Circular Keratotomy Combined With Wedge Resection in the Management of High Astigmatism After Penetrating Keratoplasty

Hanefi Çakır, M.D., Selim Genç, M.D., and Emre Güler, M.D.

Objective: To evaluate the effectiveness of circular keratotomy combined with wedge resection for the management of high astigmatism after penetrating keratoplasty (PK).

Methods: The study included seven eyes of seven patients with previous PK who underwent circular keratotomy combined with wedge resection. The uncorrected visual acuity (UCVA) and best-corrected visual acuity (BCVA), spherical equivalent (SE) refraction, and keratometric powers obtained by corneal topography were evaluated. The power vector method was used to analyze the astigmatic change postoperatively.

Results: The mean follow-up period was 18.42±8.56 months (range 12–33 months). Uncorrected visual acuity, BCVA, and SE were improved in all eyes postoperatively. The mean preoperative astigmatism reduced from 15.11±5.48 D (range, 10.0–24.4 D) to 4.98±3.01 D (range, 2.2–9.6 D), postoperatively. According to the vector analysis, the overall mean surgically induced astigmatism at last visit was 12.87±6.20 D. The most common complication was the loosening of sutures occurred in five eyes within 2 months.

Conclusions: Circular keratotomy combined with corneal wedge resection is a favorable option for the management of high astigmatism after PK.

Key Words: Circular keratotomy—Wedge resection—Penetrating keratoplasty—High astigmatism.

(*Eye & Contact Lens* 2018;44: S392–S395)

The postoperative astigmatism is the most important factor that contributes to poor visual outcome after successful penetrating keratoplasty (PK). Contact lenses or spectacles can be used to compensate for the refractive error after PK; however, both options present significant limitations.[1,2] In these patients, several surgical options have been reported to manage astigmatism that include astigmatic keratotomy,[3,4] intrastromal corneal ring segment (ICRS),[5,6] and excimer laser.[7,8]

From the Department of Ophthalmology (H.Ç.), Türkiye Hospital, Eye Clinic, İstanbul, Turkey; Department of Ophthalmology (S.G.), Prof. Dr. N. Reşat Belger Beyoğlu Eye Training and Research Hospital, İstanbul, Turkey; and Department of Ophthalmology (E.G.), Medipol University Medical School, İstanbul, Turkey.

The authors have no funding or conflicts of interest to disclose.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.eyeandcontactlensjournal.com).

Address correspondence to Emre Güler, M.D., Koşuyolu/Kadıköy, 34718 İstanbul, Turkey, guleremre83@hotmail.com

Accepted February 19, 2018.

DOI: 10.1097/ICL.0000000000000502

Corneal wedge resection has been reported to be a safe and moderately effective treatment for post-PK astigmatism.[9,10] It has been shown that corneal wedge resection corrects a higher amount of post-PK astigmatism compared with astigmatic keratotomy.[11] Wedge resections combined with relaxing incisions has also been shown to reduce a high-degree post-PK astigmatism with an average of 5.0 diopters (D).[12] However, the management of advanced post-PK astigmatism especially exceeding 10.0 D still remains challenging.

In 1992, circular keratotomy was introduced for the treatment of regular astigmatism.[13,14] The basis of the procedure is a natural law described by C. F. Gauss (1777–1855) who found that the surfaces of elastic deformable structures tend to take on spherical shapes when the volumes they contain are placed under pressure. The circular scar seemed to act like a stabilizing ring within the stroma and led to a reduction of astigmatism. We herein report our experience of circular keratotomy combined with wedge resection in cases with high post-PK astigmatism.

PATIENTS AND METHODS

This retrospective study included eyes with previous PK who underwent circular keratotomy combined with wedge resection at Türkiye Hospital between 2010 and 2014. All patients had high post-PK astigmatism (range 11.6–24.4 D) intolerance to spectacle or contact lens use. The study patients had provided their informed consent. The study was conducted in accordance with the ethical standards stated in the Declaration of Helsinki and was approved by the Local Ethics Committee.

