.14, 95% CI -0.21 to -0.07, 6 trials, n=570 eyes). The pooled analyses reported macular edema was in favour of prophylactic NSAIDs compared to steroids (RR 0.27, 95% CI 0.18 to 0.41, 5 trials, n=520 eyes). The pooled analyses reported that macular edema was in favour of NSAIDs plus steroids compared to steroids after cataract surgery (RR 0.40, 95% CI 0.32 to 0.49, 21 trials, n=3638 eyes). The pooled analyses reported that inflammation (flare) (MD -1.41, 95% CI -2.30 to -0.52, 2 trials, n= 216 eyes) and central retinal thickness (MD -22.64, 95% CI -38.86 to -6.43, 2 trials, n=121 eyes) was in favour of NSAIDs plus steroids compared to steroids after cataract surgery. None of the studies reported resource use and costs. (Lim et al., 2016) The review was judged to be at a low risk of bias.

The pooled analysis of 3 trials reported that topical nonsteroidal anti-inflammatory drugs (NSAIDs) significantly reduced the odds of developing cystoid macular edema (CME) after cataract surgery in non-diabetic patients, when compared to topical corticosteroids (odds ratio (OR)=0.11, 95% confidence intervals (CI), 0.03 to 0.37). The pooled estimate of four trials showed fewer odds of developing CME with a combination of topical corticosteroids and topical NSAIDs, compared to topical corticosteroids as a single-drug treatment in non-diabetic patients (OR=0.21, 95% CI, 0.10 to 0.44). Meta-analysis of three studies reported that topical NSAIDs significantly reduced the odds of developing CME after cataract surgery in mixed populations including both diabetic and non-diabetic subjects, compared to topical corticosteroids (OR=0.05, 95% CI, 0.02 to 0.11). Two trials showed that a combination of topical corticosteroids and NSAIDs significantly reduced the postoperative change in macular volume (MV) in mixed populations compared to topical corticosteroids as a single-drug treatment (mean difference (MD)=-0.25 cubic mm, 95% CI, -0.36 cubic mm to -0.13 cubic mm). One trial reported that a combination of topical corticosteroids and topical NSAIDs reduced the odds of developing CME after cataract surgery in diabetic patients when compared to topical corticosteroids as a single-drug treatment (OR=0.17, 95% CI, 0.05 to 0.50). Two trials suggested that intravitreal anti-vascular endothelial growth factor (VEGF) injections at the end of cataract surgery did not cause a statistically significant

reduction in the odds of developing CME, when compared to placebo (OR=0.68, 95% CI, 0.21 to 2.19) or as an additional treatment to topical corticosteroids (OR=0.13, 95% CI, 0.02 to 1.21) (Wielders et al., 2018a) The review was judged to be at a high risk of bias.

### Non-steroidal anti-inflammatory drugs plus steroids compared to steroids for prevention of macular oedema after cataract surgery

**Bibliography: Lim BX, Lim CHL, Lim DK, Evans JR, Bunce C, Wormald R. Prophylactic non-steroidal anti-inflammatory drugs for the prevention of macular oedema after cataract surgery. Cochrane Database Syst Rev 2016, Issue 11. Art. No.: CD006683. DOI: 10.1002/14651858.CD006683.pub3**

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Study event rates (%) | | | Anticipated absolute effects | |
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | With steroids | With non-steroidal anti-inflammatory drugs plus steroids | Relative effect (95% CI) | Risk with steroids | Risk difference with non-steroidal anti-inflammatory drugs plus steroids |
| **Poor vision due to macular oedema at 3 months after surgery** | | | | | | | | | | | |
| 1360 (5 RCTs) | serious[a] | not serious | serious[b] | not serious | none | ⨁⨁◯◯ Low | 36/767 (4.7%) | 44/593 (7.4%) | **RR 0.41** (0.23 to 0.76) | 47 per 1.000 | **28 fewer per 1.000** (from 36 fewer to 11 fewer) |
| **Poor vision due to macular oedema at 12 months after surgery** | | | | | | | | | | | |
| 88 (1 RCT) | very serious[a] | not serious | not serious | serious[c] | none | ⨁◯◯◯ Very low | 1/38 (2.6%) | 1/50 (2.0%) | **RR 1.32** (0.09 to 20.37) | 26 per 1.000 | **8 more per 1.000** (from 24 fewer to 510 more) |
| **Quality of life at 3 months after surgery (assessed with: COMTOL questionnaire)** | | | | | | | | | | | |
| 108 (1 RCT) | very serious[d] | not serious | not serious | serious[c] | none | ⨁◯◯◯ Very low | Data not fully reported but no between-groups differences in terms of quality of life, compliance and satisfaction scores. | | | | |
| **Central retinal thickness at 3 months after surgery (assessed with: optical coherence tomography)** | | | | | | | | | | | |
| 0 (8 RCTs) | very serious[a] | serious[e] | serious[b] | not serious | none | ⨁◯◯◯ Very low | Results ranged from -30.9 microns in favour of NSAIDs plus steroids to +7.44 microns in favour of steroids alone. | | | | |
| **Macular oedema at 3 months after cataract surgery, clinically symptomatic (assessed with: optical coherence tomography)** | | | | | | | | | | | |
| 3638 (21 RCTs) | very serious[a] | not serious | not serious | not serious | publication bias strongly suspected[f] | ⨁◯◯◯ Very low | 114/1981 (5.8%) | 213/1657 (12.9%) | **RR 0.40** (0.32 to 0.49) | 58 per 1.000 | **35 fewer per 1.000** (from 39 fewer to 29 fewer) |
| **best corrected visual acuity at 3 months after surgery (assessed with: log MAR scale from: -1.3 to 1.3)** | | | | | | | | | | | |

**Non-steroidal anti-inflammatory drugs plus steroids compared to steroids for prevention of macular oedema after cataract surgery**

**Bibliography: Lim BX, Lim CHL, Lim DK, Evans JR, Bunce C, Wormald R. Prophylactic non-steroidal anti-inflammatory drugs for the prevention of macular oedema after cataract surgery. Cochrane Database Syst Rev 2016, Issue 11. Art. No.: CD006683. DOI: 10.1002/14651858.CD006683.pub3**

| Certainty assessment | | | | | | | Summary of findings |
|---|---|---|---|---|---|---|---|
| 738 (10 RCTs) | very serious[a] | serious[e] | not serious | not serious | none | ⨁◯◯◯ Very low | All except one study found differences less than 0.1 logMAR, i.e. not clinically important |

**CI:** confidence interval; **RR:** risk ratio

Explanations

a. Unclear or high risk of bias of the included studies.
b. Outcome measure not always clearly defined
c. Small sample size, results from a single study
d. High risk of bias including selective reporting
e. Significant statistical heterogeneity detected.
f. Asymmetrical funnel plot

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## 7.6 Medication for ocular comorbidities in cataract surgery

**Output question**

What is the optimal intra- and postoperative medication regimen for patients with other ocular pathologies who undergo cataract surgery?

**P:** Adult patients with other ocular pathologies who undergo cataract surgery
**I:** Specific treatment for different ocular pathologies
**C:** Standard treatment during cataract surgery pathway
**O:** (Serious) adverse events (Incidence rate of macular edema), visual outcomes, CDVA, PROM

<u>Included ocular pathologies</u>

- Diabetic retinopathy
- Retinal diseases (AMD, epiretinal membrane)
- Uveitis
- Glaucoma
- DED

**Recommendation**

Diabetes and diabetic retinopathy

In diabetic patients without diabetic retinopathy, it is recommended to use a combination of corticosteroid and non-steroidal anti-inflammatory drug (NSAID) eye drops to prevent cystoid macular edema. (GRADE +/++)

In patients with diabetic retinopathy, a supplementary depot of triamcinolone should be considered to reduce this risk. Intraocular pressure must be monitored postoperatively when using a triamcinolone depot. (GRADE +)

Literature reports discrepancies whether anti-VEGF intravitreal intervention has no effect in preventing the occurrence of CME after cataract surgery in patients with diabetes. (GRADE +/++)

Retinal diseases

In patients with retinal diseases, topical NSAIDs should be used, and only in selected cases intravitreal anti-vascular endothelial growth factor (VEGF) injections could be considered. (GRADE +)

Uveitis

In patients with uveitis, an increased frequency and prolonged treatment with steroids is suggested. Oral steroids should be applied only in specific cases. (GRADE +)

Glaucoma

Glaucoma patients should receive carbonic anhydrase inhibitors postoperatively to minimize the potential increase in intraocular pressure (IOP) after surgery. A follow-up visit within one day after surgery is essential to monitor and control IOP. (GRADE +)

Oral acetazolamide administration postoperatively can be considered to reduce IOP elevation after cataract surgery. (GRADE +)

DED

Patients with dry eye disease should use artificial tears both before and after surgery to manage symptoms and optimize ocular surface health. (GRADE +/++)

**Considerations**

Diabetes and diabetic retinopathy

Patients with diabetes mellitus are known to have an increased susceptibility to developing CME following cataract surgery, even in the absence of concomitant diabetic retinopathy. (Chu et al., 2016a, Shakarchi et al., 2023) The use of topical corticosteroids and NSAIDs has been shown to significantly reduce the risk of CME development in this population. Research indicates that a single subconjunctival injection of triamcinolone acetonide can significantly decrease the risk of CME development within three months following cataract surgery in patients with diabetes, hence potential risk of elevated intraocular pressure has to be considered. The use of depot steroids in conjunction with topical steroids may be preferable to topical steroids alone in diabetic patients.(Wielders et al., 2018b)

Regarding additional anti-VEGF injections, discrepancies exist in the literature. Some studies have suggested that the use of an intravitreal injection with 1.25mg bevacizumab did not yield any significant reduction in postoperative macular thickness and volume in the diabetic population. (Wielders et al., 2018b, Laursen et al., 2019) Other studies have reported that anti-VEGFs provided only short-term structural protection for one month in patients receiving cataract surgery, which reverted to baseline after three months (Hsu et al., 2022), while others have suggested that intravitreal bevacizumab injection in combination with cataract surgery appears to be effective for patients with coexisting diabetic retinopathy. (Feng et al., 2019)

Moreover, further studies suggest that the use of additional NSAIDs and anti-VEGF may be more effective in preventing CME after cataract surgery in diabetic patients when compared to topical corticosteroid therapy alone. (Zhang et al., 2022, Zhao and Cheng, 2019) However, regarding the treatment of CME in diabetics, results regarding combination therapy of steroids and anti-VEGF are heterogeneous, with some studies reporting no additional visual benefit of combination therapy compared to monotherapy for CME. (Mehta et al., 2018)

Based on the current available evidence, a combination of steroid and NSAID eye drops is recommended in patients with diabetes. For patients with diabetic retinopathy, a supplementary depot of triamcinolone can be considered to further reduce the risk of CME after cataract surgery. The optimal dose for prevention of CME while preventing IOP increase still needs to be defined. There is a lack of evidence to support the routine use of anti-VEGF in patients with diabetes. (Expert opinion)

<u>Retinal diseases</u>

The literature presents a significant debate surrounding whether cataract surgery causes the age-related macular degeneration (AMD) progression. (Casparis et al., 2017, Z. Chen et al., 2022b, Kessel et al., 2015c, Liu and Cai, 2020, Yang et al., 2022) In the context of neovascular AMD, an intravitreal anti-VEGF injection in the

weeks preceding the cataract surgery procedure is recommended. However, studies have demonstrated that patients who underwent cataract surgery within six months of initiating anti-VEGF therapy were more likely to experience vision loss, indicating that this should be avoided where possible. (Daien et al., 2018)

Regarding the timing of intravitreal anti-VEGF treatments before and after the cataract surgery, the literature suggests that injections delivered during the month prior to surgery yield positive surgical outcomes. Other studies have also investigated the risk of changes in the frequency of intravitreal anti-VEGF injections required for neovascular AMD in the 12 months after cataract surgery compared to the 12 months before the surgery. Results indicated that there were no differences in disease activity, and the number of intravitreal injections required were similar, suggesting that cataract surgery had no or only a modest influence on choroidal neovascularization activity.(Mehta, 2021)

Epiretinal membrane (ERM)

Epiretinal membranes (ERM) are a crucial risk factor for the occurrence of postoperative CME, particularly in cases of higher preoperative central macular thickness. In patients with significant impairment due to an ERM, cataract surgery may be performed in combination with a pars plana vitrectomy, either consecutively or simultaneously. Studies have shown that performing a pars plana vitrectomy before cataract surgery resulted in a better visual outcome, but a similar rate of CME relative to performing cataract surgery before a pars plana vitrectomy. (Y. C. Chen et al., 2022)

Uveitis

Effective management of inflammation is essential when performing cataract surgery in uveitis patients to achieve optimal visual outcomes and minimize the risk of postoperative complications. Cataract surgery conducted after a minimum of three months of inflammation control has been observed to result in more favorable outcomes. However, there is limited evidence available regarding the management of uveitis patients undergoing cataract surgery, and no consensus exists regarding the most effective method of controlling postoperative inflammation. In some situations, oral steroids have been used to control postoperative inflammation in cataract surgery patients. However, long-term systemic use of steroids may result in adverse effects. Recent studies suggest that the use of intravitreal injection of steroids or steroid implants may be beneficial in controlling postoperative inflammation, particularly in patients who cannot tolerate systemic therapy. These findings highlight the need for a more personalized approach to the management of uveitis patients undergoing cataract surgery. (Hsieh et al., 2023, Chen et al., 2019) Based on clinical experience, it is suggested to use an increased frequency and

prolonged treatment with steroids, supplemented in selected cases with oral steroids. (Expert opinion)

Glaucoma

Limited evidence was available considering the effect of eye-pressure reducing medication after cataract surgery. The use of acetazolamide preoperatively (carbonic anhydrase inhibitor) showed a short-term (1-24 hours) reduction in IOP elevation in patients with primary open angle glaucoma, but no significant difference was found long-term. The administration of acetazolamide 3 hours postoperatively reduced the IOP elevation at 5 hours or more after surgery. Studies suggest that carbonic anhydrase inhibitors after surgery are more effective than prostaglandins or beta blockers in eyes with glaucoma. (Hayashi et al., 2017) In glaucoma patients, the use of oral or topical carbonanhydrase inhibiters, as well as topical beta-blockers should be considered. (Expert opinion)

DED

Although cataract surgery yields excellent results in most patients, over one third of patients without preexisting DED subsequently developed DED after cataract surgery. Risk factors included age, female sex, systematic medication and diseases, psychiatric conditions, preservatives in topic medication, and meibomian gland dysfunction. The surgical procedure itself can incite and worsen dry eye due to antiseptic irritation, corneal wounds, corneal nerve damage, microscopic exposure times and the phacoemulsification energy. DED assessment prior to cataract surgery is warranted, particularly MGD which can be easily overlooked. (Miura et al., 2022) The mechanisms underlying DED development after cataract surgery could include tear film instability, corneal nerve plexus changes, and ocular surface inflammation. (Caretti et al., 2019) Various treatment regimens of artificial tears are effective in treating DED by improving tear-break-up time and tear film lipid layer. Preoperative meibomian gland massage can also assist in reducing postoperative DED symptoms. (Caretti et al., 2019, Kang et al., 2021, Sahu et al., 2015, Son et al., 2020)

## Conclusion

Implications for practice

In diabetic patients, a combination of corticosteroid and NSAID eye drops is recommended to prevent CME. A supplementary subconjunctival depot of triamcinolone at the end of the case should also be considered to further reduce this risk. In patients with glaucoma, postoperative carbonic anhydrase inhibitors are recommended to minimize an IOP peak after surgery. Patients with glaucoma should

receive a follow-up visit the first postoperative day to measure the IOP. For patients with DED, pre- and postoperative use of artificial tears are recommended.

Knowledge gaps

Additional research is needed to explore varying postoperative medication strategies for preventing cystoid macular edema (CME) in accordance with the stage of diabetic retinopathy. This will help tailor and enhance postoperative care. Furthermore, it is essential to establish the optimal dosage of triamcinolone for diabetic patients.

**Identified research evidence**

**Findings from Systematic Reviews**

Twelve relevant systematic reviews were included.

In the pooled analysis, for prevention of postoperative macular edema (PME) at one month after surgery, patients received additional topical NSAIDs (odds ratio (OR) 0.221, 95% confidence interval (CI) 0.044 −0.755), intravitreal anti-VEGF agents (OR 0.151, 95% CI 0.03−0.413) injection, intravitreal steroid injection, and subtenon steroid injection exhibited a significant lower risk of PME, compared to None/Topical Steroid. At three months after surgery, both additional topical NSAIDs (OR 0.370, 95% CI 0.140−0.875) and intravitreal anti-VEGF agents (OR 0.203, 95% CI 0.101 −0.353) were significantly effective. Such protective effect did not reach statistical significance at six months after surgery. BCVA at 1 week after surgery, neither additional topical NSAIDs (mean difference (MD) 0.065, 95% CI 0.17 to 0.035) nor intravitreal anti-VEGF agents (MD 0.014, 95% CI 0.092 to 0.059) showed superior BCVA outcome, compared to None/Topical Steroids. Compared to None/Topical Steroids, patients perioperatively treated with additional anti-VEGF have 0.083 MD (95% CI 0.17 to 0.014) of LogMAR at one month after surgery. At three months, patients treated with additional anti-VEGF have a lesser magnitude but significantly better BCVA than None/Topical Steroids (LogMAR MD 0.061, 95% CI 0.11 to 0.011). In contrast, additional NSAIDs did not show superior BCVA outcome than None/Topical Steroids at one month and three months.(Zhang et al., 2022) The review was judged to be at a high risk of bias.

In the pooled analysis, a lower incidence rate was reported of macular edema at 3 months post cataract surgery among the patients receiving topical NSAIDs eye drops compared to those receiving placebo or vehicle eye drops (risk ratio (RR) 0.26, 95% confidence interval (CI) 0.15~0.43). On the other hand, no significant difference was detected in the incidence rate of macular edema at three months after cataract surgery among patients receiving intravitreal anti-VEGF injections and patients receiving sham injections (RR 0.59, 95% CI 0.32~1.09). Moreover, patients receiving intravitreal anti-VEGF injections had a significantly higher incidence rate of

macular edema compared with patients receiving topical NSAIDs eye drops (RR 2.31, 95% CI 1.04~5.14). One month after cataract surgery, no significant difference was revealed in the BCVA change of patients receiving anti-VEGF injections and that of patients receiving sham injections (mean difference (MD) −0.48, 95% CI −1.12~0.16). No significant difference between the BCVA change of patients receiving intravitreal anti-VEGF injections three months after cataract surgery and that of patients receiving sham injections (MD −0.23, 95% CI −0.51~0.05). There was also no difference detected in the BCVA change at three months after cataract surgery between the patients receiving NSAIDs eye drops and those receiving placebo or vehicle eye drops (MD −0.02, 95% CI −0.30~0.26). No significant difference was noted between the BCVA change at three months after cataract surgery in the patients receiving intravitreal anti-VEGFs and those receiving NSAIDs eye drops (MD −0.21, 95% CI −0.61~-0.19).(Hsu et al., 2022) The review was judged to be at a unclear risk of bias.

Macular Thickness (MT) For non-proliferative diabetic retinopathy (NPDR) without Diabetic macular edema (DME): the mean MT at 1 month and 6 months postoperatively was statistically significantly less in the intravitreal bevacizumab (IVB) treatment group than the control group (one study). The MT at 1 week and 1, 3, and 6 months postoperatively were statistically significantly less in the IVB treatment group (four studies). For NPDR with DME: the mean MT at 1, 3, and 6 months postoperatively was statistically significantly less in the IVB treatment group than the control group (three studies). The mean MT at 1 week and 1, 3, and 6 months postoperatively were statistically significantly less in the IVB treatment group as well (two studies). In meta-analysis of two studies, there was no statistically significant difference of the mean MT in the two groups at 1 and 3 months postoperatively (weighted mean difference (WMD) −4.34, 95% confidence interval (CI) −39.49, 30.81) and (WMD −3.54, 95% CI −39.45, 32.36), respectively. However, at 6 months postoperatively, the mean MT was statistically significantly less in the IVB treatment group (WMD −40.18, 95% CI −77.01). BCVA For NPDR without DME: The mean BCVA was statistically significantly better in the IVB treatment group than that in the cataract surgery alone group at 1 month postoperatively, but the mean BCVA at 3 and 6 months postoperatively had no statistically significant difference in the two groups (one study). Three studies applying IVR revealed that the mean BCVA at 1 week postoperatively had no statistically significant difference in the two groups. At 1 and 3 months postoperatively, no statistically significant difference in LogMAR visual acuity (one study). In contrast, in a study which employed Snellen visual acuity (one study), the mean BCVA was statistically significantly better in the IVB treatment group. At 6 months postoperatively, the mean BCVA of two studies was statistically significantly better in the IVR treatment group. For NPDR with DME: the mean BCVA at 1 week postoperatively had no statistically significant difference

in the two groups, but at 1, 3, and 6 months postoperatively, the mean BCVA was statistically significantly better in the IVB treatment group than that in the cataract surgery alone group. Two studies applying IVR revealed that the mean BCVA at 1 week and 1, 3, and 6 months postoperatively was statistically significantly better in the IVB treatment group. In the pooled analysis, the mean BCVA was not statistically significantly different in both groups at 1, 3, and 6 months postoperatively (WMD −0.05, 95% CI −0.24, 0.14) (WMD −0.04, 95% CI −0.18, 0.10) and (WMD −0.02, 95% CI −0.18, 0.15), respectively. Postoperative complications and treatment Retinopathy and maculopathy progression incidence after cataract surgery were less in the intravitreal anti-VEGF treatment group than those in the control group (one study). The incidence of neovascular glauoma progression and the rate of laser photocoagulation treatment had no difference between both groups. There was no significant increase in intraocular pressure and adverse events that were related to the injection itself, such as vitreous hemorrhage and conjunctival hemorrhage, had no statistically different between both groups. No adverse events, such as retinal detachment, severe ocular inflammation, endophthalmitis, or systemic adverse, were reported during the follow-up periods.(Zhao and Cheng, 2019) The review was judged to be at a high risk of bias.

To evaluate the efficacy of topical steroids ± nonsteroidal anti-inflammatory drugs (NSAIDs), depot steroids, and antivascular endothelial growth factors (anti-VEGFs) in preventing pseudophakic cystoid macular edema (PCME) after cataract surgery in patients with diabetes, a systematic literature search for randomized controlled trials published after 1990 was carried out in Cochrane, EMBASE, and PubMed databases. A meta-analysis was performed using risk ratios for PCME as the primary outcome and visual acuity, macular thickness, and adverse events as the secondary outcomes. Topical steroids in combination with NSAIDs prevented 75.8% of PCME events compared with steroids alone in diabetic patients without preoperative diabetic macular edema; depot + topical steroids either alone or in combination with NSAIDs were superior to topical steroids ± NSAIDs alone; however, the incidence of elevated intraocular pressure was increased. Anti-VEGF + topical steroids ± NSAIDs had no influence on PCME prevalence in patients with diabetes mellitus.(Laursen et al., 2019) The review was judged to be at a low risk of bias.

The pooled analysis reported no significant difference between intravitreal anti-VEGF/steroids and anti-VEGF monotherapy for change in best corrected visual acuity (BCVA) (mean difference [MD] -2.29 visual acuity letters, 95% confidence interval [CI] -6.03 to 1.45, 3 randomized controlled trials [RCTs], n = 188 eyes) or change in central macular thickness (CMT) (MD -0.20 µm, 95% CI -37.14 to 37.53, 3 RCTs, n = 188 eyes) at one year. Similarly, there was no significant difference between the two groups in terms of BCVA at six months (MD -0.88 VA letters, 95%

CI -2.56 to 0.80, 8 RCTs, n = 618 eyes) and at two years (MD -0.50 VA letters, 95% CI -8.42 to 7.42, 1 RCT, n = 75 eyes) and CMT at six months (MD -19.73 µm, 95% CI -40.47 to 1.01, 8 RCTs, n = 617 eyes) and at two years (MD 22.00 µm, 95% CI -45.93 to 89.93, 1 RCT, n = 75 eyes). Compared to the anti-VEGF group, the anti-VEGF plus steroid group had higher improvement of 10 letters or more (22% versus 14%) and loss of 10 letters or more (13% versus 6%). There was a significantly higher risk of adverse events (Peto odds ratio [OR] 5.66, 95% CI 3.62 to 8.84, 8 RCTs, n = 635 eyes), raised intraocular pressure (IOP) (Peto OR 8.13, 95% CI 4.67 to 14.16, 8 RCTs, n = 635 eyes) and development of cataracts (Peto OR 7.49, 95% CI 2.87 to 19.60, 8 RCTs, n = 635 eyes) in eyes receiving anti-VEGF/steroid compared to anti-VEGF monotherapy. No significant difference was found between the two groups for intraocular inflammation (Peto OR 0.53, 95% CI 0.05 to 5.08, 8 RCTs, n = 635 eyes) and systemic adverse events (Peto OR 1.32, 95% CI 0.61 to 2.86, 1 RCT, n = 103 eyes). One RCT reported no significant difference between anti-VEGF/steroid and macular laser therapy for change in BCVA at 1 year (MD 4.00 VA letters 95% CI -2.70 to 10.70, n = 80 eyes), change in BCVA at 6 months (MD 6.00 VA letters, 95% CI -0.46 to 12.46, n = 86 eyes) and at two years (MD 3.00 VA letters, 95% CI -4.52 to 10.52, n = 74 eyes). There was no significant difference between anti-VEGF/steroid and macular laser therapy for change in CMT (MD -16.00 µm, 95% CI -68.93 to 36.93, n = 80 eyes) and the risk of cataracts (Peto OR 4.58, 95% 0.99 to 21.10, n = 100 eyes), while the anti-VEGF/steroid group was associated with an increased risk of overall adverse events (Peto OR 9.28, 95% CI 3.50 to 24.60, n = 100 eyes) and elevated IOP (Peto OR 9.49, 95% CI 2.86 to 31.51, n = 100 eyes) than the macular laser group. One RCT reported no significant difference between anti-VEGF/steroid and steroid monotherapy in BCVA at one year (MD 0 VA letters, 95% CI -6.1 to 6.1) and at 6 months (MD 4 visual acuity letters, 95% CI -2.6 to 10.6), the mean CMT at one year (MD -9 µm, 95% CI -39.87 µm to 21.87µm, n = 73 eyes) and at six months (MD 1.00 µm, 95% CI -41.92 to 43.92). Similarly, there was no significant difference between the two groups in the risk of raised IOP at one year (Peto OR 0.77, 95% CI 0.19 to 3.20, n = 37 eyes). No included study reported the impact of treatment on patients' quality of life or economic data. None of the studies reported any cases of endophthalmitis.(Mehta et al., 2018) The review was judged to be at a low risk of bias.

