Anterior Lamellar Keratoplasty With a Microkeratome: A Method for Managing Complications After Refractive Surgery

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ABSTRACT

PURPOSE: To demonstrate a technique of anterior lamellar keratoplasty with standardized and automated preparation of surface-parallel cuts in both donor and recipient appropriate for addressing several problems after laser in situ keratomileusis (LASIK) and photorefractive keratectomy (PRK).

METHODS: We report a noncomparative series of ten eyes with complications after LASIK and PRK. Lamellar cuts were performed in donor and recipient eyes by means of an automated microkeratome. Lamellar grafts were fixed by only four single sutures. In two eyes, a re-lift LASIK was performed after 6 months.

RESULTS: Surgery was uneventful and visual acuity was improved in all eyes. Residual irregular astigmatism and refractive error were corrected in two eyes by means of excimer laser computer-assisted ablation and resulted in a further improvement of uncorrected and best spectacle-corrected visual acuity.

CONCLUSIONS: Anterior lamellar keratoplasty with a microkeratome can be used for the management of certain complications of PRK and LASIK. [*J Refract Surg* 2003;19:52-57]

To date, keratoplasty following refractive surgery is a rare procedure when compared to the number of corneas transplanted after cataract surgery because of postoperative corneal decompensation. However, over the past few years the frequency of refractive surgery has increased dramatically, exceeding that of cataract surgery in the USA by a factor of 2 in 1999. Thus, refractive surgery will inevitably encounter a significant increase of postoperative complications in the near future. These complications are located in the anterior cornea and include severe scarring after photorefractive keratectomy (PRK), cutting errors, and recurrent epithelial ingrowth after laser in situ keratomileusis (LASIK).[1,2]

Recently, a new technique for the management of such complications was presented: therapeutic lamellar keratoplasty with an automated microkeratome[3], which combines the known technique of superficial lamellar keratoplasty with the automated preparation of the donor lamella and the recipient wound bed using microkeratomes originally developed for LASIK. We present the results of automated anterior lamellar keratoplasty in a series of 10 eyes of 10 patients who had superficial complications after refractive laser surgery of the cornea.

PATIENTS AND METHODS

Patients

Ten eyes of 10 consecutive patients, referred to our department because of complications after refractive surgery, underwent anterior lamellar keratoplasty with a microkeratome from January 1999 to July 2000. Four eyes had an irregular corneal surface due to cutting errors and epithelial ingrowth after LASIK for correction of myopic astigmatism (Fig 1), four eyes showed apical scars after hyperopic PRK, and two eyes displayed severe scarring (haze grade 4) more than 1 year after PRK for myopia. Patient age ranged from 28 to 51 years with an average of 34 ± 12 years. Due to the multifocality and the turbidity of the corneas, only a gross refraction was possible (Table). To illustrate

