Original Article

Office-based Relaxing Incision Procedure for Correction of Astigmatism after Deep Anterior Lamellar Keratoplasty

Mohammad Ali Javadi[1,2], MD; Sepehr Feizi[1], MD, MS; Firooz Mirbabaee[1], MD; Yousef Fekri[1], MD

[1]*Ophthalmic Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran*
[2]*Central Eye Bank of Iran, Tehran, Iran*

Abstract

Purpose: To report the outcomes of a simple and effective office-based procedure for the correction of astigmatism after deep anterior lamellar keratoplasty (DALK).
Methods: This study enrolled 24 consecutive keratoconic eyes that developed an intolerable amount of graft astigmatism after DALK. The location and extension of steep semi-meridians were determined using corneal topography. Office-based relaxing incision procedures were performed at the slit-lamp biomicroscope using a 27-gauge needle. Relaxing incisions were made at the donor-recipient interface on one side of the steepest meridian with an arc length of 45° to 60° and an initial depth of approximately 70–80% of the corneal thickness. Topography was performed after 30–40 minutes and the initial incision was enhanced in depth and length. If an acceptable amount of astigmatism was not achieved, another incision was created at the opposite semi-meridian during the same session.
Results: Mean follow-up period was 13.1 ± 7.4 months. Mean preoperative best spectacle corrected visual acuity was 0.26 ± 0.14 logMAR, increasing to 0.22 ± 0.09 logMAR after the procedure (P = 0.20). Mean spherical equivalent refractive error increased from − 4.64 ± 3.06 diopters (D) preoperatively to −6.06 ± 3.15 D postoperatively (P = 0.01). Mean keratometric astigmatism was reduced by 2.95 ± 3.43 D and 5.16 ± 2.97 D measured using subtraction and vector analysis methods, respectively (P < 0.001). Microperforation occurred in one eye, which spontaneously improved with no sequelae.
Conclusion: Office-based relaxing incision is a safe and effective procedure for the treatment of corneal graft astigmatism after DALK. This approach effectively decreases the need for the more costly alternative in the operating room.

Keywords: Astigmatism; Deep Anterior Lamellar Keratoplasty; Office-based Relaxing Incision

J Ophthalmic Vis Res 2017; 12(2): 156-164

Correspondence to:
Mohammad Ali Javadi, MD. Ophthalmic Research Center, Shahid Beheshti University of Medical Sciences, Boostan 9 St., Pasdaran Ave., Tehran 16666, Iran.
E-mail: ma_javadi@yahoo.com

Received: 06-02-2016 Accepted: 05-10-2016

Access this article online

Quick Response Code:

Website: www.jovr.org

DOI: 10.4103/jovr.jovr_24_16

INTRODUCTION

Deep anterior lamellar keratoplasty (DALK) is considered an alternative procedure to penetrating keratoplasty (PK) for corneal pathologies not affecting the endothelium and Descemet's membrane (DM).[1] The advantages of

This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Javadi MA, Feizi S, Mirbabaee F, Fekri Y. Office-based relaxing incision procedure for correction of astigmatism after deep anterior lamellar keratoplasty. J Ophthalmic Vis Res 2017;12:156-64.

DALK over PK consist of eliminating endothelial graft rejection, reducing graft failure, preserving eye integrity against blunt trauma,[2] and longer graft survival due to a lower rate of endothelial cell loss.[3] However, as with PK, the main drawback of DALK is the considerable postoperative refractive error, which causes visual impairment despite a clear corneal graft.[4] Based on previous studies, 11.4–24.6% of patients undergoing DALK develop high postoperative astigmatism.[5-7] There are several options to treat astigmatism following DALK that vary from optical correction using glasses or rigid gas permeable (RGP) contact lenses to surgical interventions including relaxing incisions,[6-8] femtosecond laser arcuate keratotomy,[9] photorefractive keratectomy,[10,11] laser *in situ* keratomileusis,[12] and toric phakic intraocular lens implantation.[13] Spectacles may be insufficient when a significant amount of astigmatic anisometropia is present, and RGP contact lenses may be an option only if they are well tolerated by the patient. Astigmatic keratotomies can be precisely performed by using a femtosecond laser.[9] However, this technology is not widely available, and its cost-effectiveness needs to be taken into account. Excimer laser photoablation techniques are capable of treating coexisting spherical refractive error, but their efficacy is limited in the correction of high degrees of astigmatism.[10-12] Manual relaxing incision, performed on the steep meridian, is widely used for high astigmatism after keratoplasty because it is a safe and simple procedure with no risk of postoperative haze and minor manipulation to the allograft. This technique, however, has some disadvantages including unpredictable results and risk of corneal perforation.[7,14,15]

Currently, patients are taken to the operating room for surgical management of astigmatism after keratoplasty, which is performed with intravenous sedation. This approach is time consuming and increases overall costs, especially when the procedure is required more than once due to undercorrection or overcorrection of astigmatism. Herein, we describe a quick, well-tolerated and effective office-based technique for the management of post-DALK astigmatism. To the best of our knowledge, this is the first study reporting the outcomes of relaxing incisions performed in an office setting in keratoconic patients who developed high corneal graft astigmatism after DALK.