In the meta-analysis, at one month, the central macular thickness (CMT) significantly decreased in the dexamethasone implant (DEX) group, with a mean difference (MD) of -127.60 µm (95% confidence interval (CI) -174.59 to -80.62), while mean central macular thickness (CMT) change was non-significant in the anti-Vascular Endothelial Growth Factor (anti-VEGF) group (MD -22.91 µm, 95% CI -65.99 to 20.18). Test of group differences revealed a greater reduction of macular thickness in the DEX group compared with the anti-VEGF group (P<0.001). At three months, a significant reduction of macular thickness in the DEX group (MD -98.35 µm, 95% CI -147.15 to -49.54), while mean CMT change was non-significant in the anti-VEGF group (MD -21.61 µm, 95% CI -59.46 t 16.24). Visual improvement was significant in both

groups, with a mean gain of 14.93 letters (95% CI 12.66 to 17.21) shown in the DEX group. A better visual improvement was found in the anti-VEGF group, with a mean gain of 23.46 letters (95% CI 17.91 to 29.00, test of group differences, P=0.01). For intraocular pressure (IOP) change, data from 4 studies (68 eyes) and 6 studies (172 eyes) were pooled together at one month and three months, respectively. A mean increase of 0.54 mmHg (95% CI -1.11 to 2.18, P=0.52) and 1.20 mmHg (95% CI 0.27 to 2.12, P=0.01) was demonstrated at one month and three months, respectively. (Fallico et al., 2022) The review was judged to be at a high risk of bias.

A meta-analysis of included studies reported a significantly thinner central macular thickness (CMT) in the Intravitreal bevacizumab (IVB) injection group when compared to the control group at 1 month (mean difference [MD] = -59.23, 95% confidence interval [CI] -104.13 to -14.32; 5 studies, n = 257 participants), 3 months (MD = -45.83, 95% CI -71.20 to -20.46; 6 studies, n = 283 participants) and 6 months (MD = -42.70, 95% CI -76.37 to -9.04; 4 studies, n = 260 participants). Pooled analysis of included studies reported better mean corrected distance visual acuity (CDVA) at 1 month (MD = -0.18, 95% CI -0.25 to -0.12; 5 studies, n = 257 participants) and 3 months (MD = -0.08, 95% CI -0.15 to -0.02; 6 studies, n = 283 participants), a frequent progression of diabetic retinopathy (risk ratio [RR] = 0.33, 95% CI 0.19 to 0.58; 4 studies, n = 228 participants) and maculopathy (RR = 0.13, 95% CI 0.05 to 0.34; 2 studies, n = 125 participants) with the IVB group when compared to the control group.(Feng et al., 2019) The review was judged to be at a unclear risk of bias.

Compared with systemic steroid (with or without immunomodulatory therapy), the intraoperative intravitreal injection ofcorticosteroid or steroid implant had little or no effect in improving BCVA (logMAR) (mean difference [MD] -0.06, 95%confidence intervals [CI] -0.16 to 0.05, 4 studies, 132 participants) at four weeks. A meta-analysis of three studies showed that compared with controls, the interventions had little or no effect in reducing intraocular pressure (MD 0.55, 95% CI -0.60to 1.70, 90 participants) at four weeks. Similarly, a meta-analysis of three studies showed that compared with controls, the interventions had little or no effect on central macular thickness (MD -1.83, 95% CI -50.95 to 47.28, 102 participants) at four weeks. (Hsieh et al., 2023) The review was judged to be at a high risk of bias.

Eight cohort studies were included. Meta-analysis of 12 studies showed no association between cataract surgery and the progression of age-related macular degeneration (relative risk [RR] 1.19, 95% confidence intervals [CI] 0.89 to 1.59).. (Liu and Cai, 2020) The review was judged to be at a high risk of bias.

Meta-analysis of 12 studies showed no associations between cataract surgery and the progression of age-related macular degeneration (risk ratio [RR] 1.19, 95% confidence interval (CI) 0.89-1.59). However, a subgroup by follow-up time showedan association between cataract surgery and the increased risk of

progression of age-related macular degeneration (RR1.37, 95% CI 1.06-1.77). (Z. Chen et al., 2022b) The review was judged to be at a high risk of bias.

The pooled analysis of case-control studies reported that there was a significant difference in favour of cataract surgery when compared to observation in terms of visual acuity (logMAR) at 6 months or 12 months follow up (mean difference -0.13, 95% confidence Interval [CI] -0.17 to -0.09, 2 studies). However, there was no significant difference found between cataract surgery and observation in terms of progression to exudative age-related macular degeneration (AMD) during a 6 month or 12 months follow up (risk ratios [RR] 1.25, 95% CI 0.55 to 2.85, 2 studies). One RCT reported that there was a significant difference in favour of cataract surgery when compared to observation in terms of visual acuity (logMAR) at 6 months or 12 months follow up (-0.15, 95% CI -0.28 to -0.02). However, another RCT reported that there was no significant difference found between cataract surgery and observation in terms of progression to exudative AMD during a 6 month or 12 months follow-up (RR 3.21, 95% CI 0.14 to 75.68). (Kessel et al., 2015c) The review was judged to be at a high risk of bias.

The pooled analysis showed that cataract surgery was significantly associated with the incidence of late age-related macular degeneration (AMD) (odds ratio (OR) 1.80, 95% confidence interval (CI) 1.26–2.56), particularly geographic atrophy (OR 3.20, 95% CI 1.90–5.39). No significant associations were observed between cataract surgery and the incidence of early AMD (OR 1.15, 95% CI 0.96–1.37) and with the progression of AMD (OR 1.40, 95% CI 1.10–1.80). Subgroup analysis showed that the OR for incidence of early and late AMD was significantly higher for cataract surgery performed more than 5 years compared with less than 5 years. In subgroup analysis, the progression of AMD for a longer follow-up duration was (OR 1.97, 95% CI 1.29–3.01), but the pooled OR was not statistically significant for a shorter follow-up duration. (Yang et al., 2022) The review was judged to be at a low risk of bias.

One study reported that the immediate-surgery group showed a mean improvement in best-corrected visual acuity (BCVA) compared with the delayed-surgery group at six months (mean difference (MD) -0.15 LogMAR, 95% confidence interval (CI) -0.28 to -0.02, 56 participants). However, another study observed that there was uncertainty over which treatment group had better improvement in distance visual acuity at 12 months (MD 0.76, 95% CI -8.49 to 10.00, 49 participants). The Impact of Vision Impairment (IVI) questionnaire suggested that the immediate-surgery group showed a better vision-related quality of life than the delayed-surgery group at six months (MD in IVI logit scores 1.60, 95% CI 0.61 to 2.59). None of the included studies reported on adverse events. (Casparis et al., 2017) The review was judged to be at a low risk of bias.

**Key articles**

There was one key article selected.

The purpose of this randomized clinical trial in twelve European study centers was to compare the efficacy of perioperative treatment strategies, in addition to topical bromfenac 0.09% and dexamethasone 0.1% to reduce the risk of developing CME after uneventful cataract surgery in diabetic patients. There were 213 patients who took part in the study. The central subfield mean macular thickness at 6 and 12 weeks postoperatively was 12.3 µm and 9.7 µm lower, respectively, in patients who received subconjunctival triamcinolone acetonide compared to patients who did not (P = .007 and P = .014, respectively). There was no patient who received subconjunctival triamcinolone acetonide who developed CME. The use of intravitreal bevacizumab had no significant effect on macular thickness. (Wielders et al., 2018b)

## GRADE Table

### Anti-VEGFs and topical NSAID compared to sham injections for reducing incidence rate of macular oedema one month after cataract surgery

**Bibliography:** Zhang, R., Dong, L., Yang, Q., et al. 2022. Prophylactic interventions for preventing macular edema after cataract surgery in patients with diabetes: a Bayesian network meta-analysis of randomized controlled trials. eClinicalMedicine, 49, 101463.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Study event rates (%) | | | Anticipated absolute effects | |
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | With sham injections | With anti-VEGFs and topical NSAID | Relative effect (95% CI) | Risk with sham injections | Risk difference with anti-VEGFs and topical NSAID |
| **Incidence rate of macular oedema one month after surgery** | | | | | | | | | | | |
| 176 (3 RCTs) | serious[a] | not serious | not serious | serious[b] | none | ⊕⊕◯◯ Low | 10/89 (11.2%) | 26/87 (29.9%) | **RR 0.40** (0.22 to 0.70) | 112 per 1.000 | **67 fewer per 1.000** (from 88 fewer to 34 fewer) |
| **Best corrected visual acuity of anti-VEGF arms at 1 month after cataract surgery** | | | | | | | | | | | |
| 238 (4 RCTs) | serious[a] | serious[c] | not serious | serious[b] | none | ⊕◯◯◯ Very low | 117 | 121 | - | - | SMD **0.48 SD lower** (1.12 lower to 0.16 higher) |

**CI:** confidence interval; **RR:** risk ratio; **SMD:** standardised mean difference

**Explanations**
a. Almost all studies had some concerns with regard to the overall risk of bias.
b. Small sample size
c. Significant statistical heterogeneity detected

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# 8. Postoperative care

## 8.1 Postoperative advice

**Output question**

Which precautions does the patient have to consider after the surgery? When should the next follow-up visit take place?

**P:** Adult patients who undergo cataract surgery
**I**: Patient is provided with a detailed explanation of regulations and precautions
**C**: Patient is provided with a less detailed explanation of regulations and precautions
**O:** Visual acuity, visual function, quality of life, (serious) adverse events, postoperative refractive outcome

Provided information:
- Use of an eye cover postoperatively
- New prescription of glasses
- Prohibition for driving a vehicle

**Recommendation**

The following precautions have to be considered after surgery: the patient should take the eyedrops as intructed and seek help if vision decreased after prior vision increase, sudden appearance of black dots, flashing lights, increased pain or redness of the operated eye. Patients should not rub the eye, avoid getting water in the eye for at least one week, avoid activities that could strain the eyes for the first days after surgery, and can not drive the car after surgery and have to wait until legal clearance. (GRADE +)

New glasses can be prescribed after 4-6 weeks. Uncomplicated cases can defer follow-up visits by up to two weeks without safety reduction. (GRADE +)

**Considerations**

Cataract surgery is a quick and low-risk surgery with a high success rate, but aftercare is paramount and certain precautions must be considered.

Patients are mostly discharged from hospital the same day as the cataract surgery. In some clinics, the patient may be provided with a pad and a plastic shield over the

treated eye(s) (not medically indicated) directly after the surgery which can be removed one day after the surgery.(Dhoot et al., 2021)

After the surgery eye rubbing is discouraged for at least four weeks, even in the event of itching, as it can lead to an infection. Driving a vehicle is prohibited until a consultation with an eye doctor confirms that the vision meets the correct level. After Delayed Sequential Bilateral Cataract Surgery (DSBCS), the operated eye no longer needs a spectacle lens correction, but the unoperated eye does, so a mismatch in size and quality of the image can occur. Scuba diving is prohibited for at least three days, but swimming is allowed. While there is no available evidence regarding travelling by airplane after cataract surgery, it is generally advised to wait at least 24-48 hours after an uncomplicated procedure before flying. However, it is important to follow the surgeon's specific recommendations, as individual circumstances may vary. (Expert opinion)

Eyedrops should be taken as instructed. Showering and bathing can be continued as usual. Reading, watching TV and working at a computer can also continue without restrictions. Glasses can be prescribed once when eyes are completely healed, which is usually after 4-6 weeks.

Considering a follow-up visit after the surgery, a visit between 7 and 10 days is suggested. Studies propose that there are no additional safety gains in reviewing a patient on the first postoperative day in low-risk patients. The overall rate of serious complications was very low and not significantly different. Unscheduled visits were required by 3.8% in the deferred visit group (2 weeks postoperatively) compared to 5.1% in the group that was seen on the first postoperative day. No difference in CDVA outcomes were seen.(Kessel et al., 2015b)

It is important to advise the patient that vision might take a few days to improve. Watering of the eyes, blurred or double vision, grittiness and a red eye are considered normal after a cataract surgery. These side effects should improve within a few days but might take a few weeks to fully recover. Patients should seek help if vision decreases after prior vision increase or in the case of increased pain or redness, as well as the sudden appearance of black dots. (Expert opinion)

## Conclusion

Implications for practice

In conclusion, it is important to advise the patient to consider certain precautions postoperatively. In the rare case of postoperative complications (sudden appearance of black dots, vision decrease after prior vision increase, increased pain or redness) the patient should be advised to seek help. Follow-up visits can be deferred up to two weeks without a reduction in safety, in patients with uncomplicated surgery and no other ocular pathologies.

Knowledge gaps

Further research on the optimal timing of the follow-up visits after cataract surgery is needed. Research is needed to differentiate between different patient groups, with different underlying pathologies in order to give a detailed approach to this question.

## Identified research evidence

### Findings from Systematic Reviews

One relevant systematic review was included.

The risk of encountering postoperative complications was lower in the deferred review group (risk ratio (RR) 0.47, 95% confidence interval (CI) 0.24-0.92). The overall rate of serious complications was very low and not different between the groups (RR 1.28, 95% CI 0.28-6.4). Unscheduled visits were made by 3.8% in the deferred review group and 5.1% in the group that was seen on the first postoperative day and the difference was not statistically significant (RR 0.75, 95% CI 0.39-1.44). There was no significant between-group difference in CDVA (mean difference (MD) 0.00 (logMAR), 95% CI -0.02 to 0.01). No study evaluated the subjective satisfaction with the postoperative review regimen.(Kessel et al., 2015b) The review was judged to be at a high risk of bias.

## GRADE

**Early postoperative review compared to delayed postoperative review for long-term visual function or the well-being after cataract surgery**

**Bibliography: Kessel L, Andresen J, Erngaard D, Flesner P, Tendal B, Hjortdal J. Safety of deferring review after uneventful cataract surgery until 2 weeks postoperatively. J Cataract Refract Surg. 2015 Dec;41(12):2755-64. doi: 10.1016/j.jcrs.2015.11.010.**

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Study event rates (%) | | | Anticipated absolute effects | |
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | With delayed postoperative review | With early postoperative review | Relative effect (95% CI) | Risk with delayed postoperative review | Risk difference with early postoperative review |
| **postoperative complication rate (all complications) (follow-up: 2 weeks)** | | | | | | | | | | | |
| 886 (3 RCTs) | serious[a] | serious[b] | not serious | serious[c] | none | ⨁◯◯◯ Very low | 83/435 (19.1%) | -/451 | **RR 0.47** (0.24 to 0.92) | 191 per 1.000 | **101 fewer per 1.000** (from 145 fewer to 15 fewer) |
| **Serious complications (follow-up: 2 weeks)** | | | | | | | | | | | |

**Early postoperative review compared to delayed postoperative review for long-term visual function or the well-being after cataract surgery**

**Bibliography: Kessel L, Andresen J, Erngaard D, Flesner P, Tendal B, Hjortdal J. Safety of deferring review after uneventful cataract surgery until 2 weeks postoperatively. J Cataract Refract Surg. 2015 Dec;41(12):2755-64. doi: 10.1016/j.jcrs.2015.11.010.**

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 886 (3 RCTs) | serious[a] | not serious[b] | not serious | serious[c] | none | ⨁⨁◯◯ Low | 2/435 (0.5%) | -/451 | **RR 1.28** (0.24 to 6.74) | 5 per 1.000 | **1 more per 1.000** (from 3 fewer to 26 more) |

**Number of unscheduled visits between discharge and the 2-week postoperative review**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 886 (3 RCTs) | serious[a] | not serious | not serious | serious[c] | none | ⨁⨁◯◯ Low | 22/435 (5.1%) | -/451 | **RR 0.75** (0.39 to 1.44) | 51 per 1.000 | **13 fewer per 1.000** (from 31 fewer to 22 more) |

**corrected distance visual acuity (follow-up: range 14 days to 28 days)**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 886 (3 RCTs) | serious[a] | not serious | not serious | serious[c] | none | ⨁⨁◯◯ Low | 435 | 451 | - | The mean corrected distance visual acuity was **0** | MD **0** (0.02 lower to 0.01 higher) |

**CI:** confidence interval; **MD:** mean difference; **RR:** risk ratio

Explanations

a. High risk of bias of the included studies.
b. Significant statistical heterogeneity detected.
c. Small sample sizes

### 8.1.1 References


Dhoot, A. S., Popovic, M. M., Lee, S., et al. 2021. Eye protection following cataract surgery: a systematic review. *Can J Ophthalmol,* Epub ahead of print.

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## 8.2 Postoperative inflammation treatment in routine cataract surgery

What is the preferred postoperative medication that should be administered to treat inflammation and CME after cataract surgery?

**P:** Adult patients who will undergo cataract surgery
**I:** Treatment regime A
**C:** Treatment regime B
**O:** (Serious) adverse events (inflammation, CME), visual outcomes, quality of life

The treatment regimens include:

- Corticosteroids
- NSAIDs
- Anti-vascular growth factor (anti-VEGF)
- Combination therapies

**Recommendations**

The primary treatment options for CME after cataract surgery are topical NSAIDs or steroids. However, there is a lack of sufficient evidence to establish the optimal treatment approach for this condition. This highlights the importance of conducting future research to further explore and clarify the most effective strategies for managing CME following cataract surgery. (GRADE ++)

No definitive conclusions can be drawn regarding the clinical effectiveness of injectable medications (including intravitreal injection of anti-VEGF, sub-tenon steroid injections and intravitreal steroid implants) for the treatment of CME. (GRADE +)

**Considerations**

The incidence of clinically significant CME following cataract surgery has been reported to be as high as 2%. In most cases, the CME is a self-limiting condition that resolves spontaneously without any visual impairment. (Kessel et al., 2014) However there are instances where CME can persist or may lead to deterioration of the visual function that requires treatment. Currently, the initial management of CME consists of nonsteroidal anti-inflammatory drugs (NSAIDs) or other pharmacological agents to reduce the inflammatory response.(Orski and Gawecki, 2021)

Literature shows that the use of NSAIDs may lead to improved visual outcomes and reduced retinal swelling as compared to placebo or topical corticosteroids.(Wielders et al., 2015) However, there is still conflicting evidence regarding the efficacy of NSAIDs in patients with chronic CME. Some studies have reported that NSAID

treatment for two months does not yield any significant improvements in visual acuity, while others have suggested that administration of NSAIDs may lead to visual improvement after a prolonged treatment period of 3-4 months. (Wingert et al., 2022) Furthermore, NSAIDs may also be advantageous in the management of chronic CME following cataract surgery. However, it is important for clinicians to be aware of the potential for CME recurrence following the discontinuation of treatment. (Wielders et al., 2017)

In view of the lack of consensus on the most effective therapeutic approach to manage CME following cataract surgery, current research has focused on investigating various off-label injectable medications. These include intravitreal administration of steroids, anti-VEGF, or tumor necrosis factor-alpha inhibitors, sub-tenon steroid injections, and intravitreal steroid implants. Nevertheless, the available evidence for the efficacy of these agents is limited, with all selected studies exhibiting a moderate to high risk of bias. As a result, no definitive conclusions can be drawn yet regarding the clinical effectiveness of injectable medications for the treatment of CME. (Ahmadyar and Hansen, 2022)

## Conclusion

Implications for practice

Topical NSAIDs or steroids remain the primary treatment modality for CME following cataract surgery. Nevertheless, given the paucity of evidence concerning alternative pharmacological treatments, it may be inferred that limited evidence exists regarding the optimal management approach for this condition.

Knowledge gaps

Further research is necessary to assess the optimal treatment and duration for CME following cataract surgery. The effectiveness of NSAIDs, steroids, anti-vascular endothelial growth factor (anti-VEGF), and combination therapies for CME need to be assessed.

## Identified research evidence

### Findings from Systematic Reviews

Three relevant systematic reviews were identified.

Compared with placebo, there was no effect of topical ketorolac (0.5%) in visual acuity (two or more Snellen lines) (risk ratio [RR] 2.00, 95% confidence intervals [CI] 0.46 to 8.76; 1 trial, 22 participants). Compared with topical prednisolone (1%) orprednisolone combination therapy, there was no effect of topical ketorolac (0.5%) on visual acuity (RR 1.33, 95% CI 0.58 to3.07; 1 trial, 17 participants) and (RR 1.78,

95% CI 0.86 to 3.69; 1 trial, 17 participants) respectively. Quality of life was not measured/reported in any of the included trials. Most trials observed no between-group differences in ocular adverse events, such as corneal toxicity or elevated intraocular pressure. (Wingert et al., 2022) The review was judged to be at a low risk of bias

Three RCTs showed greater improvements in visual acuity in patients who were treated with topical non-steroidal anti-inflammatory drugs (NSAIDs) when compared to placebo. However, other RCTS which compared the efficacy of topical NSAIDs, topical corticosteroids, sub-Tenon corticosteroids, oral NSAIDs, and oral acetazolamide did not report any statistically significant differences between groups. (Wielders et al., 2017) The review was judged to be at a high risk of bias.

Eighteen studies were identified and all reported positive conclusions to their results. Fifteen case series spread across the five different treatment groups were pre-post treatment studies with no controls. The remaining three studies included a comparator for measuring improvements in visual acuity or anatomical outcomes. All studies reported positive conclusions for their results. The treatment group in these studies were intravitreal steroid injections, intravitreal vascular endothelial growth factor (VEGF) inhibitor injections, intravitreal tumor necrosis factor (TNF) alpha inhibitor injections, posterior sub-tenon steroid injections, and intravitreal steroid implants. Triamcinolone acetonide (TCA) was the only steroid administered as an intravitreal or posterior sub-tenon injection. Bevacizumab, ranibizumab, and pegaptanib made up the intravitreal VEGF injection group while intravitreal infliximab was the only TNF inhibitor found. Dexamethasone and fluocinolone acetonide were the two steroids given as intravitreal implants. The average follow-up for the studies was 9.7 months. (Ahmadyar and Hansen, 2022) The review was judged to be at a high risk of bias.

## GRADE Tables

### Non-steroidal anti-inflammatory drugs plus steroids compared to steroids for prevention of macular oedema after cataract surgery

**Bibliography:** Lim BX, Lim CH, Lim DK, Evans JR, Bunce C, Wormald R. Prophylactic non-steroidal anti-inflammatory drugs for the prevention of macular edema after cataract surgery. Cochrane Database Syst Rev. 2016 Nov 1;11(11):CD006683.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Study event rates (%) | | | Anticipated absolute effects | |
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | With steroids | With non-steroidal anti-inflammatory drugs plus steroids | Relative effect (95% CI) | Risk with steroids | Risk difference with non-steroidal anti-inflammatory drugs plus steroids |
| **Poor vision due to macular oedema at 3 months after surgery** | | | | | | | | | | | |

## Non-steroidal anti-inflammatory drugs plus steroids compared to steroids for prevention of macular oedema after cataract surgery

**Bibliography:** Lim BX, Lim CH, Lim DK, Evans JR, Bunce C, Wormald R. Prophylactic non-steroidal anti-inflammatory drugs for the prevention of macular edema after cataract surgery. Cochrane Database Syst Rev. 2016 Nov 1;11(11):CD006683.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1360 (5 RCTs) | serious[a] | not serious | serious[b] | not serious | none | ⊕⊕◯◯ Low | 36/767 (4.7%) | 44/593 (7.4%) | **RR 0.41** (0.23 to 0.76) | 47 per 1.000 | **28 fewer per 1.000** (from 36 fewer to 11 fewer) |
| **Poor vision due to macular oedema at 12 months after surgery** | | | | | | | | | | | |
| 88 (1 RCT) | very serious[a] | not serious | not serious | serious[c] | none | ⊕◯◯◯ Very low | 1/38 (2.6%) | 1/50 (2.0%) | **RR 1.32** (0.09 to 20.37) | 26 per 1.000 | **8 more per 1.000** (from 24 fewer to 510 more) |
| **Quality of life at 3 months after surgery (assessed with: COMTOL questionnaire)** | | | | | | | | | | | |
| 108 (1 RCT) | very serious[d] | not serious | not serious | serious[c] | none | ⊕◯◯◯ Very low | Data not fully reported but no between-groups differences in terms of quality of life, compliance and satisfaction scores. | | | | |
| **Central retinal thickness at 3 months after surgery (assessed with: optical coherence tomography)** | | | | | | | | | | | |
| 0 (8 RCTs) | very serious[a] | serious[e] | serious[b] | not serious | none | ⊕◯◯◯ Very low | Results ranged from -30.9 microns in favour of NSAIDs plus steroids to +7.44 microns in favour of steroids alone. | | | | |
| **Macular oedema at 3 months after cataract surgery, clinically symptomatic (assessed with: optical coherence tomography)** | | | | | | | | | | | |
| 3638 (21 RCTs) | very serious[a] | not serious | not serious | not serious | publication bias strongly suspected[f] | ⊕◯◯◯ Very low | 114/1981 (5.8%) | 213/1657 (12.9%) | **RR 0.40** (0.32 to 0.49) | 58 per 1.000 | **35 fewer per 1.000** (from 39 fewer to 29 fewer) |
| **best corrected visual acuity at 3 months after surgery (assessed with: log MAR scale from: -1.3 to 1.3)** | | | | | | | | | | | |
| 738 (10 RCTs) | very serious[a] | serious[e] | not serious | not serious | none | ⊕◯◯◯ Very low | All except one study found differences less than 0.1 logMAR, i.e. not clinically important | | | | |

**CI:** confidence interval; **RR:** risk ratio

**Explanations**

a. Unclear or high risk of bias of the included studies.
b. Outcome measure not always clearly defined
c. Small sample size, results from a single study
d. High risk of bias including selective reporting
e. Significant statistical heterogeneity detected.
f. Asymmetrical funnel plot

## Topical CS and NSAID compared to topical corticosteroids for diabetics undergoing cataract surgery

**Bibliography:** Wielders LH, Lambermont VA, Schouten JS, van den Biggelaar FJ, Worthy G, Simons RW, Winkens B, Nuijts RM. Prevention of Cystoid Macular Edema After Cataract Surgery in Nondiabetic and Diabetic Patients: A Systematic Review and Meta-Analysis. Am J Ophthalmol. 2015 Nov;160(5):968-981.e33.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With topical corticosteroids | With Topical CS and NSAID | | Risk with topical corticosteroids | Risk difference with Topical CS and NSAID |
| **cystoid macular oedema (follow-up: 3 months)** | | | | | | | | | | | |
| 251 (1 RCT) | serious[a] | not serious | not serious | serious[b] | none | ⊕⊕◯◯ Low | 21/126 (16.7%) | 3/125 (2.4%) | **OR 0.17** (0.05 to 0.50) | 167 per 1.000 | **134 fewer per 1.000** (from 157 fewer to 76 fewer) |

**CI:** confidence interval; **OR:** odds ratio

**Explanations**

a. Unclear risk of bias of the included studies.
b. Small sample size, single study; wide confidence intervals around the effect estimate

## Topical NSAID compared to topical corticosteroids for diabetics undergoing cataract surgery

**Bibliography:** Wielders LH, Lambermont VA, Schouten JS, van den Biggelaar FJ, Worthy G, Simons RW, Winkens B, Nuijts RM. Prevention of Cystoid Macular Edema After Cataract Surgery in Nondiabetic and Diabetic Patients: A Systematic Review and Meta-Analysis. Am J Ophthalmol. 2015 Nov;160(5):968-981.e33.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With topical corticosteroids | With Topical NSAID | | Risk with topical corticosteroids | Risk difference with Topical NSAID |
| **CDVA (follow-up: 3 months)** | | | | | | | | | | | |
| 62 (1 RCT) | very serious[a] | not serious | not serious | serious[b] | none | ⨁◯◯◯ Very low | 31 | 31 | - | The mean CDVA was **0** | MD **0.13 lower** (0.24 lower to 0.02 lower) |

**CI:** confidence interval; **MD:** mean difference

**Explanations**
a. Very high risk of bias of the included study
b. Small sample size, single study; wide confidence intervals around the effect estimate

## Topical NSAID compared to topical corticosteroids for nondiabetics undergoing cataract surgery

**Bibliography:** Wielders LH, Lambermont VA, Schouten JS, van den Biggelaar FJ, Worthy G, Simons RW, Winkens B, Nuijts RM. Prevention of Cystoid Macular Edema After Cataract Surgery in Nondiabetic and Diabetic Patients: A Systematic Review and Meta-Analysis. Am J Ophthalmol. 2015 Nov;160(5):968-981.e33.

| Certainty assessment | | | | | | | Summary of findings | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Participants (studies) Follow-up | Risk of bias | Inconsistency | Indirectness | Imprecision | Publication bias | Overall certainty of evidence | Study event rates (%) | | Relative effect (95% CI) | Anticipated absolute effects | |
| | | | | | | | With topical corticosteroids | With Topical NSAID | | Risk with topical corticosteroids | Risk difference with Topical NSAID |
| **cystoid macular oedema (follow-up: 3 months)** | | | | | | | | | | | |
| 175 (3 RCTs) | serious[a] | not serious | not serious | serious[b] | none | ⨁⨁◯◯ Low | 23/87 (26.4%) | 3/88 (3.4%) | **OR 0.11** (0.03 to 0.37) | 264 per 1.000 | **226 fewer per 1.000** (from 254 fewer to 147 fewer) |
| **CDVA (follow-up: 3 months)** | | | | | | | | | | | |
| 175 (3 RCTs) | serious[a] | not serious | not serious | serious[b] | none | ⨁⨁◯◯ Low | 86 | 89 | - | The mean CDVA was **0** | MD **0.07 lower** (0.24 lower to 0.11 higher) |

**CI:** confidence interval; **MD:** mean difference; **OR:** odds ratio

**Explanations**
a. Unclear or high risk of bias of the included studies.
b. Small sample size; wide confidence intervals around the effect estimate

## 8.2.1 References


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## 8.3 Remote care

### Output question

When is remote care after cataract surgery indicated for patients?