All eyes had a comprehensive preoperative and postoperative ophthalmic examination that included uncorrected visual acuity (UCVA), best-corrected visual acuity (BCVA), manifest refraction by autorefraction (TopCON), slit-lamp biomicroscopy, and corneal topography with Orbscan (Oculus Optikgera¨te GmbH, Wetzlar, Germany). Visual acuity was measured using Snellen charts.

SURGICAL TECHNIQUE

The surgical procedures were applied using retrobulbar anesthesia. Initially, the size of the graft was measured, and a same size disposable trephine was applied by suction over the graft–recipient border, and one and a 1/2 or 1/4 complete trephine turns (corresponding to approximately 380 mm) were performed. After the removal of the trephine, a guarded diamond blade set at 90% depth of the cornea was used to deepen the circular cut as close as to descemet membrane

TABLE 1. *Preoperative and Postoperative Refractive Outcomes*

Patient (years)	Time Until Wedge Resection	UCVA (Snellen)		BCVA (Snellen)		SE (Diopters)		Average K (Diopters)		Keratometric Cyl (Diopters)		Vector Change in Keratometric Cyl (Diopters)	Follow-Up (months)
		Preop	Postop	Preop	Postop	Preop	Postop	Preop	Postop	Preop	Postop		
1	5	6/600	6/6.4	6/15	6/7.5	−4.0	3.0	47.05	39.45	11.7×137	3.9×123	8.4	12
2	14	6/6,000	6/15	6/120	6/7.5	NA	−5.0	58.20	47.20	11.6×20	6.6×87	16.8	33
3	6	6/600	6/30	6/30	6/15	−6.0	−3.0	47.20	48.00	12.2×12	2.2×177	10.3	12
4	25	6/6,000	6/18.9	6/38	6/12	−12	−0.50	53.95	43.60	24.4×123	2.8×70	25.3	12
5	4	6/6,000	6/15	6/15	6/6.4	−8.0	−2.0	51.95	48.90	14.8×152	7.8×140	8.3	24
6	15	6/600	6/30	6/120	6/15	NA	−2.0	48.75	45.50	21.1×150	9.6×150	11.5	24
7	11	6/600	6/30	6/120	6/15	NA	−7.0	48.12	50.62	10.0×95	2.0×130	9.5	12

BCVA, best-corrected visual acuity; Cyl, cylinder; K, simulated keratometry; SE, spherical equivalent; UCVA, uncorrected visual acuity.

(DM), which includes perforation in some areas. After creating the keratotomy, a wedge-shaped cornea between 1.0 and 1.5 mm was excised from just inside the donor side of the graft–recipient interface. The length of the incision centered at the axis of the flatter meridian of the cornea and was extended over a range of 60 to 90°. Finally, the keratotomy was closed with a single 10 to 0 nylon running suture with 24 passes under keratoscopic control, with attempts to reduce astigmatism to a minimum degree (see Video, Supplemental Digital Content 1, http://links.lww.com/ICL/A84). Postoperative regimen included moxifloxacine 5 times a day for 1-week period and dexamethasone 5 times a day for 4-week period. Typically the sutures were left in for 1 year, with a minimum of 6 months, which were removed only when they become loose. None of the included patients had any corneal sutures left.

Main outcome measures were UCVA, BCVA, spherical equivalent (SE) refraction, and corneal topography keratometric powers. The SE was the sum of the spherical and half of the cylindrical values. The vector analysis demonstrated the degree of the astigmatic correction, which includes the final amount of astigmatism and change in astigmatism achieved by surgery.[15,16]

RESULTS

Seven eyes of seven patients (four were male and three were female) were analyzed. The mean age of patients was 45.0±9.0 years (range 36–62 years). In all patients, the indications for PK were keratoconus. The mean follow-up period was 18.42±8.56 months (range 12–33 months). Table 1 demonstrates the preoperative and postoperative data of all patients.

