·Clinical Research·

Long-term outcomes of wedge resection at the limbus for high irregular corneal astigmatism after repaired corneal laceration

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Abstract

• AIM: To evaluate the clinical value of wedge resection at corneal limbus in patients with traumatic corneal scarring and high irregular astigmatism.

• METHODS: Patients with traumatic corneal astigmatism received wedge resection at least 6mo after suture removal from corneal wound. The uncorrected distance visual acuities (UCVA) and best corrected distance visual acuities (BCVA), pre- and post-operation astigmatism, spherical equivalent (SE), safety and complications were evaluated.

• RESULTS: Ten eyes (10 patients) were enrolled in this study. Mean follow-up time after wedge resection was 37.8±15.4mo (range, 20-61mo). The mean UCVA improved from +1.07±0.55 logMAR to +0.43±0.22 logMAR (*P*=0.000) and the mean BCVA from +0.50±0.30 logMAR to +0.15±0.17 logMAR (*P*=0.000). The mean astigmatism power measured by retinoscopy was -2.03±2.27 D postoperatively and -2.83±4.52 D preoperatively (*P*=0.310). The mean SE was -0.74±1.61 D postoperatively and -0.64±1.89 D preoperatively (*P*=0.601). Two cases developed mild pannus near the sutures. No corneal perforation, infectious keratitis or wound gape occurred.

• CONCLUSION: Corneal-scleral limbal wedge resection with compression suture is a safe, effective treatment for poor patients with high irregular corneal astigmatism after corneal-scleral penetrating injury. Retinoscopy can prove particularly useful for high irregular corneal astigmatism when other measurements are not amenable.

• **KEYWORDS:** wedge resection; irregular corneal astigmatism; ocular trauma

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INTRODUCTION

Eye injury is frequently encountered in departments of ophthalmology. In the Beijing area, the rate of adults aged 40y or more suffering from eye injuries reached nearly 3% in the past 5y [1]. Zhou *et al* [2] reported that the rate of ocular trauma in a rural population of northern China was 2.1%. Between 2006 and 2011, a total of 5 541 434 patients with ocular trauma visited emergency departments in the United States[3].

The cornea, located on the front surface of the eyeball, is most susceptible to ocular trauma, which damages its transparency and regularity, and can result in astigmatism. Compared to congenital corneal astigmatism, traumatic corneal astigmatism is high and irregular. White scars of different sizes and shapes are also left on the cornea after debridement and surgery involving sutures, which not only affects the appearance, but also causes high irregular corneal astigmatism.

There are several options for the management of astigmatism[4-6]. Common methods for nonsurgical correction of astigmatism involve the use of spectacles or contact lenses. Aberrations and prismatic effects caused by an uneven corneal surface and high irregular astigmatism causes patients with spectacles to suffer intolerable levels of aniseikonia. Contact lenses are also difficult to be widely used because topographic irregularities make them difficult to fit, they are also limited in their ability to correct astigmatism, and may also cause discomfort to the patient. Surgical management of corneal astigmatism includes photorefractive keratectomy (PRK), laser *in situ* keratomileusis (LASIK), toric intraocular lens (IOL) implantation, conductive keratoplasty (CK), corneal wedge resection, and relaxing incision. All of these approaches have proven to be effective, although each has its own complications [7-10], besides, the costs of these surgeries are relatively expensive.

Patients with eye injuries are mainly industry and agriculture production workers and school-aged children, most of whom have a poor economic status. They require a simple, inexpensive, and effective method for treating their vision problem. Corneal limbus wedge resection for the treatment of corneal astigmatism is one such appropriate option. Previous researchs have reported that patients with pellucid marginal degeneration or keratoconus after penetrating keratoplasty were treated with wedge resection [11-16], here we describe a case series in which we performed corneal limbal wedge resection for treating traumatic corneal astigmatism in patients from poor economic conditions. To our knowledge, no other study has evaluated the effects of wedge resection to correct high irregular astigmatism after eye injury.

SUBJECTS AND METHODS

This retrospective case series included 10 eyes (10 subjects) with traumatic corneal astigmatism treated with corneal limbal wedge resection from March 1, 2005 to June 30, 2008. The study was approved by the Institutional Ethics Committee of Medical College of Zhengzhou University. All patients related information were obtained from patient consent.

