MAXIMIZING THE REFRACTIVE ENHANCEMENT OF ASTIGMATISM CORRECTION

The Optimeyes surgery planning tool predicts how each individual cornea will react to arcuate corneal relaxing incisions, giving surgeons the foundation for more personalized procedures and patients the promise of more precise results.

BY RUPERT MENAPACE, MD, FEBO

It is common for us to find ocular astigmatism in our patients, and studies have indicated that up to 40% of those who present for cataract surgery have at least 1.00 D of astigmatism and up to 22% have at least 1.50 D of astigmatism.[1-3]

Because astigmatism decreases UCVA, and because so many of our patients have some level of astigmatism, treatment at the time of cataract surgery is a crucial component of the procedure. Many surgeons advocate for the correction of any astigmatism 1.00 D or greater; however, others would correct even 0.50 D of astigmatism to minimize corneal distortions and to give patients the best possible vision, especially in low light conditions and much more so with multifocal IOLs.

Astigmatism can be corrected with toric IOLs or with arcuate corneal relaxing incisions (CRIs). Toric IOLs can be used to correct higher amounts of astigmatism, and arcuate incisions can correct moderate, low, and very low corneal astigmatism (<0.75 D), where current toric IOL models are not available. One advantage of CRIs is that corneal astigmatism is corrected in the plane where it exists, potentially providing patients with better optical quality. As the use of multifocal IOLs escalates, correction of low astigmatism becomes increasingly important because it is much more destructive to multifocal optic images compared to monofocal optic images. With multifocal IOLs, the eye's corneal astigmatism should approach zero.

Recent advances in cataract surgery have helped us to address astigmatism as routine practice in cataract surgery. Yet even with the incorporation of advanced diagnostics and IOL power calculations that account for surgically induced astigmatism, refractive errors can still occur. Now in addition to traditional methods of measuring astigmatism, which include manual or automated keratometry, corneal topography, and corneal tomography, surgeons can access the Optimeyes software (Optimo Medical) in order to more accurately predict an individual's outcome after astigmatism correction with arcuate CRIs. This cataract surgery planning tool uses biomechanical virtual simulations that are based on corneal measurements to evaluate each individual eye preoperatively, and then it uses mathematics and algorithms to plan the procedure based on those calculations.

CURRENT AND FUTURE USES

The virtual eye model created by Optimeyes helps us to not only plan our procedures but also to minimize risks in advance of that actual procedure. This is especially beneficial in eyes with very low amounts of corneal astigmatism. Other than toric lenses, Optimeyes will be able to treat corneal astigmatism with unevenly sized or nonorthogonally arranged corneal bowties (ie, asymmetric astigmatism) in a personalized approach by individually adapting the entire incisional pattern (eccentricity, depth, and length) to any given cornea. With a full-arc depth-dependent approach[4] based on mathematical modeling, we will be able to treat this common astigmatism successfully.

In clinical practice, Optimeyes can help surgeons to advance cataract surgery from a simple visual rehabilitation procedure to a maximized refractive enhancement procedure. The software is easy to implement into clinical practice, as it works seamlessly with an advanced topographer like the Pentacam (Oculus Optikgeräte) or Galilei (Ziemer). The data from either device are imported into the Optimeyes system and anonymized, and then a virtual simulation of the eye is created in just a few minutes. The current software also calculates the length of the incision that would fit the individual cornea best to reduce a given amount of astigmatism. The result is depicted as color-coded topography (Figure 1), which makes it easy to judge the expected result. In the future,

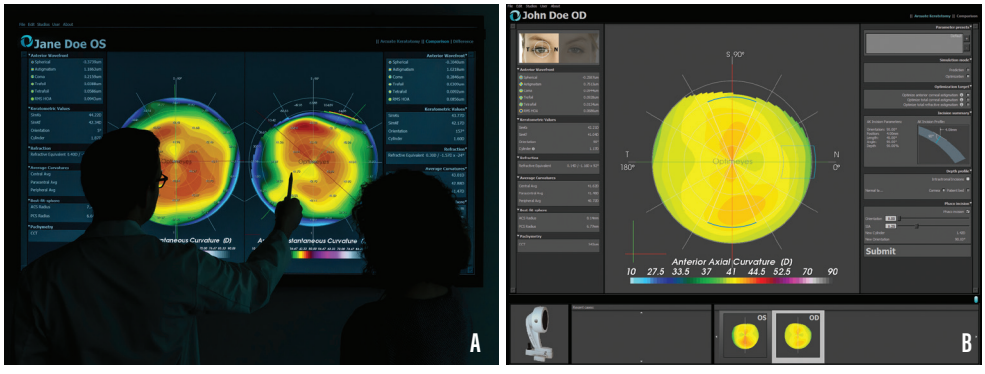

Figure 1. The Optimeyes result is depicted as color-coded topography (A,B).