All patients had improved UCVA postoperatively. None of the patients had a UCVA of 6/120 preoperatively, whereas all were able to achieve a UCVA of 6/30 or better postoperatively. Postoperatively, all patients had improved visual acuity that was managed with spectacles. The preoperative BCVA improved to 6/15 or better. SE values were only obtained in four eyes and all these were decreased postoperatively. In case 1, the SE showed a hyperopic shift postoperatively (preoperative −4.0 to +3.0 D postoperatively).

The mean preoperative keratometric cylinder was 15.11±5.48 D (range, 10.0–24.4 D). Postoperatively, this was reduced to a mean of 4.98±3.01 D (range, 2.2–9.6 D). The mean preoperative "average keratometry" was 50.74±4.17 D (range, 47.05–58.20 D), and postoperatively, the mean average keratometry was 46.18±3.73 D (range, 39.45–50.62 D). The vector analysis demonstrated that the mean surgically induced astigmatism was 12.87±6.20 D at the last visit (Fig. 1).

The most common complication is the suture loosening that occurred in 5 eyes within 2 months. The wound was cleaned, washed with moxifloxacin, and resutured under the keratoscope. No other complications were observed.

DISCUSSION

Excimer laser techniques for instance photorefractive keratectomy (PRK)[7] and laser in situ keratomileusis (LASIK)[8] have been

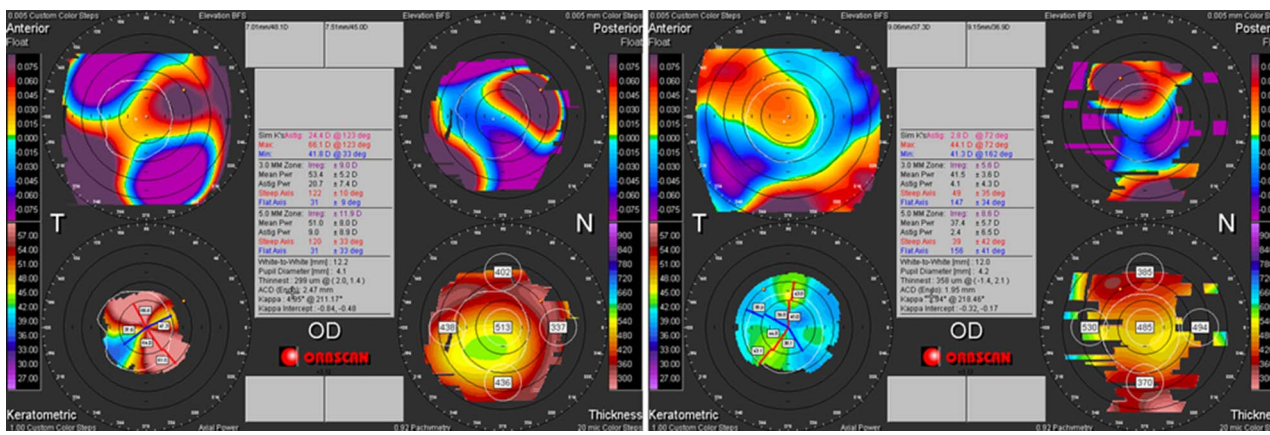

FIG. 1. The preoperative and postoperative topography of case 4 showing a significant improvement in astigmatism. full color online

reported to be successful for the treatment of post-PK astigmatism however, these methods include some limitations. Photorefractive keratectomy has been reported to result regression of astigmatism and corneal haze.[17] Laser in situ keratomileusis is limited by the corneal thickness and the amount of the refractive error, in particular for hypermetropia. Furthermore, LASIK includes the risk of graft dehiscence and flap dislocations.[18,19]

Astigmatic keratotomy is an established method of addressing high degrees of post-PK astigmatism that cannot be managed by spectacle lenses or hard contact lenses.[3,4] Astigmatic keratotomy spares the visual axis and provides rapid visual rehabilitation. This flattens the given meridian with reciprocal steepening of the meridian 90° away, known as a "coupling effect.[4] However, poor predictability, corneal perforation, and wound dehiscence are the leading disadvantages.[20]

