Numerical simulations that take into account individual patients’ specific corneal characteristics could improve refractive outcomes in femtosecond cataract surgery, suggests a preliminary clinical study presented at the XXX Congress of the ESCRs.

“We are convinced that patient-specific numerical simulations have the potential to become an essential tool for planning in femtosecond cataract surgery,” said Harald Studer PhD, University of Bern, Switzerland.

The prospective clinical study was limited to assessing how well a standardised biomechanical cornea model customised with individual topography data could predict refractive and topographic outcomes in manual cataract surgery. However, the simulation methodology, produced on behalf of Integrated Scientific Services AG, Port, Switzerland might eventually take advantage of the precision of femtosecond-assisted surgery and advanced topographic, tomographic and even corneal biomechanical measurements to plan and execute a wide range of incisions to reliably correct astigmatism and other aberrations.

**Clinical study**

Dr Studer started with the question of whether it is possible to create patient-specific surgical planning aids with numerical simulations. He designed a clinical study involving 13 cataract patients without previous eye surgery who were able to undergo topography. The goal was to see how well a numerical model based on known biomechanical properties and modified with patient-specific topographic data could predict outcomes based on specific cataract incision characteristics.

All patients underwent standard cataract surgery. During surgery, parameters of the main incision, including distance from the limbus, length, width and angular orientation, were recorded by the surgeon using callipers. Patients also underwent three topography measurements with a Pentacam (Oculus), one before surgery, a second immediately after surgery and a third one month after surgery.

The numerical simulation was based on corneal biomechanical features previously identified by Dr Studer and other researchers. They included incompressibility, which is influenced by water content; isotropic tissue matrix, which includes proteoglycans, glycosaminoglycans and keratocytes; major collagen fibres with a realistic distribution based on x-ray scatter investigations; and collagen cross-links (Studer H. J Biotech 43 (2010) 836-842). The resulting mesh was warped to individual topography measurements to create a patient-specific finite element model.

Data from the incisions was entered in the model and the refractive and topographic results were simulated. The simulations were then compared with the actual surgical outcomes to determine the validity of the prediction model.

**Predicting outcomes**

Surgically induced astigmatism, including both changes in sphere and cylinder, were mostly within 0.25 dioptre. This means the outcome can be predicted almost within the precision of the measurement device, Dr Studer said. Comparing differences in predicted vs. actual post-op topography elevation, the majority were below 5.0 microns, which also is close to the precision of the measuring device, he added.

Dr Studer was encouraged by the results. “The simulations were not tuned by any means to match the clinical results. This shows us that the material definition we have is pretty close to reality, and we have the potential to predict other types of surgery...”

A clinical trial of femtosecond-assisted cataract surgery is planned, he said. So far, the model applies to cataract surgery only. But Dr Studer believes models could also be developed for limbal relaxing incisions. With the advent of devices for measuring corneal biomechanical properties in vivo, such as the Corves ST (Oculus), the model could be further individualised, he noted.

*Harald Studer PhD*

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