METHODS

In this interventional case series, keratoconic patients who underwent DALK and developed a significant amount of post-keratoplasty astigmatism were considered for relaxing incisions performed in an office setting. Inclusion criteria included post-DALK keratometric astigmatism ≥5 diopters (D) at least 3 months after complete suture removal, stable refractive error, and corrective spectacles and/or RGP contact lens intolerance. Informed consent was signed by all participants, after explaining the purpose of the intervention. The study was approved by the Ethics Committee of the Ophthalmic Research Center, Shahid Beheshti University of Medical Sciences.

Computerized corneal topography (TMS-I, Topographic Modeling System, version 1.61; Computed Anatomy Inc., New York, USA) was used to determine the steep and flat meridians. The length of the relaxing incisions was determined by the borders of the steep semi-meridians and ranged from 45º to 60º. Office-based relaxing incision procedures were performed at the slit-lamp biomicroscope under topical anesthesia by an experienced anterior segment surgeon (MAJ) who had also performed DALK. Relaxing incisions were made at the donor-recipient interface under direct visual inspection on one side of the steepest meridian using a 27-gauge needle [Figure 1].

The initial depth of the incision was approximately 70–80% of the corneal thickness. Topography was repeated after 30–40 minutes to evaluate the impact of a relaxing incision on reducing the magnitude of astigmatism. The initial incision was enhanced when an acceptable amount of astigmatism (≤4.0 D) was not achieved. For enhancement, the depth and/or length of the incision were increased. When necessary, another relaxing incision was created at the opposite semi-meridian. At the conclusion of the procedure, 0.5% chloramphenicol and 0.1% betamethasone eye drops were instilled. The same medications were continued postoperatively every six hours for two weeks. Follow-up examinations were performed at days 1, 7, and 30 and during the following months as necessary. The procedure was repeated if astigmatic regression occurred during the follow-up period.

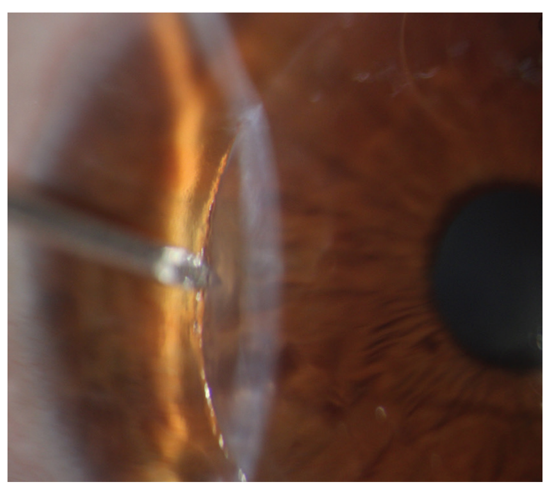

Figure 1. A 27-gauge needle was used to create a relaxing incision at the donor-recipient interface. The slit beam and high magnification of the slit-lamp biomicroscope allow precise estimation of the depth of the incision.

Preoperatively, uncorrected visual acuity (UCVA) and best spectacle corrected visual acuity (BSCVA), refractive and keratometric astigmatism, and manifest refraction were measured. After the procedure, UCVA, BSCVA, refractive and keratometric astigmatism, manifest refraction, and changes in astigmatism induced by relaxing incisions, determined by subtraction and vector analysis methods,[16] were measured. If the office-based relaxing incisions were required more than once due to astigmatic regression, the final results were considered for data analysis. All complications were also recorded.

Statistical Analysis

Data were analyzed using SPSS statistical software version 21 (IBM Corp., Armonk, NY, USA). The mean and standard deviation, range, frequency and percentage were used to express data. The normal distribution of continuous variables was verified using a Kolmogorov-Smirnov test and a Q-Q plot. Comparisons between the pre- and postoperative values were performed using a paired *t*-test or Wilcoxon rank-sum test for normal and non-normal continuous variables, respectively. Binary variables were compared using a MacNemar test. A P value <0.05 was considered to be statistically significant. All reported P values are two-sided.

RESULTS

Twenty-four consecutive (11 right) eyes of 24 keratoconic patients including 18 male subjects and 6 female subjects underwent the office-based relaxing incision procedure from March 2010 to December 2014. Mean patient age at the time of keratoplasty was 28.4 ± 8.7 (range, 16 to 57) years. Recipient trephine size ranged from 7.75 to 8.50 (7.97 ± 0.15) mm and donor-recipient disparity was 0.25 mm in all cases. The time interval from DALK and complete suture removal to the first in-office procedure was 26.3 ± 19.0 (range, 12 to 34) months and 10.9 ± 6.8 (range, 3 to 16) months, respectively. Eighteen (75.0%) eyes needed only one procedure, whereas the remaining eyes required two ($n = 4$; 16.7%) or three ($n = 2$; 8.3%) interventions. The patients were followed up for 13.1 ± 7.4 (range, 6 to 37) months after the first office-based procedure.

