Bilateral Small Incision Lenticule Extraction (SMILE) After Penetrating Keratoplasty

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ABSTRACT

PURPOSE: To report a case of successful bilateral small incision lenticule extraction (SMILE) performed on a patient who had penetrating keratoplasty and astigmatic keratotomy in the right eye and penetrating keratoplasty in the left eye.

METHODS: Case report.

RESULTS: Astigmatic keratotomy was used to reduce astigmatism of the right eye because astigmatism was higher than the maximum correction limitation of SMILE. Bilateral SMILE was performed afterward. Although there were no difficulties during lenticule separation and removal of the right eye, wound dehiscence occurred during lenticule separation of the left eye. Two sutures were used at both ends of the incision, and the remainder of the procedure was successfully completed. Visual acuity improved to 20/50 in both eyes without correction, and the corrected distance visual acuities were 20/50 and 20/30 in the right and left eyes, respectively, at the 6-month postoperative visit.

CONCLUSIONS: SMILE is a potentially effective alternative in correcting refractive errors in patients following penetrating keratoplasty. However, studies with a larger patient population with longer follow-up periods are needed to confirm these initial findings.


Penetrating keratoplasty (PKP) may be followed by significant ametropia that makes visual rehabilitation challenging. Regular or irregular astigmatism is the most common refractive error after PKP, followed by myopia. In the presence of irregular astigmatism or anisometropia, spectacles confer limited visual rehabilitation, with rigid gas-permeable contact lenses providing better results. However, rigid gas-permeable contact lenses have limitations because of corneal topographical problems, tear-film instability, and intolerance. Numerous surgical trials have tried to overcome such limitations. Surgical methods to improve astigmatism following PKP include astigmatic keratotomy, compression sutures, wedge resection, and, more recently, excimer laser photorefractive surgery. Although excimer laser photorefractive surgery can correct spherical and cylindrical refractive errors, corneal haze formation and loss of corrected distance visual acuity (CDVA) after photorefractive keratectomy (PRK) and flap-related complications and keratectasia following LASIK are limitations.

Small incision lenticule extraction (SMILE) is a relatively new technique that can correct myopic astigmatism without flap creation through the use of a femtosecond laser. When considering its efficacy, predictability, safety, and postoperative ocular surface health, recent studies have reported that this procedure provides excellent clinical outcomes. Mastropasqua et al. reported positive results in a case of SMILE after deep anterior lamellar keratoplasty (DALK). However, SMILE after PKP has not been reported.

We therefore describe the results in a patient who underwent bilateral SMILE after PKP and astigmatic keratotomy in the right eye and PKP in the left eye.

CASE REPORT

A 15-year-old boy with mucopolysaccharidosis presented with gradual decrease of vision in both eyes. His CDVA was 20/200 in both eyes, and slit-lamp examination showed a diffuse, full-thickness stromal opacity in both eyes with normal intraocular pressure. PKP was performed for visual rehabilitation in both eyes by a surgeon (YTC), and a 7.75-mm donor corneal button was secured over a 7.5-mm recipient corneal bed with interrupted 10-0 nylon sutures.

Seven years after PKP, the corneal grafts were clear in both eyes. Suture removal was done except for six sutures that were left for wound stability in both eyes. The uncorrected distance visual acuity (UDVA) and CDVA of the right eye were 20/400 and 20/50, respectively (refractive error: -1.50 -8.00 × 10°; keratometry: 41.75 diopters [D] at 10°, 47.75 D at 100°). The UDVA and CDVA of the left eye were 20/50 and 20/40, respectively (refractive error: -2.00 -3.50 × 40°; keratometry: 41.25 D at 40°, 44.50 D at 130°).