Intrastromal corneal ring segment implantation has been reported to be an effective option for management of astigmatism after PK.[5,6,21,22] In a previous study, Prazeres et al.[21] demonstrated significantly decreased refractive astigmatism after ICRS implantation in 14 post-PK eyes. In a case series, Arriola-Villalobos et al.[5] found that the mean corneal astigmatism reduced from 7.07 D to 4.48 D after ICRS implantation. Similarly, Coscarelli et al.[22] showed that the mean corneal astigmatism decreased from 3.37 D to 1.69 D after ICRS implantation. Recently, Lısa et al.[6] reported that the mean corneal astigmatism improved from 6.98 D to 3.87 D after ICRS implantation in 32 post-PK eyes.

Corneal wedge resection was developed by Troutman[9] to correct high post-PK astigmatism. In this procedure, a wedge of corneal tissue is excised from the donor or the host cornea along the flattest meridian, and the "shortened" tissue is apposed with tight sutures causing steepening. Many published studies have reported the effect of corneal wedge resection in the management of post-PK astigmatism that demonstrates a reduction of astigmatism 3.7 D to 12.9 D.[10,23]

Circular keratotomy was introduced for the treatment of regular corneal astigmatism by Krumeich and Kezirian in 1992[13,14] However, because of low predictability, it has been abandoned by the use excimer laser treatments. The goal is to equalize the mechanical forces on the central cornea by eliminating the differences in the arc lengths, thereby reducing uneven biomechanical stress that may lead to irregular astigmatism. Recently, circular keratotomy was suggested for preventing the progression of keratoconus because of its stabilizing effect on the cornea as a result of the circular scar.[23]

All included patients were referred to our clinic for re-PK because of very high astigmatism intolerant to spectacles or contact lenses. Because the central of the graft was clear in all eyes, we performed our combined surgery without the use of an allogenic graft that includes the risk of open eye surgery and rejection. In our clinic, we perform a variety of surgical techniques in the treatment of post-PK astigmatism including astigmatic keratotomy, PRK/LASIK, and wedge resection. Because of our observations, the wedge resection was the most effective method to decrease the post-PK astigmatism that ranges between 3.0 D and 5.0 D. Because the patients included the current study that had astigmatism higher than 10 D, we performed the combination of circular keratotomy and wedge resection to gain the additive effect of each method. In addition, we believe that the combination of both methods may provide a more homogenous vectorial deviation in astigmatic power compared with wedge resection alone. Circular keratotomy as deep as DM that causes perforation in some areas does not seem to induce new corneal scarring only, but more like doing the PK again with a more circular host corneal bed created with the wedge resection.

Although the combination of each method is safe and effective, low predictability is a major concern. Furthermore, the follow-up of these cases is time consuming. The technique is depended on the strength of the sutures intraoperatively. Also, these sutures should continue to be tight in the 1st month of the surgery during the wound healing response. Within the 2 months of the surgery, we observed suture loosening in 5 eyes, which may be related to the pulling of the peripheral tissue. These loose sutures had to be replaced.

This study has some limitations. First is the small number of patients. Second is the retrospective nature of the study. A single postop visit was used for outcomes analysis; it should be better to present outcome data over time.

In conclusion, circular keratotomy combined with corneal wedge resection may be a favorable approach for the management of high astigmatism (particularly higher than 10 D) after PK where other treatments are not amenable. However, our findings should be confirmed in future studies considering these limitations.