Mean preoperative UCVA and BSCVA were 1.13 ± 0.29 (range, 0.30 to 1.60) logMAR and 0.26 ± 0.14 (range, 0.10 to 0.70) logMAR, respectively. These figures were 1.04 ± 0.46 (range, 0.30 to 1.48) logMAR and 0.22 ± 0.09 (range, 0.10 to 0.40) logMAR at the final follow-up, respectively. There was no significant change in UCVA ($P = 0.63$) and BSCVA ($P = 0.20$). A gain of 1, 2, and 7 lines of UCVA were found in 3 (12.5%) eyes, while no change in UCVA was documented in 19 (79.2%) eyes, and 2 (8.3%) eyes lost 1 line and 3 lines of UCVA. Furthermore, a gain of 1 to 3 lines in BSCVA was found in 7 (29.2%) eyes, and BSCVA was maintained in 15 (62.5%) eyes. Two (8.3%) eyes lost 1 and 2 lines of BSCVA. Preoperatively, 17 (70.8%) eyes had BSCVA of 20/40 or better; the corresponding figure at final follow-up was 21 (87.5%) eyes ($P = 0.75$).

Mean keratometry significantly increased from 47.02 ± 1.81 (range, 43.5 to 50.25) D preoperatively to 47.45 ± 1.88 (range, 43.0 to 51.0) D postoperatively ($P = 0.04$). Mean spherical equivalent refractive error increased from – 4.64 ± 3.06 (range, −1.0 to – 12.0) D preoperatively to – 6.06 ± 3.15 (range, −1.25 to – 13.5) D postoperatively, which was statistically significant ($P = 0.01$) and indicated a myopic shift after office- based relaxing incision.

Keratometric astigmatism was reduced from 7.0 ± 2.03 (range, 5.0 to 13.0) D preoperatively to 4.05 ± 2.81 (range, 1.0 to 13.5) D postoperatively ($P < 0.001$). The average keratometric astigmatism was reduced by 2.95 ± 3.43 D (42.1%) and 5.16 ± 2.97 D (73.7%) when measured with subtraction and vector analysis methods, respectively. Mean preoperative refractive astigmatism was 6.28 ± 1.20 (range, 4.0 to 9.0) D, decreasing to 3.45 ± 1.80 (range, 0 to 8.50) D postoperatively ($P < 0.001$). The reduction in refractive astigmatism was 2.83 ± 2.16 D (45.1%) and 4.84 ± 2.55 D (77.1%) when measured with subtraction and vector analysis methods, respectively. No eyes had keratometric astigmatism of 4 D or less preoperatively. This rate increased to 66.7% after the procedure ($P < 0.001$). Corresponding figures for refractive astigmatism were 4.2% preoperatively and 62.5% postoperatively ($P < 0.001$).

In the 18 eyes that underwent the procedure only once, keratometric astigmatism was 2.72 ± 1.25 (range, 1.0 to 4.0) D immediately after the procedure and remained stable until the end of follow-up (2.39 ± 0.70 D, 1.0 to 3.0 D; $P = 0.35$), as shown in Figure 2a. In the 6 eyes that required the procedure more than once, keratometric astigmatism dramatically increased from 2.67 ± 1.53 (range, 1.0 to 4.0) D immediately after the procedure to 7.17 ± 5.84 (range, 6.50 to 13.50) D just before the second intervention ($P < 0.001$, Figure 2b).

Complications

Microperforation at the site of relaxing incision occurred in 1 (4.2%) eye, presenting a slight leak. The postoperative course in this eye was uneventful and the leak self-sealed after 2 days without the development of a shallow anterior chamber or DM detachment. Two (8.3%) eyes experienced an episode of subepithelial graft rejection 22 and 48 days after the procedure, which resolved with frequent topical 0.1% betamethasone eye drops. Astigmatism regressed to the pretreatment values in six eyes after the initial procedure, necessitating the repetition of the procedure, which effectively reduced astigmatism in 4 eyes. Two (8.3%) eyes, however, required relaxing incisions with concomitant adjustment sutures performed in the operating room after the failure of repeated in-office procedures.

CASE PRESENTATIONS

Case 1

A 30-year-old keratoconic man with a history of DALK underwent relaxing incisions at both sides of the steep meridian three months after complete suture removal to reduce post-DALK astigmatism. Before the procedure, UCVA was 20/400, which improved to 20/40 with – 1.5 – 11.75 × 165. Keratometry readings were 41.01 × 174/51.43 × 84 [Figure 3a]. At the last follow-up examination, which was performed 7 months after the relaxing incisions, UCVA and BSCVA remained unchanged, but refractive error and keratometry were reduced to – 3.75 – 3.0 × 35 and 45.10 × 28/47.01 × 118, respectively, indicating a reduction of 8.51 D in keratometric astigmatism [Figure 3b].

Case 2

A 27-year-old man with a history of big-bubble DALK, performed for keratoconus, had high astigmatism 4 months after complete suture removal. At this time, UCVA was 20/200 and BSCVA was 20/30. The refractive error and keratometry were – 1.50 – 6.0 × 140 and 42.70 × 143/48.27 × 53, respectively [Figure 4a]. Relaxing incisions were made at both sides of the steep meridian, which immediately led to an overcorrection of astigmatism (–3.5 – 4.0 × 60 and 44.28 × 54/47.40 × 144). Astigmatic regression occurred after seven months resulting in an increase in refractive astigmatism (–1.0 – 6.0 × 140) and keratometry (42.62 × 143/48.58 × 53, Figure 4b). Another relaxing incision was created, which led to the complete elimination of astigmatism (–4.5 sphere and 45.73/45.73, Figure 4c). Four months after the second procedure, another intervention was required to correct regressing astigmatism (–3.0 – 4.0 × 135 and 43.90 × 142/47.71 × 52, Figure 4d). At the final follow-up examination performed 8 months after the third intervention, UCVA was 20/80

