Circular keratotomy moulds and holds keratoconic cornea

Cheryl Guttman
in Rome

USING circular keratotomy to create a firm stromal scar is an effective method for preventing keratoconus progression in eyes with early disease, reported Jörg H. Krumeich MD, Bochum, Germany, at the 9th ESCRS Winter Refractive Surgery meeting.

He presented data with over six years of follow-up supporting this conclusion. He also presented three-year follow-up data confirming that circular keratotomy combined with implantation of an intrastromal titanium ring within the keratotomy incision appears to be effective for halting corneal steepening, while the combined procedure allows for ongoing astigmatic correction accomplished by reshaping the ring under keratoscopic control.

Dr Krumeich reported having performed circular keratotomy alone in 35 eyes and with implantation of the intrastromal ring in 11 eyes. All had stage I or II keratoconus. Follow-up extends to five years after suture removal in all eyes treated with the keratotomy plus ring implantation and for up to two years after suture removal in eyes that underwent circular keratotomy alone.

He noted that the K-value readings have remained stable within 0.5 D, and that there have been no complications. During the six years of follow-up in the group undergoing circular keratotomy alone, the mean change in K value was 0.02 D.

“So far we have seen no hint of forward bulging of the cornea lying within the keratotomy,”

He commented that follow-up in eyes that underwent circular keratotomy with ring implantation was too short for statistical analysis, but he believes that continued observation would show this combined procedure affords even better astigmatic stability.

Moulding the central cornea

The circular keratotomy procedure moulds the central cornea into a rounded dome by harnessing the force of intraocular pressure combined with the mechanical force created by pressing the cornea against the inner spherical shape of the trephine, explained Dr Krumeich, who developed the technique.

“Pushing the cornea against the spherical contour inside the hollow space of the trephine before the cut is made creates mechanical forces that eliminate the differences in the arc lengths, which are the basis of irregularity in the keratoconic cornea. The higher pressure within the eye relative to barometric pressure provides additional force for enhancing the attempt to round the central cornea,” he said.

The 7.0 mm circular keratotomy is created using the Guided Trephine System (GTS). The incision is performed to 80% depth according to Orbscan measurements at the actual site of the incision and then closed with a double-running, anti-torque suture.

“Whether or not the ring is placed, the suturing must be done under keratoscopic control to assure the wound remains round.”

“Whether or not the ring is placed, the suturing must be done under keratoscopic control to assure the wound remains round. The round wound takes away most of the astigmatism, but the double-running anti-torque suture must also be completely circular or else the cornea will be pulled by the peripheral tension that is a feature of eyes with keratoconus,” Dr Krumeich said.

In eyes where the ring is implanted, changes in astigmatism that occur after the sutures are removed are addressed by reshaping the ring from circular to oval in order to shorten lengthening radii. The remodelling of the ring’s geometry is also done under keratoscopic control using the keratoscope’s ring as the reference mark.

Discussing other options to halt progression of early keratoconus Dr Krumeich also mentioned epikeratophakia where a donor button custom-cut with an excimer laser based on the patient’s refraction is placed onto the cornea.

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Disparity between real and expected corneal shape impacts on vision quality

Dr. Jimenez and his associate Dr. Rosario G. Anera at the Department of Optics, University of Granada, Spain carried out a study which included 37 eyes treated with LASIK using the Corneal Interactive Programmed Topographic Ablation (LIGI, Italy) software.

“Clearly further research is needed in this field, including mathematical models, because it is crucial to make the deviation between real and expected corneas as minor as possible.”

“We decided to use CIPTA because it is an explicitly known equation and the algorithm tries to minimise the spherical aberration. This ablation profile fixes the expected corneal asphericity of a subject, and therefore makes it possible to study differences between expected and real data,” explained Dr. Jimenez.

Using CIPTA involves several interactive steps. The software suggests treatment parameters such as centre and axis of refractive treatment, minimal useful refractive diameters, transition zone and refractive correction, which the surgeon can then modify according to his needs.

Aspheric ablation profile
Dr. Jimenez explained that the CIPTA programme selects a final programmed asphericity for the 37 patients was Q=-0.51 (±0.18). The mean preoperative spherical equivalent was −3.1 D. To assess visual performance, contrast sensitivity function was measured at spatial frequencies of 1.5, 3, 6, 12 and 18 cycles-per-degree. Corneal analysis was then performed using VOL-CT software (Sarver & Associates).

Dr. Jimenez found that the average difference between real and expected corneal shape was 0.061 (±0.005 mm), enough to affect the postoperative visual outcomes.

“These differences are significant for the correction of eye aberrations. They exceed the one-quarter wavelength rule (61 microns>0.14 microns) and these deviations increase with the degree of initial ametropia and postop appearance of circular keratotomy cut.

Asphericity values of Q=-0.46 in the majority of cases, optimising the spherical aberration and visual performance. In this study series, the average of the final results,” noted Dr. Jimenez.

Contrast sensitivity less than expected
Experimental data on mesopic contrast sensitivity tests demonstrated that CIPTA provides significant improvements for 12 and 18 cycles-per-degree compared to non-customised ablation, although Dr. Jimenez noted that the improvement was lower than expected from computational simulations.

Dr. Jimenez said that using an algorithm with a known equation enables the differences between predicted and actual corneal topographic maps to be demonstrated. “These differences really exist and they are significant for visual performance. This happens with all ablation algorithms, not just CIPTA. While CIPTA did improve contrast sensitivity results, the improvement is lower than might be expected,” he said.

Dr. Jimenez stressed the importance of further studies that could help to improve the accuracy of ablation algorithms in the future.

“Clearly further research is needed in this field, including mathematical models, because it is crucial to make the deviation between real and expected corneas as minor as possible. Otherwise, eye corrections cannot be effectively achieved,” he said.

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Dermot McGrath in Rome

DIFFERENCES between actual and expected corneal shape after aspherical corneal ablation can have a clinically significant impact on quality of vision, according to a Spanish investigator who presented his results to the 9th Winter Refractive Surgery meeting of the ESCRS.

“A major problem in refractive surgery is the differences between real and expected after-surgery corneal shape. In addition, the fact that most algorithms are proprietary limits the possibility of improvements to ablation algorithms. Data on corneal shape after surgery show discrepancies between expected and real data and these differences do have the potential to reduce visual performance,” said Jose Jimenez MD.

“This procedure is relatively more costly and time-consuming, but it allows correction of up to 3.0 D of correction of sphere and cylinder in eyes with higher amounts of keratoconus-related ametropia,” he said.

Collagen cross-linking induced with topical application of riboflavin and exposure to ultraviolet-A light is another alternative for stopping the progression of keratoknosis in eyes with early keratoconus. However, while that also seems to be effective for stopping keratoconus progression, it does not correct the related ametropia, Dr. Krumeich noted.