Unexpected overcorrection with femtosecond laser-assisted astigmatic keratotomy following deep anterior lamellar keratoplasty

Ashbala Khattak, MD, Haider R. Cheema

A 25-year-old man had deep anterior lamellar keratoplasty for advanced keratoconus. One year after surgery, the corneal astigmatism after suture removal was 6.0 diopters. Femtosecond laser-assisted astigmatic keratotomy (AK) was performed 18 months after the keratoplasty, resulting in a marked unexplained overcorrection that significantly dropped the visual acuity. The AK incisions were resutured to decrease the overcorrection effect. The overcorrection persisted until 8 months after the procedure, when the effect of the AK regressed unexpectedly.

Financial Disclosure: Neither author has a financial or proprietary interest in any material or method mentioned.

JCRS Online Case Reports 2014; 2:45–49 © 2014 ASCRS and ESCRS

High astigmatism in a corneal graft is not the rule but is a frequent visual-rehabilitation challenge after transplantation.1 In these eyes, astigmatic keratotomy (AK) is often performed to decrease the astigmatism to a more acceptable level.2 3 Prior to the introduction of the femtosecond laser, AK was performed manually. However, the reliability and reproducibility of the manual technique varies.1 With the advent of femtosecond lasers, the procedure can be performed with increased certainty of achieving the target parameters.3 We present an unusual case of a young patient who had deep anterior lamellar keratoplasty (DALK) followed by a femtosecond laser-assisted AK for high postoperative corneal astigmatism.

CASE REPORT

A 25-year-old man had DALK for advanced keratoconus disease of the cornea in the right eye. One year after all the sutures had been removed, the patient was not satisfied with the corrected distance visual acuity (CDVA) in that eye. The postoperative uncorrected distance visual acuity (UDVA) was 20/200, the CDVA was 20/40, and the manifest refraction was –3.0 –4.0 × 135. Slitlamp examination of the right eye showed a clear corneal graft with all sutures removed. The lens was clear. The rest of the anterior segment examination, the intraocular pressure, and the fundus examination were unremarkable. On topography, the keratometry reading was 46.9 @ 42/40.8 @ 132 with 6.1 diopters (D) of topographic astigmatism (Figure 1, A).

After informed consent was obtained, AK was performed in the right eye with the iFS laser (Advanced Medical Optics, Inc.) under topical anesthesia. Before the procedure, the cornea was marked at the horizontal meridian and the steep axis to reduce the error induced by cyclotorsion in the supine position. Topical anesthesia was instilled in the eye. Pachymetry was obtained well within the graft-host interface at the intended site of the AK incisions with an ultrasonic pachymeter. The AK specifications were determined using an AK nomogram previously used for femtosecond laser-assisted AK. The laser parameters for performing AK were reviewed thoroughly before the procedure. The cornea was docked with the laser’s docking system, and 2 paired AK incisions were placed along the steep axis of the cornea with a 6.5 mm optical zone (Figure 2). The surgery was completed uneventfully. The patient was started on moxifloxacin 0.5% (Vigamox) 4 times a day and a tapered dose of prednisolone acetate 1.0% (Pred Forte).

Postoperatively, the patient stated that his vision improved remarkably for the first few days and then deteriorated. At the 1-month visit, the UDVA was 20/200 and manifest refraction was –5.0 –6.0 × 45 with a CDVA of 20/60. The corneal topography showed 39.53 @ 41/51.3 @ 131 with 11.7 D of corneal astigmatism (Figure 3, A). A corneal optical coherence tomography (OCT) image was obtained to confirm the depth of the incision. The intended depth of incisions was seen on the image (Figure 4). The...
AK incisions were resutured to decrease the effect of the incisions. However, there was no effect on the corneal topography (Figure 3, B). The manifest refraction remained unstable for several months.

Six months after the AK procedure, the manifest refraction was $+1.50 \times 110$ and the CDVA was 20/60 (Figure 3, C). The patient was counseled regarding the unpredictability of AK and delayed further intervention for a few more months. At 8 months, the patient was seen in the clinic. There was significant improvement: The manifest refraction was $-6.00 \times 25$ and the keratometry showed $45.1 @ 30/48 @ 120$ with only 2.9 D of topographic astigmatism. The patient was very satisfied with his CDVA. One year after surgery, the patient’s vision had improved to 20/20 with a manifest refraction of $-2.00 \times 40$. Corneal topography showed $45.1 @ 30.7/47.5 @ 120.7$ with 2.4 D of topographic astigmatism (Figure 1, B).