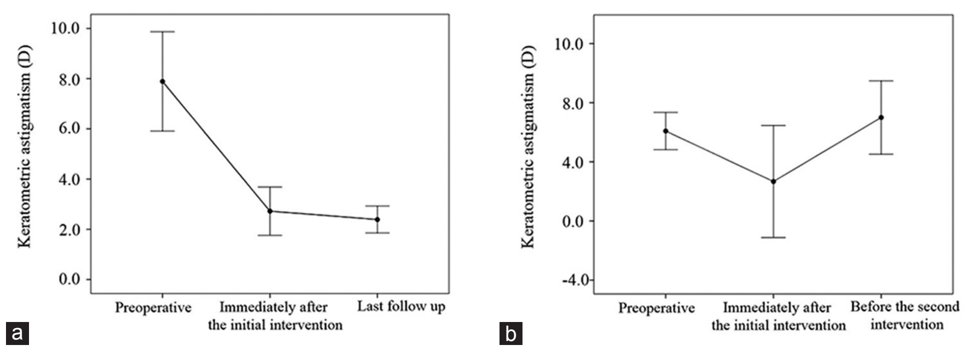

Figure 2. Changes of keratometric astigmatism at different time points after the office-based relaxing incision procedure. (a) Astigmatism was reduced immediately after the procedure and did not show significant changes or regression of correction by the end of follow-up in 18 eyes. (b) After a dramatic decrease following the first intervention, astigmatism regressed to the pretreatment value in 6 eyes, necessitating the second intervention.

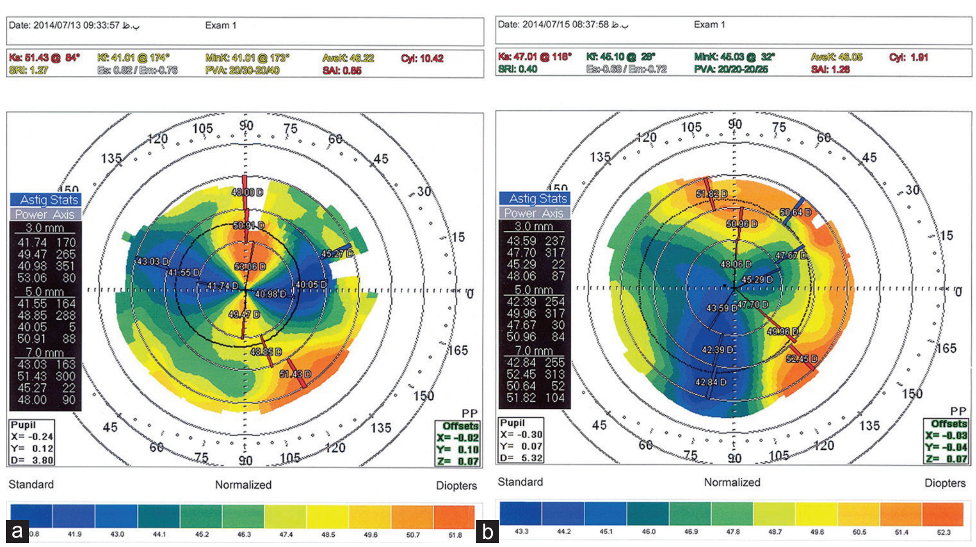

Figure 3. Topography map of case 1 before (a) and after (b) the office-based relaxing incisions, illustrating a marked reduction of the topographic astigmatism from 10.42 D preoperatively to 1.91 D seven months after the procedure. D, diopter.

