KERATOCONUS RESEARCH
ICRS implantation with the femtosecond laser for the treatment of keratoconus – results according to the new SA.ANA classification

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Keratoconus is a progressive disease of the cornea. It is characterised by steepening and paracentral thinning, more in the corneal apex, with distortion of the corneal surface resulting in irregular astigmatism.

Intrastromal corneal ring segments (ICRS) are indicated in patients with keratoconus with low vision with spectacles or contact lenses, or intolerance to contact lenses as a way to delay or avoid corneal grafting. The main advantages are reversibility, stability and security, since it is an additive intrastromal procedure which adds “corneal tissue”, that does not require intraocular manoeuvres.

The definition of the location of the intrastromal corneal rings and its dimensions has varied widely, with unpredictable results, with an apparently similar keratoconus achieving good and bad results with one or two ring segments.

There are several types of intrastromal ring segments on the market. The Keraring are triangular rings of PMMA (polymethylmethacrylate) available in two models (SI-5 and SI-6) with thickness from 150 to 350 μm with 50 μm increments. The SI-5 model, with an isosceles triangular shape and truncated at the apex in 40 μm, has an optical zone of 5mm; the SI-6, with a scalene triangular shape and truncated at the apex in 120 μm, has 5.5mm or 6mm OZ and both can have 90, 120, 150, and 210 degrees of arc length. This variety allows multiple combinations and, theoretically, an implant better targeted to each patient.

**SA.ANA classification**

For comprehension of the topographic and refractive results obtained with the intrastromal rings’ implantation, a database was created compiling 3,450 eyes implanted between January 2004 and December 2009, from nine Iberian surgeons. This study culminated in the creation of the SA.ANA classification, which is based on a simple and fast algorithm, based on two criteria: symmetry and axiality. The rings can be symmetrical (two similar rings) or asymmetrical (two different rings or a single ring), axial (on the flat axis) or non-axial (axis away from the flat one in at least 30°), which compose the acronym SA.ANA (Symmetric, Asymmetric, Axial, Non-Axial). The position of the rings is obtained from this classification, identifying the type of ectasia. The axis of the coma is also considered in the choice of the location of the ring. While in markedly asymmetric ectasias (AA1 and AA2) the coma axis is usually coincident with the flat axis, in intermediate ectasias (SNA, ANA1, 2 and 3) it is closer to the steepest axis. In these cases, the choice could fall on the axis of the coma or on an intermediate axis between the coma and the flat axis, depending on the values in question. In asymmetric SA-AANA categories (AA1, AA2, ANA1, ANA 2 and ANA3) one or two rings are implanted according to the topographic cylinder. The thickness of the ring segment is still limited by the corneal pachymetry in the area of the implantation.

Thirty eight eyes (23 patients, 15 men and eight women aged between 22 and 65 years (37.6 ± 10.14) were evaluated. The mean follow-up time was 6.2 months (SD= 5.2; range three to 27 months). The inclusion criteria were contact lenses intolerant keratoconus, transparency of the central cornea, minimum pachymetry of more than 400 μm and thickness on the area of the incision exceeding 450 μm.

All procedures were performed under topical anaesthesia. The incision was made on the steepest topographic meridian and the tunnel performed at 70 per cent of the corneal thickness. Since the introduction on the market we used preferentially 6mm diameter ring segments. The intracorneal ring segments were implanted easily immediately after the laser. A hydrophilic contact lens was applied in all patients and removed on the first postoperative day (see image).

The mean spherical equivalent changed from preoperative -3.55 D (SD 2.72, range -7.75 to +4.50) to -2.33 D (SD 2.87, range -8 to + 5.5) in the postoperative period, and this reduction was statistically significant (P= 0.003). The mean decrease in cylindrical power after the surgery was 1.0 D, from 3.38 D (SD 1.38, range +0.5 to +6.0) to 2.38 D (SD 1.73, range 0 to +8.0).

Similarly, topographic astigmatism showed a significant decrease from 3.34 D (SD 2.47, range +0.3 to +8.4) to 1.44 D (SD 1.72, range 0 to +5.2) (P= 0.04).

The mean BCVA (logMAR) improved from preoperative 0.42 (SD 0.2) to postoperative 0.22 (SD 0.14) (P< 0.0001). Twenty seven eyes (71.1 per cent) gained at least two lines of vision, 15 eyes (39.5 per cent) gained three or more lines of vision, seven eyes (18.4 per cent) showed no change in BCVA and no eye lost vision.

**Innovative approach**

The mean coma aberration showed a reduction (third-order component Z3) from 0.0034 to 0.0025 (P = 0.055). The preoperative and postoperative aberation coefficient changed from 2.47 to 2.58.

The SA.ANA classification was AA1 in 27 of the 38 eyes, ANA1 in four eyes, SA on three eyes, AA in two eyes and SNA1 in two eyes.

The visual discomfort in patients with keratoconus and with transparent cornea comes from myopia, astigmatism and high order aberrations (HOA), particularly the coma2. In fact, the results of stromal rings implantation are worse in keratoconus with high comatic default, comatic axis clearly distinct from the astigmatic axis and irregular patterns of keratoconus2.

In conclusion, the introduction of intrastromal corneal ring segments with the femtosecond laser based on a classification that considers the keratoconus in its multiple facets (refractive, topographical and aberrometric) is an innovative approach, based on the pathophysiology of the disease and extremely promising in treatment of keratoconus. The results presented in this study are very encouraging, however, further studies are needed, with longer follow-up and greater number of patients, to refine the SA.ANA classification and create clearer guidelines in relation to astigmatic versus aberrometric correction.

**References**
