

Intrastromal Astigmatic Keratotomy With the Femtosecond Laser

A nonpenetrating approach for the correction of keratometric and refractive astigmatism.

BY ZAINA AL-MOHTASEB, MD, AND WILLIAM W. CULBERTSON, MD

Residual astigmatism after cataract surgery and keratoplasty results in decreased UCVA and dissatisfied patients.¹ Spectacles and contact lenses are nonsurgical treatments for residual astigmatism. Astigmatic keratotomy (AK), which was initially performed using a diamond blade, is a surgical method for reducing refractive and keratometric corneal cylinder. The incisions cause flattening of the steepest meridian and steepening of the opposite meridian, which is called *coupling*, and lessens the astigmatism with little or no change in the spherical equivalent.² Manual AKs are associated with unpredictable outcomes and complications, including wound gape, epithelial ingrowth into the incision, infection, haze, scarring, and rarely, corneal perforation.³ Conversely, the depth, length, and contour of the incisions are more accurate and precise when AK is performed with the femtosecond laser.^{4,5}



Figure 1. A slit-lamp photograph of an eye 1 month after intrastromal astigmatic keratotomy (ISAK).

LASER ANTERIOR PENETRATING AKs

Laser AK has been successfully performed to correct residual astigmatism after penetrating keratoplasty, deep anterior lamellar keratoplasty, Descemet stripping endothelial keratoplasty, cataract surgery, and in naturally occurring astigmatism.⁴⁻¹¹ In a prospective randomized trial, Hoffart et al compared manual (Hanna Arcitome; Moria) versus laser-assisted AK (Femtec; Technolas Perfect Vision) in 20 eyes.¹² The laser group (n = 10) showed a higher reduction of cylindrical power than the manual group (n = 10), although undercorrection was detected in both groups. There was greater misalignment of the axis, one microperforation, and one off-center incision in the manual group. No complications were reported in the laser group.¹²

Wetterstrand et al reported that laser penetrating AKs led to a 40% to 66% reduction in refractive cylinder and a 36% to 40% reduction in keratometric cylinder.¹³ When compared to mechanical anterior penetrating techniques, the reduction was 30% to 54% in refractive cylinder and 35% in keratometric cylinder.¹²⁻¹⁶

LASER NONPENETRATING AKs

More recently, nonpenetrating laser ISAK has been introduced. Because intrastromal AKs do not penetrate the epithelium or the endothelium, there is less risk of infection, wound gape, epithelial ingrowth, or graft perforation compared to penetrating AKs. Compared to full-thickness AKs, intrastromal AKs should also incite less inflammation, have quicker visual recovery,



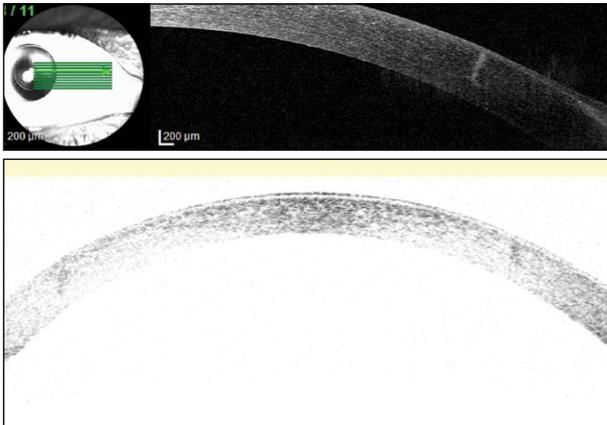


Figure 2. Optical coherence tomography images of the same eye 1 month after ISAK.

and enhance patients' comfort (Figure 1-3).³

Venter et al reported the outcomes of correcting mixed astigmatism with nonpenetrating ISAK in patients with previous refractive surgery.¹⁷ The investigators performed ISAK with the IntraLase iFS laser (Abbott Medical Optics) at 80% of the thinnest corneal thickness within the 7-mm optical zone on 112 eyes. All patients had a statistically significant improvement in uncorrected distance visual acuity with an average gain of 2 lines. The percentage of eyes with a visual acuity of 20/20 or better increased from 13.4% preoperatively to 67.6% postoperatively. Additionally, during an average of 7.6 months (54%), the mean value of refractive cylinder decreased from 1.20 ± 0.47 D preoperatively to 0.55 ± 0.40 D postoperatively. There was a statistically significant reduction in the mean value of refractive cylinder of less than 0.50 D in 61% of the patients postoperatively com-

pared to 2.5% preoperatively. Refractive cylinder, however, was still undercorrected.

Rückl and colleagues treated 16 patients with less than 3.00 D of corneal astigmatism (naturally occurring or after cataract surgery) with paired symmetric ISAK.¹ With the IntraLase iFS, the investigators placed paired arcuate cuts 100 μ m below the epithelium and above the endothelium. Refractive astigmatism was significantly reduced from 1.41 ± 0.66 D (mean) preoperatively to 0.33 ± 0.42 D (mean) 6 months postoperatively (76.6%). The mean topographic astigmatism was significantly reduced from 1.50 ± 0.47 D preoperatively to 0.63 ± 0.34 D 6 months postoperatively (58%). The mean uncorrected distance visual acuity also significantly improved, and there were no episodes of postoperative inflammation, wound gape, or epithelial ingrowth.

Wetterstrand et al performed ISAK on 16 eyes of 16 patients who had significant astigmatism following penetrating keratoplasty.¹³ The incisions were made inside the graft-host junction, were 90° in length, 90 μ m below the epithelium, and at 90% depth of the stroma. The investigators reported a statistically significant decrease in refractive cylinder (3.10 ± 2.10 D [46%]) and in topographic anterior cylinder (5.10 ± 4.70 D [54%]). The average topographic cylinder stabilized 1 month postoperatively. One patient developed a bulge in the temporal incision 2 weeks postoperatively and was treated with compression sutures. Two eyes were undercorrected, and three eyes were overcorrected.