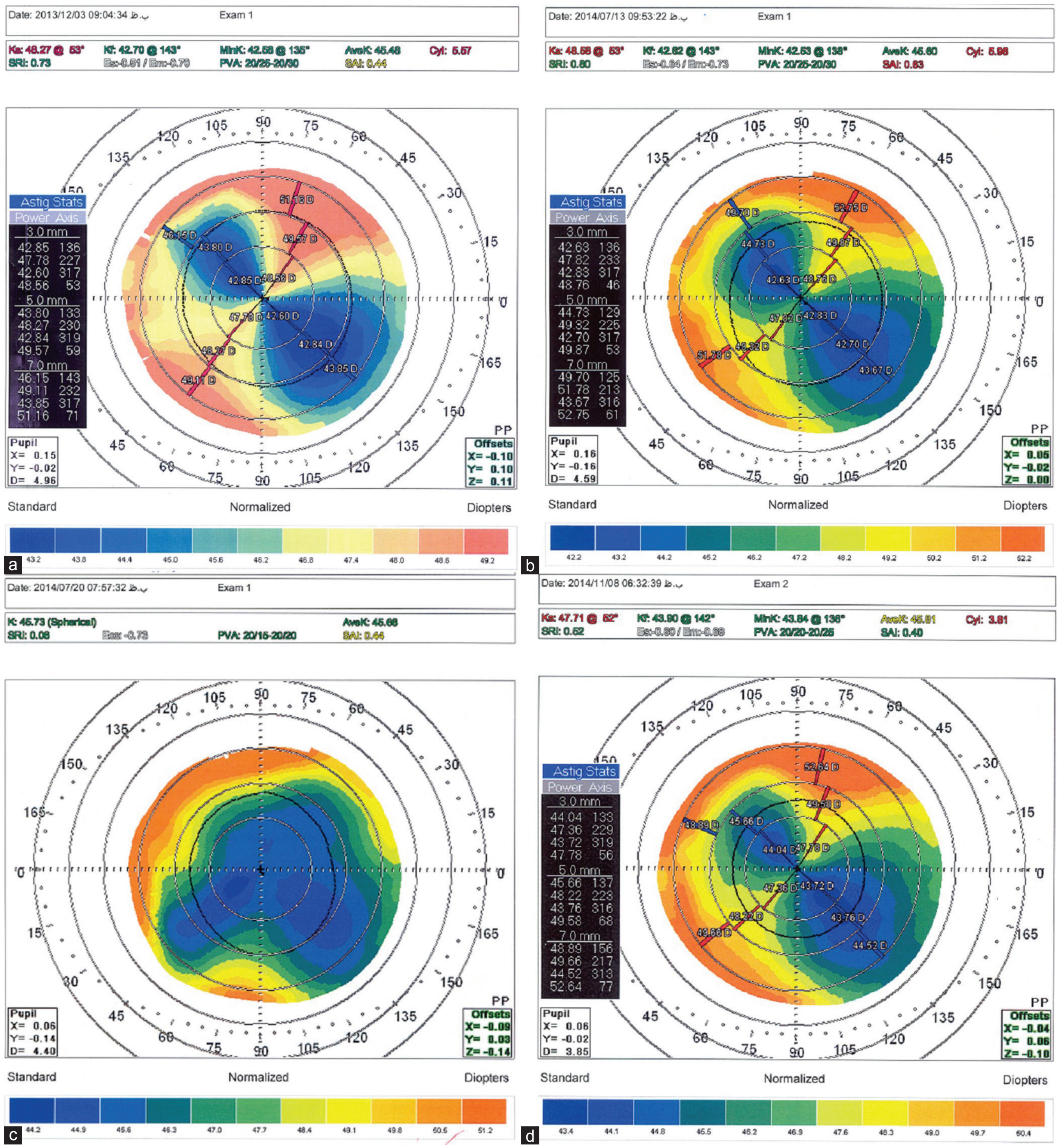

Figure 4. (a) Topography map of case 2 before the office-based relaxing incision procedure demonstrating an astigmatism of 5.57 D. (b) Astigmatism regressed to the pretreatment value (5.96 D) seven months after the first procedure. (c) Topographic astigmatism completely disappeared 30 minutes after the second procedure. (d) Topography map before the third intervention indicating a regression of 3.81 D in keratometric astigmatism four months after the second approach. D, diopter.

increasing to 20/30 with – 3.50 – 2.0 × 140 and keratometry readings were 45.12 × 155/47.53 × 65.

Case 3

A 27-year-old man with severe keratoconus underwent big-bubble DALK in the left eye. Six months after complete suture removal, he presented with high astigmatism. On examination, UCVA was 20/180 and spectacle-corrected (+3.0 – 8.0 × 165) distance visual acuity was 20/40. Keratometry readings were 41.98 × 170/51.42 × 80 [Figure 5a]. Three consecutive relaxing incisions were performed in the office with