**P:** Patients who underwent cataract surgery
**I:** Postoperative remote care/digital care (refraction/visual acuity/ IOP/ fundoscopy/ complications review)
**C:** Postoperative standard/routine care
**O:** (Serious) adverse events

### Recommendation

Postoperative remote care after cataract surgery might replace short-term clinical examination to better allocate hospital resources and increase time and cost efficiency. Accuracy and validity of remote care and telemonitoring are still to be evaluated. (GRADE +)

Screening has to be performed prior to allocating patients to a certain group that will receive remote care. Patients at an increased risk of complications or patients with comorbidities which may adversely affect their postoperative outcome should be prioritized for traditional postoperative hospital care. (GRADE +)

### Considerations

Cataract surgery is one of the most frequently performed surgeries worldwide. Postoperative management consisting of routine clinical examinations to assess the visual outcomes and possible adverse events after the surgery is required. (Lee and Afshari, 2017) In general, cataract surgery shows a low tendency of postoperative complications, leading to mostly uneventful postoperative clinical visits. This has been confirmed by the European Registry of Quality Outcomes for Cataract and Refractive Surgery (EUREQUO), with 98% of the procedures proceeding smoothly. (ESCRS and EUREQUO, 2021 [accessed 2.5.23]) Limited time and resources in hospitals has lead to the idea of performing postoperative follow-up remotely.

Cataract surgery is typically performed in day care centers, and the usual postoperative follow-up involves a short-term clinical evaluation in the days following the procedure. Research has shown that short-term telephone follow-up after uncomplicated cataract surgery is a feasible and safe alternative to in-person follow-up visits (Ruiss et al., 2024, Al-Ani et al., 2023). Moreover, innovative technologies

for automated telephone follow-up after routine cataract surgery have demonstrated high levels of patient acceptability (Khavandi et al., 2023). Currently, safety and efficacy trials for the use of this tool in cataract patients are conducted.(de Pennington et al., 2021).

As teleconsultations with cataract patients are only partially applicable due to the absence of objective outcome parameters such as visual acuity and refractive state, upcoming eHealth applications may provide a solution. A web-based visual acuity tool has been validated for assessing visual acuity in patients who have undergone cataract surgery. This test can serve as an interim assessment of visual acuity during the postoperative cataract care pathway, fulfilling screening purposes. (Wanten et al., 2023) Moreover, since a significant portion of cataract patients belong to the older generation, the introduction of these eHealth technologies may encounter some barriers. With regards to eHealth tools, certain digital skills are necessary to adequately perform assessments using digital platforms.(Claessens et al., 2023)

For the successful adoption of eHealth technologies, further research on validity, safety, cost-effectiveness, user acceptability, and patient perspectives is imperative. Furthermore, the introduction and utilization of eHealth technologies in the patient care pathway must always be in accordance with the patient.(Wanten et al., 2023)

Currently, only routine cataract surgery patients are suitable for the implementation of remote care. Patients with ocular comorbidities that may impact the outcome of the surgery, those at an increased risk of complications, or individuals who experience intraoperative complications are not suitable for remote care and should receive conventional clinical care after surgery.(Muijzer et al., 2021) Based on current clinical expertise, remote care can be considered for uncomplicated cataract surgical patients. Practical advantages, such as overcoming long travel distances or accommodating systemic diseases that impair travel, are deemed to outweigh potential disadvantages, including potentially less control over postoperative healing and visual improvement. (Expert opinion)

## Conclusion

Implications for practice

Remote postoperative care has yet to be fully evaluated, but it holds promise as a more cost-effective way to allocate hospital resources and reduce patients' time expenses, including timely hospital visits and waiting hours. While web-based visual acuity assessments have been validated for use among cataract surgery patients, additional research is needed for broad implementation of this tool in the cataract surgery pathway.

Knowledge gaps

Research is necessary to evaluate the safety, efficacy, user acceptability, and cost-effectiveness of eHealth applications following cataract surgery. Additionally, insights into the implications and shortcomings of eHealth in practice are necessary to further optimize the cataract care pathway using these technologies.

**Identified research evidence**

**Findings from Systematic Reviews**

No relevant systematic reviews were identified.

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# 9. Complication management

In general, cataract surgery is a procedure with a high safety profile and low incidence of complications. Complications can occur during or after the cataract surgery procedure, in the early or late postoperative period. This chapter will give a brief overview of the most common adverse and serious adverse events associated with cataract surgery.

## 9.1 Serious adverse events during cataract surgery

**Output question**

What kind of serious adverse events can occur during cataract surgery?

Posterior capsule rupture with/without vitreous loss

This complication can lead to suboptimal visual acuity outcomes and the presence or absence of vitreous loss is an important factor in this. Risk factors for a posterior capsule rupture include both patient, surgeon and machine related risk factors: obesity, COPD, older age, type of cataract, corneal opacities, pseudoexfoliation, high myopia, shallow anterior chambers, glaucoma, surgeon experience, or machine related factors including poor visualisation, machine dysfunction and interruption of flow infusion causing anterior chamber collapse. (Segers et al., 2022a, Henderson et al., 2014, Zare et al., 2009) According to the EUREQUO, the prevalence of this complication with/without vitreous loss lies between 0.60% and 1.65%, with a decreasing trend in the last few years. (Segers et al., 2022a)

Dropped nucleus

If lens fragments drop into the vitreous during surgery, this might be caused by zonule weakness or PCR. During surgery, the capsule is at risk for damage due to the surgery instrumentation during the procedure. Risk factors for the occurrence of dropped nucleus include small pupil size, floppy iris syndrome, hard nucleus, very old age, trauma, and pseudoexfoliation syndrome. In the case of dropped nucleus, the surgeon should refer the patient to a retina specialist or perform a posterior vitrectomy if trained to perform this.(American Academy of Ophthalmology Preferred Practice Pattern Cataract and Anterior Segment Committee, 2021, Lundström et al., 2020) The EUREQUO reported a prevalence of drupped nucleus of 0.071% in the period between 2008 and 2018.(Lundström et al., 2020)

Zonular dialysis (ZD) with vitreous loss

In case of an advanced stage of ZD, vitreous loss may occur. See additional information at the ‘Zonlular dialysis without vitreous loss’ section.

Iris damage with need of reconstruction

If there is severe iris damage, reconstruction might be necessary. See additional information at ‘Iris damage’ section.

IOL damage during insertion

Currently, there are numerous manufacturers producing various IOLs with different materials and designs. The cartridge and implantation system of hydrophobic surfaced high-water content IOLs have structural features that may pose challenges during the learning process and potentially cause damage to the IOL during implantation. To ensure a successful implantation, it is important to proceed slowly and with caution when transferring the IOL into the cartridge and pushing it forward into the capsule using the plunger. This will help prevent any potential difficulties that may arise during the learning process of the implantation system. (Celik et al., 2021)

Suprachoroidal haemorrhage

Suprachoroidal haemorrhage (SCH) is a serious complication that can occur during intraocular surgeries, including cataract surgery. This complication arises when blood accumulates in the suprachoroidal space, typically due to increased intraocular pressure (IOP) and rupture of the posterior ciliary arteries or vortex veins. Risk factors for SCH include a history of glaucoma, elevated intraoperative pulse, and high IOP prior to surgery. Additionally, the use of certain cardiovascular medications (such as anticoagulants), advanced age, and atherosclerosis have been associated with SCH. (Flores Márquez et al., 2023) The estimated incidence of SCH was 0.04%.(Ling et al., 2004)

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## 9.2 Adverse events during cataract surgery

**Output question**

What kind of adverse events can occur during cataract surgery?

Anterior capsule tear
Anterior capsule tears may happen during the capsulorhexis formation, lens sculpting and lens fragments removal during surgery. In the case of an anterior capsule tear, this can extend to involve the posterior capsule resulting in an increased risk for dropped nucleus.

Iris damage
Iris and iris sphincter damage can cause an irregular pupil and permanent mydriasis, which influences the visual function and appearance of the patient. The visual function can be disrupted by the presence of glare or light scattering, reduced visual acuity, decreased contrast sensitivity and so on. Iris damage this may also be problematic in future surgeries.
During surgery, a small pupil is the most important risk factor for iris damage. Systemic alpha-adrenergic antagonists also cause pharmaceutical miosis during surgery, which can be result in intraoperative floppy iris syndrome (IFIS). IFIS is a very important risk factor for iris damage, since it is particularly prone to prolapse.(Foster et al., 2021) The prevalence of IFIS or iris prolapse varies from 0.5 to 2.0%, and the prevalence iris or ciliary body injury is 0.6-1.2%.(Liu et al., 2017) FLACS is more associated with intraoperative miosis than CCS.

Zonular dialysis without vitreous loss
ZD includes damage of the zonula and thereby loss of support for the lens capsule. ZD increases the risk for subluxation or dislocation of the intraocular lens during and after cataract surgery. Risk factors for ZD include pseudoexfoliation syndrome, high myopia, trauma, cataract surgery, pars plana vitrectomy or intravitreal injections, brunescent cataract, and retinitis pigmentosa.(Zhang et al., 2023) During surgery, the risk for ZD can be reduced by a stable anterior chamber and adequate mydriasis.(American Academy of Ophthalmology Preferred Practice Pattern Cataract and Anterior Segment Committee, 2021) Zonular rupture has a prevalence of up to 2.0% in low-risk cases, and up to 9.0% in high risk patients (with previous pars plana vitrectomy).(American Academy of Ophthalmology Preferred Practice Pattern Cataract and Anterior Segment Committee, 2021)

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## 9.3 Serious adverse events after cataract surgery

**Output question**

What kind of serious adverse events can occur after cataract surgery?

Inflammation

*Endophthalmitis*

Endophthalmitis is defined as a serious intraocular inflammation after cataract surgery this is usually caused by infection of a microorganism. Certain risk factors increase the likelihood of developing this condition, such as posterior capsule rupture during surgery, the need for anterior vitrectomy, vitreous loss, immunodeficiency, active blepharitis, lacrimal duct obstruction, inferior incision location, incomplete removal of lens cortex, previous intraocular injections, lower surgical volume, and less experienced surgeons, as well as older age and male gender. The most commonly involved microorganism is the staphylococcus epidermis.(American Academy of Ophthalmology Preferred Practice Pattern Cataract and Anterior Segment Committee, 2021, Lemley and Han, 2007) The prevalence of endophthalmitis varies from 0.006-0.04%.(Liu et al., 2017)

*Toxic anterior segment syndrome (TASS)*

This is a form of multifactorial, but non-infectious endophthalmitis, which includes an inflammatory response of the anterior chamber within 1-2 days of the cataract surgery.(Cutler Peck et al., 2010) Preventive strategies include adequate sterilization and cleaning of the surgery instruments and minimizing the use of enzymatic detergents. (American Academy of Ophthalmology Preferred Practice Pattern Cataract and Anterior Segment Committee, 2021) The prevalence of TASS after a cataract surgery is 0.1-2.1% (Liu et al., 2017)

Retinal detachment

Retinal detachment or retinal tears is a delayed complication of cataract surgery. Risk factors for this complication include high myopia/high axial length, absence of a Posterior Vitreous Detachment (PVD), capsule tear, younger age, premature retinopathy and early development of cataracts. (American Academy of Ophthalmology Preferred Practice Pattern Cataract and Anterior Segment Committee, 2021) The prevalence of a retinal detachment after cataract surgery is 0.1-1.3%. (Liu et al., 2017) (Daien et al., 2015)

Pseudophakic bullous keratopathy

Pseudophakic Bullous Keratopathy (PBK) includes the development of irreversible corneal edema after cataract surgery. The corneal stroma and epithelium edema (including epithelial bullae formation) is caused secondary to the induced endothelial

trauma performed by the cataract surgery. (Narayanan et al., 2006) The prevalence of PBK is 0.01%.(Gurnani and Kaur, 2023)

Intraocular lens related complications

Different complications may require an intraocular lens reoperation, including IOL dislocation or luxation, malposition, damage, opacification or calcification, remaining postoperative refractive errors or the presence of photic phenomena.
IOL dislocation, which is related to weakness of the capsular bag, zonulae, or damaged haptics, may require repositioning or replacement of the IOL. The most important risk factors include: prior vitreoretinal surgery, aging, high myopia, inflammation, retinitis pigmentosa, diabetes mellitus, mature cataract, previous acute angle-closure episode, connective tissue disorders.(Gross et al., 2004, Hayashi et al., 2007, Matsumoto et al., 2012, Su and Chang, 2004) The prevalence of intraocular lens decentration or dislocation is 0.1-1.7%(Liu et al., 2017)
In the case of toric IOLs, rotation of the IOL after implantation causes postoperative residual corneal astigmatism. A reoperation may be necessary to realign the IOL in the proper position. (American Academy of Ophthalmology Preferred Practice Pattern Cataract and Anterior Segment Committee, 2021)

Additionally, IOL exchange may be needed when the patient suffers from unbearable photic phenomena or remaining postoperative refractive error or if there is IOL damage. Although, eyes which underwent IOL exchange or explant have a 2.5 times higher risk (RR= 2.60, 95% CI 1.13-6.02, p-value=0.025) to have a final best-corrected visual acuity of <20/60, compared to eyes which only underwent cataract surgery.(Abdalla Elsayed et al., 2019) The decision for reoperation should be made based on the risks and potential benefits and weighed against alternative non-invasive solutions.(American Academy of Ophthalmology Preferred Practice Pattern Cataract and Anterior Segment Committee, 2021)

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## 9.4 Adverse events after cataract surgery

**Output question**

What kind of adverse events can occur after cataract surgery?

Posterior capsular opacification (PCO)
This is the most common complication after cataract surgery and is due to residual lens epithelial cells in the capsular bag. These epithelial cells migrate and proliferate onto the posterior capsule and cause opacification. PCO can be treated by performing a YAG laser capsulotomy.(Stager et al., 2006) The prevalence of PCO varies between 0.3 and 28.4%.(Liu et al., 2017) but is typically around 5% or less with modern surgical techniques and IOL designs. PCO can affect vision in different ways according to the type of PCO and the type of IOL.

Capsular contraction syndrome
Capsular contraction syndrome (CCS), also called anterior capsule contraction syndrome, anterior capsule fibrosis or phimosis can occur after cataract surgery with implantation of an IOL when there is a contraction of the anterior capsulotomy followed by fibrosis. CCS may obstruct the visual axis or dislocate the IOL. The pathogenesis of this syndrome is not fully understood but it may be caused by metaplasia and fibrosis of the remaining lens epithelial cells in or around the capsular bag after cataract surgery. Known risk factors include: small diameter of the capsulorrhexis, zonulary weakness or laxity, pseudoexfoliation syndrome, retinitis pigmentosa, diabetes mellitus, chronic intraocular inflammatory conditions, and high myopia.(Hartman et al., 2018) The prevalence of capsular contraction syndrome postoperatively is 0.47-3.3%.(Liu et al., 2017)

Elevated intraocular pressure
Elevated intraocular pressure (IOP) or IOP spikes may occur in the early postoperative period after cataract surgery. Most of the IOP elevations will return to normal within 24 hours after surgery. In healthy eyes these IOP spikes are usually of little consequence, but may be problematic in patients with glaucoma. (Tranos et al., 2004) If there is a severe acute IOP spike after surgery, patients may suffer from pain and nausea. A sustained elevated IOP may lead to corneal edema, endothelial damage, and corneal decompensation. In the postoperative period, corticosteroids may lead to an elevated IOP in eyes that are corticosteroid responders. In this case, cessation of these corticosteroids might be considered, but controlling the IOP must be balanced against the need for postoperative inflammation control.(American Academy of Ophthalmology Preferred Practice Pattern Cataract and Anterior

Segment Committee, 2021) of elevated IOP after cataract surgery varies between 0.3-18.1%.(Liu et al., 2017)

Inflammation

*Cystoid macular edema (CME)*

CME is characterized by macular thickening, a disrupted blood-retinal barrier, and an increased permeability of the perifoveal capillaries. Capillary leakage causes accumulation of fluid within the intracellular or extracellular spaces of the retina. (Scholl et al., 2011) Risk factors for CME include, male gender, older age, previous episode of uveitis, posterior capsule rupture with vitreous loss, diabetic retinopathy, prior vitreoretinal surgery, retinitis pigmentosa, and retained lens fragments in the capsular bag. In general, CME is associated with an inflammatory status of the operated eye.(American Academy of Ophthalmology Preferred Practice Pattern Cataract and Anterior Segment Committee, 2021) The prevalence of CME after cataract surgery is 1.2-11.0%.(Liu et al., 2017)

*Postoperative anterior uveitis*

Anterior uveitis is an inflammation of the anterior part of the uvea (the iris and ciliary body). If the uveitis does not resolve within a few weeks after cataract surgery, this inflammation is defined as prolonged. In case of sustained inflammation after cataract surgery, this might be associated with retained lens fragments, herpetic eye disease, previous episodes of uveitis, and chronic endophthalmitis (subacute infection with the propionibacterium acnes). Clinicians should also check postoperative eye drop regime complicance. The prevalence of uveitis after cataract surgery is 1.1-1.8% (includes chronic uveitis).(Liu et al., 2017)

Corneal edema

Corneal edema can be described as an increase of the corneal thickness due to extracellular fluid accumulation in the corneal epithelium and stroma. The fluid accumulation is caused by damage to the endothelialcell barrier and the pump function of the endothelial cells. The edema causes loss of transparency, but in most patients, this will resolve in the first weeks after surgery. An important risk factor for this adverse event is Fuchs' endothelial dystrophy.(Bagheri et al., 2016) The prevalence of corneal edema after cataract surgery is 0.1-5.4%.(Liu et al., 2017)

Binocular imbalance and double vision

While not a frequent occurrence, diplopia can be a surprising and disappointing complication for both the patient and surgeon following cataract surgery. Preoperative risk factors for diplopia include underlying eye muscle disorders, previous ocular surgeries, and pre-existing neurologic or systemic diseases. During surgery, the use of anesthesia and surgical technique, as well as inadvertent damage to the extraocular muscles or nerves, can increase the risk of diplopia.

However, the use of local anesthesia over retrobulbar or peribulbar anesthesia has reduced the incidence of postoperative diplopia. The experience of the surgeon in performing this type of anesthesia also plays an important role in avoiding this complication. Postoperatively, risk factors for diplopia include inflammation, cystoid macular edema, and delayed-onset muscle paralysis. The incidence of diplopia after cataract surgery is reported to be less than 1%. (Gawęcki and Grzybowski, 2016)

Dry Eye Disease (DED)

Symptoms of DED are a common complaint among ophthalmological patients, with symptoms that include ocular fatigue, discharge, epiphora, and a foreign body sensation. The relationship between cataract surgery and DED is still a matter of debate. Some studies suggest that the negative effects of cataract surgery on the ocular surface taper off within 1-3 months, while others indicate that these complaints persist for a long time after surgery and lead to dissatisfaction. Postoperative eyedrops, reduced eye rubbing, and adequate blinking after cataract surgery are believed to contribute to preserving the ocular surface.
Meibomian gland dysfunction (MGD) is a significant risk factor for DED, and it is also known to cause postoperative dry eye symptoms. Studies suggest that cataract patients with pre-existing MGD are more likely to experience symptoms such as eye irritation, disrupted tear film stability, and damage to the corneal surface. Other risk factors for DED after cataract surgery include age, female gender, systemic diseases and medications, psychiatric conditions, preservatives in eye drops, larger corneal wounds, longer microscopic exposure times, and greater phacoemulsification energy. (Lu et al., 2021, Miura et al., 2022, Naderi et al., 2020) In total, 37.4% of patients who did not have pre-existing DED developed DED after cataract surgery. (Miura et al., 2022)

Refractive surprise and presbyopia induction

Cataract surgery not only improves vision but also provides refractive benefits to patients. Several factors affect refractive outcomes, including age, corneal astigmatism, axial length (AL), and anterior chamber depth (ACD), which can be influenced by the selection of the intraocular lens (IOL) type. Intraoperative factors such as biometry measurement accuracy, surgical techniques, and the type of IOL being implanted play a crucial role in achieving the desired refractive outcome. Accurate IOL power calculation is also essential for success. Postoperative factors include inflammation, medication use, and IOL position stability. Patients who can still accommodate must be aware of presbyopia induction after cataract surgery if they do not choose a presbyopia-correcting IOL. (Khoramnia et al., 2022)

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# 10. Cost-effectiveness

**Output question**

What is the cost-effectiveness of specific cataract surgery-related decisions?