Optimeyes will also integrate individual corneal biomechanical data as measured by the Corvis tonometer (Oculus Optikgeräte), thus incorporating the individual corneal deformation response into its calculations.

Using Optimeyes with a femtosecond laser combines the precision of personalized treatment planning with the ability to perform customized laser-guided incisional patterns of perfect length, depth, and perpendicularity. This combination maximally exploits the potential of incisional correction of regular corneal astigmatism. The future vision is that the treatment parameters calculated by Optimeyes using the extracted personalized data of an advanced topographer or tomographer will be directly fed into the laser, essentially integrating astigmatic correction as a routine step into the workflow of laser cataract surgery. There is also potential for Optimeyes to be used in planning intrastromal nonsurface-penetrating CRIs with a femtosecond laser that cuts Bowman membrane while preserving the integrity the overlying corneal epithelium.

Also in the future, with the current trend toward digitalization in medicine, there is a great opportunity for the digital twin of an individual's eye that Optimeyes creates to be used in surgical planning for other ocular conditions. Digitalization is a prerequisite to find out how the individual cornea will react to a given procedure. This is true not only for this particular surgery, but in many other ocular surgeries as well.

PROMISING RESULTS

At our clinic, we have conducted three separate studies to evaluate the effectiveness, stability, and safety of surface-penetrating paired arcuate CRIs for the correction of low to moderate corneal astigmatism (0.75–2.50 D). In the first study, we used a nomogram that was extracted from the results of an earlier study conducted with a femtosecond laser.[5] We used the Femto LDV Z8 (Ziemer) to perform the corneal incisions. The optical zone and incisional depth of the arcuate incisions were fixed at 8.5 mm and 80%, respectively, and only the incisional length was varied according to the height of the corneal astigmatism and the age of the patient. Patients (N = 66) were at least 50 years of age, and all eyes had perfectly symmetric astigmatism.

With promising results using the nomogram, we then decided to conduct a second study using the finite-element-based suggestions calculated by Optimeyes, rather than the nomogram, to evaluate the results of surface-penetrating paired arcuate incisions in eyes with perfectly symmetric astigmatism. The hope is to define the superiority of the Optimeyes suggestions to those of the nomogram. At the same time, we also started a third study, again using the Optimeyes software, but in this one we aim to correct asymmetric corneal astigmatism with unevenly sized and/or nonorthogonal bowties. We expect results to indicate that Optimeyes significantly improves the predictability of incisional correction of symmetric astigmatism and also allows precise correction of asymmetric astigmatism.

The latter two studies have just begun, but we are confident that using the Optimeyes calculations will significantly improve the results with incisional correction of low to moderate regular corneal astigmatism, including that with asymmetric bowties.

CONCLUSION

The benefit of Optimeyes is that it can help us to fully explore the potential of incisional correction of corneal astigmatism. Femtosecond laser arcuate incisions are easy to integrate as an additional step in a standard femtosecond laser pretreatment workflow, with no additional costs, and they improve patients' UCVA by eliminating or reducing astigmatism (Figure 2).

Optimeyes is particularly useful in the treatment of low astigmatism, which is prevalent in the cataract surgery population. Despite the many advances made in cataract surgery and in astigmatism correction procedures, this is the only software currently available to implement posterior surface curvature and biomechanical response data into astigmatism correction calculations.

I believe that Optimeyes harnesses great potential in the correction of low to moderate astigmatism with arcuate CRIs.

Figure 2. Postoperatively, patients can experience increased UCVA due to the elimination of astigmatism.

So far, the software is used in eyes with symmetric regular astigmatism by creating symmetric incisions with the same eccentricity and depth, with a personalized length depending on the eye. In the future, the Optimeyes software will allow us to adapt and fine-tune the eccentricity, length, and depth of arcuate CRIs to correct regular astigmatism, symmetric or asymmetric. This advance will expand the therapeutic potential of incisional astigmatic correction, especially when combined with the precision of femtosecond laser technology. ■

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