Subjects All patients presented with a cornea penetrating injury, and were implanted with IOL because of traumatic cataract, some also underwent coreoplasty in order to make the pupil near normal size. Inclusion criteria: patients with no strabismus, no amblyopia, no glaucoma, no uveitis, no keratitis, no history of ocular surgery, and no long-term use of ocular medicine before the current trauma. All treatments were performed at least 6mo after complete suture removal from the corneal wound; the corneal laceration extended no more than 3 mm beyond the corneal limbus, and all eyes had astigmatism ⩾3.00 diopter (D). Data collected included age, sex, injured eyes, size and shape of the wound, preoperative uncorrected visual acuity (UCVA), preoperative best corrected visual acuity (BCVA), retinoscopy optometry results, operative methods, postoperative UCVA, postoperative BCVA, and postoperative retinoscopy optometry results. All patients were examined by the same experienced optometrist using retinoscopy to determine the maximum degree of irregular astigmatism, and the steepest and flattest meridians. Scar size was measured using calipers under surgical microscope. UCVA and BCVA were evaluated on the Snellen's scale and converted to logMAR visual acuity for analysis.

Methods The paired arcuate incisions were placed at 0.5-1.0 mm before the corneal-scleral intersection, centered on the axis of the flatter meridian of the cornea, with a range of 45°-90°, and a depth of two-thirds to three-quarters of the corneal thickness. A thin sliver of tissue with a width of 0.5-1 mm was excised from the cornea. The wound was closed with a 10-0 polypropylene suture; all sutures were left in place, and the knot was buried in the cornea. During the operation, we used a Placido disk. The tightness of sutures was adjusted in order to make the image of the Placido disk on the cornea appeared as regular concentric circles (Figures 1, 2). All surgeries were performed by an experienced specialist (Zheng GY). During the period of 4wk after operation, tobramycin-dexamethasone eye drops and pranoprofen eye drops were administered four times a day, the former should be tapered in the period.

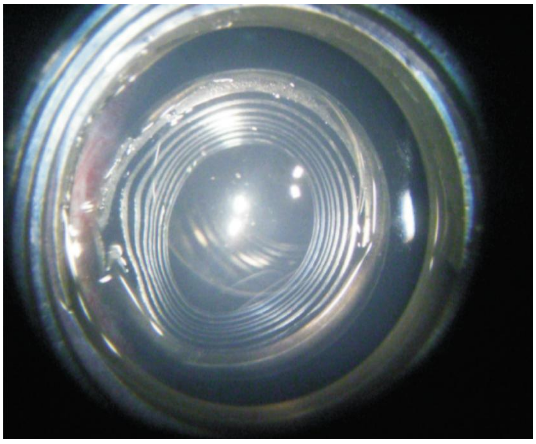

Figure 1 Preoperative image of Placido disk on the cornea Before wedge resection at the corneal limbus, the image of Placido disc in the traumatic corneal scarring showed irregular concentric circles.

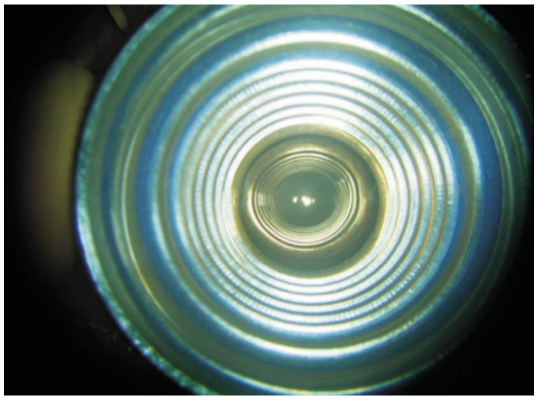

Figure 2 Postoperative image of Placido disk on the cornea After wedge resection at the corneal limbus, the image of the Placido disc in the traumatic corneal scarring showed concentric circles.

Statistical Analysis Descriptive data are shown as the mean±standard deviation (SD). A paired Student's t-test was used to compare preoperative and postoperative data. A P value less than 0.05 was considered significant.