Included topics:

- Endophthalmitis prevention
- Prevention of inflammation/CME after cataract surgery
- Toric intraocular lenses
- Immediate sequential bilateral cataract surgery (ISBCS)
- Femtosecond laser assisted cataract surgery

**Endophthalmitis prevention**

The use of cefuroxime in the prophylaxis of endophthalmitis after cataract surgery was compared with no use of antibiotic prophylaxis. The incremental cost-effectiveness ratio was €2427.72 per Quality Adjusted Life-Years (QALY), when comparing the use of cefuroxime with no use of antibiotics as prophylaxis. The use of cefuroxime in order to prevent endophthalmitis was found cost-effective.(Rękas et al., 2020)

**Prevention of inflammation/CME after cataract surgery**

<u>Patients without and with diabetes</u>

The prevention of CME using a combination treatment with topical bromfenac and dexamethasone was found cost-effective in preventing CME after cataract surgery when compared with monotherapy with either drug in patients without diabetes. The incremental cost-effectiveness ratio was € 6544 per QALY for the group who received combination therapy compared with the group who received dexamethasone alone.(Simons et al., 2021)

For patients with diabetes subconjunctival injection of triamcinolone was found effective and cost-effective in preventing CME after cataract surgery compared with combination therapy consisting of subjconjunctival injection of triamcinolone and intravitreal bevacizumab. The incremental cost-effectiveness ratio was € 321 984 per QALY for the combination group compared with the triamcinolone alone group.(Simons et al., 2022)

### Toric intraocular lenses

The bilateral toric IOL implantation in cataract patients with corneal astigmatism was reported to be not cost-effective in comparison with bilateral monofocal IOL implantation. The QALYs were slightly lower in the toric IOL group (0.30 vs 0.31; P=0.75). The incremental cost-effectiveness ratio was reported to be €2500 to € 20 000 per QALY when comparing toric IOLs to monofocal IOLs. (Simons et al., 2019)

### Femtosecond laser assisted cataract surgery

Compared to the conventional cataract surgery (phacoemulsification), the femtosecond laser was not found to be superior and did not provide an additional benefit in cataract surgery. FLACS was not found to be cost-effective. The incremental cost-effectiveness ratio of the French FEMCAT-study was € 10 703 saved per additional patient who had a treatment success with phacoemulsification compared with FLACS. (Schweitzer et al., 2020) The FACT-study reported an incremental cost-effectiveness ratio of £167 120 per QALY of FLACS compared with phacoemulsification.(Day et al., 2021)

### Immediate Sequential Bilateral Cataract Surgery (ISBCS)

Studies found significant cost-savings for Immediate Sequential Bilateral Cataract Surgery (ISBCS) when compared to Delayed Sequential Bilateral Cataract Surgery (DSBCS).(Leivo et al., 2011, Lundström et al., 2009, Neel, 2014, O'Brien et al., 2010, Rush et al., 2015, Spekreijse et al., 2023) A computer based-econometric modelling calculated the cost-effectiveness of ISBCS of $1431 per QALY, when compared to DSBCS.(Malvankar-Mehta et al., 2013) A multicentre non-inferiority randomised controlled trial showed superior cost-effectiveness for ISBCS with slightly higher QALYs. The incremental cost-effectiveness ratio was ranging from €2500 to €80 000 of ISBCS compared with DSBCS per QALY. These societal cost savings effects for this approach mainly resulted from the one day less care admission. Additionally, ISBCS led to faster visual rehabilitation, with no increased risk of complications or large deviations from target refraction.(Spekreijse et al., 2023)

## Evidence table

| Study reference | Clinical Setting | Target population | Intervention | Comparator | Perspective (e.g. Societal or Health care or Third party payer) | Types of costs considered (direct, indirect) | Study period and Time horizon | Outcome measure | ICER |
|---|---|---|---|---|---|---|---|---|---|
| Rękas et al. (2020) | Twenty-four European ophthalmology clinics (ESCRS Endophthalmitis study data) | Patients after cataract surgery | Cefuroxime | No intervention | Public Third party payer perspective (National Health Fund Poland) | Direct costs associated with administration and postoperative endophthalmitis treatment costs | 2003-2006, time horizon: 12 months | Incidence of postoperative endophthalmitis, VFQ-39, SF-6D | €2427.72 per QALY |
| Simons et al. (2021) | Seven ophthalmology clinics in the Netherlands and Belgium (ESCRS PREMED study) | Patients without diabetes after cataract surgery | Combination treatment of topical bromfenac and dexamethasone | 1) Monotherapy topical bromfenac 2) Monotherapy topical dexamethasone | Healthcare perspective | Directs costs healthcare institution | 2013-2016, time horizon: 3 months | Incidence of postoperative cystoid macular edema, CDVA, Health-related quality of life (HUI-3), NEI VFQ-25 | €6544 per QALY (combination therapy vs dexamethasone) |
| Simons et al. (2022) | Seven ophthalmology clinics in the Netherlands and Belgium (ESCRS PREMED study) | Diabetic patients after cataract surgery | 1) Combination treatment of subconjunctival triamcinolone acetonideand intravitreal bevacizumab 2) Monotherapy subconjunctival triamcinolone acetonde 3) Monotherapy intravitreal bevacizumab | No additional treatment | Healthcare perspective | Directs costs healthcare institution | 2013-2016, time horizon: 3 weeks | Incidence of postoperative cystoid macular edema, CDVA, Health-related quality of life (HUI-3), NEI VFQ-25 | €321 984 per QALY (combination group vs. triamcinolone group) |
| Simons et al. (2019) | Two ophthalmology clinics in the Netherlands | Patients with bilateral cataract and ≥1.25D corneal astigmatism | Toric IOL monofocal implantation | Non-toric monofocal IOL implantation | Societal perspective | Direct and indirect costs (societal and healthcare perspective) | 2010-2012, time horizon: 6 months | Distance spectacle independence, UDVA, CDVA, Health-related quality of life (HUI-3), NEI VFQ-25 | €2500 to €20 000 per QALY (QALYs slightly lower in intervention group) |
| Schweitzer et al. (2020) | Five University hospitals in France (FEMCAT study) | Patients with unilateral or bilateral cataract | Femtosecond laser-assisted cataract surgery (FLACS) | Phacoemulsification cataract surgery (PCS) | Healthcare perspective | Direct costs healthcare institution | 2013-2015, time horizon : 12 months | Success rate of surgery (absence of severe perioperative complication, best-corrected visual acuity ≤ 0.0 logMAR, absolute refractive error ≤0.75D, unchanged postoperativ | € 10 703 saved per additional patient who had treatment success with PCS compared with FLACS |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | e corneal astigmatism power and axis), VF-14 | |
| Day et al. (2021) | Three NHS hospitals in the United Kingdom (FACT study) | Patients with unilateral or bilateral cataract | Femtosecond laser-assisted cataract surgery (FLACS) | Phacoemulsification cataract surgery (PCS) | Healthcare perspective | Direct costs healthcare institution | 2015-2017, time horizon: 12 months | Uncorrected distance visual acuity (UDVA), EQ-5D 3L, EQ-5DV, Catquest-9SF | £167 120 per QALY |
| Malvankar-Mehta et al. (2013) | Data used of one hospital in London | Patients with bilateral cataract | Immediately Sequential Bilateral Cataract Surgery (ISBCS) | Delayed Sequential Bilateral Cataract Surgery (DSBCS) | Public Third party payer (Ministry of Health Canada) | Direct costs healthcare institution | NA, time horizon: 3 months | Success rate surgery (BCVA of 20/40 or better), occurrence of endophthalmitis and cystoid macular edema, utility values were obtained from a comprehensive literature search | $1431 per QALY |
| Spekreijse et al. (2023) | Ten hospitals in the Netherlands (BICAT-NL study) | Patients with bilateral cataract | Immediately Sequential Bilateral Cataract Surgery (ISBCS) | Delayed Sequential Bilateral Cataract Surgery (DSBCS) | Societal and health-care perspective | Direct and indirect costs (societal and healthcare perspective) | 2018-2020, time horizon: 3 months | Proportion of second eyes with a target refractive outcome of ≤1.0D 4 weeks postoperatively, NEI-VFQ-25, Catquest-9SF, EQ-5D-5L, HUI-3 | €2500 to €80 000 per QALY |

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# 12. Appendices

## 12.1 Appendix 1 – Literature searches

**KSR Evidence**
**https://ksrevidence.com/**
**Date searched: 16.01.23**
**Records found: 390**

1 (cataract* or lens or lenses or pseudoaphak* or "pseudo aphak*" or pseudophak* or "pseudo phak*") adj3 (extract* or aspirat* or operat* or remov* or surg* or excis* or implant* or emulsif* or cryoextract*) in All text 384 results
2 (cataract* or lens or lenses or pseudoaphak* or "pseudo aphak*" or pseudophak* or "pseudo phak*") adj3 (phakectom* or zonulolys* or capsulor?hexis or pha?oemulsif* or "pha?o emulsif*" or lensectom* or capsulotom*) in All text 60 results
3 (cataract* or lens or lenses or pseudoaphak* or "pseudo aphak*" or pseudophak* or "pseudo phak*") adj3 (MSICS or ECCE or ICCE) in All text 3 results
4 cataract* adj3 ("intraocular lens*" or "implantable lens*" or IOL or IOLs) in All text 52 results
5 cataractom* in All text 0 results
**6 #1 or #2 or #3 or #4 or #5 in All text 390 results**

**The Cochrane Library (Wiley) – Issue 1 of 12, January 2023**
**Date searched: 17.01.23**
**Records found:**
**CDSR 155**
**CENTRAL 4137**

#1 MeSH descriptor: [Cataract] explode all trees 1668
#2 MeSH descriptor: [Cataract Extraction] explode all trees 2884
#3 (cataract* or lens or lenses or pseudoaphak* or "pseudo aphak*" or pseudophak* or "pseudo phak*") near/3 (extract* or aspirat* or operat* or remov* or surg* or excis* or implant* or emulsif* or cryoextract*) 8364
#4 (cataract* or lens or lenses or pseudoaphak* or "pseudo aphak*" or pseudophak* or "pseudo phak*") near/3 (phakectom* or zonulolys* or capsulor?hexis or pha?oemulsif* or "pha?o emulsif*" or lensectom* or capsulotom*) 1888
#5 (cataract* or lens or lenses or pseudoaphak* or "pseudo aphak*" or pseudophak* or "pseudo phak*") near/3 (MSICS or ECCE or ICCE) 130
#6 cataract* near/3 ("intraocular lens*" or "implantable lens*" or IOL or IOLs) 612
#7 cataractom* 0
**#8 #1 or #2 or #3 or #4 or #5 or #6 or #7 with Cochrane Library publication date Between Jan 2005 and Jan 2023, in Cochrane Reviews 155**
**#9 #1 or #2 or #3 or #4 or #5 or #6 or #7 with Publication Year from 2005 to 2023, in Trials 5836; After removal of ongoing clinical trials: 4137**

**MEDLINE and Epub Ahead of Print, In-Process, In-Data-Review & Other Non-Indexed Citations and Daily (Ovid): 1946 to January 13, 2023**
**Date searched: 17.01.23**
**Records found: 2630**

1 exp Cataract/su 169
2 exp Cataract Extraction/ 36669
3 ((cataract$ or lens or lenses or pseudoaphak$ or pseudo aphak$ or pseudophak$ or pseudo phak$) adj3 (extract$ or aspirat$ or operat$ or remov$ or surg$ or excis$ or implant$ or emulsif$ or cryoextract$)).ti,ab. 40599
4 ((cataract$ or lens or lenses or pseudoaphak$ or pseudo aphak$ or pseudophak$ or pseudo phak$) adj3 (phakectom$ or zonulolys$ or capsulor?hexis or pha?oemulsif$ or pha?o emulsif$ or lensectom$ or capsulotom$)).ti,ab. 4067
5 ((cataract$ or lens or lenses or pseudoaphak$ or pseudo aphak$ or pseudophak$ or pseudo phak$) adj3 (MSICS or ECCE or ICCE)).ti,ab. 656
6 (cataract$ adj3 (intraocular lens$ or implantable lens$ or IOL or IOLs)).ti,ab. 2472
7 cataractom$.ti,ab. 2
8 or/1-7 53876
9 randomized controlled trial.pt. or "randomized controlled trials as topic"/ 738561
10 controlled clinical trial.pt. 95157
11 random$.ti,ot. 291776
12 placebo.ab. 234892
13 clinical trials as topic.sh. 200746
14 randomly.ab. 399797
15 trial.ti. 277478
16 or/9-151422297
17 exp animals/ not humans.sh. 5082680
18 16 not 17 1319288
19 8 and 18 4278
**20 limit 19 to yr="2005 -Current" 2630**

*RCT filter:* Based on - Box 3.c Cochrane Highly Sensitive Search Strategy for identifying randomized trials in MEDLINE: sensitivity-maximizing version (2008 revision); Ovid format. Lefebvre C, Glanville J, Briscoe S, et al. Technical Supplement to Chapter 4: Searching for and selecting studies. In: Higgins JPT, Thomas J, Chandler J, et al. (eds). Cochrane Handbook for Systematic Reviews of Interventions Version 6.3 (updated February 2022). Cochrane, 2022. Available from: https://training.cochrane.org/handbook.

**Embase (Ovid): 1974 to 2023 January 13**
**Date searched: 17.01.23**
**Records found: 3761**

1 exp *cataract/su 8845
2 exp *cataract extraction/ 27748
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4 ((cataract$ or lens or lenses or pseudoaphak$ or pseudo aphak$ or pseudophak$ or pseudo phak$) adj3 (phakectom$ or zonulolys$ or capsulor?hexis or pha?oemulsif$ or pha?o emulsif$ or lensectom$ or capsulotom$)).ti,ab. 5521
5 ((cataract$ or lens or lenses or pseudoaphak$ or pseudo aphak$ or pseudophak$ or pseudo phak$) adj3 (MSICS or ECCE or ICCE)).ti,ab. 783
6 (cataract$ adj3 (intraocular lens$ or implantable lens$ or IOL or IOLs)).ti,ab. 3312
7 cataractom$.ti,ab. 1
8 or/1-7 56368
9 crossover-procedure/ or double-blind procedure/ or randomized controlled trial/ or single-blind procedure/ 825304

10 (random$ or factorial$ or crossover$ or cross over$ or cross-over$ or placebo$ or (doubl$ adj blind$) or (singl$ adj blind$) or assign$ or allocat$ or volunteer$).ti,ab,ot. 2680886
11 9 or 10 2790134
12 animal/ or animal experiment/ 4504186
13 (rat or rats or mouse or mice or murine or rodent or rodents or hamster or hamsters or pig or pigs or porcine or rabbit or rabbits or animal or animals or dogs or dog or cats or cow or bovine or sheep or ovine or monkey or monkeys).ti,ab,ot,hw. 7429594
14 12 or 13 7429594
15 exp human/ or human experiment/ 24553889
16 14 not (14 and 15) 5597958
17 11 not 16 2509725
18 8 and 17 5911
19 limit 18 to yr="2005 -Current"4389
20 ("conference abstract" or "conference review").pt. or conference$.so,st. 4718854
21 (letter or editorial or note).pt. 2924787
22 20 or 21 7643620
**23 19 not 22 3761**

*RCT filter:* Lefebvre C, Manheimer E, Glanville J. Chapter 6: searching for studies. 6.3.2.2. What is in The Cochrane Central Register of Controlled Trials (CENTRAL) from EMBASE? In: Higgins JPT, Green S (editors). *Cochrane Handbook for Systematic Reviews of Interventions* Version 5.1.0 [updated March 2011]. The Cochrane Collaboration, 2011. Available from https://handbook-5-1.cochrane.org/.

## 12.2 Appendix 2 – Evidence summaries

Evidence summaries are listed in alphabetical order by the first author.

**A**

Based on a study by Abdelmassih et al that included 401 eyes, preoperative SD-OCT scanning was found to be more effective in detecting macular abnormalities, than regular fundoscopy. The most common anomalies were age-related macular degenerations and epiretinal membrane. The occurrence of previously undetected macular abnormalities could especially be seen in patients over the age of 70 years with reduced CNVA. Patients over the age of 70 years with a previously known history of glaucoma had the highest prevalence of abnormalities in the retinal nerve fiber layer. (Abdelmassih et al., 2018)

Sphere changed from −1.77±6.57D (−11.00 to 7.00) preoperatively to 0.08±0.79D (−1.25 to 1.75) postoperatively (p=0.211), and cylinder changed from −2.95±1.71D (−7.00 to −0.75) to −1.40±1.13D (−3.25 to 0.00) (p=0.016). UDVA (logMAR) changed from 1.33±0.95 (0.40 to 2.77) to 0.32±0.38 (0.00 to 1.30) (p=0.008) and CDVA (logMAR) changed from 0.32±0.45 (0.01 to 1.77) to 0.20±0.36 (−0.03 to 1.30) (p=0.013). Efficacy and safety indexes were 1.38 ±0.58 and 1.17±0.66, respectively. Refraction and corneal topography were stable during the follow-up (9.10±5.54 months, 3–15) MICS surgery using corneal topography data and standard formulas for the calculation of the IOL power is a safe and effective procedure regarding keratometric stability, visual and refractive results. (Alió et al., 2014)

In another study of 598 evaluated cases, 33 patients (5.52%) had an occult macular abnormality. The most common pathology found in these patients was idiopathic epiretinal membrane, which was detected in 17 eyes (51.52%), followed by vitreomacular traction in nine eyes (27.27%), and dry age-related macular degeneration in four eyes (12.12%). Full-thickness macular holes and a lamellar macular hole were found in two patients (6.06%) and one patient (3.03%), respectively. The frequency of cortical cataracts was significantly lower in patients without macular lesions (P = 0.012) than in those with macular lesions. Multivariate logistic regression analysis revealed that age >70 years (P = 0.025 and odds ratio [OR] =11.12), smoking history (P = 0.043 and OR = 3.43), and hypertension were independently associated with occult macular lesions. The surgical plan was changed for five patients (0.83%).(Alizadeh et al., 2021)

In a randomised controlled trial evaluated the effects of therapeutic advice and education on anxiety and satisfaction in patients undergoing cataract surgery. A reduction in anxiety was observed among patients undergoing therapeutic advice (24.8 ± 3.69) compared to controls (33.9 ± 2.36), (P = 0.006). (Anwaar et al., 2022)

A comparative cross-sectional study including 34 patients with silicon-filled eyes, showed that patients undergone optical biometry using an IOLMaster had better visual acuity (0.25±0.7 logMAR, 0.63±0.09 logMAR, p=0.000) outcomes, a lower postoperative refractive error (0.22±0.02 D, 0.72±0.17 D, p=0.000) when compared to patients in which acoustic biometry using an A-scan was performed. The results showed a statistically significant difference in postoperative axial length between the two devices. (p=0.04).(Anwar et al., 2022)

In this retrospective case-control study, A total of 114 neovascular AMD patients [55 (48%) in exudative group and 59 (52%) in disciform group] were included. Preoperative logMAR BCVA was significantly improved after cataract surgery [0.8 (0.6-1.0) vs. 0.4 (0.4-0.7), P < 0.001 in exudative AMD; 1.85 (1.1-1.9) vs. 1.09 (0.8-1.9), P = 0.001 in disciform scar], however this improvement was not evident during the study period in patients with both exudative AMD and disciform scar [0.6 (0.3-1.1), P = 0.313 in exudative AMD; 1.30 (1-1.9), P = 0.03 in disciform scar]. The disease activation incidence was not statistically significant between surgery and control groups in patients with exudative AMD [5 (25%) patients in surgery group and 8 (22%) patients in the control group, P = 0.886, Cox proportional hazards regression analysis]. In disciform scar, disease activation was demonstrated in 4 (17%) patients in the surgery group; however, no patient in the control group had disease activation (P = 0.009, HRs could not be estimated, 95% CI 0.001-43.49, Cox proportional hazards regression analysis). Cataract surgery has benefit on early postoperative visual improvement in patients who have neovascular AMD. The disease activation incidence was not impacted after surgery in exudative AMD. (Arikan Yorgun et al., 2018)

The greatest increase in mean tSFCT compared to baseline was observed between W1 and M1 with values of 23.33 ± 2.96μm and 31.84 ± 2.88μm, respectively, for the PEX and non-PEX groups (P = 0.014). Additionally, the greatest increase in SF-SCVL thickness compared with baseline occurred at M1 with values of 6.66 ± 1.97μm and 26.52 ± 1.92μm, respectively, for the PEX and non-PEX groups (P < 0.001). The peripapillary choroidal thickness only showed a significant difference between the groups at the inferior measurement point with values of 117.94 ± 14.15μm and 137.52 ± 34.53 μm, respectively, for the PEX and non-PEX groups (P = 0.032). (Aslan and Oktem, 2020)

**B**

The HRs for CRVO and BRVO developing in patients who underwent cataract surgery compared with matched control participants who did not during the first year after either cataract surgery or baseline visit were 1.26 [95% confidence interval [CI], 1.16–1.38; P < 0.001] and 1.27 [95% CI, 1.19–1.36; P < 0.001], respectively, after

controlling for age, sex, race, insurance, and history of DR, glaucoma, and narrow angles. Diabetic retinopathy was the strongest predictor related with CRVO (2.79 [95% CI, 2.43–3.20; P < 0.001]) and BRVO (2.35 [95% CI, 2.09–2.64; P < 0.001]) onset after cataract surgery.Cataract surgery is associated with a small elevated risk of retinal vein occlusions within the first year; however, there is low incidence and unlikely to be clinically significant. (Bagdasarova et al., 2021)

This was a prospective, randomized, parallel-group, controlled, assessor- and patient-masked clinical study. 282 patietns with bilateral cataracts were randomized to DFT015 or SN60WF and followed-up for 6 months. When compared with SN60WF, DFT015 had a greater mean DCIVA (least squares means of −0.139), and mean DCNVA and comparable CDVA at month 6. The authors concluded that DFT015 provided superior intermediate and near vision and a similar visual disturbance profile compared with an aspheric monofocal IOL.(Bala et al., 2022)

In a retrospective, non-randomized chart review of 156 patients, the study evaluated visual and refractive outcomes of a transitional conic toric intraocular lens (IOL) for the correction of corneal astigmatism in patients undergoing cataract surgery. All patients had preoperative regular corneal astigmatism > 0.75 diopters (D) and underwent consecutive phacoemulsification and toric IOL implantation. The patients were divided into groups based on emmetropia or mild myopia for monovision. All outcomes were analysed preoperatively and 3, 6, and 12 months postoperatively. In total, the toric IOL was implanted in 97 eyes of 61 patients. None of the eyes lost any line of CDVA 6 months postoperatively. Almost all eyes (98%) were within ±1.00 D of attempted spherical correction. The mean preoperative keratometric cylinder was 1.92 ± 1.04 D (range 0.75–6.78), and the mean postoperative refractive cylinder was 0.77 ± 0.50 D (range 0–2.25), with 81% of the eyes with ≤1.00 D of residual cylinder. Two IOLs required realignment due to an intra-operative positioning error. Eleven eyes required enhancement with corneal refractive surgery.(Bandeira et al., 2018)

Another study in eyes with late AMD at baseline that had not received cataract surgery, 2 groups were compared for incident late AMD: (1) eyes that received cataract surgery after the baseline visit and before any evidence of late AMD and (2) eyes that remained phakic until study completion. Follow-up was least 2 years. Matched-pairs analysis, Cox regression models and logistic regression models were used that were adjusted for, sex, smoking, age, education, study treatment group, and severity of AMD. The definition of Late AMD was the presence of geographic atrophy or neovascular AMD detected on annual stereoscopic fundus photographs or as documented by medical records, including intravitreous injections of anti-vascular endothelial growth factor medication. A total of 1767 eligible eyes (1195 participants) received cataract surgery; 1981 eyes (1524 participants) developed late AMD during a mean (range) follow-up period of 9 (1-12) years. The Cox regression model demonstrated no increased risk of late AMD development after cataract

surgery: hazard ratio, 0.96; 95% confidence interval (CI), 0.81-1.13 (P = 0.60) for right eyes and hazard ratio, 1.05; 95% CI, 0.89-1.25 (P = 0.56) for left eyes. Of the matched pairs, late AMD was identified in 408 eyes that received cataract surgery and in 429 phakic controls: odds ratio (OR) 0.92 (95% CI, 0.77-1.10; P = 0.34). The risk of post cataract surgery late AMD from the logistic regression model was not statistically significant (risk ratio, 0.92; 95% CI, 0.56-1.49; P = 0.73). Cataract surgery did not increase the risk of developing late AMD among AREDS2 participants with up to 10 years of follow-up. This study provides data for counseling AMD patients who might benefit from cataract surgery. (Bhandari et al., 2022)

Axial length and anterior chamber depth possess an essential role in refractive status of the eye in different age groups. This study recruited 240 patients (480 eyes) who attended eye OPD of Department of Ophthalmology at NIMS Medical College & Hospital Jaipur, Rajasthan, India. Patients attended the eye OPD between July 2011 to December 2012 and had no prior significant history of any ocular disease. Hypermetropic eyes have shallow anterior chamber depth and shorter axial length as compared to myopic and emmetropic eyes (Bhardwaj and Rajeshbhai, 2013)

Patients with CNV not previously treated with PDT or anti-angiogenic drugs were randomized 1:1:1 to verteporfin PDT plus monthly sham intraocular injection or to sham verteporfin PDT plus monthly intravitreal ranibizumab (0.3 mg or 0.5 mg) injection and evaluated every 3 months. The primary intent-to-treat efficacy analysis was at 12 months, with ongoing assessments to 24 months. Key measures included the percentage losing <15 letters from baseline visual acuity (VA) score (month 12 primary efficacy outcome measure), percentage gaining >or=15 letters from preoperarively, and mean change over time in VA score and FA-assessed lesion characteristicsOf 423 patients (143 PDT, 140 each in the 2 ranibizumab groups), >or=77% in each group completed the 2-year study. Consistent with results at 12 months, at month 24 the VA benefit from ranibizumab was statistically significant (P<0.0001 vs. PDT) and clinically meaningful: 89.9% to 90.0% of ranibizumab-treated patients had lost <15 letters from baseline (vs. 65.7% of PDT patients); 34% to 41.0% had gained >or=15 letters (vs. 6.3% of PDT group); and, on average, VA was improved from baseline by 8.1 to 10.7 letters (vs. a mean decline of 9.8 letters in PDT group). Changes in lesion anatomic characteristics on FA also favored ranibizumab (all comparisons P<0.0001 vs. PDT). Overall, there was no imbalance among the groups in rates of serious adverse events. In the pooled ranibizumab groups, 3 of 277 (1.1%) patients developed presumed endophthalmitis in the study eye (rate per injection = 3/5921 [0.05%]). In this 2-year study, ranibizumab provided greater clinical benefit than verteporfin PDT in patients with age-related macular degeneration with new-onset, predominantly classic CNV. Rates of serious adverse events were low. (Brown et al., 2009)

**C**

This study evaluated the effects of carbomer sodium hyaluronate trehalose (CHT) and sodium hyaluronate eye drops on tear film stability and ocular discomfort after cataract surgery. Sixty patients who were scheduled for unilateral cataract surgery took part in the study. After phacoemulsification, subjects were split into groups who received carbomer sodium hyaluronate trehalose (trehalose group) or sodium hyaluronate tears (HG group) substitute. There was a steeper break up time (BUT) increase in the trehalose group compared to patient treated with hyaluronic acid ($P$<0.001). However, there was an opposite trend based on the OSDI questionnaire, as trehalose patients evidenced a significantly major improvement ($P$<0.001), and in seven days mean values reduced by more than three times. There were trends for a reduction in fluorescein staining among both treatments, however, this was not statistically significant. Finally, there was a significantly greater global satisfaction score ($P$<0.001) in CHT. CHT was both effective and well tolerated in reducing dry eye disease symptoms and in improving the clinical outcome after cataract surgery. The new formulation was more effective than commonly used sodium hyaluronate in treating ocular irritation and tear film alterations on some parameters (BUT, OSDI).(Caretti et al., 2019)

Intraoperative floppy-iris syndrome (IFIS) is related to the use of systemic alpha (1)-antagonists, and tamsulosin though it may aslo be seen in the absence of these causes. The incidence and severity of IFIS are wide ranging; however, the syndrome is related to a higher rate of complications after cataract surgery, particularly when the condition is not identified or expected. Asking patients before surgery about use of alpha (1)-antagonists currently or in the past is therefore essential as the iris atrophy induced by the medications is irreversible. Intraoperative floppy-iris syndrome surgical management strategies include pharmacologic measures, the use of high-viscosity ophthalmic viscosurgical devices, and mechanical dilating devices. However, sphincterotomies and pupil stretching are ineffective. Whether used alone or jointly, these small-pupil techniques increase the surgical success rate in these cases. Stopping the alpha(1)-antagonist preoperatively is of questionable value as the damage has been done. (Chang, 2008)

This study included 437 optometrists and 50 ophthalmologists, who completed a survey of two clinical cases. Experienced (median 22 years) optometrists reported they would provide target refraction advice, whilst less experienced (median 10 years) would leave this to the Hospital Eye Service. The former group reported it was in the patient's best interest to make an informed decision as they had seen many myopic patients who read uncorrected pre-operatively and were unhappy that they could no longer do so after surgery. Inexperienced optometrists reported a fear of overstepping their authority when making decisions and so feel it is better done by the ophthalmologist. The ophthalmologists estimated their percentage of emmetropic target refractions over the last year to have been 90%.(Charlesworth et al., 2022)

Patients with uveitis represent a rare subset of the population undergoing cataract surgery. They also pose several challenges which require unique consideration and strategy. Careful maintenance of disease quiescence for a minimum of three months prior to surgery maximizes postoperative outcomes. However, these patients are still at an increased risk for pseudophakic cystoid macular edema, which can be refractory to the traditional steroid treatments. This review synthesised the foundations of preoperative optimization, intraoperative considerations, and postoperative management of uveitic cataracts, with a particular focus on literature surrounding prevention and treatment of refractory postoperative cystoid macular edema. (Chen et al., 2019)