**DISCUSSION**

High astigmatism is very common after keratoplasty, leading to a poor visual outcome due to ametropia and anisometropia.1,4 Conservative options to correct high astigmatism such as spectacles or contact lenses are usually not very successful. Surgical options include manual AK, wedge resection, compression sutures, phakic intraocular lenses, photorefractive keratectomy (PRK), and laser in situ keratomileusis (LASIK).5-8 Recently, there is a trend toward femtosecond laser-assisted AK. This technique has the advantage of greater precision in creating the calculated AK incisions than the manual technique.8,9 The predictability of the laser-assisted AK has improved significantly, as shown by the published data; however, the reliability of the technique is not absolute. The reasons for the marked overcorrection seen in our patient could be an aggressive treatment plan, wound gaping, or deeper than intended cuts in the cornea.12 However, these reasons do not explain the amount of overcorrection in our patient. Another explanation could be the timing of the procedure. The surgery was performed 4 months after the suture removal, which might be a little early to have achieved a stable corneal graft.

The healing characteristic of the graft-host scar dictates a varying response of the cornea to the incisional treatment.13 Considering that our patient had DALK and not a full-thickness penetrating keratoplasty (PKP), the wound-healing attributes of DALK could play a role in the exaggerated response to the procedure.
treatment. Kubaloglou et al.\textsuperscript{14} showed similar outcomes of AK in PKP and DALK groups; however, the technique used in this study was manual and not laser assisted. The overcorrection rate was in fact higher in the PKP group (41\%) than in the DALK group (35\%). A case report by Yoo et al.\textsuperscript{15} showed a similar response.

**Figure 3.** Topography maps of the right eye after AK. A: One month after AK. B: After resuturing the AK incisions. C: Six months after AK. D: One year after AK incisions.

**Figure 4.** Optical coherence tomography image of the cornea indicating the depth of the AK incisions. A: Superior incision. B: Inferior incision.
to AK performed in an eye that had had Descemet-stripping endothelial keratoplasty. The full-thickness incisions in that case explained the marked overcorrection and axis flip after femtosecond laser-assisted AK.

The coupling ratio of AK in our patient after a year is approximately 1:3, where there is only 1 unit flattening of the steep meridian, 3 unit steepening of the flat meridian, and a more myopic refraction. The scarring in the AK incisions over time most likely decreased the effect of overcorrection to a more acceptable level (Figure 5). The patient is now more suitable for a further refractive procedure to address the residual astigmatism and myopia provided the stability of vision, refraction, and topography is maintained for several months.

Venter et al.17 and Rückl et al.18 have recently shown the efficacy of intrastromal femtosecond laser-assisted AK in treating astigmatism. A case report by Viswanathan and Kumar19 also showed the ability to treat high astigmatism with intrastromal AK in one patient. This technique of femtosecond laser-assisted intrastromal AK may result in more predictable and controlled outcomes as the surface layers of the cornea are not breached.

Cleary et al.20 have reported a pilot study using beveled femtosecond AK to treat high astigmatism after keratoplasty. They suggest that the effect of beveling the incision to 135 degrees instead of the conventional 90 degrees may prove beneficial in early stability of refraction after AK due to less chance of wound gaping and early healing. This effect may diminish the probability of overcorrection in treating post-keratoplasty astigmatism. However, more studies have to be done to determine whether the intrastromal and beveled AK are better than conventional femtosecond laser-assisted AK.

In the era of femtosecond lasers, new techniques and variations of AK are evolving to tackle high astigmatism after keratoplasty. Limited data about femtosecond laser-assisted AK in deep anterior keratoplasty are available. A nomogram different from the one used for PKP may be needed for this group of patients. Thus, clinicians treating these patients should be aware of unexpected outcomes until robust nomograms have been established.