RESULTS

Ten eyes of 10 patients were enrolled in this study. The age at the time of surgery was 20.60±11.34y (range: 7-34y); 5 patients were children and 5 were adults. All of the children were male, and the average age was 10.20±2.86y (range: 7-14y). Adults included 3 men and 2 women; the average age was 31.00±3.24y (range: 27-34y). The size of scar was 5.05±2.09 mm (range: 3.0-9.5 mm). The shape of scar was classified into three categories: zigzag line, beeline, and triangle, with 6 eyes, 3 eyes and 1 eye respectively (Figure 3). There were 6 eyes of scar crossed the central 5-mm area of cornea, and 4

Table 1 Clinic data of patients with high irregular astigmatism after repaired corneal laceration

No.	Sex	Age (a)	Eye	Shape of scar	Size of scar (mm)	Lens status	Preoperative UCVA	Preoperative BCVA	Preoperative retinoscopy	Follow-up period (mo)
1	M	28	L	Zigzag line	9.5	IOL	CF/50 cm	0.25	+1.00/-7.50×60	53
2	F	34	R	Zigzag line	4.5	IOL	0.15	0.3	+0.50/-4.00×75	61
3	F	33	R	Beeline	3.5	IOL	0.3	0.8	+0.50/+3.00×65	37
4	M	8	L	Zigzag line	4.0	IOL	0.08	0.3	0/+4.50×180	21
5	M	33	L	Triangle	6.5	IOL	0.05	0.12	+1.75/-6.00×180	42
6	M	7	L	Zigzag line	7.0	IOL	CF/60 cm	0.08	+3.25/-6.75×65	39
7	M	12	R	Zigzag line	4.0	IOL	0.1	0.3	+1.75/-5.00×150	23
8	M	27	L	Beeline	3.0	IOL	0.15	0.5	-1.00/-4.00×5	57
9	M	10	R	Beeline	3.0	IOL	0.3	0.6	-0.50/+3.00×90	20
10	M	14	L	Zigzag line	5.5	IOL	0.2	0.4	+0.50/-5.50×150	25

M: Male; F: Female; L: Left; R: Right; IOL: Intraocular lens; UCVA: Uncorrected visual acuity; BCVA: Best corrected visual acuity.

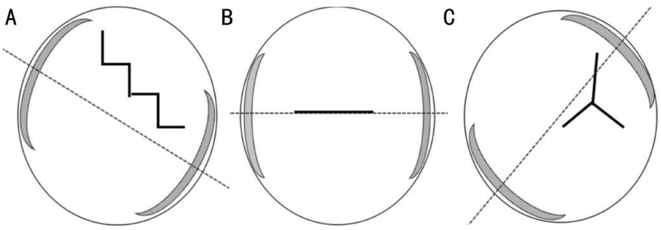

Figure 3 Schematic diagrams of 3 shapes of traumatic corneal scars.

eyes located outside the area. The average follow-up period was 37.8 ±15.4mo (range: 20-61mo). A summary of the patients' characteristics can be found in Table 1.

The mean postoperative UCVA at the last follow-up was +0.43±0.22 logMAR (range: +0.10 to +0.80 logMAR), and the mean preoperative UCVA was +1.07 ±0.55 logMAR (range: +0.50 to +2.00 logMAR); the UCVA was significantly better after the surgery (t=5.727, P=0.000). The mean postoperative BCVA at the last follow-up was +0.15 ± 0.17 logMAR (range: 0 to +0.50 logMAR), and the mean preoperative BCVA was +0.50±0.30 logMAR (range: +0.10 to +1.10 logMAR); this difference was statistically significant (t=6.194, P=0.000; Figures 4, 5).

The mean astigmatism power as measured by retinoscopy was -2.03 ±2.27 D postoperatively, at the last follow-up (range: -4.50 to +1.25 D), which was not statistically significantly different (t=-1.076, P=0.310) from the -2.83± 4.52 D (range: -7.50 to +4.50 D) preoperative value. The mean spherical equivalent refraction (SE) was -0.74±1.61 D (range: -3.25 to +1.625 D) postoperatively, at the last follow-up, compared to -0.64±1.89 D (range -3.00 to +2.25 D) preoperatively. This difference was also not statistically significant (t=0.543, P=0.601; Figures 6, 7).

Safety In one case, a suture was removed postoperatively because the suture was too tight; a loose suture was removed and tied again in two cases. Two cases presented with mild pannus near the sutures; however, long term follow-up showed no growth of the corneal pannus. There were no other complications, such as corneal perforation intraoperatively, or infectious keratitis and wound gape postoperatively.