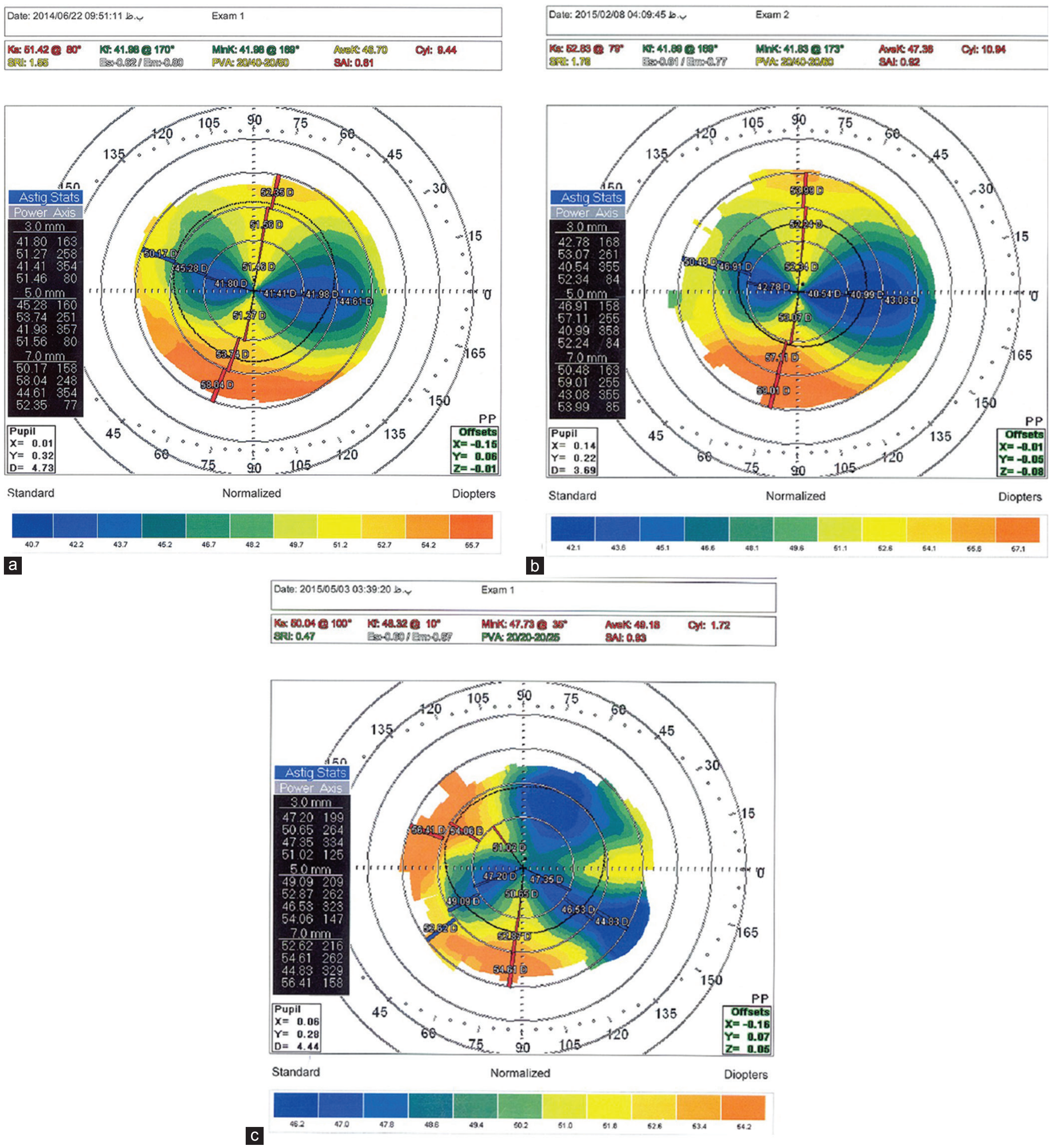

Figure 5. (a) Topography map of case 3 before the office-based relaxing incision procedure demonstrating an astigmatism of 9.44 D. (b) After three procedures, astigmatism regressed to 10.94 D. (c) Topography map showing an evident decrease in astigmatism (from 9.44 D to 1.72 D) after relaxing incisions with concomitant adjustment sutures were performed in the operating room. D, diopter.

12 months between the first and second procedure and one month between the second and third procedure. Five months after the third approach, astigmatic regression to the pretreatment value was observed (+2.50 – 10.0 × 170 and 41.89 × 169/52.83 × 79, Figure 5b). The patient was scheduled for relaxing incisions with concomitant adjustment sutures in the operating room. Suture removal was selectively started 3 weeks later and completed after 2 months. At the final follow-up examination, UCVA and BSCVA improved to 20/60 and 20/25, respectively, with

a refraction of − 2.50 − 3.0 × 180. Keratometry readings were 48.32 × 10/50.04 × 100 [Figure 5c].

DISCUSSION

Similar to PK, postoperative refractive error is the primary reason for patient dissatisfaction after DALK and prevents patients from achieving acceptable visual acuity.

Management of this complication varies from spectacles to RGP contact lenses to surgical interventions. DALK is a relatively new technique of corneal transplantation compared with PK. Therefore, data on surgical treatment for high astigmatism after this type of corneal transplantation is limited.[6-13] Noble et al[6] performed either arcuate keratotomy (2 eyes) or Ruiz procedure (2 eyes) to reduce post-DALK astigmatism. After arcuate keratotomy, a mean reduction of 57% (from 4.9 D to 2.1 D) in refractive astigmatism was achieved, while the average reduction after a Ruiz procedure was 26% (from 7.75 D to 5.75 D).[6] In a study by Kubaloglu et al[8] a pair of incisions was made at the steep meridian 0.5 mm inside the recipient cornea through 90% of the corneal depth with arc lengths of 90 degrees. They reported a reduction of 3.27 ± 2.15 D in keratometric astigmatism with an overcorrection rate of 35%.[8] Nubile et al[9] performed femtosecond laser-assisted arcuate keratotomy 1 mm inside the graft edge in 12 consecutive patients who underwent PK (n = 10) or big-bubble DALK (n = 2) and reported a reduction in mean astigmatism of 4.7 D in the whole study group. However, they did not distinguish the amount of astigmatic reduction between the PK and DALK groups. We previously demonstrated that differences in surgical technique between these two types of corneal transplantation result in a more exaggerated response to relaxing incisions made at the donor-recipient interface after DALK.[7] Therefore, we adopted a modified technique in which the relaxing incisions made at the steep meridians were simultaneously sutured; then, the effect of the incisions were smoothly controlled through selective suture removal starting a few days after the operation.[7] Using this technique, we reported that post-DALK keratometric astigmatism was reduced by 3.8 D and 5.5 D measured with subtraction and vector analysis methods, respectively.[7] The effect of relaxing incisions depends on depth, arc length, and distance from the corneal center.[14,17] Therefore, instead of suturing the incision made at the steep meridian that comprises 90% of corneal thickness, other possible modifications can be considered to prevent overcorrection of astigmatism. These include applying relaxing incisions with a smaller arc length that does not cover the entire "red area" or locating partial thickness incisions that do not reach the DM.