This study aimed to determine whether refractive complications can be prevented by applying the currently most accurate method of intraocular lens (IOL) power calculation in the post-radial keratotomy (RK) in 24 eyes. In 83.4% cases, implantation of an IOL aiming for plano in the 24 post-RK eyes resulted in a hyperopic refraction. The choice of an IOL targeting myopia reduced the frequency of hyperopia to 42.0% (24 cases). The authors concluded that unintentional hyperopia can be decreased but not eliminated as a complication of post-RK cataract surgery. The accuracy of the IOL power calculation can be improved if myopia is targeted.(Chen et al., 2003)

A total of 259 and 159 eyes received PPV (ERM-CATA) before and after cataract surgery (CATA-ERM), respectively. The ERM-CATA group resulted in a better final BCVA (logMAR: 0.274 vs. 0.558, $p < 0.001$) and greater BCVA gain (logMAR VA change: −0.379 vs. −0.220, $p = 0.001$) compared to the CATA-ERM group. At baseline BCVA was positively correlated with final BCVA ($p < 0.001$), whilst baseline CMT, final CMT, and postoperative CMT changes were not positively correlated. There was no significant difference between the groups regarding PCMO incidence (15.4% vs. 19.5%, $p = 0.287$). Additionally, final BCVA changes also did not significantly differ between eyes with and without PCMO. PCMO incidence was greater (29.40% vs. 16.30%, $p = 0.008$) in eyes with baseline CMT ≥ 500 μm. (Y. C. Chen et al., 2022)

One hundred and thirteen eyes took part in this study. There were 8 (21.6%) incomplete capsulotomies and 1 anterior capsule tear in group A (standard position, with 300 μm symmetrically pre- and post-anterior capsule). Meanwhile, only 2 eyes (5.1%) had incomplete capsulotomy, with none showing capsule tear in group B (increased distance with 400 μm symmetrically pre- and post-anterior capsule). Whilst only 1 eye (2.7%) had incomplete capsulotomy, and no capsule tear occurred, in group C (unsymmetrical distances of 200 μm pre- and 400 μm post-anterior capsule). Mean femtosecond laser capsulotomy time was longer in group B compared with groups A and C. Average cumulative dispersed energy, IOL centrality and corrected distance visual acuity was similar in all groups. Reducing pre-anterior capsule and increasing post-anterior distance to adjust femtosecond laser

capsulotomy distance may decrease incomplete capsulotomy and be more effective in white cataract surgery. Group I patients had pseudoexfoliation syndrome (n=46), previous glaucoma surgery (n=11), angle-closure or open-angle glaucoma (n=14), and posterior synechiae with iritis (n=77). In group I Rupture of the zonular fibres was experienced by six patients and the IOL was implanted in the sulcus. Rupture of the small iris-sphincter and small hemorrhages was experienced in four eyes during pupillary manipulation; however, they were not evident at the completion of surgery. No intraoperative complications occurred in group II patients, Indications of significant iritis and corneal edema were seen more frequently in group I eyes (26 eyes and 20 eyes, respectively) on the first dau post-surgery when compared to group II eyes (ten eyes and six eyes, respectively). Intraocular pressure was <20 mmHg in all eyes in both groups. At one-month post-surgery the pupil was round and reactive to light, the anterior chamber was quiet, and the cornea was clear in all eyes. The best-corrected visual acuity on the Snellen chart was 20/40 (Monoyer's scale) or better in both groups. (Z. Chen et al., 2022a)

A literature review included 16 papers, of which six were randomized controlled trials. It was reported that cataract surgery worsens (usually temporary) dry eye disease and ocular parameters. In case of performing cataract surgery in patients with (risk) for ocular surface diseases, these patients should be recognized and treated pre- and postoperatively. The preoperative management for optimizing the ocular surface, improves the visual acuity postoperatively.(Chuang et al., 2017)

Bromfenac and dexamethasone were both equally effective in reducing inflammation in the anterior chamber of the eye. Laser flare increased 24 hours after surgery and progressively decreased once treatment commenced. There were no statistically significant differences between dexamethasone and bromfenac at all time points. Post-surgery in both groups visual acuity improved steadily. There were similar mean macular thickness in both the dexamethasone and bromfenac arms after 1 month, respectively. (Coassin et al., 2019)

In this cohort study including 112 eyes, preoperative detection of epiretinal membrane by spectral domain OCT was a risk factor for Pseudophakic cystoid macular edema after cataract surgery (in 5 of 16 eyes ($\chi$ = 0.08, odds ratio 4.53). It is therefore recommended to perform a spectral domain OCT prior to cataract surgery as the presence of an epiretinal membrane may not be noticed during a fundus examination. Other variables such as posterior vitreous detachment, subfoveal choroidal thickness, diabetes, or hypertension were not significantly associated with PCME in this study. Limitations as in the limited patient cohort must be considered. (Copete et al., 2019)

**D**

There were 124 patients that had cataract surgery who were compared to 372 matched controls. The mean (95% confidence interval) visual acuity increase was 10.6 letters (7.8, 13.2; P < .001) 12 months after surgery; of which 26.0% had gained ≥3 lines and 1.6% had lost ≥3 lines of VA. Twelve months after surgery visual acuity (mean [standard deviation]) was higher in eyes that had cataract extraction when compared with controls (65.8 [17.1] vs 61.3 [20.8] letters, respectively, P = .018). The majority of visits where the choroidal neovascular (CNV) lesion was graded as active and the mean number of injections were similar before and after surgery (P = .506 and P = .316, respectively), whilst the control group observed a decrease in both. Therefore, it is conceivable to suggest that surgery slightly increased the level of activity of the CNV lesion. Mean [SD] VA prior to surgery was lower in eyes that observed an increase of ≥15 letters compared with eyes that acquired 0-14 letters (40.2 [21.4] vs 62.1 [15.1], P < .001). For patients undergoing cataract surgery within the first 6 months of anti-VEGF therapy are more likely to lose rather than gain vision (20.8% lost vision vs 12.8% and 4.4% gaining ≥15 or 0-14 letters respectively, P = .023). Age, receiving an injection at least 2 weeks prior to surgery, and the CNV lesion type had no noticeable relationship with VA outcomes. (Daien et al., 2018)

A retrospective comparative analysis was conducted on 163 eyes of 97 patients undergoing phacoemulsification and implantation of IOL. Ocular biometry using IOLMaster laser interferometry was performed. Predicted refractive outcomes pre and post lens constant adjustment were compared to actual refractive outcomes. Mean preoperative spherical equivalent was +5.44D ± 1.97D. Mean axial length was 21.20 mm ± 0.60 mm. MAE for Hoffer Q (0.62D, ±0.52D) and Holladay 1 (0.66D ± 0.52D) were significantly lower than SRK/T (MAE 0.91D ± 0.64D; P = <0.0005 and P = 0.001 respectively), but not Haigis (MAE 0.82D ± 0.83D, P = 0.071 and 0.22 respectively) when using standard IOL constants. MAEs for all formulae were significantly reduced by IOL constant adjustment (all P = <0.001). No statistically significant differences in MAEs between formulae (range 0.50-0.57D, P = 0.57) were observed following this. Increasing MAE was significantly associated with reducing axial length and increasing IOL power for all formulae. Prediction errors between eyes were significantly correlated across all formulae (all P = <0.0001) and explained 32-42% of the variance in prediction error between eyes for bilateral cases(Day et al., 2018)

Use of ocular bandages (n=6), eye patches (n=4), instant vision (n=2), and eye shields (n=1) were reported. There was no difference in final best corrected visual acuity (BCVA). The major difference in treatment modalities were patient preferences and the incidence of symptoms. Self reported symptoms were lower or equivalent for the ocular bandage group compared to the other groups (n=7 studies). Pain (n=3), foreign-body sensation (n=4), photophobia (n=3), and tearing (n=3) were also reduced in the ocular bandage compared with other treatment modalities. Two studies also reported reduced postoperative tear film stability in patients using an eye patch or instant vision. Two studies reported reduced tear film breakup time

(TBUT) for the eye patch relative to the ocular bandage, and another study reported increased TBUT for instant vision compared with the eye patch. Patients preferred the eye patch when given the option between instant vision and an eye patch (one study). The review was judged to be at a high risk of bias.(Dhoot et al., 2021)

This study recruited 400 patients (400 eyes). Mean flare values four weeks postoperatively, were significantly higher in Group 1 than in Group 2 (P=.003). The incidence of macular edema on OCT and clinically significant macular edema were not significantly different between groups (P=.685 and P=.386, respectively).(Dieleman et al., 2011)

**E**

Another prospective study included 190 participants who filled in a questionnaire before cataract surgery. The questionnaire identified five critical topics to discuss preoperatively. These were - the chance of visual acuity improvement, the timing of visual improvement, the risk of visual acuity decrease, the risk and effects of not having the cataract surgery done, and the severe adverse events. Written information before cataract surgery was requested by most patients (85.7%).(Elder and Suter, 2004)

Patients with uveitis were reviewed to examine the visual outcomes identify risk factors for postoperative uveitis, macular edema and Nd:YAG capsulotomy after phacoemulcification and IOL implantation. The visual acuity was significantly better (p 0.001), and 64.4% and 71.3% of patients achieved >2 Snellen’s lines of visual improvement at the first postoperative and final visits. The cumulative probability of doubling of the visual angle was 52% over 6 years of follow-up, and this occurred at a higher rate in the presence of preoperative retinal or optic nerve lesions (hazard ratio (HR) (95% CI) 4.49 (1.41 to 14.29)). Three months after the operation, uveitis was more likely to develop in female patients (OR (95% CI) 6.21 (1.41 to 27.43)) and the presence of significant intraoperative posterior synechiae (OR (95% CI) 8.43 (1.09 to 65.41)); macular edema was more likely to develop in patients who developed postoperative uveitis (OR (95% CI) 7.45 (1.63 to 34.16)). Nd: YAG (neodymium-doped yttrium aluminium garnet; Nd: Y3Al5O12) capsulotomy was performed at a higher rate in patients aged (55 years (HR (95% CI) 2.28 (1.06, 4.93)) and in those with hydrogel IOLs (HR (95% CI) 3.71 (1.04 to 13.20)), with plate-haptic silicone IOLs (HR (95% CI) 0.23 (0.08 to 0.64)) and three-piece silicone IOLs (HR (95% CI) 0.19 (0.05 to 0.74)) in comparison to those with polymethylmethacrylate IOLs. (Elgohary et al., 2007)

Another study reported no significant differences in the MedAEs predicted by the Hoffer Q and Haigis formulae (0.40 and 0.40 diopter [D], respectively). The difference between the refractive errors predicted by the Hoffer Q and Haigis

formulae increased significantly as the ACD decreased (R(2) = 0.644, P < .001). The MedAE predicted by the Haigis formula (0.40 D) was significantly smaller than predicted by the Hoffer Q formula (0.66 D) in eyes with an ACD of less than 2.40 mm (P = .027). No significant differences were found between the MedAEs predicted by the Hoffer Q and Haigis formulae in eyes with an ACD of 2.40 mm or more. The differences between the predicted refractive errors of the Hoffer Q and Haigis formula increased as ACD decreased in short eyes. Therefore, ACD should be considered when evaluating accuracy of the IOL power calculation formulae in short eyes.(Eom et al., 2014)

There were 470 participants (mean [SD] age, 72.2 [7.0] years; 290 women [61.7%]) inlcuded within the study, of which 94 participants in each group were included in the analysis.The mean CST was 250.7 (95% CI, 247.6-253.7) µm in the preoperative prednisolone plus NSAID group, 250.7 (95% CI, 247.8-253.7) µm in the postoperative prednisolone plus NSAID group, 251.3 (95% CI, 248.2-254.4) µm in the preoperative NSAID group, 249.2 (95% CI, 246.2-252.3) µm in the postoperative NSAID group, and 255.2 (95% CI, 252.0-258.3) µm in the sub-Tenon group (dexamethasone phosphate) three months post surgery. No statisitcally significant differences in CST or visual acuity compared with control and no differences between preoperative and postoperative groups were reported. However, it should be noted that 47 of 83 participants (56.6%) in the sub-Tenon group required additional anti-inflammatory treatment. (Erichsen et al., 2021b)

Patients undertaking phacoemulsification for age-related cataract were randomized to 1 of 5 treatment groups: ketorolac and prednisolone eyedrops combined (Pred+NSAID-Pre [control group] and Pred+NSAID-Post group) vs ketorolac monotherapy (NSAID-Pre and NSAID-Post groups) vs sub-Tenon depot of dexamethasone (dropless group). Drops were applied until 3 weeks postoperatively, starting 3 days preoperatively in the Pre groups and on the day of surgery in the Post groups. Measurements of aqueous flare at baseline and 3 days postoperatively were recorded. (Erichsen et al., 2021a)

**F**

A prospective randomized controlled trial (n=61 patients) showed that there was a statistically significant difference between the mean value of preoperative PALT (cognitive assessment) (11.29±4.77) (and the postoperative PALT (10.27±5.63) (p-value =0.004) for patients who used additional lidocaine to their local anaesthesia (peribulbar injection technique) during cataract surgery. For the group of patients which received bupivacaine as additional treatment, a statistically significant difference was found for the preoperative (10.29±5.05) and postoperative (9.82±4.96) PALT (P-value -0.021)., and between the mean value of preoperative VF and postoperative VF (P-value =0.002). There was no statistically significant difference found between the two study groups.(Fathy et al., 2019b)

A prospective randomized clinical trial included 60 patients undergoing cataract surgery by phacoemulsification. 30 patients received local anaesthesia (peribulbar anaesthesia) with lidocaine (2%) and 30 patients received topical anaesthesia oxybuprocaine (benozinate hydrochloride 0.4%). No statistically significant difference between local and topical anaesthesia groups in the mean of responses to the 11 statements of Iowa satisfaction with anesthesia scale (ISAS) (P = 0.071). Regarding cognitive assessment, there was a statistically significant postoperative decline in the local anaesthesia group in both PALT scores (P = 0.005) and VF scores (P = 0.01). In the topical anaesthesia group, there was no statistically significant difference between pre- and postoperative PALT scores (P = 0.326) or VF scores (P = 0.199). (Fathy et al., 2019a)

Emerging literature has linked postoperative surprises to corneal curvature, axial length, and estimation of the effective IOL position. This case presentation demonstrates, an inaccuracy in the axial length measurement can lead to a myopic surprise. A literature review has highlighted that prevention of postoperative refractive surprises requires highly experienced nurses, technicians, and/ or biometrists to take meticulous measurements using biometry devices, and surgeons to re-evaluate these calculations prior to the surgery. (Fayette and Cakiner-Egilmez, 2015)

The study was a retrospective case series of 96 post-myopic and 47 post-hyperopic eyes. In the post-myopic group, the Barret True-K method had a mean absolute error (MAE) of 0.36D, the Haigis-L formula 0.41D, ACRS mean 0.42D, Shammas 0.52D, Potvin-Hill 0.45D and Wang-Koch-Maloney method 0.55D In the post-hyperopic patient group, the Barret True-K method had a MAE of 0.41D, the ACRS-mean 0.46D, Shammas 0.52D and Haigis-L method 0.49D. A statistically significant difference was found for post-myopic eyes between the Barret True-K method and the Haigis-L method, which had respectively 44.8% and 34.4% of the refractive outcomes within 0.25D from the target outcome. For outcomes within 0.50D this was 71.9% and 67.7% (not statistically significant). The Barret True K had 42.6% of the post hyperopic eyes within 0.25D, and both the Barret True-K and ACRS-mean had 70.2% for the eyes within 0.5D. (Ferguson et al., 2022)

This study examined 168 eyes with implantation of several multifocal IOLs. Photopic, mesopic pupil size and the average between both (average pupil size) was measured using the Keratograph 5M (Oculus Optikgeräte). In total, 84.5% and 95.8% of eyes had a photopic pupil size of 3 and 3.5 mm or less, respectively. The mesopic pupil size was greater than 4.5 mm in 39.3% and greater than 5 mm in 16.7% of eyes. The average pupil size was 3.5 and 4 mm or less in 54.2% and 85.1% of eyes, respectively. Mesopic pupil size resulted in a steeper decrease with age than photopic pupil size: 0.028 versus 0.015 mm/year, respectively. Statistically significant differences were found among the four age groups (P < .0005). (Fernandez et al., 2020)

The prevalence of ERM was 13.9% among 1394 participants with retinal photographs taken 1 month postoperatively. ERM was detected in 3.1% and 14.8%, respectively of 1040 participants with retinal photographs from preoperative and 1-month-postoperative visits, with the low diagnostic agreement (kappa [0.17]). Of 1119 subjects without ERM 1-month post-surgery, the 3-year cumulative incidence of ERM was 11.2% (95% confidence interval [CI], 9.4%-13.4%; cellophane reflex 6.6%; preretinal fibrosis 4.2%). The age-standardized 3-year incidence of ERM in the surgical cohort (12.1%, 95% CI 8.6%-16.9%) was higher than the 5-year incidence of the Blue Mountains Eye Study subsample (4.4%, 95% CI 3.0%-6.0%). (Fong et al., 2013)

To assess visual acuity outcomes after surgey for catracts in patients with age-related macular degeneration (AMD) of varying degrees 4757 participants enrolled in the Age-Related Eye Disease Study (AREDS), a prospective, multicenter, epidemiological study of the clinical course of cataract and AMD and a randomized controlled trial of antioxidants and minerals. Standardized lens and fundus photographs, performed at baseline and annual visits, were graded. History of cataract surgery was obtained every 6 months. Analyses utilised multivariate logistic regression. Visual acuity data were analyzed for 1939 eyes that had cataract surgery during AREDS. 6.9 months was the mean duration from surgery to measurement of postoperative BCVA. After adjustment for multiple variables including age at surgery, gender, type, and severity of cataract, the mean change in visual acuity at the next study visit after surgery was as follows: Eyes without AMD gained 8.4 letters of acuity (P<0.0001), eyes with mild AMD gained 6.1 letters of visual acuity (P<0.0001), eyes with moderate AMD gained 3.9 letters (P<0.0001), and eyes with advanced AMD gained 1.9 letters (P = 0.04). The statistically significant increase in visual acuity after surgery was maintained for an average of 1.4 years after surgery. On average, participants with varying severity of AMD benefited from cataract surgery with increased visual acuity postoperatively. This average gain in visual acuity persisted for at least 18 months. (Forooghian et al., 2009)

A prospective case series included 29 patients (57 eyes) to assess the influence of angle kappa and alpha on visual acuity after multifocal IOL implantation. Monocularly, the mean postoperative logarithm of the minimum angle of resolution (logMAR) uncorrected distance, intermediate, and near visual acuities were 0.03 ± 0.09 (SD), 0.05 ± 0.11, and 0.11 ± 0.09, respectively. The mean postoperative logMAR corrected distance, distance-corrected intermediate, and distance-corrected near visual acuities were −0.01 ± 0.05, 0.04 ± 0.09, and 0.11 ± 0.08, respectively. The mean OSI, MTF cutoff, and Strehl ratio were 1.27 ± 0.84, 32.03 ± 10.80 cycles per degree, and 0.17 ± 0.05, respectively. The OSI (r = 0.398, P = .005), MTF (r =

−0.437, P = .002), and Strehl ratio (r = −0.419, P = .003) values were significantly correlated with angle κ. (Fu et al., 2019)

**G**

This review documented the methods used to calculate the power of the intraocular lens (IOL) which will be implanted in cataract surgery in  in eyes with keratoconus. If the keratometric value used was based on the standard refractive index (1.3375), it resulted in a postoperative refractive error with a tendency to hyperopia. The SRK/T formula yielded the best outcomes. The greater the severity of keratoconus the greater was the deviation of the postoperative refractive status from the target outcome. (Garzón et al., 2020)

Forty-one eyes of 41 patients were identified with an axial length <22 mm. the mean Axial length was 21.51 mm with a range of 21.96 to 20.29 with a, and IOL power ranging from 23 -29 dioptres (D). The Hoffer Q formula demonstrated a mean prediction error of 0.61 D (SD 0.80) when compared with the SRK-T, which demonstrated a mean prediction error of 0.87 D (SD 0.829). A paired t-test found that the Hoffer Q hadsignificantly more accuracy than the SRK-T formula (P<0.001). Hoffer Q was demonstrated to be more accurate than the SRK-T formula in this series of eyes <22 mm axial length when customised ACD constants are not used. This study emphasises  the importance of monitoring outcomes, and suggests different customisations are needed for different formulae, with a higher correction if the SRK-T formula is used for short eyes. (Gavin and Hammond, 2008)

This retrospective case series aimed to compare final spherical equivalent refractions in patients with RKs undergoing routine cataract surgery using keratometry values in 26 RK eyes (20 patients) with at least 3 months of postoperative follow-up data. Minimal overcorrections were achieved with TMS flattest K (mean -0.68±0.60 D, 73% within ±0.50 D, and 88% within ±1.00 D of the surgical goal) and IOLMaster K set for target -1.00 D (mean -0.66±0.61 D, 69% within ±0.50 D, and 88% within ±1.00 D of the surgical goal).  The authors concluded that  using the IOL Master K values combined with the Haigis formula set for target refraction -1.00 D produces acceptable results aiming for -0.50 D final SE refractions in former RK patients undergoing routine cataract surgery. (Geggel, 2015)

This was a prospective interventional single-arm study aimed to compare the refractive predictability of ray tracing IOL calculations based on OCT data versus traditional IOL calculation formulae based on reflectometry in patients with a history of previous myopic laser vision correction (LVC).The authors found that the best ray tracing combination (Anterion-OKULIX) resulted in an arithmetic statistically significantly lower prediction error than that achieved with the Barret True-K no-history formula calculation (-0.13 D and -0.32 D, respectively), while the Barret TK

NH had the lowest SD. The absolute prediction error was 0.26 D and 0.35 D for Anterion-OKULIX and Barret TK NH, respectively (statistically not significant). The authors concluded that ray tracing calculation based on OCT data from the Anterion device can yield similar or better results than traditional post LVC formulae. (Gjerdrum et al., 2021)

A literature review summarized the evidence of astigmatism assessment before cataract surgery. Evaluation of astigmatism before cataract surgery offers the opportunity to perform screening for keratoconus. In keratoconic eyes, anterior corneal astigmatism (ACA) was mainly against-the-rule, and posterior corneal astigmatism (PCA) was with-the-rule. The cut-off of 1.8D for ACA was used for differentiating keratoconic and normal eyes, with a sensitivity and specificity of 90.2%. For the PCA, the cut-off value was 0.4, with a sensitivity and specificity of 89.5% and 85.0%, respectively. Besides, it was found that total corneal astigmatism (TCA) was significantly correlated with the ACA and PCA. The PCA, which only can be predicted from ACA measurements, may be variable in keratoconic eyes. Including all these measurements could improve postoperative outcomes.(Gupta and Caty, 2018)

**H**

Eyes with epiretinal membranes assessed at 4 to 12 weeks postoperatively gained 0.27 (0.32) logMAR (approximately 3 Snellen lines), with 200 of 448 (44.6%) improving by 0.30 logMAR or more (≥3 Snellen lines) and 32 of 448 (7.1%) worsening by 0.30 logMAR or more. Reference eyes gained a mean (SD) of 0.44 (0.26) logMAR (approximately 4 Snellen lines), with 48 583 of 77 408 (62.8%) improving by 0.30 logMAR or more and 2125 of 77 408 (2.7%) worsening by 0.30 logMAR or more. Although all eyes with preoperative VA of 20/40 or less improved, only reference eyes with preoperative VA of more than 20/40 showed improvement. Cystoid macular edema developed in 57 of 663 ERM eyes (8.6%) (95% CI, 6.69-10.98) and 1731 of 125 435 reference eyes (1.38%) (95% CI, 1.32-1.45) (P < .001). Epiretinal membrane surgery was performed in 43 of 663 (6.5%) ERM eyes. (Hardin et al., 2018)

Pseudoexfoliation patients were more likely to be men (P = 0.014), to have a nuclear opalescence grade of more than 4 (P = 0.001), and to have a pupil size of less than 6 mm (P < 0.001) when compared with controls. One-year postoperative best-corrected visual acuity was comparable (P = 0.09). Complication rates at 1 year were 2.7% and 2.5% in the pseudoexfoliation and control groups, respectively (P = 0.82). Following age and nuclear opacity adjustment, average endothelial cell loss was 14.7% in the pseudoexfoliation group and 12.7% in the control group at 1 year (P = 0.066). Pseudoexfoliation eyes without the shallow anterior chamber, small pupils, or apparent zonulopathy may represent eyes with lower risks of complications. Patients

with smaller pupils and denser cataracts, pseudoexfoliation eyes without clinically apparent preoperative zonulopathy were not at a higher risk of intraoperative or postoperative complications or worse visual outcomes after cataract surgery. (Haripriya et al., 2019)

To explore cataract surgery on intraocular pressure (IOP) control in eyes with angle-closure glaucoma (ACG) and open-angle glaucoma (OAG) we included 74 eyes with ACG and 68 eyes with OAG havingsurgery for cataracts. The IOP was assessed, and the number of glaucoma medications recorded preoperatively, 1 month postoperatively, and then at 3-month intervals. IOP control in the 2 groups was compared using survival analysis, with failure being defined as an IOP greater than 21 mm Hg, addition of medications, or the need for further glaucoma surgery. The mean IOP and number of medications reduced significantly post-surgery in both groups (P <.0001). However, the mean reduction in IOP and percentage of IOP reduction in the ACG group were greater than in the OAG group, and less medications were required in the ACG group. The cumulative survival probability of IOP control at the 24 months point was 91.9% in the ACG group and 72.1% in the OAG group. The survival curve in the ACG group was significantly better than in the OAG group (P =.0012). The IOP was controlled without medication in 30 eyes (40.5%) in the ACG group and 13 (19.1%) in the OAG group; the difference between groups was significant (P =.0055). Cataract surgery substantially reduced IOP, and the number of medications required for IOP control in glaucomatous eyes. Specifically, cataract extraction normalized the IOP in most eyes with ACG. (Hayashi et al., 2001)