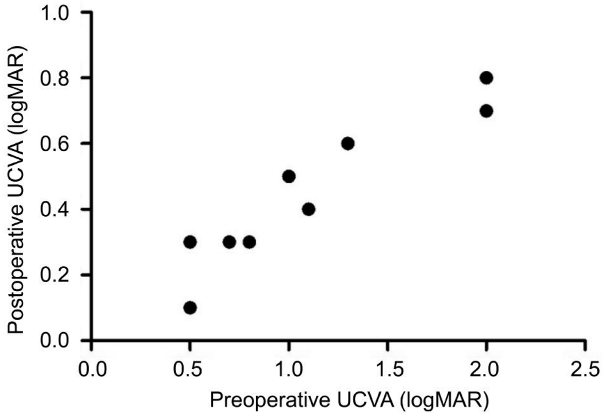

Figure 4 Scatterplot of UCVA (logMAR) pre - and postoperatively.

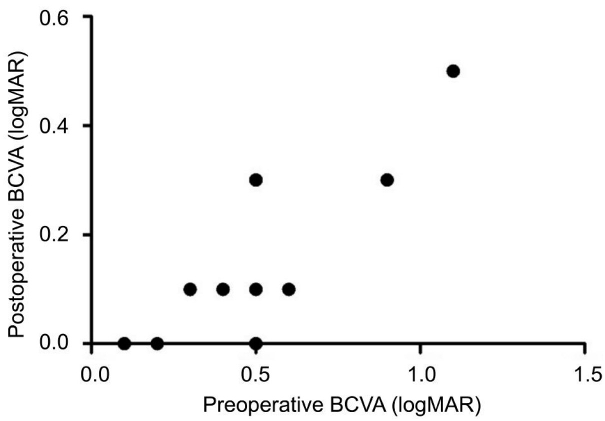

Figure 5 Scatterplot of BCVA (logMAR) pre - and postoperatively.

DISCUSSION

The common methods of evaluating corneal curvature are photokeratometry, corneal topography, and optometry. Photokeratometry requires at least a 3-mm area with transparent and smooth surface of the central cornea for measurement, but the area is often damaged when eye injuries occur. Scanning-slit corneal topography (Obscan II, Bausch & Lomb, Rochester, NY, USA) cannot obtain stable

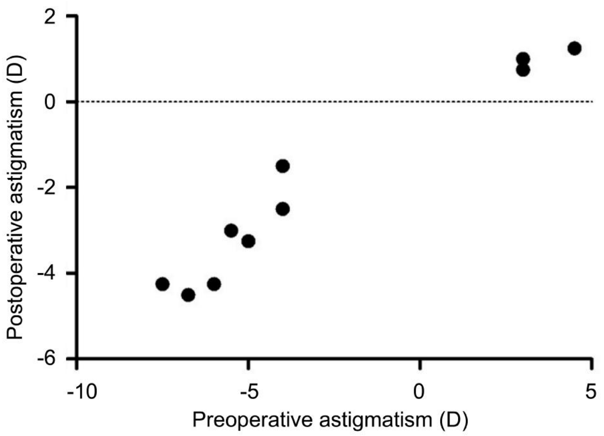

Figure 6 Scatterplot of astigmatism power pre – and postoperatively.

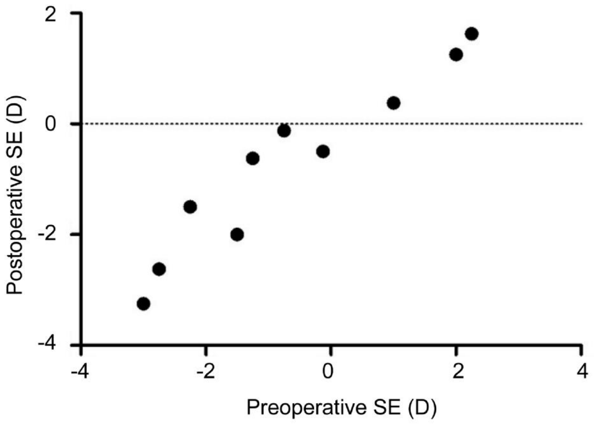

Figure 7 Scatterplot of spherical equivalent (SE) pre – and postoperatively.

topography with an uneven corneal surface. Automatic optometry can also not be applied to a corneal scar. Therefore, retinoscopy is used to examine the curvature of a traumatized cornea. Since astigmatism of the injured eye is mainly derived from traumatized cornea, corneal astigmatism correction should improve the patients' visual acuity.