In the present study, we report outcomes of relaxing incisions in an office setting using topical anesthesia for the management of post-DALK astigmatism. Our results indicate that the average keratometric astigmatism was reduced by 2.95 D (42.1%) and 5.16 D (73.7%) measured with subtraction and vector analysis methods, respectively. This approach could reduce astigmatism to a level (from 7.0 D to 4.05 D, on average) where spectacle correction is possible. These results compare favorably with the results of the abovementioned studies using interventions in a surgical facility.[6-9]

In addition to an analysis of the changes in the magnitude of astigmatism, the current study evaluated changes in corneal graft power and found a myopic shift after relaxing incisions. This finding implies that the coupling (steep/flat) effect of relaxing incisions is greater than 1, which is due to forward bowing of the graft when the tension on the graft is removed after the procedure. We previously reported a similar result after relaxing incisions for the management of post-PK astigmatism.[18]

In our study, an improvement in corneal graft astigmatism was not associated with a significant improvement in UCVA and BSCVA. The maintenance of UCVA is mainly the result of the increase in spherical equivalent refraction negating the decrease of corneal graft astigmatism. The limited non-significant improvement in BSCVA is probably due to the irregular component of the astigmatism, which remained largely unchanged. Kubaloglu et al[8] reported no change in BSCVA after astigmatic keratotomy for post-DALK astigmatism. They attributed this finding to the rotation of the intended treatment, which could be a source of corneal higher order aberrations. On the contrary, a significant improvement in BSCVA (from 0.29 ± 0.10 logMAR to 0.22 ± 0.10 logMAR) was reported in our previous study in which relaxing incisions with concomitant adjustment sutures were used to treat post-DALK astigmatism.[7] This observation suggests that the latter technique can render the corneal graft to be more regular compared to the office-based relaxing incision technique. However, a comparative study focused on the wavefront analysis is warranted to evaluate the outcomes of these two methods that we have introduced for the management of post-DALK astigmatism.

Regarding complications in our series, a microperforation was observed at the site of the incision in one (4.2%) eye. The main intraoperative complication of a relaxing incision for post-keratoplasty astigmatism is micro- and macroperforation with a reported incidence between 2% and 38%.[15,17,19-21] In DALK, a corneal perforation may cause severe complications, such as Descemet's detachment and a double anterior chamber. In our series, however, the microperforation was self-sealing and the postoperative course was uneventful in the complicated eye. In patients without sufficient compliance, the risk of DM perforation during the procedure may increase. Other complications following relaxing incisions described in the literature are graft rejection, overcorrection and change of astigmatism axis.[7,8,22,23] Subepithelial graft rejection occurred in 2 (8.3%) eyes in our series within 2 months after the intervention, which was successfully treated with frequent topical betamethasone 0.1%.

A potential complication of the office-base relaxing incision is the corneal infection as the intervention is performed in a non-sterile setting; however, it did not occur in the current series. We also did not encounter any overcorrection. Instead, astigmatism regressed to the pretreatment values in six eyes due to a wound healing response necessitating the repetition of the procedure. After conventional astigmatic keratotomy, the wound is primarily filled with epithelium before fibroblasts synthesize new collagen fibers, which separates the cut margins and retains the effect of relaxing incisions.[24] A previous study used *in vivo* confocal microscopy to assess the wound healing pattern of femtosecond laser astigmatic keratotomy.[9] It found the early wound healing is characterized by an epithelial plug deeply filling the gap. The epithelial ingrowth is partially replaced by a loosely arranged fibrotic scar that induces wound contraction over time.[9] In 6 eyes of our series, excessive collagen fiber synthesis by fibroblasts within the gap could lead to a change in the wound architecture, hence decreasing in the surgical effect of relaxing incisions. The results of the current study indicated that office-based relaxing incisions can be safely repeated one or more times, which effectively reduced astigmatism in 4 of these 6 eyes.

The current interventional case series deserves particular attention for several reasons. First, the procedure we describe here reduces astigmatism in the office setting without the need for conscious sedation, resulting in both time and cost savings. Second, using the slit beam with high magnification allows more precise estimation of the depth of the incision compared to depth estimation by conventional en-face microscopy in the operating room. Therefore, this approach makes it possible to titrate the effect of the relaxing incision through gradually increasing the depth and/or the length of the incision put in the donor-recipient interface. Third, serial topography can be performed to evaluate the effect of each incision in the office setting. In contrast, the effect of relaxing incisions in the surgical facility is usually monitored using hand-held keratoscopes. This method is not accurate enough to determine subtle corneal power changes over the entire optical zone. Fourth, in the majority of cases, a relaxing incision is the only procedure performed at a single time. However, it is sometimes combined with other interventions, such as cataract extraction and posterior chamber intraocular lens (IOL) implantation in order to address lens opacity and high corneal graft astigmatism. Because graft refractive power is changed by relaxing incisions, accurate IOL power calculation can be a matter of concern in such a combined intervention. Office-based relaxing incisions can be carried out first to reduce astigmatism, followed by cataract extraction and IOL implantation when the graft curvature becomes stable.

In conclusion, this preliminary investigation highlights the potential usefulness of the office-based relaxing incision procedure for the treatment of post-DALK astigmatism. This procedure can provide an alternative to more expensive and time-consuming surgical techniques. Further investigations recruiting a larger sample size are necessary to better evaluate the clinical and topographic outcomes of this simple and non-expensive approach.