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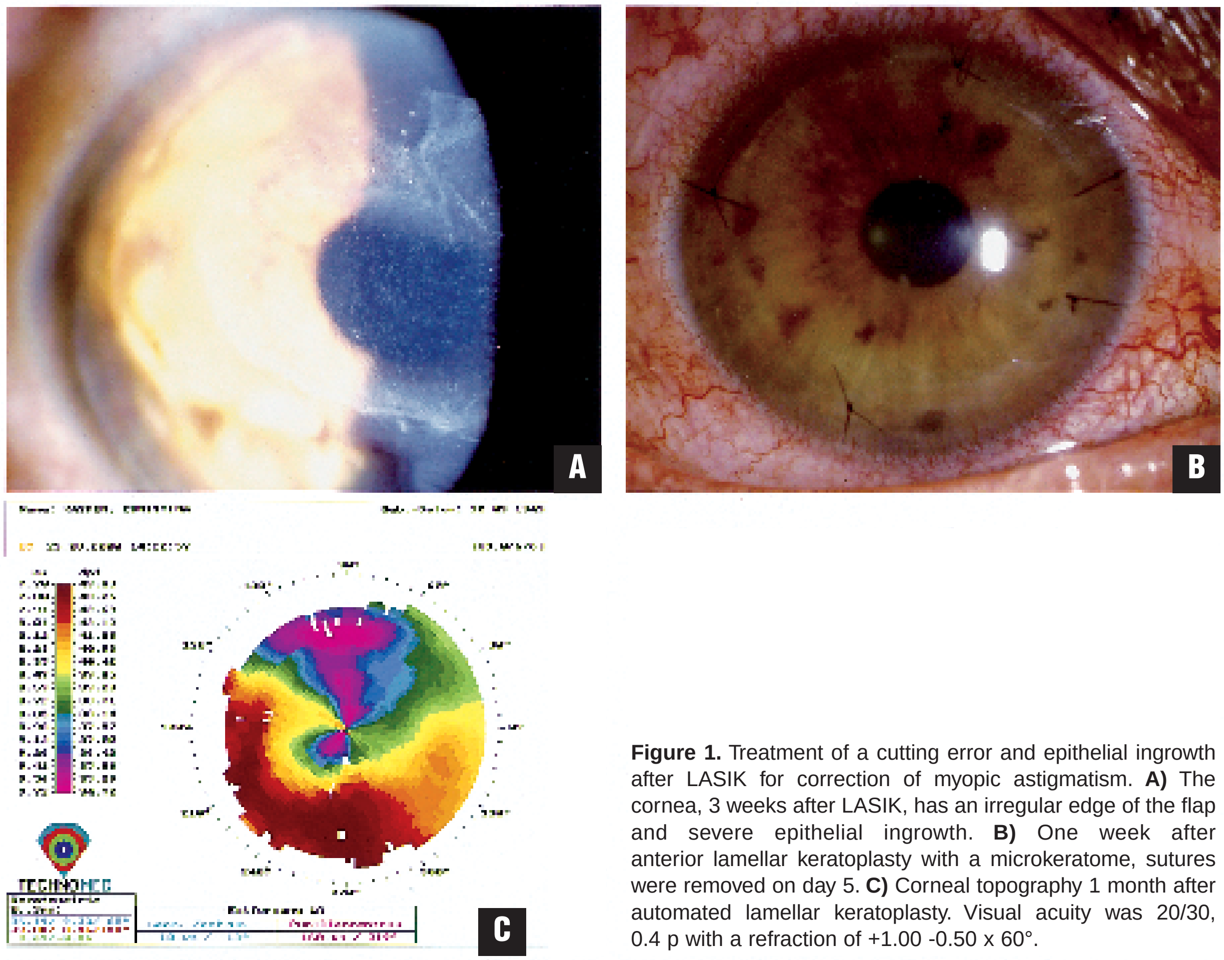

Figure 1. Treatment of a cutting error and epithelial ingrowth after LASIK for correction of myopic astigmatism. **A)** The cornea, 3 weeks after LASIK, has an irregular edge of the flap and severe epithelial ingrowth. **B)** One week after anterior lamellar keratoplasty with a microkeratome, sutures were removed on day 5. **C)** Corneal topography 1 month after automated lamellar keratoplasty. Visual acuity was 20/30, 0.4 p with a refraction of +1.00 -0.50 x 60°.

Table
Visual Acuity After Automated Anterior Lamellar Keratoplasty With a Microkeratome

Eye No.	Reason for Grafting	Preoperative		Postoperative		
		UCVA*	BSCVA†	UCVA	BSCVA	Manifest Refraction (D)
1	Complicated LASIK	20/200	20/200	20/80	20/40	+2.25
2	Complicated LASIK	CF§	CF	20/40	20/30	+1.00 -1.00 x 70°
3	Complicated LASIK	20/200	20/100	20/80	20/40	+0.50 -2.50 x 160°
4	Complicated LASIK	10/400	20/400	20/60	20/50	-0.50 -2.0 x 35°
5	Severe scar after PRK	20/400	20/200	20/100	20/60	-2.50
6	Severe scar after PRK	CF	20/100	20/80	20/30	-1.50 -1.00 x 40°
7	Apical scar after hyperopic PRK	20/200	20/200	20/200	20/50	+5.00
8	Apical scar after hyperopic PRK	CF	20/400	20/60	20/40	+2.50 -1.00 x 90°
9	Apical scar after hyperopic PRK	20/200	20/100	20/40	20/30	+1.75
10	Apical scar after hyperopic PRK	20/200	20/200	20/80	20/25	+1.75 -1.00 x 180°