Wedge resection induces astigmatism in the meridian of surgery. van Rij and Waring [17] pointed out that wedge resection closed by sutures in the anterior part of the cornea removes more tissue from the anterior part than from the posterior part, thereby producing a depression of the cornea limbus and a steepening of the central cornea in the surgical meridian. In the opposite meridian, the cornea becomes flattened. Since corneal wedge resection was first described as a treatment for astigmatism by Troutman [18] in 1973, researchers have applied it to correct corneal astigmatism. Over the years, there have been several reports of treatment of high astigmatism after penetrating keratoplasty by corneal wedge resection[11-13]. de la Paz *et al* [11] reported a study of 22 eyes that underwent wedge resection in the host corneal tissue for high irregular astigmatism after penetrating keratoplasty for keratoconus. They found the lowest degree of astigmatism at 3y postoperatively, with a tendency toward regression at 5y postoperatively. MacLean *et al* [14] applied wedge excision to correct corneal astigmatism caused by pellucid marginal degeneration; the mean keratometric astigmatism was 13.8 D (range: 8-25 D) preoperatively, 1.4 D (range: 0.5-4 D) at 3-12mo postoperatively, and 2.1 D (range: 0.5-5.5 D) at 14-138mo in the long-term follow-up.

Researchers have also applied wedge resection and beveled penetrating relaxing incision for the treatment of corneal astigmatism caused by pellucid marginal corneal degeneration. The mean keratometric astigmatism was reduced from 15.1 D preoperatively to 4.6 D at 6mo postoperatively, and was stable at further follow-ups [15]. There have also been reports on the use of femtosecond-laser arcuate wedge-shaped resection for the correction of high astigmatism [19-20], but the cost was too high, and the effect was not superior to those of other astigmatism correction surgeries.

To our knowledge, no study has evaluated the effects of wedge resection in the treatment of high irregular astigmatism after corneal laceration. In our study, we found the mean astigmatism power to be reduced from -2.83±4.52 D (range: -7.50 to +4.50 D) preoperatively to -2.03±2.27 D (range: -4.50 to +1.25 D) at 20-61mo in the long-term follow-up. Over long-term follow-up, the mean decrease of astigmatism in the present study was 2.33±0.59 D (range, 1.50-3.25 D), which was different from that reported by previous studies (reaching more than 10 D). One reason for this may be the different method used for detecting astigmatism: astigmatism changes in other reports were mainly evaluated based on the change of corneal curvature, while astigmatism changes reported in this study were based on the results of retinoscopy. Another reason may be the difference in the location of the surgical incision: the incisions in this study were made on the corneal limbus, while those reported in literature were closer to the center of the cornea.

Some researchers also assessed the effect of wearing rigid gas permeable contact lenses on correcting irregular astigmatism and providing increased visual acuity for patients with traumatic corneal scarring. In their study, only 22.2% patients had a successful fit; the remaining patients all complained of ocular discomfort, some found it inconvenient to take care of the lenses, while others with good visual acuity in the fellow eye did not want the inconvenience of a lens[21].

Corneal wedge resection also has its disadvantages: the scope for correction of astigmatism is limited, and the choice and tightness of the sutures require serious consideration by the surgeon. In our study, the first case was closed up with 10-0 nylon sutures, and a rapid refractive regression appeared 6mo after surgery. The nylon line material is strongly elastic, while polypropylene suture material is not elastic and the tension of the suture was therefore more intact. Thus, we replaced the nylon sutures with polypropylene sutures for the patient, and for the next 9 patients, 10-0 polypropylene sutures were used. The tightness of all sutures on 1 incision should be uniform, as the effect would otherwise be compromised. Among our cases, 2 developed mild pannus related to the large suture span, but the range of pannus was limited with no sign of progressive growth.

In conclusion, corneal limbal wedge resection is a safe, moderately effective, and inexpensive treatment for high irregular corneal astigmatism after corneal-scleral penetrating injury. Retinoscopy may prove particularly useful for patients with high irregular corneal astigmatism when other measurement approaches are not feasible. In this study, some patients with poor compliance were not included in the analysis. Hence, more cases are needed to evaluate the relationship between the length of incision, the width of incision, and the correction of astigmatism, and to improve the surgical correction of astigmatism further.