This study evaluated the prophylactic effect of oral acetazolamide against increased intraocular pressure (IOP) immediately post cataract surgery in eyes with primary open-angle glaucoma (POAG) and to determine what the appropriate administration time of oral acetazolamide to prevent IOP elevation should be. Ninety eyes from 90 patients were assigned randomly to 1 of 3 groups: (1) oral acetazolamide (500 mg) administration 1 hour preoperatively, (2) oral acetazolamide (500 mg) administration 3 hours postoperatively, or (3) no acetazolamide administration. All patinets had well-controlled POAG scheduled for phacoemulsification. From 3 to 7 hours postoperatively there was an elevation in mean IOP among all groups, which then decreased at 24 hours. Mean IOP at 1 and 3 hours postoperatively, was significantly lower in the group receiving oral acetazolamide preoperatively compared to the other 2 groups (postoperative administration or no administration; P ≤ 0.0031). The IOP at 5, 7, and 24 hours postoperatively, was significantly lower in both the preoperative and postoperative administration groups compared to the non-administration group (P ≤ 0.0224). The elevation of intraocular pressure of more than 100% occurred in 1 eye (3.3%) in the preoperative administration group, 7 eyes (23.3%) in the postoperative administration group, and 8 eyes (26.6%) in the non-administration group, respectively. the preoperative administration group observed a significantly lower incidence compared to other groups. (P = 0.0459). There was a short term IOP

elevation experienced ins eyes with POAG from 3 to 7 hours after phacoemulsification. The administration of oral acetazolamide 1 hour preoperatively significantly lowered the IOP elevation from 1 to 24 hours, while administrating oral acetazolamide 3 hours postoperatively reduced the IOP elevation at 5 hours or more after surgery.(Hayashi et al., 2017)

KCN formulae had lowest RMSEs in all eyes and BU2 KCN:M-PCA performed the best among KCN formulae in all subgroups. In severe KCN eyes, if TK values are unavailable, the BU2 KCN: P-PCA performed better than the top-ranked non-KCN formula (SRK/T). In non-severe KCN eyes, if TK values are unavailable, EVO 2.0 K was statistically superior to the next competitor (Kane K). H1-EKR had the highest RMSE. (Heath et al., 2023)

This prospective case series consisted of 11 consecutive patients with otherwise healthy eyes who an IOP of at least 40 mm Hg 4 to 6 hours after phacoemulsification. After decompression of the anterior chamber, the IOP was measured at 0, 15, 30, 45, and 60 minutes or until it exceeded 40 mm Hg.The mean IOP 4 to 6 hours after surgery was 47.09 mm Hg +/- 7.92 (SD) (range 40 to 68 mm Hg). After decompression, the IOP reduced significantly to a mean of 4.73 +/- 3.00 mm Hg at 0 minutes (P<.001) and then progressively increasedto 23.36 +/- 10.80 mm Hg at 15 minutes (P<.001), 33.82 +/- 11.74 mm Hg at 30 minutes (P=.005), 35.00 +/- 6.53 mm Hg at 45 minutes (P=.015), and 38.50 +/- 2.51 mm Hg at 60 minutes (P=.041). Marked IOP spikes were observed in eyes without glaucoma or ocular hypertension after uneventful phacoemulsification. Anterior chamber decompression immediately lowered IOP, but the effect was transient. (Hildebrand et al., 2003)

Phacoemulsification and uneventful capsulorhexis was undertaken by all patients of this study. Participants had a mean age of 72.22 ± 10.1 years. There wasa mean follow-up period of 18.57 ± 15.42 months. There was statistically significant improvement in mean BCVA from 1.45 ± 0.65 preoperatively to 0.94 ± 0.55 logMAR postoperatively ($p < 0.001$), and the number of eyes with a BCVA of 20/100 or better increased from 4 to 14. Types of complications post-treatment included corneal edema in two eyes and reactivation of the previous corneal pathology in five eyes, respectively. An improvement in visual acuity after surgery was not observed in four eyes, which could be a consequence of co-existing ocular co-morbidities. Pentacam corneal densitometry and ASOCT reported no significant correlations with final visual outcome. However, a statistically significant relationship between the severity of corneal opacity and improvement range in BCVA ($r = -0.782$, $P = 0.001$) was observed by using an OCT grading method.(Ho et al., 2018)

Results demonstrated that each model's incidence of late AMD increases with age. The overall adjusted ARF is 50.82%. In the maximally adjusted model, AR is 0.48%, 1.59%, and 4.02%, and NNH is 208, 63, and 25 for persons 65, age 65–75, and >75,

respectively.  While across all ages cataract surgery represents a doubling of the incidence of late AMD, the adjusted ARs are not large because late AMD is an uncommon disease, and the per cent incidence is low, especially at younger ages. Advancing age causes a decrease in the NNH, which reflects the increased incidence of late AMD at older ages in persons with and without cataract surgery. These analyses were undertaken to describe the absolute risk, as derived solely from our data, of late AMD that may be attributed to cataract surgery to quantify the doubling of odds of incident AMD in persons with cataract surgery, as previously reported by our group. The adjusted ARF for cataract surgery compared with cataract care is roughly 50% for late AMD. The OR associated with these comparisons (OR, 1.96;95% CI, 1.28–3.02) was significant.3 However, the ARs in the current analyses are quite small (range, 0.48–4.03). The results of this study suggest that the risk of late AMD is enhanced in the presence of cataract surgery on a population level. (Howard et al., 2013)

**J**

This article reviews literature on the complications of cataract surgery in patients with benign prostate hyperplasia (BPH) treated with alpha 1A-blockers.(Jan Teper et al., 2011)

For near visual acuity, pooled analysis of five studies reported no significant difference in uncorrected near visual acuity (UNVA) (mean difference (MD) 0.02, 95% confidence interval (CI) −0.03, 0.06) and distant-corrected near visual acuity (DCNVA) (MD 0.04, 95% CI −0.02, 0.10) between the bifocal IOLs and trifocal IOLs. For intermediate VA: bifocal IOLs had a significantly worse performance in UIVA compared with trifocal IOLs (MD 0.09, 95% CI 0.01,0.17), but no difference in DCIVA (MD 0.09, 95% CI −0.04, 0.23). For distant visual acuity: no statistically significant difference between the two groups was observed, and the distant VA results were similar (MD 0.01, 95% CI −0.01, 0.04 for UDVA; MD 0.00, 95% CI − 0.01, 0.01 for CDVA). No differences were observed in terms of spectacle independence, contrast sensitivity, postoperative refraction, and posterior capsular opacification between trifocal group to that of the bifocal group.(Jin et al., 2019)

In a prospective study of 60 patients, the mean axial length measured by immersion A-scan was less (22.91 mm) than when measured by optical biometry (23.15 mm), including a mean difference of 0.24 mm (p=0.133). The mean postoperative residual refraction was greater (0.90) in the group measured by the A-scan, compared to the group measured by the IOLMaster (0.70), with a difference of 0.20 (p=0.166). The difference between the actual IOL placed and the predicted emmetropic IOL, this was higher in the A-scan group (1.35) compared to the other group (0.96) (mean difference 0.39 (p=0.021)).(Joshi et al., 2019)

**K**

This retrospective study assessed the predictability of intraocular lens (IOL) power calculation after cataract surgery for keratoconus. 102 eyes of 71 consecutive keratoconic patients who developed cataract were reviewed. The refraction achieved was significantly more hyperopic than the targeted refraction, when keratometric readings were used ($p = 0.001$). At 1 month, 36% and 63% of the eyes were within ±0.5 and ±1.0 D, respectively, of the targeted correction. There was a significant correlation between prediction error and mean keratometry (Pearson correlation coefficient $r = -0.545$, $p < 0.001$). No vision-threatening complications occurred in any case. Refraction was significantly more myopic than the initial targeted refraction when total corneal refractive power was used ($p = 0.013$). Phacoemulsification with IOL implantation appears to besafe, effective and accurate in mild keratoconus. There was, however, a large amount of hyperopic shift in advanced keratoconic patients, when keratometric readings were used for IOL power calculation, and when total corneal refractive power was used there was a slight, myopic shift occurred. (Kamiya et al., 2018)

This study evaluated the effects of 0.05% cyclosporine A (CsA) on lipid layer thickness (LLT) and meibomian glands after cataract surgery using the LipiView® ocular surface interferometer. Fifty participants (50% women), with a mean (SD) age of 65.94 (10.35) years. Four participants in group A and five in group B were excluded from data analysis as they were lost to follow-up 1 month after cataract surgery. Therefore, 41 participants providing 41 eyes were split into two groups; 21 subjects were treated with CsA and 20 subjects with CMC. Am comparison of clinical measurements between groups A and B which were taken at the last visit, TBUT and LLT showed significant differences ($p = 0.035$ and $p = 0.047$). There was a significant difference after cataract surgery in TBUT between participant during follow up using CsA and those using CMC ($p = 0.003$). Preoperative LLT and the use of CsA were identified as independent parameters for postoperative LLT ($R2 = 0.303$; $p = 0.008$ and $p = 0.045$, respectively). The follow-up duration yielded a positive correlation with the difference between the preoperative and postoperative values of LLT in the group treated with CsA ($R2 = 0.738$ and $p < 0.001$). The results of this study highlight that treatment with 0.05% CsA is more effective than 0.5% CMC, following cataract surgery in improving TBUT and LLT. Higher preoperative LLT and the postoperative use of CsA could potentially be significant determinants of a higher postoperative LLT value.(Kang et al., 2021)

In white cataracts, the two-stage continuous curvilinear capsulorhexis technique helps prevent unexpected capsulotomy tears, sudden radialization of the CCC, and other intraoperative complications arising from high intracapsular pressure. This method facilitated safe cataract surgery in cases of white cataracts and were validated by ultrasonography. (Kara-Junior et al., 2009)

The pooled analysis reported no significant differences between patients randomised to ISBCS or surgery on two different dates in any intra- or postoperative complication (including sensation of dry eyes) (risk ratio [RR] 0.76, 95% confidence interval [CI] 0.55 to 1.07, 2 studies, 2613 participants). Similarly, no significant differences were found between the groups regarding outcomes, the number of serious postoperative complications (corneal edema, macular edema, wound leak, or iris prolapse) (RR 1.63, 95% CI 0.55 to 4.78, 2 studies, 2613 participants) and subjective visual function (standardised mean difference [SMD] 0.01, 95% CI -0.47 to 0.48, 2 studies, 2096 participants). Overall, the quality of evidence was low to very low. None of the included studies reported on the prevalence of postoperative anisometropia. (Kessel et al., 2015a)

Another study explored the outcome after surgery for cataracts in patients with neovascular AMD treated with intravitreal anti-vascular endothelial growth factor (VEGF) injections in routine clinical practice. Early Treatment of Diabetic Retinopathy Study (ETDRS) visual acuity and frequency of anti-VEGF injections were assessed before and after surgery. 89 eyes were included from 89 patients who had undergone surgery after being treated with a median of 10 (range 3-36) anti-VEGF injections for neovascular AMD. There was an improvement in Visual acuity by a mean of 7.1 [95% confidence interval (CI) 4.6-9.6] ETDRS letters in the first 6 months after cataract surgery. The requirment of anti-VEGF injections did not alter after surgery with an average of 1.5 in the 6 months prior to surgery versus 1.7 in the 6 months after surgery ($p = 0.25$). Visual improvement was better in patients when there was less time from latest injection to cataract surgery. Cataract surgery improves vision in patients undergoing treatment for neovascular AMD. Cataract surgery was not associated with increased need for anti-VEGF treatment and patients who were in active anti-VEGF treatment had better visual outcomes than patients who had cataract surgery after long injection-free periods. (Kessel et al., 2016c)

This systematic review aimed to compare the efficacy of topical steroids with topical nonsteroidal anti-inflammatory drugs (NSAIDs) in controlling inflammation and preventing pseudophakic cystoid macular edema (PCME) after uncomplicated, age-related cataract surgery. The main outcomes were postoperative inflammation and pseudophakic cystoid macular edema. Fifteen RCTs were identified. The incidence of postoperative inflammation was lower in patients randomized to NSAIDs. The prevalence of PCME was significantly higher in the steroid group compared with the NSAID group: risk ratio (RR) 5.35 (95% confidence interval, 2.94-9.76). The quality of evidence ranged from high to low. The authors recommended using topical NSAIDs to prevent inflammation and PCME after routine cataract surgery. (Kessel et al., 2014)

The study recruited 108 patients who were equally split into two groups. Group A mean age was 58.87±9.69 years (range: 33 to 84 years) whilst group B mean age

was 57.77±8.93 years (range: 30 to 78 years) (p=0.544). All patients in both groups had some degree of inflammation in the anterior chamber on the first operative day. On the 14th postoperative day, anterior chamber cells were present in 4(7.4%) eyes in Group A and in 3(5.55%) eyes in Group B (p>0.999), while aqueous flare was present in 5(9.25%) eyes in Group A and 9(16.66%) eyes in Group B (p=0.391). There was no aqueous flare evident in any eyes from either group six-week post operation. (Khan et al., 2016)
This prospective non-randomized controlled study examined 50 eyes. All eyes were measured using ultrasound A scan and partial coherence interferometry by an IOLMaster preoperatively. The IOL power of the implanted lens was based on the IOLMaster values. The mean absolute error was 0.686±0.493 using the A-scan and 0.731±0.528 when using the the the IOLMaster (p=0.656). The mean error was -0.531±0.498 and -0.612±0.590 (p=0.460), for the A-scan and the IOLMaster respectively.(Khan et al., 2019)

In the pooled analysis, no difference in corrected or uncorrected distance vision between multifocal and standard intraocular lenses (IOLs) was observed. For corrected or uncorrected distance vision, there were no statistically significant differences between newer diffractive lenses and refractive lenses. Multifocal IOLs were superior for near vision (1,025 patients, mean difference in logMAR of -0.26 (95% confidence interval (CI) -0.37, -0.15)), spectacle dependence (12 studies, 1,237 patients, relative risk of 0.27 (95% CI 0.20, 0.38)) and quality of vision (6 studies, 596 patients, the standardised mean difference of -0.54, (95% CI -1.12, 0.04)) as compared to monofocal. However, multifocal IOLs had worse pooled results for the outcomes of glare (9 studies, 847 patients, risk ratio of 1.36 (95% CI 1.15, 1.61) and halos (7 studies, 754 patients, the risk ratio of 3.14 (95% CI 1.63, 6.08) as compared to monofocal IOLs. Newer multifocal lenses had statistically significantly better outcomes than older diffractive lenses or refractive lenses, when compared to monofocal IOLs, in near vision, quality of vision, and risk of halos. (Khandelwal et al., 2019)

Povidone-iodine (PI) solution has long been applied to the ocular surface and periocular skin since to prevent endophthalmitis in cataract surgery. The use of PI solution kills bacteria in vitro quickly at dilute concentrations (0.05%-1.0%). In various scenarios, PI kills bacteria rapidly at diluted concentrations than more conventional (5%-10%) concentrations. This could be due to a larger availability of diatomic free iodine in dilute solution, which is the bactericidal component of PI. The concentration has been shown to be related to the  toxicity of PI, both in vitro and clinically. Current recommendation by the American Academy of Ophthalmology and the European Society of Cataract and Refractive Surgeons regarding PI use advise using 5% PI pre-surgery. An alternative dosing strategy uses dilute PI repetitively throughout cataract surgery (0.25% every 30 seconds). (Koerner et al., 2018)

This study compared image-guided system accuracy (Callisto eye; Carl Zeiss, Oberkochen, Germany) with a manual marking technique in the positioning of a toric

intraocular lens (IOL). The Callisto eye system group, comprised 45 eyes, and the manual marking technique group, was composed of 35 eyes. There were no statistical differences between groups, regarding the preoperative values which included:  the SE, corneal cylinder, axial length, logMAR UDVA, and logMAR CDVA. No significant differences were observed between groups at postoperative 3 months, in the logMAR UDVA, logMAR CDVA, degree of misalignment of toric IOL, or mean deviation from target-induced astigmatism values. The mean deviation degree from the intended axis was 2.04±1.84 in the Callisto eye system group and 3.24±2.64 in the manual marking technique group. However, this difference did not have any effect on the logMAR UDVA.(Kose and Erdogan, 2020)

The Pyhähjärvi Cataract Study included 93 consecutive patients living in Finland. The patient group with a mean visual acuity of 0.30 log MAR or worse in the better eye and/or 0.52 logMAR in the worse eye had successful cataract surgery in 59 to 83% of cases.(Kuoppala et al., 2012)

Risk factors causing the onset or progression of ERM on spectral domain optical coherence tomography (SD-OCT) after cataract surgery was investigated within this study. A significant risk for the onset or progression of ERM after cataract surgery was observed in eyes with partial posterior vitreous detachment (PVD; $p < 0.001$), hyper-reflective foci (HF) on the inner retinal surface ($p < 0.001$), vitreoschisis ($p = 0.014$), and discrete margin of different retinal reflectivity (DMDRR; $p = 0.007$) on ultra-widefield fundus photography (UWF-FP). The multivariate analysis showed that partial PVD (HR, 3.743; 95% confidence interval [CI], 1.956-7.162; $p < 0.001$), HF (HR, 2.330; 95% CI, 1.281-4.239; $p = 0.006$), and DMDRR on UWF-FP (HR, 3.392; 95% CI, 1.522-7.558; $p = 0.003$) were the independent risk factors for the onset or progression of ERM after cataract surgery after adjustment for other confounding factors.(Kwon et al., 2021)

**L**

In most comparative studies, pseudophakic monovision was compared with the implantation of multifocal intraocular lenses (IOLs) (9b studies). They demonstrated that monovision could provide very good (one study) to excellent (three studies) distance visual outcomes. Three studies indicated no statistically significant difference in UNVA between monovision patients and multifocal or accommodating groups. Two studies on pseudophakic monovision indicated that contrast sensitivity was decreased at high frequencies but still remained in the normal range and one study indicate that patients in the monovision group had significantly better contrast sensitivity than multifocal patients. One study reported that all patients achieved good distance and intermediate visual acuities (logMAR 0 and 0.10 respectively), while a remarkable reduction of near vision was also described (63.33% had logMAR 0.30). A study reported patients who underwent successful monovision presented the reversal threshold only at low decreasing contrast. Excellent visual outcomes and high satisfaction for patients were also reported in three more studies.

Regarding spectacle independence, pseudophakic monovision could provide a significant reduction of spectacle use postoperatively (eight studies). However, there were studies that showed significant superiority of the multifocal technique (three studies). The effect of pseudophakic monovision in daily activities was examined in four studies. Accordingly, less difficulty during computer work without glasses (two studies), better reading ability than multifocal patients (one study) and improved driving (one study) were reported. One study reported that there were more patients in the multifocal group who had dysphotopsia symptoms than in monovision (P<0.01 and P=0.024). (Labiris et al., 2017)

A prospective cohort study consisting of 3038 participants, reported that cataract surgery significantly lowered the risk of dementia development. Patients who underwent cataract surgery had a hazard ratio of 0.71 (95% CI, 0.62-0.83; p<0.01) for dementia, compared with participants without cataract surgery. No statistically significant association was found between glaucoma surgery and the risk for dementia.(Lee et al., 2022)

The changes in postsurgery IOP over time were significantly different between glaucoma, exfoliation syndrome, and normal (P = 0.005). There was lower Intraocular pressure in the normal group (n = 25) than in both the glaucoma (n = 18) and exfoliation syndrome (n = 19) groups (P<0.001). With 1 drop of prophylactic timolol maleate 0.5% at completion of surgery, the normal group (n = 25) again had lower IOP than those of the glaucoma (n = 15) and exfoliation syndrome (n = 20) groups (P<0.001). Treatment with timolol maleate 0.5% significantly altered postoperative IOP over time in the glaucomatous eyes (P = 0.003) but did not afect the exfoliation syndrome (P = 0.4) or normal (P = 0.5) eyes. Intraocular pressure > 25 mmHg did not occurin the normal eyes. Intraocular pressure > 25 mmHg and > 30 mmHg was observed in 10 (55%) and 5 (28%) glaucoma patients, and 5 (27%) and 2 (11%) exfoliation syndrome patients, Timolol maleate 0.5% eliminated IOP spikes > 30 mmHg and lowered the frequency of IOP > 25 mmHg in both groups to 14% in the glaucoma group and 5% in the exfoliation syndrome group. Most IOP increases were observed at post surgically at 4 hours. The mean IOP was <20 mmHg in all groups 1 day following surgery. Medically well-controlled glaucoma patients and patients with exfoliation syndrome may experience increased IOP shortly after cataract surgery. Instillation of timolol maleate 0.5% at the end of the procedure in this series eliminated IOP > 30 mmHg, but IOP elevation below that level can still occur. (Levkovitch-Verbin et al., 2008)

There was an increase in central retinal thickness (CRT) in DEX but not in TA-treated eyes at 7 days (+1.2 ± 20.1 μm and −9.2 ± 24.8 μm, p = 0.031), at 28 days (+23.8 ± 62.6 μm and −3.3 ± 27.7 μm, p = 0.008) and at 90 days (+8.5 ± 24.4 μm and −5.5 ± 33.4 μm, p = 0.026), respectively. Both groups increased aqueous flare from baseline but remained higher in DEX eyes at 90 days (+3.3 ± 9.9 photons/ms and −0.2 ± 6.6 photons/ms, p = 0.021). Corrected distance visual acuity (CDVA) and

IOP changes were similar, and ocular tolerance was good in both groups. (Lindholm et al., 2020)

On study EDF performed significantly better than trifocal IOLs under both photopic and scotopic conditions. One study reported that EDF IOLs performed better than trifocal IOLs at a frequency of 1.5 cycles per degree under scotopic conditions. Two studies reported no difference in contrast sensitivity between EDF and trifocal IOLs. Halos: two studies reported no significant difference in halos between EDF and monofocal IOLs, one study EDF IOLs resulted in more frequent halos than monofocal IOLs, one study both EDF and trifocal IOLs resulted in more frequent halos than did monofocal IOLs, and five studyreported no difference in halos between EDF and trifocal IOLs. EDF IOLs resulted in higher spectacle independence (risk ratio (RR) 2.81, 95% CI 1.06 to 7.46, P=0.04) than monofocal IOLs. Compared with trifocal IOLs, EDF IOLs produced worse near visual acuity (mean difference (MD) 0.10, 95% CI 0.07 to 0.13). Serious postoperative complications were rare, with no adverse events were reported in most studies. (Liu et al., 2019)

This prospective, single-center, open label, randomized study of 26 eyes (13 per group) from 20 patients evaluated and compared the efficacy of toric intraocular lens (IOL) implantation and aspheric IOL implantation with steep-axis incision for correcting mild to moderate corneal astigmatism in cataract patients with corneal astigmatism of 1.0–2.0D. The test group had the AcrySof® IQ Toric IOL implanted, and the control group had the AcrySof® IQ IOL implanted with a steep-axis corneal incision. All patients underwent examinations of uncorrected distance visual acuity (UCDVA), corrected distance visual acuity (CDVA), subjective refraction, and corneal astigmatism before surgery and at the 1-day, 1-month, and 3-month follow-ups. Vector astigmatism analysis was evaluated using the Alpins method. The test group had better vision than the control group at the 3-month follow-up and had more cases with a UCDVA of 20/20 (10/13 vs. 4/13). The surgically induced astigmatism (SIA) vector of the test group was higher than that of the control group (1.22±0.64 vs. 0.84±0.45). The correction index of the test group was closer to 1 compared to that of the control group (0.7 vs. 0.46). Approximately 85% of patients in the test group had an angle of error within −15° to 15°. However, only 23% of patients in the control group were within that range. Despite steep-axis corneal incision proving to be cost-saving and easy-to perform, its astigmatism-correcting efficacy was not as good as the Toric IOL implantation for cataract patients with low to moderate corneal astigmatism.(Liu et al., 2021)

**M**

The intracameral use of mydriatic combinations enhacing the preoperative mydriasis is gaining in popularity. This can be achieved by either bolus injection of the pharmacological agent or by constant irrigation during phacoemulsification. The former expands the pupil, while the latter is prevents the pupil constricting. The introduction of femtosecond-assisted cataract surgery was followed by a range of adverse effects including prostaglandin release into the aqueous humor causing pupil constriction. This can be improved by preoperative administration of

nonsteroidal anti-inflammatory drugs at least 1 day prior to surgery. Nevertheless, devices for pupil expansion may be required in around 10% of cases. Following the success of the Malyugin ring (MicroSurgical Technology Inc., Redmond, Washington, USA) multiple manufacturers introduced pupil expansion devices of various designs. They are variable with regards to materials, pupillary margin fixation mechanisms, and ease of manipulations during implantation and removal. The combination of appropriate pre and intraoperative pharmacological pupil dilatation and pupil expander devices facilitated safe and effective cataract surgery in the vast majority of patients with insufficient mydriasis. (Malyugin, 2018)

Cataract surgery has been reported with increasing frequency in corneal refractive surgery population. These patients had preoperative CDVA comparable to patients without previous corneal refractive surgery. Patients who were younger were at higher risk of worse postoperative CDVA, especially if they had preoperative CDVA of logMAR 0.0(6/6) or better. (Manning et al., 2015)

Another prospective, randomized, controlled clinical study aimed to evaluate the effectiveness and safety of the DFT015 intraocular lens (IOL) (AcrySof IQ Vivity Extended Vision), compared with an aspheric monofocal control IOL (AcrySof IQ model SN60WF). 218 patients (435 eyes) were evalujated. DFT015 had a greater mean monocular photopic DCIVA ($P < 0.001$), similar mean monocular photopic CDVA, and greater mean monocular photopic DCNVA ($P < 0.001$) when compared with SN60WF. The authors concluded that DFT015 is safe and effective for the visual correction of aphakia, had better DCIVA and DCNVA, with comparable CDVA and visual disturbances to the SN60WF monofocal IOL. (McCabe et al., 2022)

Two of the most common eye diseases of aging are cataract and age-related macular degeneration (AMD). Substantial improvements in quality of life and reductions in the risk of falls can be achieved following surgery for visually significant cataracts in patients with AMD. To identify pre-existing macula disease the use of pre-operative optical coherence tomography is recommended where possible. Careful counselling of patients is required before cataract surgery, this is especially required with respect to the expected visual outcome, intraocular lens choice and potential risks of surgery. Data from ‘real-world’ settings have implied 6 months of intravitreal anti-VEGF therapy for neovascular AMD before cataract surgery is compatible with optimum long-term visual outcomes. Patients who received intravitreal therapy for neovascular AMD should be advised of the slightly higher risk of intraoperative complications and the surgeon should be prepared to manage these during the operation. During cataract surgery, any unwanted exposure to light should be avoided, as this will reduce the risk of phototoxicity. The implementation of careful planning of intravitreal therapy for neovascular AMD prior to cataract surgery will allow for a greater recovery time of the eye in the postoperative period ahead of any further planned intravitreal therapy. (Mehta, 2021)