**Uncorrected visual acuity*
†Best spectacle-corrected visual acuity
§Count fingers

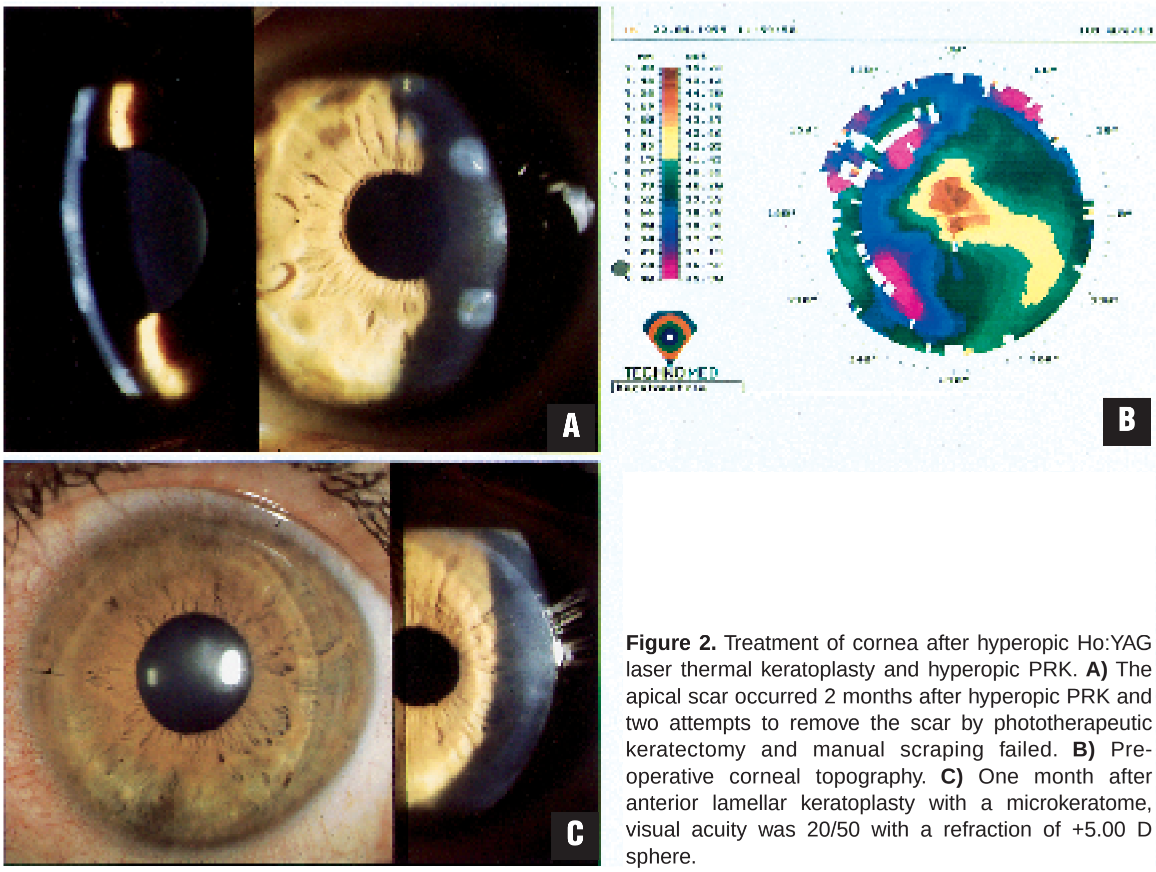

Figure 2. Treatment of cornea after hyperopic Ho:YAG laser thermal keratoplasty and hyperopic PRK. **A)** The apical scar occurred 2 months after hyperopic PRK and two attempts to remove the scar by phototherapeutic keratectomy and manual scraping failed. **B)** Preoperative corneal topography. **C)** One month after anterior lamellar keratoplasty with a microkeratome, visual acuity was 20/50 with a refraction of +5.00 D sphere.

preoperative multifocality, a videokeratograph is shown in Figure 2. Informed consent was obtained after a thorough explanation of the benefits and risks of the operation. Institutional review board approval was not required for this study.