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REFERENCES

1 Wang JD, Xu L, Wang YX, You QS, Zhang JS, Jonas JB. Prevalence and incidence of ocular trauma in North China: The Beijing Eye Study. *Acta Ophtalmol* 2012;90(1):e61-e67.

2 Zhou J, Wang FH, Lu H, Liang YB, Wang NL. Ocular trauma in a rural population of North China: The Handan Eye Study. *Biomed Environ Sci* 2015;28(7):495-501.

3 Haring RS, Canner JK, Haider AH, Schneider EB. Ocular injury in the United States: emergency department visits from 2006-2011. *Injury* 2016;47(1):104-108.

4 Lee BS, Lindstrom RL, Reeves SW, Hardten DR. Modern management of astigmatism. *Int Ophthalmol Clin* 2013;53(1):65-78.

5 Goggin M, Alpins N, Schmid LM. Management of irregular astigmatism. *Curr Opin Ophthalmol* 2000;11(4):260-266.

6 Read SA, Vincent SJ, Collins MJ. The visual and functional impacts of astigmatism and its clinical management. *Ophthalmic Physiol Opt* 2014;34(3):267-294.

7 Toda I, Yamamoto T, Ito M, Hori-Komai Y, Tsubota K. Topography-guided ablation for treatment of patients with irregular astigmatism. *J Refract Surg* 2007;23(2):118-125.

8 Xu W, Ye P, Yao K, Ma J, Xu H. Conductive keratoplasty for the treatment of astigmatism induced by corneal trauma or incision. *J Refract Surg* 2010;26(1):33-42.

9 Mozayan E, Lee JK. Update on astigmatism management. *Curr Opin Ophthalmol* 2014;25(4):286-290.

10 Maedel S, Hirnschall N, Chen YA, Findl O. Rotational performance and corneal astigmatism correction during cataract surgery: aspheric toric intraocular lens versus aspheric nontoric intraocular lens with opposite clear corneal incision. *J Cataract Refract Surg* 2014;40(8):135513-135562.

11 de la Paz MF, Sibila GR, Montenegro G, de Toledo JA, Michael R, Barraquer R, Barraquer J. Wedge resection for high astigmatism after penetrating keratoplasty for keratoconus: refractive and histopathologic changes. *Cornea* 2010;29(6):595-600.

12 Hari L, Daya SM. Corneal wedge resection to treat progressive keratoconus in the host cornea after penetrating keratoplasty. *J Cataract Refract Surg* 2003;29(2):395-401.

13 Ezra DG, Hay-Smith G, Mearza A, Falcon MG. Corneal wedge excision in the treatment of high astigmatism after penetrating keratoplasty. *Cornea* 2007;26(7):819-825.

14 MacLean H, Robinson LP, Wechsler AW. Long-term results of corneal wedge excision for pellucid marginal degeneration. *Eye (Lond)* 1997;11(5):613-617.

15 Busin M, Kerdraon Y, Scorcia V, Zambianchi L, Matteoni S. Combined wedge resection and beveled penetrating relaxing incisions for the treatment of pellucid marginal corneal degeneration. *Cornea* 2008;27(5):595-600.

16 Maccheron L J, Daya SM. Wedge resection and lamellar dissection for pellucid marginal degeneration. *Cornea* 2012;31(6):708-715.

17 van Rij G, Waring GO. Changes in corneal curvature induced by sutures and incisions. *Am J Ophthalmol* 1984;98(6):773-783.

18 Troutman RC. Microsurgical control of corneal astigmatism in cataract and keratoplasty. *Trans Am Acad Ophthalmol Otolaryngol* 1973;77(5):OP563-OP572.

19 Buzzonetti L, Petrocelli G, Laborante A, Mazzilli E, Gaspari M, Valente P. Arcuate keratotomy for high postoperative keratoplasty astigmatism performed with the intralase femtosecond laser. *J Refract Surg* 2009;25(8):709-714.

20 Ghanem RC, Azar DT. Femtosecond-laser arcuate wedge-shaped resection to correct high residual astigmatism after penetrating keratoplasty. *J Cataract Refract Surg* 2006;32(9):1415-1459.

21 Zheng B, Shen L, Walker MK, Zhang Z, Zheng J, She X, Zhou J, Xu Z, Chen Y. Clinical evaluation of rigid gas permeable contact lenses and visual outcome after repaired corneal laceration. *Eye Contact Lens* 2015;41(1):34-39.