In a final study, reported about a total of 13301 cataract operations with an AcrySof SN60WF implant and 5200 operations with a SA60AT implant (Alcon Laboratories, Inc., Fort Worth, TX). A single eye per patient was included in the final analysis, resulting in a total of 18501 cases. The performance of each formula was assessed with respect to the error in predicted spherical equivalent and the effect of applying the Wang-Koch (WK) adjustment for eyes with axial length >25.0 mm on 4 of the formulae was evaluated. For the SN60WF, the standard deviation of the prediction error, in order of lowest to highest, was the Barrett Universal II (0.404), Olsen (0.424), Haigis (0.437), Holladay 2 (0.450), Holladay 1 (0.453), SRK/T (0.463), and Hoffer Q (0.473), and the results for the SA60AT were similar. The Barrett formula was significantly better than the other formulae in postoperative refraction prediction ($P < 0.01$) for both IOL types. There was a general shift from hyperopic to myopic outcomes in long eyes following the application of the WK axial length modification. The lowest prediction error for the 2 IOL models studied was reported with the Barrett Universal II formula. (Melles et al., 2018)

Mean IOP decreased from 15.4 ± 2.2 mmHg (baseline) to 14.1 ± 3.2 mmHg at 1 week ($p = 0.03$) in the injection group, whilst the topical group maintained a stable IOP at 1 week (16.3 ± 2.6 mmHg) compared to baseline (16.1 ± 2.7 mmHg; $p = 0.74$). Mean IOP at 1 month, was 14.3 ± 2.6 mmHg ($p = 0.03$) in the injection group and 15.6 ± 2.3 mmHg ($p = 0.2$) in the topical group, respectively. Highest levels of intraocular inflammation were observed at the 1-week postoperative visit in both groups., This was followed by a decline to negligible levels at 1 month.(Merkoudis et al., 2014)

There are various risk factors associated with dry eye disease (DED) after cataract surgery. These can cause a wide range of heterogeneous symptoms which includes a decrease in quality of vision. The prevalence and characteristics of DED after cataract surgery was evaluated by undertaking a systematic review and meta-analysis. The systematic review included 36 studies which were published between 2013 and 2020. Nine of these in the meta-analysis of DED prevalence after cataract surgery. The review showed that 37.4% (95% CI 22.6-52.3; 206/775) of patients without preexisting DED developed DED after cataract surgery. The predominate risk factors for DED after cataract surgery were age, female sex, systemic diseases, systemic medications, psychiatric conditions, preexisting DED, meibomian gland dysfunction, preservatives in eye drops, surgery techniques, and lifestyle. The peak severity of DED occurred 1 day postoperatively and persisted for at least 1-12 months following cataract surgery. Therefore, consistent follow-up for DED is recommended for at least 1 month after cataract surgery. An effective treatment in the prevention and treatment of post cataract surgery related DED is the administration of preservative-free diquafosol tetrasodium solution and preoperative meibomian gland treatment. As one in three patients develop DED after cataract surgery, careful DED management and treatment is pertinent after cataract surgery to improve satisfaction, vision quality and overall patient quality of life.(Miura et al., 2022)

A literature review reported that patients with FECD require preoperative assessment of endothelial cell size, density and morphology to assess the severity of the disease and other pertinent risk factors. Patients with a preoperative endothelial cell density of less than 1000 cells/mm$^2$ with or without a central corneal thickness of >640 µm, are at high risk for corneal decompensation after cataract surgery. Perioperative techniques, adapted biometry calculation and specific intraocular lens selection assist in optimizing the visual acuity outcomes and duration of recovery after cataract surgery.(Moshirfar et al., 2022)

A literature review evaluated cataract surgery in keratoconus patients. There is currently a challenge in obtaining reliable intraocular lens calculations in keratoconus patients; the optical biometry usually overestimates the corneal power in these patients, which causes a postoperative hyperopic shift. Higher K values of the eyes, the greater the risk of a postoperative hyperopic biometry error. The review recrecommends to aim for a slight myopic target with the actual K values for keratoconus patients with a maximum K value of 55D. Performing corneal crosslinking (CXL) or implanting intrastromal corneal ring segments before cataract surgery may improve postoperative visual outcomes due to better biometry examinations and IOL calculations.(Moshirfar et al., 2018)

This study compared a web-based digital assessment of visual acuity and refractive error to a conventional supervised assessment in 50 patients with keratoconus and complex refractive errors (between -6 and +4 diopters). There was an overall mean difference of the uncorrected visual acuity of -0.01 LogMAR (95%LoA:-0.63–0.60). Web based derived digital assessment significantly underachieved compared to the conventional method (0.22±0.32 logMAR vs. -0.01±0.13 LogMAR, P <0.001) when measuring the corrected visual acuities. (Muijzer et al., 2021)

Six hundred twenty-six patients were enroled. had maculopathy detectable only on OCT which included: 26 (4.2%) epiretinal membrane (ERM), 25 (4%) dry age-related macular degeneration (AMD), 19 (3%) vitreomacular traction (VMT), 5 (0.8%) lamellar macular hole (LMH), 2 (0.3%) cystoid macular edema (CMO) and 1 (0.2%) wet AMD. 166 (26.5%) had maculopathy on OCT, of which only 48 (7.7%) had known history of maculopathy. In fellow eyes, 29 (4.6%) had significant findings and 29 (4.6%) were unable to have SLIO or OCT due to dense cataract. (Murphy et al., 2022)

**N**

In a prospective study, 200 eyes from 200 patients were randomized to undergo either assessment using the Lenstar LS 900 or immersion A-scan ultrasound biometry to determine the IOL dioptric power preoperatively. No statistically significant differences were found between the target spherical equivalent and the

actual postoperative spherical equivalent using the Lenstar LS 900 (p-value = 0.632) and the A-scan ultrasound biometry (p-value = 0.438) devices.(Naicker et al., 2015)

A randomized clinical trial was performed with the aim to compare the outcomes after toric intraocular lens (tIOL) or peripheral corneal relaxing incisions (PCRI) for keratometric astigmatism (KA) between 0.75 and 2.5 diopters (D) during cataract surgery in eighty eyes (80 participants). The primary outcomes were uncorrected (UCDVA) and best-corrected distance logMAR visual acuity (BCDVA) at 12 months. 61% vs 53% had UDCVA of 20/25 or better, 100% vs 76% gained ≥1 lines, and 59% vs 43% were within ±0.13 D spherical equivalent at 12 months. For the duration of the study, there were changes in posterior corneal tilt, coma, and hexafoil in the PCRI group. The mean rotation of the tIOLs was 1.8 ± 1.4 degrees at 12 months. The authors concluded that there was no difference in visual acuity, although more tIOL patients gained ≥1 line and were within ±0.13 D. (Nanavaty et al., 2017)

The utility of OCT in cataract surgery continues to expand with different applications from preoperative planning, intraoperative image-based treatments, and postoperative care, such as complication management. The essential roles of OCT in managing postoperative complications include characterization of maculopathy, assessment of IOL stability and optical changes. The study recommends using OCT, wherever clinically indicated, as routine use may neither always be clinically necessary nor economically feasible for every patient prior to cataract surgery. (Nguyen and Chopra, 2013)

A hospital-based prospective interventional comparative randomized control trial included 261 patients. This study evaluated the SIA in clear corneal incisions with a temporal approach and superior approach phacoemulsification. Patients were divided for phacoemulsification into groups A and B, which underwent temporal and superior clear corneal approaches. The results of this study show a mean preoperative Log MAR score of 0.9 in both groups (groups A and B, P = 0.557). After 7 (visual acuity score) and 90 (best-corrected visual acuity) days postoperatively, there were statistically significant differences in the means between the two groups with the temporal approach showing less astigmatism on day 30 and day 90.(Nikose et al., 2018)

**P**

Patients undergoing cataract surgery were split into two groups: one watched a video about expectations for cataract surgery and the other about the anatomy of cataracts. In total, 84% of patients believed they had already heard enough or too much information preoperatively. More risks and discomfort were expected in the group who watched the anatomy video. Postoperatively, greater satisfaction, a better understanding and less anxiety was witnessed in the expectations video group. There were no statistically significant differences between the expected visual acuity

outcomes postoperatively and the discomfort or risk experienced during the surgery. (Pager, 2005)

A recent systematic review which included 21 studies regarding current image-guided systems used for cataract surgery or refractive lens exchange was performed in March 2018. Studies compared image-guided systems to alternative keratometric devices regarding their accuracy, repeatability, and reproducibility in measurement of keratometric values, astigmatism magnitude and axis, as well as in IOL power calculation. The image-guided systems were also compared with conventional manual ink-marking techniques for aligning toric IOLs. Image-guided systems appear to be accurate and reliable with highly repeatable and reproducible measurements regarding keratometry and IOL power calculation, but not yet interchangeable with the current established and validated keratometric devices. However, they are superior over the conventional manual ink-marking techniques for toric IOL alignment. (Panagiotopoulou et al., 2019)

This literature review synthesised eleven studies and evaluated the outcomes of varying IOL power calculations in eyes who underwent myopic LASIK or PRK. The mean predictive errors were 0.57±0.68 (Haigis), 1.07±1.18, (Hoffer Q) 0.82±1.10 (Holladay II) and 1.68±1.3415 (SRK/T). Eyes which previously had refractive surgery, the Barret True-K and Barret True-K no history methods had the best results including median absolute errors of 0.33D and 0.4D, with 67.4% and 57.6% of the eyes within 0.5D of target, respectively. Besides, the OCT, Potvin-Hill, intraoperative aberrometry, and Haigis-TK had similar outcomes, although these methods require devices which may not be generally available. Methods that use a lot of historical data (clinical history method, corneal bypass method, and Feiz-Mannis), including manifest refraction, pre- and postcorneal refractive surgery keratometry, showed 26% to 44% of the eyes with refractive outcomes within 0.5D. Of the methods using some historical data (pre- and postcorneal refractive surgery manifest refraction), the Barret True-K showed the best refactive outcomes with, respectively, 67.4% and 93% of the eyes within 0.5D and 1.0D of the predicted target. (Pantanelli et al., 2021)

In a follow-up study by the IRYSS group, it was reported that the predictive variables for visual acuity improvement after cataract surgery were preoperative visual acuity, age, ocular comorbidity, and complexity of the cataract surgery. A multivariate logistic model in the derivation sample showed that the final visual acuity ranged from 0-44 and VF-15 scores ranged from 0-24. The was no statistical significance when performing the receiver operating characteristic curves in the derivation and validation samples. The corresponding areas under the curve ranged from 65% to 80%, with a positive predictive value between 74% and 85%, respectively.(Perea-Milla et al., 2011)

An observational study that included 457,128 patients of which 23,331 had a prior diagnosis of dementia showed that patients diagnosed with dementia were half as likely as patients without to undergo cataract surgery (hazard ratio 0.53, 95% CI 0.53-0.54).(Pershing et al., 2019)

The IOP before surgery, 1 year after surgery, and at the final chart recording in 588 eyes having phacoemulsification with IOL implantation was reviewed retrospectively. Prior to surgery, eyes were divided into 5 groups based on IOP at surgery, patient age at surgery, years of postoperative follow-up, and a comparison between IOP at 1 year and IOP at the final check. The final mean IOP reduction was 6.5 mm Hg (27%) in the 31 to 23 mm Hg presurgical IOP group (n = 19), 4.8 mm Hg (22%) in the 22 to 20 mm Hg group (n = 62), 2.5 mm Hg (14%) in the 19 to 18 mm Hg group (n = 86), and 1.6 mm Hg (9%) in the 17 to 15 mm Hg group (n = 223). In the 14 to 9 mm Hg group (n = 198), the mean Stratifying eyes according to presurgical IOP showed greater long-term IOP reductions than previously reported. The reduction was proportional to the presurgical IOP. The eyes with the highest presurgical IOP saw the greatest decrease. There were no changes to IOP in eyes with the lowest presurgical IOP. The IOP reductions at 1 year were maintained over 10 years and were similar in patients of all ages. (Poley et al., 2008)

This retrospective review aimed to analyze intraocular lens (IOL) orientation data from an online toric back-calculator for determining differences in lens type. (Potvin et al., 2016) 8,229 calculation records included intended orientation and lens identification data. 5,674 calculations (69%) involved lenses oriented ≥5° from their intended position. The percentage of lenses was 0.89% overall, but the percentage varied significantly between specific toric lens brands ($P<0.05$). The authors concluded that “The percentage of eyes with lens orientation ≥5° from intended in the Toric Results Analyzer data set was <1% of toric IOLs in general, with the relative percentage of Tecnis(®) Toric IOLs significantly higher than AcrySof(®) Toric IOLs. Both of these had higher rates than the Staar(®) Toric and Trulign(®) Toric lenses, with the availability of higher Tecnis and AcrySof cylinder powers a likely contributing factor. The AcrySof Toric IOL appears to be less likely than the Tecnis Toric IOL to cause residual astigmatism as a result of misorientation. The Tecnis Toric IOL appears more likely to be misoriented in a counterclockwise direction; no such bias was observed with the AcrySof Toric, the Trulign(®) Toric, or the Staar Toric IOLs. (Potvin et al., 2016)

## Q

This retrospective consecutive cross-sectional study aimed to analyze the accuracy of the current intraocular lens power calculation formulae using standard keratometry (K) and total keratometry (TK) data in patients with flat and steep corneas. A total of 231 eyes from 231 patients were evaluated. The Emmetropia Verifying Optical

(EVO) formula using TK data showed the lowest SD (0.383) and MAE (0.30) and the highest percentage of cases with a PE within ±0.5 D (81.4%) in the entire study cohort., In the flat keratometry group, the EVO (p = 0.042), Haigis (p = 0.043), Hoffer Q (p = 0.038) and Holladay 1 (p = 0.013) formulae using TK data had significantly lower SD compared with K data. The lowest SD (0.357) and MAE (0.28) was observed for the EVO formula using TK data.In the steep keratometry group, the Hoffer Q (p = 0.036) and SRK/T (p = 0.029) formulae using TK data had significantly lower SD compared with K data.The authors concluded that the TK data set showed a better trend of refractive outcomes, especially in the flat and steep keratometry groups; EVO (TK) and BUII TK formulae were indicated for eyes with K values lower than 42 D and K values higher than 46 D, respectively. (Qin et al., 2023)

A large Spanish prospective cohort study (IRYSS group) consisting of 6107 patients (4657 (76%) had simple cataracts, and 1450 (24%) had ocular comorbidities). The main predictive factors for clinically relevant visual acuity improvement after cataract surgery were low preoperative visual acuity, younger age, and low surgical complexity, among cataract patients without comorbidities. Among the group of cataract patients with ocular comorbidities, in addition to the factors of the no-comorbidity group, these factors included: preoperative visual function and expected postoperative visual acuity. The sensitivity and specificity of a decision tree for clinically relevant improvement of visual acuity after cataract surgery, based on preoperative visual acuity, low surgical complexity, and white cataract, were 83% and 36%, respectively. In the group of cataract patients with comorbidities, this decision tree based on preoperative visual acuity and visual function, low surgical complexity, predicted postoperative visual acuity, and type of ocular comorbidity), has a sensitivity of 83% and specificity of 49%.(Quintana et al., 2010)

**R**

Another study included 949 eyes. The mean and median absolute predictive errors were 0.29 diopters (D) and 0.23 D (Barrett II), 0.31 D and 0.24 D (Hill-RBF), and 0.31 D and 0.25 D (intraoperative aberrometry), respectively (P > .05). Statistical difference in the IOL prediction methods was not influenced by the axial length stratification. Barrett II outperformed the OIA toric multifocal (P = .011) group. Postoperative refraction was within 0.50 D of target in 84% (Barrett II), 83% (Hill-RBF), and 82% (OIA) of eyes (P > .05). Comparing the OIA to the Barrett II and Hill-RBF calculators, there was no clinical difference in the toric multifocal group. Regarding postoperative predicted spherical equivalent, for patients without a history of refractive surgery and good potential visual acuity, refractive outcome was not improved by utilizing the OIA.(Raufi et al., 2020)

The visual, refractive outcomes and endothelial cell density were comparable between the 3 groups after 5 weeks post treatment. The median circularity index of

FLAC was statistically significantly different to M-CCC or PPC (1-10) groups (P<0.01) but PPC (11-20) was comparable to FLAC. Decentration of IOL center in relation to capsulotomy was seen only between the PPC (1-10) group and FLAC group (P=0.02). With regards to the pupil, the IOL was well centred in all groups (P = 0.46), although this was not statistically significant. The quality of vision parameters were comparable between groups for parameters including: the higher order aberrations, spherical aberration, coma, trefoil, modular transfer function, and Strehl ratio. (Reddy et al., 2021)

This retrospective case series aimed to compare the accuracy of intraocular lens power prediction for eyes with average keratometry (K) readings greater than 46.00 diopters (D) and lower than 42.00 D. The study comprised of 171 eyes (79, K reading >46.00 D; 92, K reading <42.00 D). For K readings >46.00 D, myopic errors were obtained using the SRK/T and Hill-RBF formulae whereas hyperopic errors were obtained with the Olsen C-constant and Haigis (-0.31 D, -0.17 D, 0.18 D, and 0.17 D, respectively). The percentage of eyes with an absolute error within ±0.50 D from target refraction ranged from 60.8% (SRK/T) to 83.0% (Hill-RBF). For K readings < 42.00 D, myopic errors were seen using the Haigis, Hill-RBF, Hoffer-Q, and Olsen-C formulae respectively (-0.31 D, -0.14 D, -0.22 D, and -0.17 D) and a hyperopic error using the SRK/T formula (0.16 D). The refractive prediction within ±0.50 D ranged between 75.0% for Haigis and 96.7% for Barrett Universal II. The authors concluded that power calculation for eyes with flat corneas and steep corneas requires the use of specific formulae for accurate postoperative results; and an adjustment method of the SRK/T formula has been proposed. (Reitblat et al., 2017)

This study aimed to evaluate different calculation approaches for toric intraocular lens (IOL) calculation in cases with high posterior corneal astigmatism (PCA) in 173 consecutive cases of toric IOL implantation. Seventeen eyes (10%) were investigated with a PCA of 0.80 D or greater. The mean absolute error was the lowest for Barrett's measured PCA (0.55 ± 0.38) followed by Barrett's predicted PCA mean absolute error (0.65 ± 0.31), vector summation (0.69 ± 0.33), and the Abulafia-Koch formula (0.80 ± 0.36). The rate of eyes with prediction errors within 0.25 D or less was the highest for Barrett's measured PCA (29.4%) followed by Barrett's (5.9%) and no eyes for the Abulafia-Koch formula and vector summation. The authors suggest that in cases of high PCA, the Barrett toric calculator using direct measurements of PCA may have a potential advantage over predicted PCA in toric IOL calculations and vector summation of the anterior and posterior corneal astigmatism.(Reitblat et al., 2020)

The fourth study reported that after optimization, the MEs of the Barrett Universal II, Haigis, and Olsen formulae were 0.04 diopter (D) ± 0.48 (SD), 0.04 ± 0.66 D, and 0.04 ± 0.52 D, respectively, and the MedAEs were 0.37 D, 0.46 D, and 0.39 D, respectively (P = .044; Haigis versus Barrett: P = .038). In the extreme myopia 1

group, all 3 formulae produced small MedAEs (P = .662). In the extreme myopia 2 group, the Haigis formula produced a significantly greater MedAE than the Barrett Universal II formula (P = .007; Haigis versus Olsen: P = .055). The Haigis formula affected the accuracy in myopic eyes, was affected by the AL and keratometry value, whereas the accuracy of the Barrett Universal II and Olsen formulae was affected only by AL. In eyes with an AL of 28.0 to 30.0 mm, all formulae were accurate. In eyes with AL of 30.0 mm or more, the Barrett Universal II formula was better than the Haigis formula,(Rong et al., 2019)

**S**

The purpose of this study was to investigate dry eye following phacoemulsification surgery and evaluate its relation to associated intra-operative risk factors. A prospective observational study measured 100 eyes from 100 patients without preoperative dry eye. Schirmer's Test I, tear meniscus height, tear break-up time, and lissamine green staining of cornea and conjunctiva were performed preoperatively and at 5 days, 10 days, 1-month, and 2 months after phacoemulsification surgery, along with the assessment of subjective symptoms, using the dry eye questionnaire. All dry eye test values significantly deteriorated following phacoemulsification surgery along with an increase in subjective symptoms. There improvements after 1-month postoperatively, but preoperative levels were not achieved till 2 months after surgery.  Patients should be warened fo the dry eye inducing risk factor associated with phacoemulsification prior to surgery. The clinician should also be cognizant that increased CDE can induce dry eyes even in eyes that were healthy preoperatively. In addition, intraoperative exposure to the microscopic light should be minimized. (Sahu et al., 2015)

This study assessed the refractive accuracy of different intraocular lens (IOL) power calculation formulae for in eyes with keratoconus. The final spherical equivalent was -0.52 D ±1.61 (SD). Among 41 eyes, the mean PE was positive (hyperopic surprise) with all formulae; the lowest PE (0.91 D) and MedAE (0.62 D) were obtained with the SRK/T formula. In stage I eyes (n = 21), the MedAE ranged between 0.43 and 0.91 D; the SRK/T formula achieved the lowest MedAE and the highest rate of eyes with a PE within ±0.50 (61.9%). In stage II eyes (n = 13), the MedAE ranged between 0.75 D and 1.50 D; the SRK/T formula achieved the lowest MedAE and the highest rate of eyes with a PE within ±0.50 (30.8%). In stage III eyes (n = 7), the MedAE was higher than 2.50 D with all formulae. All formulae led to a hyperopic refractive outcome in keratoconic eyes, with the SRK/T being the most accurate formula. These results were worse in advanced stages of the disease. (Savini et al., 2019)

Another study discussed that new formulae for IOL power calculation have been introduced with the aim of improving the accuracy of refraction prediction in eyes undergoing cataract surgery. These include the Barrett Universal II, the Emmetropia Verifying Optical (EVO), the Kane, the Næser 2, the Olsen, the Panacea, the Pearl

DGS, the Radial Basis Function (RBF), the T2 and the VRF formulae. The group refractive index originally developed for the IOLMaster may not represent the best method to convert the optical path length into a physical distance. The issue of posterior and total corneal astigmatism (TCA) is discussed in relation to toric IOLs; the latest formulae for toric IOLs and their results are also reported.(Savini et al., 2020)

A retrospective case series included 136 eyes with Fuchs' dystrophy undergoing cataract surgery. Fifty eyes had a preoperative corneal thickness of ≥600 μm, of which 5 eyes penetrating keratoplasty was needed within the first year after cataract surgery. The remaining 45 eyes had an average best corrected distance visual acuity of 20/35. The patients with a corneal thickness of >640 μm, 83% did not require penetrating keratoplasty within one year after cataract surgery and had a postoperative best corrected distance visual acuity of 20/50.(Seitzman et al., 2005)

Clinical data from cataract surgery procedures undertaken between January 1, 2012 and August 31, 2015 in the Moorfields main and satellite sites were anonymized and extracted, including prior occurrence and number of intravitreal injections. Logistic regression was conducted with the Hosmer-Lemeshow test for goodness of fit to generate odds ratios for possible risk factors.In total, 62 994 cataract surgery procedures were completedover the study period, of which 1035 (1.64%) were in eyes with previous intravitreal injection(s). PCR occurred in 650 (1.04%) eyes. After logistic regression, prior intravitreal injection was associated with an increased risk of PCR (P = .037), with an odds ratio of 1.66. The number of previous injections, indication for injections, and service undertaking the surgery were not associated with increased risk of PCR (P > .1).Eyes with prior IVI have an elevatedrisk of PCR. This was not affected by number of prior injections, indication for injections, or the specialty undertaking the surgery. (Shalchi et al., 2017)

A randomized, prospective interventional study consisting of 130 patients compared surgically induced astigmatism (SIA), total and posterior corneal curvature, pachymetry, and their stabilization after 2.2 and 2.8 mm precise corneal incision in phacoemulsification. Group 1 was operated with a 2.2 mm incision, and group 2 with a 2.8 mm incision, respectively. In both groups, there was a deceased mean SIA from week 1 to week 6 and an increase in SIA with the increased hardness of cataracts. Posterior keratometry (k1 and k2) showed statistically significant steepening in the first postoperative week, followed by gradual flattening until week six. Pachymetry increased significantly (P value < 0.001 in both groups) in the first week in both groups and stabilised at 3 weeks after that. In summary, there was no significant difference between both groups; the 2.2 mm incision shows no better effect on SIA than the larger 2.8 mm incision. In addition, the spectacle prescription can ideally be given by 6 weeks postoperatively.(Sheoran et al., 2022)

The patient's own conjunctival normal bacterial flora is typically the cause of postoperative endophthalmitis after cataract surgery. To prevent endophthalmitis a three step approach has been suggested, this being: (1) "border control" to prevent microorganisms from entering the eye by disinfecting the ocular surface is the most important measure; (2) bacteria that have gained access into the anterior chamber are reduced by irrigation; (3) bacteria remaining in the anterior chamber and vitreous at the end of surgery are controlled by antibacterial drugs. A new method for irrigating the ocular surface with povidone-iodine has been developed, "he Shimada technique". This uses a disinfectant with potent microbicidal effect and established effective and safe concentrations for eye tissues. Povidone-iodine displays a bactericidal effect for a wide concentration range of 0.005-10%, but 0.1% povidone-iodine provides the greatest activity and takes the quickest time of only 15 s to accomplish microbicidal effect. When treated to irrigate the ocular surface every 20-30 s during cataract surgery, 0.25% povidone-iodine is feasibly diluted to around 0.1%. Irrigation with 0.25% povidone-iodine during cataract surgery significantly reduced bacteria contamination rate in the anterior chamber compared with saline (p = 0.0017). This was done without causing any corneal endothelial damage. (Shimada and Nakashizuka, 2021)

There were 118 cases among 16070 cataract surgeries (incidence, 0.73%). The OR for the relationship of macular edema with PA+NSAID was 0.45 (95% CI, 0.21-0.95) and that for TA injection was 1.21 (95% CI, 0.48-3.06) when compared with PA alone. The frequency of intraocular pressure spikes of 30 mmHg or more between postoperative days 16 and 45 was 0.6% in the topical PA group, 0.3% in the topical PA+NSAID group (P = 0.13), and 0.8% for the TA group (P = 0.52). Black race was associated with a risk of macular edema (OR, 2.86; 95% CI, 1.41-5.79).(Shorstein et al., 2015)

There were 198 eyes included in this study. Of which 99 eyes from 73 patients received the injection. The remaining 99 eyes from 82 patients received topical drops. There was a single intraoperative posterior capsule tear that occurred in each group. Symptomatic breakthrough inflammation necessitating treatment occurred in eleven (11.1%) eyes in the injection group and 3 (3%) in the drop group (P = 0.0488). There was a development of macular edema in one (1%) eye in the injection group and zero (0%) in the drop group (P = 1.0). There were no reports of elevated intraocular pressure or infectious sequela occurred in either group (P = 1.0).118 cases from 16 070 cataract surgeries (incidence, 0.73%). Compared with PA alone, the OR for the relationship of macular edema with PA+NSAID was 0.45 (95% CI, 0.21-0.95) and that for TA injection was 1.21 (95% CI, 0.48-3.06). The frequency of intraocular pressure spikes of 30 mmHg or more between postoperative days 16 and 45 was 0.6% in the topical PA group, 0.3% in the topical PA+NSAID group (P = 0.13), and 0.8% for the TA group (P = 0.52). A risk of macular edema was associated with black race (OR, 2.86; 95% CI, 1.41-5.79). (Singhal et al., 2019)