Financial Support and Sponsorship

The study was financially supported by the Ophthalmic Research Center of Shahid Beheshti University of Medical Sciences, Tehran, Iran and the Central Eye Bank of Islamic Republic of Iran.

Conflicts of Interest

There are no conflicts of interest.

REFERENCES

1. Shimmura S, Tsubota K. Deep anterior lamellar keratoplasty. *Curr Opin Ophthalmol* 2006;17:349-355.
2. Anwar M, Teichmann KD. Deep lamellar keratoplasty: Surgical techniques for anterior lamellar keratoplasty with and without baring of Descemet's membrane. *Cornea* 2002;21:374-383.
3. Benson WH, Goosey CB, Prager TC, Goosey JD. Visual improvement as a function of time after lamellar keratoplasty for keratoconus. *Am J Ophthalmol* 1993;116:207-211.
4. Vail A, Gore SM, Bradley BA, Easty DL, Rogers CA, Armitage WA, et al. Conclusions of the corneal transplantation follow up study. Collaborating Surgeons. *Br J Ophthalmol* 1997;81:631-636.
5. Fontana L, Parente G, Tassinari G. Clinical outcomes after deep anterior lamellar keratoplasty using the big-bubble technique in patients with keratoconus. *Am J Ophthalmol* 2007;143:117-124.
6. Noble BA, Agrawal A, Collins C, Saldana M, Brogden PR, Zuberbuhler B, et al. Deep anterior lamellar keratoplasty (DALK): Visual outcome and complications for a heterogeneous group of corneal pathologies. *Cornea* 2007;26:59-64.
7. Javadi MA, Feizi S, Mirbabaee F, Rastegapour A. Relaxing incisions combined with adjustment sutures for post-deep anterior lamellar keratoplasty astigmatism in keratoconus. *Cornea* 2009;28:1130-1134.
8. Kubaloglu A, Coskun E, Sari ES, Gunes AS, Cinar Y, Pinero DP, et al. Comparison of astigmatic keratotomy results in deep anterior lamellar keratoplasty and penetrating keratoplasty in keratoconus. *Am J Ophthalmol* 2011;151:637-643.
9. Nubile M, Carpineto P, Lanzini M, Calienno R, Agnifili L, Ciancaglini M, et al. Femtosecond laser arcuate keratotomy for the correction of high astigmatism after keratoplasty. *Ophthalmology* 2009;116:1083-1092.
10. Pedrotti E, Sbabo A, Marchini G. Customized transepithelial photorefractive keratectomy for iatrogenic ametropia after penetrating or deep lamellar keratoplasty. *J Cataract Refract Surg* 2006;32:1288-1291.
11. Leccisotti A. Photorefractive keratectomy with mitomycin C

after deep anterior lamellar keratoplasty for keratoconus. *Cornea* 2008;27:417-420.

12. Acar BT, Utine CA, Acar S, Ciftci F. Laser *in situ* keratomileusis to manage refractive errors after deep anterior lamellar keratoplasty. *J Cataract Refract Surg* 2012;38:1020-1027.
13. Al-Dreihi MG, Louka BI, Anbari AA. Artisan iris-fixated toric phakic intraocular lens for the correction of high astigmatism after deep anterior lamellar keratoplasty. *Digit J Ophthalmol* 2013;19:39-41.
14. Wilkins MR, Mehta JS, Larkin DF. Standardized arcuate keratotomy for postkeratoplasty astigmatism. *J Cataract Refract Surg* 2005;31:297-301.
15. 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.
16. Holladay JT, Cravy TV, Koch DD. Calculating the surgically induced refractive change following ocular surgery. *J Cataract Refract Surg* 1992;18:429-443.
17. Poole TR, Ficker LA. Astigmatic keratotomy for post-keratoplasty astigmatism. *J Cataract Refract Surg* 2006;32:1175-1179.
18. Feizi S, Javadi MA. Corneal graft curvature change after relaxing incisions for post-penetrating keratoplasty astigmatism. *Cornea* 2012;31:1023-1027.
19. Riddle HK Jr, Parker DA, Price FW Jr. Management of postkeratoplasty astigmatism. *Curr Opin Ophthalmol* 1998;9:15-28.
20. Karabatsas CH, Cook SD, Figueiredo FC, Diamond JP, Easty DL, et al. Surgical control of late postkeratoplasty astigmatism with or without the use of computerized video keratography: A prospective, randomized study. *Ophthalmology* 1998;105:1999-2006.
21. Koay PY, Mc Ghee CN, Crawford GJ. Effect of a standard paired arcuate incision and augmentation sutures on postkeratoplasty astigmatism. *J Cataract Refract Surg* 2000;26:553-561.
22. Bahar I, Levinger E, Kaiserman I, Sansanayudh W, Rootman DS, et al. IntraLase-enabled astigmatic keratectomy for postkeratoplasty astigmatism. *Am J Ophthalmol* 2008;146:897-904.
23. Fares U, Mokashi AA, Al-Aqaba MA, Otri AM, Miri A, Dua HS, et al. Management of postkeratoplasty astigmatism by paired arcuate incisions with compression sutures. *Br J Ophthalmol* 2013;97:438-443.
24. Leung DY, Yeung EF, Law RW, Young AL, Lam DS, et al. *In vivo* confocal microscopy of epithelial inclusions from aberrant wound healing after astigmatic keratotomy. *Cornea* 2004;23:299-301.