Using a Laser for Arcuate Incisions

Femtosecond laser astigmatic keratotomy allows ophthalmologists to correct corneal astigmatism at the time of the cataract surgery with a higher degree of precision and reproducibility than manual techniques.

BY RICHARD M. AWDEH, MD; HEWITT HANAFEE; AND ANA-PAULA CANTO, MD

Corneal astigmatism is a common cause of refractive error in patients undergoing cataract surgery. Recent studies have estimated the prevalence of preoperative astigmatism to be nearly 87%, with 66% of patients having between 0.25 and 1.25 D of astigmatism and 22% of patients having higher degrees of cylinder.[1,2] Corneal astigmatism, particularly irregular astigmatism, also occurs after penetrating keratoplasty (PKP) and limits the patient's visual rehabilitation.[3]

Uncorrected astigmatism decreases patients' visual acuity and affects their quality of life and independence.[4] Numerous modalities treat different kinds of astigmatism, including glasses, contact lenses, excimer laser ablation, toric IOLs, limbal relaxing incisions (LRIs), and astigmatic keratotomy (AK). The high expectations of today's patients have surgeons looking for the best procedure and technology with which to optimize patients' visual outcomes and satisfaction. The manual performance of AK and LRIs is associated with many variables that can interfere with surgical results. Femtosecond laser technology allows surgeons to address this problem.

PRECISION

Femtosecond laser astigmatic keratotomy (FSAK) holds many advantages over incisions created manually with a blade. Variables affecting the latter include the surgeon's technique and experience; the instrumentation used; the precision with which the surgeon obtains a regular, smooth, and perfect incision at exactly the desired depth and length within the targeted optical zone; and the accuracy of the intraoperative determination of the proper corneal axis for the incision's placement. Possible complications include over- or undercorrection, infection, dry eye syndrome, and corneal perforation.[5]

FSAK is a precise and reproducible way of correcting naturally occurring astigmatism,[6] post-PKP astigmatism,[3] and astigmatism after cataract surgery. The technology eliminates the variability in the incision's creation by allowing the surgeon to direct the laser's photodisruptive effect at precisely the length, depth, and orientation he or she wishes. The incision is thus reproducible, regular, and smooth, and the result is more consistent outcomes (Figures 1 and 2).

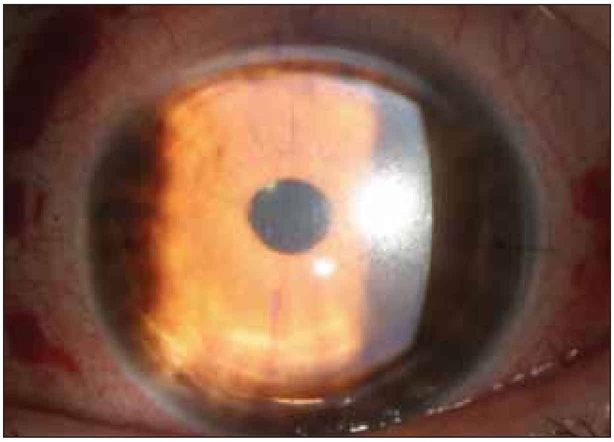

Figure 1. Slit-lamp photograph showing the AK incisions created with a femtosecond laser.

CREATIVITY

The femtosecond laser gives surgeons room for creativity in terms of the shape and architecture of incisions. The ophthalmologist can create the incision in the sub-Bowman corneal stroma, while leaving the corneal epithelium and Bowman layer intact. This astigmatic incision is minimally invasive and decreases the risk of epithelial ingrowth and infection. Theoretically, this approach should enhance wound healing and improve patients' comfort by decreasing the postoperative symptoms of dry eye syndrome and minimizing the loss of corneal sensation.