To reduce astigmatism of the right eye, astigmatic keratotomy was performed by the same surgeon (YTC) as previously described. A 7.5-mm ring was marked. A beveled, full-thickness, 5.7-mm wide incision was made at the 12-o’clock position and 1 mm outside of the ring marking. No intraoperative or postoperative complication was observed during the follow-up period. One month later, the CDVA in the right eye was 20/50 (refractive error: -3.00 -5.50 × 10°; keratometry: 41.25 D at 40°, 44.50 D at 130°; keratometry: 41.25 D at 40°, 44.50 D at 130°).
42.00 D at 10°, 45.25 D at 100°), and remained unchanged for 2 months.

After confirming a stable refraction, the SMILE procedure was planned for both eyes with the objective of reducing the spherical equivalents. The patient underwent preoperative examination including specular microscopy (Noncom ROBO CA: Konan Medical, Tokyo, Japan), topography (Orbscan IIz: Bausch & Lomb, Rochester, NY), and dual Scheimpflug analysis (Galilei; Ziemer Ophthalmic Systems, Port, Switzerland). Endothelial cell densities were 2,192 and 1,508 cells/mm² and central corneal thicknesses were 491 and 505 µm for the right and left eyes, respectively.

The same surgeon (YTC) performed SMILE using a VisuMax 500-kHz femtosecond laser (Carl Zeiss Meditec, Jena, Germany). The laser settings were a 35 femtosecond laser pulse and 4.5 µm spacing. The lenticule diameters were 6.1 and 6.2 mm, and the intended cap thicknesses were 100 and 110 µm. The lenticule thicknesses were 123 and 101 µm, and the expected residual corneal beds were 268 and 294 µm for the right and left eyes, respectively. The cap diameter was 1 mm larger than the lenticule diameter, and the incision was 2 mm long in both eyes. The target refractive corrections were -3.25 -5.00 × 10° and -2.25 -3.50 × 40° for the right and left eyes, respectively. The surgical procedure was performed as previously described. The remaining six sutures were not cut or penetrated by femtosecond lasers, and no wound dehiscence occurred while the lenticule was being created.

Separation of the right eye lenticule was performed without any difficulties, although the lenticule was caught by one previous PKP suture while it was being removed. However, it was removed with gentle pulling using McPherson forceps. During the first manual step for lenticule separation of the left eye, wound dehiscence between the graft and recipient bed near the incision was noticed. It was approximately 2 mm long. The target refractive corrections were -3.25 -5.00 × 10° and -2.25 -3.50 × 40° for the right and left eyes, respectively. The surgical procedure was performed as previously described. The remaining six sutures were not cut or penetrated by femtosecond lasers, and no wound dehiscence occurred while the lenticule was being created.

After surgery, the patient was treated with 0.5% moxifloxacin (Vigamox; Alcon, Hünenberg, Switzerland) for 7 days, 0.1% fluorometholone (Oulmetholone; Samil Pharmaceutical Co., Ltd., Seoul, Korea), and preservative-free hyaluronic acid lubricating drops (0.1% Hyalein Mini; Santen Pharmaceutical Co., Ltd., Osaka, Japan) for 4 weeks. One week after SMILE, the UDVA and CDVA of the right eye were 20/50 and 20/50, respectively (refractive error: +0.75 -3.00 × 20°). The UDVA and CDVA of the left eye were 20/70 and 20/50, respectively (refractive error: +3.00 -6.00 × 30°). The patient complained of mild blurred vision and a foreign body sensation, and mild inflammation was observed using slit-lamp examination. However, there was no sign of infection, opacification, or graft rejection. Figure A (available in the online version of this article) shows a slit-lamp photograph of the left eye at 1 week after surgery. At 1 month after SMILE, all sutures were removed.

At 6 months after SMILE, the UDVA and CDVA of the right eye were 20/50 and 20/50, respectively (refractive error: +1.00 -2.00 × 15°; keratometry: 38.5 D at 15°, 41.25 D at 105°). In comparison, the UDVA and CDVA of the left eye were 20/50 and 20/30, respectively (refractive error: +2.00 -3.00 × 175°; keratometry: 42.25 D at 175°, 43.5 D at 85°). The endothelial cell densities were 2,051 and 1,538 cells/mm², respectively. Figure B (available in the online version of this article) shows dual Scheimpflug images taken during preoperative examinations of both eyes, 1 week after astigmatic keratotomy of the right eye and 3 months after SMILE of both eyes.