REFERENCES

1. Genvert GI, Cohen EJ, Arentsen JJ, et al. Fitting gas-permeable contact lenses after penetrating keratoplasty. *Am J Ophthalmol* 1985;99:511–514.
2. Matsuda M, MacRae SM, Inaba M, et al. The effect of hard contact lens wear on the keratoconic corneal endothelium after penetrating keratoplasty. *Am J Ophthalmol* 1989;107:246–251.
3. Bohringer D, Dineva N, Maier P, et al. Long-term follow-up of astigmatic keratotomy for corneal astigmatism after penetrating keratoplasty. *Acta Ophthalmol* 2016;94:e607–e611.
4. Wilkins MR, Mehta JS, Larkin DF. Standardized arcuate keratotomy for postkeratoplasty astigmatism. *J Cataract Refract Surg* 2005;31:297–301.
5. Arriola-Villalobos P, Diaz-Valle D, Guell JL, et al. Intrastromal corneal ring segment implantation for high astigmatism after penetrating keratoplasty. *J Cataract Refract Surg* 2009;35:1878–1884.
6. Lisa C, Garcia-Fernandez M, Madrid-Costa D, et al. Femtosecond laser-assisted intrastromal corneal ring segment implantation for high astigmatism correction after penetrating keratoplasty. *J Cataract Refract Surg* 2013;39:1660–1667.
7. Lazzaro DR, Haight DH, Belmont SC, et al. Excimer laser keratectomy for astigmatism occurring after penetrating keratoplasty. *Ophthalmology* 1996;103:458–464.
8 Donnenfeld ED, Kornstein HS, Amin A, et al. Laser in situ keratomileusis for correction of myopia and astigmatism after penetrating keratoplasty. *Ophthalmology* 1999;106:1966–1974; discussion 1974–1965.
9. Troutman RC. Microsurgical control of corneal astigmatism in cataract and keratoplasty. *Trans Am Acad Ophthalmol Otolaryngol* 1973;77:OP563–OP572.
10. Ezra DG, Hay-Smith G, Mearza A, et al. Corneal wedge excision in the treatment of high astigmatism after penetrating keratoplasty. *Cornea* 2007;26:819–825.
11. Krachmer JH, Fenzl RE. Surgical correction of high postkeratoplasty astigmatism. Relaxing incisions vs wedge resection. *Arch Ophthalmol* 1980;98:1400–1402.
12. Belmont SC, Lazzaro DR, Muller JW, et al. Combined wedge resection and relaxing incisions for astigmatism after penetrating keratoplasty. *J Refract Surg* 1995;11:472–476.
13. Krumeich JH, Knuelle A. Circular keratotomy for the correction of astigmatism. *Refract Corneal Surg* 1992;8:204–210.
14. Krumeich JH, Knulle A, Daniel J. Improved technique of circular keratotomy for the correction of corneal astigmatism. *J Refract Surg* 1997;13:255–262.

15. Miller JM. Clinical applications of power vectors. *Optom Vis Sci* 2009;86: 599–602.
16. Egrilmez S, Dalkilic G, Yagci A. Vector analysis software on analyzing astigmatism. *Turk J Ophthalmol* 2003;33:404–416.
17. Campos M, Hertzog L, Garbus J, et al. Photorefractive keratectomy for severe postkeratoplasty astigmatism. *Am J Ophthalmol* 1992;114:429–436.
18. Afshari NA, Schirra F, Rapoza PA, et al. Laser in situ keratomileusis outcomes following radial keratotomy, astigmatic keratotomy, photorefractive keratectomy, and penetrating keratoplasty. *J Cataract Refract Surg* 2005; 31:2093–2100.
19. Hardten DR, Chittcharus A, Lindstrom RL. Long term analysis of LASIK for the correction of refractive errors after penetrating keratoplasty. *Cornea* 2004;23:479–489.
20 Butrus SI, Ashraf MF, Azar DT. *Postkeratoplasty Astigmatism: Etiology, Management and Femtosecond Laser Applications*. St. Louis, MO, Mosby-Elsevier, 2007, pp 549–559.
21. Prazeres TM, Souza AC, Pereira NC, et al. Intrastromal corneal ring segment implantation by femtosecond laser for the correction of residual astigmatism after penetrating keratoplasty. *Cornea* 2011;30:1293–1297.
22. Coscarelli S, Ferrara G, Alfonso JF, et al. Intrastromal corneal ring segment implantation to correct astigmatism after penetrating keratoplasty. *J Cataract Refract Surg* 2012;38:1006–1013.
23. Krumeich JH, Kezirian GM. Circular keratotomy to reduce astigmatism and improve vision in stage I and II keratoconus. *J Refract Surg* 2009;25: 357–365.