REFERENCES

1. McCartney DL, Whitney CE, Stark WJ, Wong SK, Bernitsky DA. Refractive keratoplasty for disabling astigmatism after penetrating keratoplasty. Arch Ophthalmol 1987; 105:954–957
2. Poole TR, Ficker LA. Astigmatic keratotomy or post-keratoplasty astigmatism. J Cataract Refract Surg 2006; 32:1175–1179
3. Fares U, Sarhan AR, Dua HS. Management of post-keratoplasty astigmatism. J Cataract Refract Surg 2012; 38:2029–2039
4. Ward MS, Wanding GR, Goins KM, Sulphin JE, Kitzmann AS, Wagoner MD. Photorefractive keratectomy modification of post-keratoplasty anisometric refractive errors. Cornea 2013; 32:273–279
5. Kook D, Bühren J, Klaproth OK, Bauch AS, Derhartunian V, Kohnen T. Astigmatische Keratotomie mit dem Femtosekundenlas-er. Korrektur hoher Astigmatismen nach Keratoplastik/Astigmatic keratotomy with the femtosecond laser. Correction of high astigmatism after keratoplasty. Ophthalmologie 2011; 108:143–150
6. Al-Mohaimed MM. Penetrating keratoplasty or keratoconus: visual and graft survival outcomes. Int J Health Sci 2013; 7:67–74. Available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3612418/pdf/67.pdf. Accessed May 30, 2014
7. Kirkness CM, Ficker LA, Steele AD, Rice NS. Refractive surgery for graft-induced astigmatism after penetrating keratoplasty for keratoconus. Ophthalmology 1991; 98:1786–1792
8. Ghoreishi M, Naderi Beni A, Naderi Beni Z. Visual outcomes of Femto-LASIK for correction of residual refractive error after corneal graft. Graefes Arch Clin Exp Ophthalmol 2013; 251:2601–2608
9. Hoffart L, Touzeau O, Borderie V, Laroche L. Mechanized astigmatic arcuate keratotomy with the Hanna arcitome for astigmatism after keratoplasty. J Cataract Refract Surg 2007; 33:862–868
10. Bahar I, Levinger E, Kaiserman I, Sansanayudh W, Rootman DS. IntraLase-enabled astigmatic keratotomy for postkeratoplasty astigmatism. Am J Ophthalmol 2008; 146:897–904
11. Kumar NL, Kaiserman I, Shehadeh-Mashor R, Sansanayudh W, Rittenour R, Rootman DS. IntraLase-enabled astigmatic keratotomy for post-keratoplasty astigmatism: on-axis vector analysis. Ophthalmology 2010; 117:1228–1235
12. Alió JL, Ismail MM. Management of astigmatic keratotomy overcorrections by corneal sutures. J Cataract Refract Surg 1994; 20:13–17
13. Hoppenreijs VP, Van Rij G, Beekhuis WH, Rijnveeld WJ, Rinkel-van Driel E. Causes of high astigmatism after penetrating keratoplasty. Doc Ophthalmol 1993; 85:21–34
14. Kubaloglug A, Coskun E, Sarı ES, Gunes AS, Cinar Y, Piñero DP, Kutluturk I, Ozerturk Y. Comparison of astigmatic keratotomy results in deep anterior lamellar keratoplasty and penetrating keratoplasty in keratoconus. Am J Ophthalmol 2011; 151:637–643
15. Yoo SH, Kymionis GD, Ide T, Diakonis VF. Overcorrection after femtosecond-assisted astigmatic keratotomy in a post-Descemet-stripping automated endothelial keratoplasty patient. J Cataract Refract Surg 2009; 35:1833–1834
16. Taneri S, Azar DT, Nordan LT. The incisional management of astigmatism. In: Azar DT, ed, Refractive Surgery, 2nd ed. St. Louis, MO, Mosby Elsevier, 2007; 325–338
17. Venter J, Blumenfeld R, Schallhorn S, Pelouskova M. Non-penetrating femtosecond laser intrastromal astigmatic

Figure 5. The AK incisions 1 year after surgery.
keratotomy in patients with mixed astigmatism after previous refractive surgery. J Refract Surg 2013; 29:180–186

18. Rücks T, Dexl AK, Bachernegg A, Reischl V, Riha W, Ruckhofer J, Binder PS, Grabner G. Femtosecond laser-assisted intrastromal arcuate keratotomy to reduce corneal astigmatism. J Cataract Refract Surg 2013; 39:528–538

19. Viswanathan D, Kumar NL. Bilateral femtosecond laser-enabled intrastromal astigmatic keratotomy to correct high post-penetrating keratoplasty astigmatism. J Cataract Refract Surg 2013; 39:1916–1920

20. Cleary C, Tang M, Ahmed H, Fox M, Huang D. Beveled femtosecond laser astigmatic keratotomy for the treatment of high astigmatism post-penetrating keratoplasty. Cornea 2013; 32:54–62

First author:
Ashbala Khattak, MD
The Dhahran Eye Specialist Hospital, Dhahran, Saudi Arabia