No complication such as keratitis, ectasia, opacification, or graft rejection was observed during the follow-up period. The patient was satisfied with the uncorrected vision and did not complain of dryness or pain.

**DISCUSSION**

We recently reported satisfactory results following a combined procedure of full-thickness astigmatic keratotomy and SMILE. In contrast to DALK, there is always the risk of dehiscence after PKP, even after several years. In our case, it was 7 years since the patient underwent PKP, but wound dehiscence occurred during separation of the lenticule in the left eye even though we did not remove all sutures of the PKP for corneal stability. Refractive correction is usually done following complete suture removal after PKP. However, we recommend leaving some sutures in place before SMILE for corneal stability because there is a strong possibility of wound dehiscence even many years after PKP is performed, and astigmatism can be controlled by suture removal or compression after SMILE. Furthermore, the use of a higher cutting energy when a lenticule is made is helpful, and extreme care is required during separation and removal of the lenticule. This procedure should also be performed in the operating room to reduce the risk of infection. There is no standard waiting time for SMILE after PKP, but it is generally accepted that the patient should wait at
least 1 year to reduce the possibility of wound dehiscence. Wound dehiscence and cutting of the remaining sutures can occur during lenticule separation, and the lenticule can be caught by sutures during lenticule removal.

By performing SMILE after PKP instead of PRK or LASIK, we could minimize the risk of corneal haze, which is common after PRK. We could also avoid dry eye syndrome and traumatic loosened flaps, which are common after LASIK. In addition, because SMILE preserves the anterior segment of the cornea, which has a greater biomechanical strength than the posterior segment, SMILE is thought to have enhanced mechanical stability compared to LASIK or PRK.

The refraction was +1.00 -2.00 × 15° and +2.00 -3.00 × 175° for the right and left eyes, respectively, at 6 months.
after SMILE. This refractive error is not high compared to previous studies. Mastropasqua et al.\textsuperscript{11} reported that the refractive error after SMILE following DALK was +1.50 -3.00 × 50\degree, and Kwitko et al.\textsuperscript{14} reported that the mean astigmatism after LASIK following PKP was 2.82 ± 2.42 D. Furthermore, if requested by the patient, we could correct astigmatism with astigmatic keratotomy during the follow-up period, although our patient was already satisfied with the visual outcome. The large refractive error of the left eye at postoperative week 1 and the significant change in refraction of the left eye from postoperative week 1 to 6 months was the result of the corneal sutures and their removal. The CDVA of the right eye did not improve even though the refractive error improved significantly, and it is assumed that the patient has visual deprivation amblyopia.

This case demonstrates that SMILE can be an effective alternative, with numerous advantages, for the treatment of refractive errors in patients following PKP. However, studies with more patients and longer follow-up periods are needed to establish the long-term outcomes and safety of SMILE as a second procedure after PKP.

**AUTHOR CONTRIBUTIONS**

Study concept and design (YTC); data collection (BKK, SJM, DGL); analysis and interpretation of data (BKK); writing the manuscript (BKK, SJM, DGL); critical revision of the manuscript (YTC); supervision (SJM, YTC)

**REFERENCES**


Figure A. Slit-lamp photograph of the left eye 1 week after surgery. Six sutures of the penetrating keratoplasty and two sutures toward the 11-o’clock position, which were done during small incision lenticule extraction, were left for wound stability.
Figure B. Dual Scheimpflug images. 

(A) Preoperative examination of the right eye. The steepest keratometry value was 51.40 diopters. 

(B) Preoperative examination of the left eye. 

(C) Examination of the right eye after astigmatic keratotomy showing corneal steepness was reduced. Examination of the (D) right and (E) left eyes after small incision lenticule extraction. The cornea was flat and thin.