This prospective clinical trial included 40 patients undergoing cataract surgery. All patients previously showed symptoms of evaporative dry eye disease measured by the Symptom Assessment in Dry Eye (Visual Analogue Scale [VAS]) questionnaire, Ocular Surface Disease Index (OSDI), and tear break-up time (TBUT) of less than 10 seconds. Patients were prescribed EvoTears four times a day for 5 weeks and administered 15 minutes after the standard postoperative topical anti-inflammatory regimen. There was an increase in median TBUT at 5 weeks postoperatively from 6.8 to 14 seconds (P <0.001). The was a decrease in the average total corneal staining score from 3.35 to 2.36 seconds (P < 0.001). The was an improvement in the mean CDVA from 0.41 to 0.14 logMAR (P < 0.001), in addition to statistically significant decreases in all scores from the VAS questionnaire at 5 weeks postoperatively. This study observed improvements in tear film, ocular surface, and subjective impressions of patients with dry eye disease 5 weeks after cataract surgery after the use of EvoTears. There was an indication for good efficacy and tolerability by physicians' and patients' assessments of EvoTears, this suggests its suitability in postoperative management of the ocular surface in patients with dry eye disease.(Son et al., 2020)

**T**

In a prospective clinical study included 106 patients undergoing cataract surgery, 32 patients that did not want any information regarding surgery risks and preferred to leave the entire decision-making to their ophthalmologist. Twenty-two patients requested a prediction of their visual acuity postoperatively, and 46 patients desired general information about possible complications. In the last group, 25 patients specifically wanted more granular information regarding the myriad of possible complications. (Tan et al., 2008)

Patients were 2.68 times more likely to intraoperative complications (P < 0.001) with PEX. These patients had a higher incidence of lens subluxation, zonular dehiscence, and vitreous loss (*P* < 0.001). Although posterior capsule rupture (PCR) was the most common intraoperative complication during cataract surgery (4.8%), the presence of pseudoexfoliation was not associated with PCR (*P* > 0.05). There was no association between patients with pseudoexfoliation and postoperative complications such as corneal decompensation, raised intraocular pressure, and intraocular lens decentration (*P* > 0.05). Pseudoexfoliation did not cause corneal decompensation (*P* > 0.05), although corneal decompensation was the most common postoperative complication of cataract surgeries (0.18%). Patients with PEX had a higher rate of intraoperative complications, mainly vitreous loss, zonular dehiscence, and lens subluxation/dislocation. Poorer visual outcomes were reported in those with PXM following cataract surgery. Patients with pseudoexfoliation should be identified, and precautions should be taken to minimize these complications for better visual outcomes. (Thevi and Abas, 2019)

The aim of this study was to assess the central macular imaging captured with an optical biometer based on Swept-Source OCT (SS-OCT) scan as a screening strategy for identifying macular diseases in patients prior to cataract surgery. 1,114 eyes of 749 consecutive patients underwent both an examination with the IOL Master 700 SS-OCT technology (Carl Zeiss) as well as the conventional Spectral-Domain OCT (SD-OCT) (Spectralis OCT, Heidelberg) device analysis on the same day. Optical biometer SS-OCT scans showed a mean sensitivity of 0.81 and a mean specificity of 0.84. Optical biometer with SS-OCT scan can be useful for detecting macular structural abnormalities in patients undergoing cataract surgery, but conventional SD-OCT remains important to confirm the presumed diagnosis. (Tognetto et al., 2019)

This study investigated the visual and refractive outcomes in patients with keratoconus undergoing cataract surgery. Cataract removal with a toric IOL significantly improved visual acuity and decreased astigmatism in keratoconic eyes with a topographic central relatively regular astigmatic component. Lower mean error in predicted refraction compared with conventional calculating formulae were observed in keratoconus-specific formulae. Posterior corneal power within the Barrett True-K formula for keratoconus improved IOL power prediction accuracy. (Ton et al., 2021)

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**V**

57 eyes were included in the study. The PE was not significantly different from zero for SRK/T, Barrett True-K (predicted and measured), and Kane keratoconus formulae (range 0.09 to 0.22 D, $P > .05$). The AE of Barrett True-K predicted (median 0.14 D) and Barrett True-K measured (median 0.10 D) were significantly lower from Barrett Universal II (median 0.47 D) and Kane (median 0.50 D), $P < .001$. (Vandevenne et al., 2023)

**W**

The study aimed to evaluate refractive accuracy of current intraocular lens (IOL) formulae in 73 eyes with keratoconus. All formulae had a positive mean predicted error ranging from 0.10 to 4.38 diopters (D). The Barrett Universal II formula resulted

in the lowest median absolute error for stage I (n = 46, 0.445 D) and II (n = 22, 0.445 D) eyes. Whilst also resulting in the highest percentage of eyes with predicted error within ±0.50 D for both stage I (52%) and II (50%) eyes. The Haigis formula had the lowest median predicated error (1.90 D) and the highest percentage of eyes with predicted error within ±0.50 D (40%) in stage III eyes (n = 5). Corneal power measured by optical biometers was higher than measurements by Pentacam keratometry. The most accurate formula was the Barrett Universal II for mild to moderate disease. Finally, Pentacam keratometry may help avoid hyperopic outcomes. (K. M. Wang et al., 2020)

In one study, segmented ALs were up to 0.29 mm larger in short eyes and 0.50 mm shorter in long eyes. The differences in ALs correlated negatively with the displayed ALs (r values, -0.941 to -0.913; P < 0.001). The MAEs were significantly less using segmented ALs for all formulae except the Olsen in both the entire group and the long eye subgroup (AL, ≥26 mm) and for the Holladay 1 and Hoffer Q in the short eye subgroup (AL, ≤ 22 mm). Segmented ALs produced a greater percentage of eyes within 0.5 D of error for all formulae except the Olsen and Haigis for the entire group, for long eyes, and for the Holladay 1 in short eyes. The segmented ALs were larger in short eyes and smaller in long eyes compared with the displayed ALs calculated with a single group refractive index for the entire eye. There was an improvement in the refractive accuracy with segmented ALs in short eyes with the Hoffer Q and Holladay 1 formulae and also in long eyes with all formulae with the exception of the Olsen formula where no improvement was observed. (L. Wang et al., 2019)

This review examined various methods and outcomes of IOL power calculations for such eyes, focusing on toric, multifocal, and EDF IOLs. Seventy articles were reviewed, categorizing methods into three groups based on their utilization of historical data acquired before corneal refractive surgery. Results showed that in eyes with prior myopic LASIK or PRK, hyperopic LASIK or PRK, and RK, 0% to 85%, 38.1% to 71.9%, and 29% to 87.5%, respectively, achieved refractive prediction errors within ±0.5D. For toric IOL implantation meeting specific criteria, 80%, 84%, and 69% of eyes, respectively, achieved postoperative astigmatism of 0.50 D or less. Tools like the ASCRS postrefractive IOL calculator, which incorporates multiple formulas, can aid clinicians. Toric, EDF, and multifocal IOLs may offer excellent results in appropriately selected cases adhering to specific corneal topographic criteria.(Wang and Koch, 2021)

This article discusses challenges in IOL power calculation, different approaches for IOL power calculation, and investigates refractive outcomes associated with various methods,  and IOL type selection for these eyes. When automated keratometry was applied with theoretical formulas for eyes without prior laser vision correction, it resulted in consistently hyperopic predictions. Mean absolute errors ranged from 0.72 to 1.9 diopters (D), and median absolute errors ranged from 0.65 to 1.73 D. Only a small percentage (8%-40%) of eyes were within 0.5 D of the target spherical equivalent (SE). Formulas tailored to patients with a history of laser vision correction, requiring both pre-surgery keratometry and manifest refraction, improved accuracy,

with 26%-44% of eyes within 0.5 D of the target SE. Formulas relying solely on preoperative keratometry or no historical data yielded lower MAEs (0.42-0.94 D) and MedAEs (0.30-0.81 D) and higher proportions (30%-68%) within 0.5 D of the target SE. Combining multiple methods yielded the best results, with the lowest reported MedAEs (0.31-0.35 D) and the highest proportions (66%-68%) within 0.5 D of the target SE. Notably, refractive outcomes were less accurate in eyes that had undergone previous excimer laser surgery for myopia compared to those without such history. (Wang and Koch, 2022)
Optimized AL values were highly correlated with the IOLMaster AL (R(2) from 0.960 to 0.976). The method of optimizing AL significantly reduced the mean numerical errors for IOLs greater than 5.00 diopters (D) from +0.27 to +0.68 D to -0.10 to -0.02 D and for IOLs of 5.00 D or less from +1.13 to +1.87 D to -0.21 to +0.01 D, respectively (all P<.05). In multiple validation data sets, this method significantly reduced the percentage of eyes that would be left hyperopic. (Wang et al., 2011)

The study enrolled 36 eyes (24 patients). The mean toric IOL misalignment was significantly less in the image-guided group than in the manual group 1 hour (1.3 degrees ± 1.6 [SD] versus 2.8 ± 1.8 degrees; P = .02) and 3 months (1.7 ± 1.5 degrees versus 3.1 ± 2.1 degrees; P < .05) postoperatively. The mean residual refractive cylinder was -0.36 ± 0.32 D and -0.47 ± 0.28 D in the image-guided group and manual group, respectively (P > .05). The mean UDVA was 0.03 ± 0.10 logarithm of minimum angle of resolution (logMAR) and 0.04 ± 0.09 logMAR, respectively (both P > .05). No intraoperative complications occurred during any surgery. (Webers et al., 2017)

Weill et al enrolled 453 eyes; 42 eyes (9.2%) were excluded because of non-interpretable SD-OCT scans attributable to advanced cataract, leaving scans of 411 eyes of 411 patients for study inclusion. Macular pathologies were detected by SD-OCT in 167 eyes (40.6%), including age-related macular degeneration (50%), epiretinal membrane (28.3%), and cystoid macular edema (12.8%). Overall, the management of 107 patients (26.0%) was modified because of macular SD-OCT findings, which were either missed (22.8%) or underestimated (3.2%) by the fundus biomicroscopic examination. Changes in preoperative patient management included altering patient consultation regarding presbyopia correction solutions (73 eyes [17.8%]) and referral to a retinal specialist for consultation (34 eyes [8.3%]).(Weill et al., 2021)

This study reviewed the problems and current power calculation methods after laser refractive surgery. Difficulties after LVC derive from different parameters including: the measurement of anterior corneal radii, asphericity, and the predicted effective lens position. A central issue is that most conventional 3rd generation formulae estimate lens position amongst other parameters on keratometry, which is altered in post-LVC eyes. Total keratometry (IOLM700) in combination with the Barrett True-K, EVO 2.0 (emmetropia verifiying optical formula), or Haigis formula is relatively uncomplicated and seems to provide good results, as does the Barrett True-K

formula with standard keratometry. The ASCRS (American Society of Cataract and refractive Surgery) calculator combines results of various formulae and averages results, which allows for direct comparisons between formulaes. Further research is required to evaluate the efficacy of tomography-based raytracing with OKULIX and the Castrop formulae either with a thick lens cornea model, or different total power values. (Wendelstein et al., 2022a)

This study aimed to evaluate the outcome of a Web-based refraction compared with the golden standard of manifest refraction. A total of 200 eyes of100 healthy participants were examined. The Web-based assessment of refractive error had excellent correlation compared with the reference test (intraclass correlation coefficient=0.92). UCVA was similar between the tests (P=.21). Visual acuity was better using the Web-based tool (P<.01). The Web-based tool achieved the best results in participants with mild myopia (ie, <3 D yielding a corrected visual acuity of >1.0 in 90% (n=77) of participants. The authors conclude that in healthy eyes with mild myopia, Web-based eye testing is a valid and safe method for measuring visual acuity and refractive error . (Wisse et al., 2019)

**X**

In this meta-analysis, the mean uncorrected distance visual acuity (UDVA) in the trifocal group was significantly better than that in the bifocal group (weighted mean difference (WMD) -0.03, 95% confidence interval (CI) -0.05 to -0.01), but the difference (0.03 log MAR) was not clinically significant. Regarding uncorrected intermediate visual acuity (UIVA), the mean UIVA in the trifocal group was insignificantly better than that in the bifocal group (WMD -0.07, 95% CI -0.20 to 0.05, P=0.25). Three studies indicated that the AT Lisa tri 839MP trifocal IOL showed significantly better UIVA than bifocal IOLs, and four studies indicated that Fine Vision trifocal IOLs had significantly better UIVA than bifocal IOLs. For uncorrected near visual acuity (UNVA), the mean UNVA in the trifocal group was insignificantly better than that in the bifocal group (WMD -0.04, 95% CI -0.11 to 0.02). There was a statically significant difference between the two groups in residual cylinder (WMD 0.11, 95% CI 0.02 to 0.20), and subgroup AT Lisa tri 839MP trifocal also showed significant better UNVA than bifocal IOLs (WMD -0.13, 95% CI -0.17 to -0.08). No significant differences were observed in spectacle independence (WMD 1.27, 95% CI 0.89 to 18.15), patient satisfaction (WMD 4.01, 95% CI 0.07 to 22.72), residual sphere (WMD -0.03, 95% CI -0.18 to 0.13), SE (WMD 0.04, 95% CI: -0.09 to 0.16) or complications (WMD 2.08, 95% CI: 0.35 to 12.43). (Xu et al., 2017)

**Y**

There was a statistically significant, but small difference in the overall effect for monocular uncorrected distance visual acuity (UDVA) (mean difference [MD] -0.06; 95% confidence interval [CI] -0.10 to -0.02; 6 studies) and monocular corrected distance visual acuity (CDVA) (MD -0.02; 95% CI -0.03 to 0.00; 8 studies) that favoured IOL with better vision. Five studies reported no significant difference

between trifocal and bifocal groups in the postoperative monocular uncorrected near visual acuity (UNVA) (MD -0.01; 95% CI -0.07 to 0.04) and distance-corrected near visual acuity (DCNVA) (MD -0.01; 95% CI -0.06 to 0.04). Two studies reported no significant difference between trifocal and bifocal groups in postoperative monocular uncorrected intermediate visual acuity (UIVA) (MD -0.10; 95% CI -0.36 to 0.17) and distance-corrected intermediate visual acuity (DCIVA) (MD -0.12; 95% CI -0.36 to 0.13). Three studies reported no significant difference between trifocal and bifocal groups in postoperative binocular UDVA (MD -0.04; 95% CI -0.08 to 0.00), UIVA (MD -0.04; 95% CI -0.09 to 0.02) and (MD -0.03; 95% CI -0.10 to 0.05). (Yang et al., 2018)

This retrospective study aimed to investigate the effect of anterior chamber depth (ACD) on the refractive outcomes of the SRK/T, Holladay 1, Hoffer Q and Haigis formulae in short, normal, long and extremely long eyes in patients who had uncomplicated cataract surgery. Median absolute errors (MedAEs) predicted by the SRK/T, Holladay 1, Hoffer Q and Haigis formulae were compared to the Friedman test. the Haigis formula revealed the highest MedAE in short eyes with an ACD < 2.5 mm. The difference in MedAE with the Hoffer Q formula was statistically significant (P = 0.002)., The Haigis formula significantly differed from the Holladay 1 (P = 0.002) and Hoffer Q (P = 0.005) formulae in the ACD < 2.5 mm group in normal eyes., The differences in MedAEs were statistically significant (P = 0.018, P = 0.001, respectively) and the Haigis formula had the lowest MedAEsin long eyes and extremely long eyes with an ACD ≥ 3.5 mm. In 1,123 eyes, refractive errors predicted by the Haigis formula showed a significant negative correlation with the ACD (R2 = 0.002, P = 0.047). The authors concluded that the Hoffer Q formula is preferred over the other formulae in short eyes with an ACD shallower than 2.5 mm; in short and normal eyes with an ACD < 2.5 mm the Haigis formula might underestimate ELP. (Yang et al., 2017)

This prospective study was a single-arm, non-masked, non-randomized trial in a single private practice evaluated clinical outcomes of toric IOL implantation based on a calculator that considered posterior corneal astigmatism (PCA) and effective lens position. The back-calculated theoretical results using a legacy calculator that did not consider PCA was compared to the residual refractive cylinder (RRC). Distance visual acuity (best corrected and uncorrected) and manifest refraction were also analysed, along with preoperative and postoperative keratometry. thirty-four subjects providing 46 eyes were available for data analysis. All eyes presented spherical equivalent refraction within 0.5D of intended. Uncorrected visual acuity was 20/25 or better in 86% of eyes targeted for emmetropia. The residual cylinder was 0.50D or less in 96% of eyes, with a maximum of 0.75D examined. The difference between the residual cylinder and the expected cylinder from calculations was significantly lower for the calculator that included consideration of PCA and ELP relative to the one that did not.(Yeu et al., 2020)

Preoperative flare was reported at 9.0 ± 0.6 pu/ms and central retinal thickness (CRT) 269.6 ± 1.9 µm (mean ± SEM). On day 28 post-surgery, flare was 22.1 ± 2.9 pu/ms for DEX, 17.4 ± 2.5 pu/ms for DICL and 13.0 ± 1.6 pu/ms ($p < 0.05$) for their combination. There was an increase in central retinal thickness (CRT) to 31.5 ± 8.8 µm for DEX, 6.0 ± 0.8 µm ($p = 0.001$) for DICL, and 3.5 ± 0.5 µm ($p < 0.001$) for their combination. The occurrence of ocular symptoms related to the eye drops was 11% for DEX, 37% for DICL and 34% for their combination ($p < 0.001$). Clinically significant pseudophakic cystoid macular edema (PCME) was reported in seven eyes which were all treated with DEX ($p < 0.001$). (Ylinen et al., 2018)

Another pooled analysis of seven studies (n=230) reported that the IOL group had significantly better binocular distance VAs corrected with defocus levels of -0.5 (mean difference [MD] -0.03 logarithm of the minimum angle of resolution [logMAR], 95% confidence interval [CI] -0.05 to -0.01), -1.0 (MD -0.10 logMAR, 95% CI -0.13 to -0.07), -1.5 (MD -0.08 logMAR, 95% CI -0.09 to -0.07) and -2.5 (MD -0.02 logMAR, 95% CI -0.04 to -0.01) diopters compared to the bifocal IOL group in patients who underwent cataract surgery or refractive lens exchange. Moreover, the trifocal IOL group showed significantly better monocular uncorrected distance (MD -0.04 logMAR, 95% CI -0.07 to -0.01, 9 studies, n=636) and intermediate VAs (MD -0.07 logMAR, 95% CI -0.13 to -0.01, 4 studies, n=280) compared to the bifocal IOL group. However, no significant differences were observed between the two groups in terms of spectacle dependence (2 studies), postoperative refractive error (10 studies), contrast sensitivity (5 studies), glare (2 studies) and higher-order aberrations (2 studies). (Yoon et al., 2018)

Wider pupillary stretching during surgery resulted in deteriorated pupillary functions after surgery. Eyes of patients receiving long-term miotic therapy with pilocarpine demonstrated poorer pupillary reaction after surgery. Inappropriate use of the flexible iris retractor causes an atonic, chronically enlarged postoperative pupil. To avoid postoperative pupillary complications, miotic pupils should not be stretched to larger than a 5.0 x 5.0 mm square. (Yuguchi et al., 1999)

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Another study including 83 cataract patients, compared video-based training to an educational booklet. Both the video and the booklet improved patients' understanding of cataract surgery. The mean value for each domain of self-management score was 3.87 ± 1.68 before and 6.65 ± 1.38, $p<0.001$ for general information; 3.92 ± 2.10 before and 8.20 ± 1.77, $p<0.001$ for prevention and management of cataract; and 13.6 ± 5.01 before and 21.82 ± 3.82, $p<0.001$ for postoperative self-care, in the group who had video-based training. The mean value for each domain of self-management score was 3.55 ± 1.95 before and 6.23 ± 1.55, $p<0.001$ for general information; 3.37 ± 2.28 before and 7.79 ± 2.32, $p<0.001$ for prevention and management of cataract; and 11.76 ± 6.76 before and 19.09 ± 5.81,

p<0.001 for postoperative self-care, for the educational booklet training. The video-based training was statistically significantly better when measuring the self-care performance compared to the patients who had the educational booklet when corrected for the effect of age (p=0.037).(Zarifsanaiey et al., 2022)

Another study evaluated and compared the accuracy of different IOL power calculation formulae for eyes with axial length (AL) than 26.00 mm. 407 eyes of 219 patients with AL longer than 26.0 mm were reviewed. The refractive prediction errors of multiple IOL power calculation formulae using User Group for Laser Interference Biometry (ULIB) constants were assessed. 171 eyes were enrolled. The lowest mean absolute error (MAE) was held by the Barrett Universal II formula and SRK/T and Haigis had similar MAE, with statistically highest MAE seen with the Holladay and Hoffer Q formulae. The IQR of the Barrett Universal II formula was also the lowest. The Barrett Universal II formulae demonstrated the highest percentage of eyes within ±1.0 D and ±0.5 D of the target refraction (97.24% and 79.56%, resp.). The lowest predictive error and the least variable predictive error produced was with Barrett Universal II formula compared with the SRK/T, Haigis, Holladay, and Hoffer Q formulae. For high myopic eyes, the Barrett Universal II formula may be preferable choice. (Zhang et al., 2016)

For uncorrected near visual acuity (NVA), there was a significant difference between trifocal and bifocal intraocular lenses (IOLs) implantation (mean difference (MD) −0.00, 95% confidence interval (CI) −0.015 to −0.001). For distant-corrected NVA, there were no significant differences between trifocal and bifocal IOLs implantation (MD −0.00, 95% CI −0.02 to 0.02). Subgroup analyses results revealed that trifocal IOLs with FineVision were greater than bifocal IOLs (1 RCT, MD −0.01, 95% CI −0.018 to −0.002). For intermediate VA, trifocal IOLs were linked with improved uncorrected intermediate VA (IVA) when compared to bifocal IOLs (MD −0.06, 95% CI −0.10 to −0.02). Distant-corrected IVA was significantly different between trifocal and bifocal IOLs (MD −0.06, 95% CI −0.14 to 0.02). Subgroup analysis showed a significant difference between trifocal IOL with AT LISA tri 839MP and bifocal IOL with AT LISA 809M for uncorrected (MD −0.12, 95% CI −0.19 to −0.04) and distant-corrected IVA (MD −0.10, 95% CI −0.18 to −0.03). Moreover, subgroup analysis revealed that trifocal IOLs with FineVision showed an association with improved uncorrected IVA when compared to bifocal IOLs (1 RCT; MD −0.04, 95% CI −0.06 to −0.02). For distant VA, the meta-analysis results showed no significant difference between trifocal and bifocal IOLs for uncorrected distant VA (MD −0.014, 95% CI −0.029 to 0.001. Distant-corrected VA was also not different between trifocal and bifocal IOLs (MD −0.00, 95% CI −0.01 to 0.01). Moreover, all subgroup analyses results based on IOL types showed no statistically significant differences for uncorrected and distant-corrected DVA between trifocal and bifocal IOLs. For patient's satisfaction, the meta-analysis results suggested no significant differences

between trifocal and bifocal IOLs with regard to patient's satisfaction (risk ratio (RR) 0.97, 95% CI 0.87 to 1.09) The pooled analysis results also revealed that trifocal IOLs have significantly decreased the posterior capsular opacification (PCO) incidence when compared to bifocal IOLs (RR 0.54, 95% CI 0.31 to 0.95). (Zhang et al., 2021)

Another study found  no significant differences in uncorrected and corrected distance VA (UDVA and CDVA) between trifocal intraocular lenses (IOLs) and the hybrid multifocal-extended depth of focus (EDF) IOL (mean difference (MD) 0.010, 95% confidence interval (CI −0.010 to 0.030 for UDVA; MD 0.007, 95% CI −0.007 to 0.021 for CDVA). In terms of intermediate visual performance, the hybrid multifocal-EDF IOL provided better, uncorrected intermediate VA (UIV) (MD 0.055, 95% CI 0.016 to 0.093) and comparable corrected intermediate VA (CIVA) (MD 0.039, 95% CI −0.008 to 0.086) with trifocal IOLs. In addition, the trifocal group presented significantly better results of uncorrected near VA (UNVA) (MD −0.143, 95% CI −0.192 to −0.010) and corrected near VA (CNVA) (MD −0.149, 95% CI −0.217 to −0.082). Concerning refraction, no significant difference was reported in spherical equivalent between the trifocal and the hybrid multifocal-EDF groups (MD −0.040, 95% CI −0.092 to 0.011). In sensitivity analysis, spherical equivalent results revealed significantly better performance in the trifocal group than the hybrid multifocal-EDF group (MD −0.057, 95% CI −0.101 to −0.013). For the far and intermediate distances, spectacle independence did not reveal significant differences between the two groups. However, trifocal IOLs were 10% more likely to achieve spectacle independence at near distance (risk ratio (RR) 1.103, 95% CI 1.036 to 1.152). Trifocal IOLs were 32% more likely to generate a halo effect (RR 1.318, 95% CI 1.025 to 1.696). Furthermore, although three studies observed fewer glare disturbance in the hybrid multifocal-EDF IOL, the results did not reveal significance (RR 1.251, 95% CI 0.889 to 1.761). (Zhong et al., 2021)

From a sample of 2823 eyes the postoperative corrected distance visual acuity (CDVA) was 0.3 logMAR or better in 88.7% [2505] of eyes. The mean differences between preoperative and postoperative RCCQ2 and CQ scores were -3.09 and -2.39, respectively. There was an improvement in visual function with surgery in 91.5% (2163/2364) of patients. There were weak but statistically significant correlations of postoperative CDVA with postoperative refraction, PROMs, and complications were found ($0.133 \leq r \leq 0.289$, $p < 0.001$). A predictive postoperative CDVA model (R2: 0.254) consisting of 10 variables was developed. The model included preoperative CDVA, different ocular comorbidities, age, gender, and intraoperative complications. Additionally, another predictive postoperative CQ model (R2: 0.148) of consisting a total of 14 variables was created. This model included preoperative CQ, target refraction and previous surgeries.(Zijlmans et al., 2021)

### 12.3 Appendix 3 – Evidence Critical Appraisals

The critical appraisals can be found in [supplemental document]

### 12.4 Appendix 4 – Conflicts of Interest

Conflicts of interest can be found in [supplementary document]