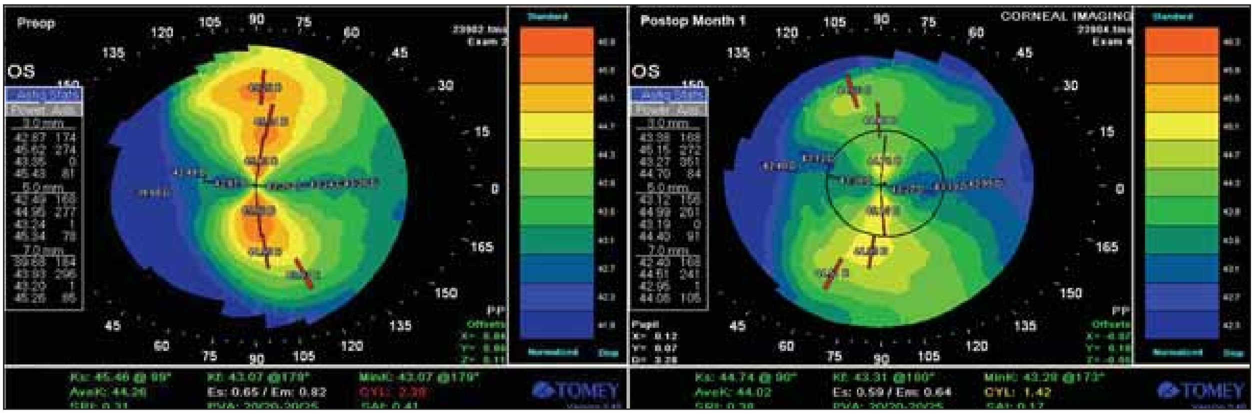

Figure 2. Pre- and postoperative topography demonstrates a reduction in astigmatism with FSAK.

Instead of the traditional perpendicular corneal incision, the surgeon may elect to create a beveled corneal incision by changing the side-cut angle on the treatment software. David Huang, MD, has discussed his experience with a beveled incision in six post-PKP eyes. He reported a gain in UCVA and BCVA and a reduction in the magnitude of the keratometric cylinder. Dr. Huang has suggested that the advantage of the beveled incision is that it does not gape.[7]

TECHNIQUE

Several femtosecond lasers can execute an AK, but the only platforms currently cleared by the FDA for the creation of these incisions are the LenSx femtosecond laser (Alcon Laboratories, Inc., Fort Worth, TX) and the IntraLase FS laser (Abbott Medical Optics Inc., Santa Ana, CA).

Before planning the incision, it is important that the surgeon understand the coupling phenomenon. Specifically, flattening of the incised steep meridian is accompanied by a steepening 90º away of the meridian that is not incised.

The first step in planning the FSAK procedure is to obtain the manifest refraction with the precise astigmatic power and axis. Next, the ophthalmologist must determine the topographic amount of cylinder and the steepest corneal axis. He or she then chooses the surgical plan based on a nomogram. Although many nomograms are available for performing AK and LRIs, none was designed for use with a femtosecond laser. At the Bascom Palmer Eye Institute, we use a modified Lindstrom nomogram that takes into account the patient's age and the magnitude of the astigmatism. We use this nomogram to determine the optical zone diameter (mm) and the angular length (degrees) of the incision. We calculate the depth of each incision based on the lowest pachymetric reading along the intended incision. The incision's depth should be 90% of the thinnest pachymetry reading for naturally occurring astigmatism and 75% for post-PKP astigmatism. To prevent full-thickness corneal incisions, it is important to identify accurately the thinnest pachymetry at the intended site of the incisions (an ultrasound pachymeter or anterior segment optical coherence tomography may be used).