Viswanathan and Kumar performed ISAK with the LenSx Laser (Alcon) on an eye with bilateral high astigmatism after penetrating keratoplasty.³ Bilateral ISAK cuts were made 60 μ m below the epithelium

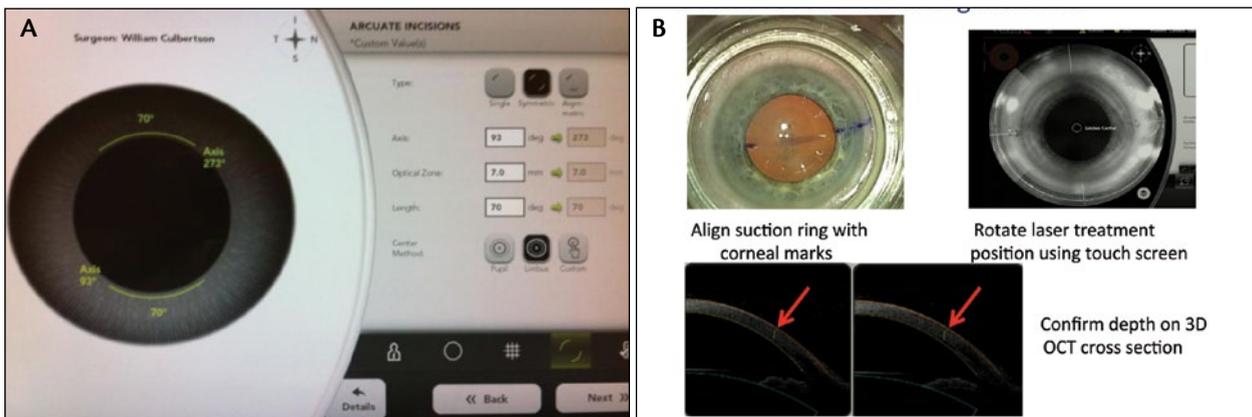


Figure 3. Basic ISAK procedure using the Catalys (A). Initially align the suction ring with the corneal marks, then rotate the laser treatment position using the touch screen to align with the marks, and then confirm the depth on three-dimensional optical coherence tomography cross section (B).

and at 90% of the stromal depth with care not to penetrate the Bowman or Descemet membranes. Four months postoperatively, the patients had a 65% and 89% reduction in preoperative astigmatism of the right and left eyes, respectively (from 11.92 D and 10.40 D to 4.10 D and 1.12 D). The coupling ratio was less than 1, which led to a myopic shift in refraction.

Culbertson and Yoo performed ISAK with the Catalys Precision Laser System (Abbott Medical Optics) in 29 eyes with preoperative topographic corneal astigmatism ranging from 0.50 D to 1.90 D (mean, 1.03 D).¹⁸ All patients underwent routine phacoemulsification with implantation of an IOL. The average preoperative corneal astigmatism was reduced from 1.03 D to a clinically insignificant 0.34 ±0.23 D (range, 0-1.12 D). The corneal cylinder was overcorrected (“flipped”) in 22% of eyes, and in one eye, the postoperative cylinder increased from 0.63 D to 1.12 D with flipping of the axis. There were no macroperforations either anteriorly or posteriorly, although a small bubble of gas could often be observed popping through a microperforation of Descemet membrane or the corneal epithelium, indicating a clinically insignificant venting of laser gas.

OUR TREATMENT PROTOCOL

Currently, we only treat small amounts of corneal cylinder (< 1.50 D) with ISAK with the goal of reducing it to less than 0.50 D. For corneal cylinder greater than 1.25 D, we implant a toric IOL, because we find them to be more predictable than anterior penetrating limbal relaxing incisions.

CONCLUSION

Recent studies of nonpenetrating ISAK in naturally occurring astigmatism and astigmatism following refractive, cataract, and penetrating keratoplasty surgeries show great promise for correcting astigmatism with minimal risk and increased comfort for patients. Although the studies discussed demonstrate an average decrease in residual keratometric and refractive astigmatism, over- and undercorrections were also noted. The treatment protocols were heterogeneous, and the authors used different lasers. To acquire more accurate and predictable outcomes, nomograms for commercially available femtosecond lasers are needed. In addition, studies with ISAK to correct astigmatism after deep anterior lamellar keratoplasty and Descemet stripping endothelial keratoplasty and in high, naturally occurring astigmatism are desired

to define the role of ISAK. Longer follow-up to evaluate the possibility of regression as well as comparative studies with laser nonpenetrating AKs are also necessary. ■

Section Editor Kathryn M. Hatch, MD, practices corneal, cataract, and refractive surgery at Talamo Hatch Laser Eye Consultants in Waltham, Massachusetts. Dr. Hatch may be reached at (781) 890-1023; kmasselam@gmail.com.

Section Editor Colman R. Kraff, MD, is the director of refractive surgery for the Kraff Eye Institute in Chicago.

William W. Culbertson, MD, is the Lou Higgins professor of ophthalmology and director of the Cornea Service and Refractive Surgery at Bascom Palmer Eye Institute, University of Miami. He is a consultant to Abbott Medical Optics. Dr. Culbertson may be reached at wculbertson@med.miami.edu.



Zaina Al-Mohtaseb, MD, is an instructor at Bascom Palmer Eye Institute, University of Miami. She acknowledged no financial interest in the products or companies mentioned herein. Dr. Al-Mohtaseb may be reached at zaina1225@gmail.com.



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