The fourth step of FSAK is marking the patient's steepest corneal axis using a marking pen at the slit lamp prior to entering the operating suite. After completing these steps, the ophthalmologist enters the surgical plan into the femtosecond laser. The keratoplasty mode is used with the IntraLase FS laser, and all of the cutting options are turned off so that only the anterior side-cut treatment planning window is on. The parameters entered in the planning window are

- posterior depth of the incision (µm)
- anterior side-cut diameter (mm), which refers to the optical zone diameter determined by the nomogram
- anterior side-cut energy (mJ)
- cutting position (degrees) and angle (arc length) of the first incision
- cutting position (degrees) and angle (arc length) of the second incision
- side-cut angle (degrees), spot separation, and layer separation
- depth in contact glass, which is selected according to the manufacturer's recommendations (usually, it is 50 µm for the IntraLase, but a minus value can be used to stop the incision before it reaches the glass)

Once the patient is under the surgical microscope, a drop of anesthetic is placed on the eye, and the center of the pupil is marked. Next, the optical zone marker is centered on the pupil to mark the optical zone diameter, and an axis marker is used to mark the planned locations of the incisions. The suction ring and applanation cone are then engaged to the patient's eye. The IntraLase treatment screen will show the location of the planned

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> "FSAK ... correct[s] corneal astigmatism ... with a higher degree of precision and reproducibility than manual techniques."

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arcuate incisions, and the surgeon can gently (in order to avoid a loss of suction) rotate the eye using the suction ring to ensure proper axial alignment. If necessary, he or she can modify the centration of the optical zone on the screen. After the laser treatment is complete, the surgeon opens the incisions with a Sinskey hook and applies topical antibiotic and steroid drops to the eye.

Astigmatic incisions after PKP should be placed 0.5 to 1 mm inside the graft-host junction, and the surgeon should use a modified nomogram for AK after PKP.

CONCLUSION

FSAK is exciting, because it allows ophthalmologists to correct corneal astigmatism at the time of the cataract surgery with a higher degree of precision and reproducibility than manual techniques. Caution is warranted in patients with ectatic disorders, highly irregular astigmatism, limbal peripheral corneal pathology, extreme dry eye disease, and ocular surface disease. ■

Richard M. Awdeh, MD, is the director of technology transfer and innovation and an assistant professor of ophthalmology at the Bascom Palmer Eye Institute in Miami. He is a consultant to Abbott Medical Optics Inc., Alcon Laboratories, Inc., and Bausch + Lomb. Dr. Awdeh may be reached at (305) 482- 5135; rawdeh@med.miami.edu.

Ana-Paula Canto, MD, is a cornea fellow at the Bascom Palmer Eye Institute in Miami. She acknowledged no financial interest in the products or companies mentioned herein.

Hewitt Hanafee is a research associate at the Bascom Palmer Eye Institute in Miami. He acknowledged no financial interest in the products or companies mentioned herein.

1. Bourne RR, Dineen BP, Ali SM, et al. Prevalence of refractive error in Bangladeshi adults: results of the National Blindness and Low Vision Survey of Bangladesh. *Ophthalmology*. 2004;111(6):1150-1160.
2. Ferrer-Blasco T, Montés-Micó R, Peixoto-de-Matos SC, et al. Prevalence of corneal astigmatism before cataract surgery. *J Cataract Refract Surg*. 2009;35(1):70-75.
3. Nubile M, Carpineto P, Lanzini M, et al. Femtosecond laser arcuate keratotomy for the correction of high astigmatism after keratoplasty. *Ophthalmology*. 2009;116(6):1083-1092.
4. Wolffsohn JS, Bhogal G, Shah S. Effect of uncorrected astigmatism on vision. *J Cataract Refract Surg*. 2011;37(3):454-460.
5. Price FW Jr, Grene RB, Marks RG, Gonzales JS. Arcuate transverse keratotomy for astigmatism followed by subsequent radial or transverse keratotomy. ARC-T Study Group. Astigmatism Reduction Clinical Trial. *J Refract Surg*. 1996;12(1):68-76.
6. Abbey A, Ide T, Kymionis GD, Yoo SH. Femtosecond laser-assisted astigmatic keratotomy in naturally occurring high astigmatism. *Br J Ophthalmol*. 2009;93(12):1566-1569.
7. Bethke W. New approach to femtosecond AK. *Review of Ophthalmology*. http://www.revophth.com/content/d/refractive_surgery/c/26705/. Published February 15, 2011. Accessed June 14, 2011.