Examination

Preoperatively and at months 1, 3, and 6 after surgery, patients received a standard ophthalmic examination including uncorrected (UCVA) and best spectacle-corrected visual acuity (BSCVA), slit-lamp microscopy, indirect fundus examination (with subsequent direct ophthalmoscopy using the Goldmann contact lens in the presence of apparent retinal lesions), applanation tonometry, and corneal topography (C-scan, Technomed, Baesweiler, Germany). Central and peripheral corneal thickness (SP-2000, Tomey, Nagoya, Japan) was measured before surgery.

Surgery

The basic idea of anterior lamellar keratoplasty with a microkeratome is to create a free disc in the donor and recipient eye using the identical automated microkeratome. The donor graft is then placed on the host wound bed and fixed with four temporary and one permanent superficial suture in a way that allows lifting of the graft and additional laser ablation in the bed, to correct residual refractive error and irregular astigmatism, if needed.

Preparation of Graft

The graft was prepared out of the whole eye with controlled intraocular pressure (IOP). The eye was pressurized using a canula inserted through the optic nerve connecting the vitreous cavity with a water reservoir to achieve an IOP of 60 mmHg. Recipient and donor corneas were marked with an asymmetric 5-ray radial marker. Only eyes with intact epithelium were used for transplantation.

Particular care was taken regarding the following to guarantee constant donor corneal disc diameter. In eight eyes the lamella was prepared by means of the Schwind microkeratome II (Schwind, Kleinostheim, Germany) equipped with a special cutting head that provides lamellae of thickness 180 ± 26 µm, as determined by optical pachymetry in pig eyes. Briefly, the cornea was applanated by means of a quartz plate, followed by the cut, which was performed using a surface-parallel sapphire blade. A second suction ring fixed the disc during the cut and cut length was adjusted electronically to create a free disc. The disc had a constant diameter of 8.5 mm due to the geometry of the applanation area of the microkeratome. To achieve constant corneal thickness, only corneas from donors who died less than 12 hours prior to transplantation were used. To avoid swelling of the transplant after harvesting, it was stored in Licorol DX-solution (Chauvin, Labege, France) until the recipient wound bed was prepared appropriately.

In the two eyes with cutting errors after LASIK, the identical technique was used. Here, however, a microkeratome of the Cariazzo-Barraquer type (Supratome, Schwind, Kleinostheim, Germany) was used and the cut was completed manually with a blade.

Preparation of Recipient Bed

The recipient cornea was prepared by creation of a free surface-parallel lamella using the identical marker and automated microkeratome as in the donor eye. In the two eyes with cutting errors, again, the existing cut was completed manually. In one eye (after hyperopic PRK) a lateral canthotomy was performed to obtain sufficient suction. The wound bed was cleaned carefully with a wet sponge and a blunt hockey knife and the epithelium was stripped back at the cut edges. The entire procedure was performed under retrobulbar anesthesia.

Transplantation

The graft was placed onto the wound bed with the graft marks aligned to those of the recipient. After two temporary sutures, four single superficial sutures were placed at 3, 6, 9, and 12 o'clock so that tension lines would form a regular rhombus. Sutures were placed superficially in the anterior stroma crossing the wound bed only, close to the edge. The interface was then carefully floated with balanced salt solution to prevent epithelial ingrowth. An additional superficial suture was placed nasally superior and remained at least 6 months or until a decision could be made whether a re-lift of the transplant was necessary. At the end of the procedure, a bandage soft contact lens soaked with ofloxacine 0.5% was used to decrease postoperative foreign body sensation.

Postoperative Management

The bandage contact lens was removed at postoperative day 1 and the corneal epithelium was examined by fluorescein staining. As soon as the epithelium was fluorescein-negative, the four radial sutures were removed. Until removal of the sutures, topical medication included antibiotic drops (ofloxacine 0.5%) every 2 hours. After removal of the sutures, patients were instructed to use rimexolol drops (Vexol, Alcon, Ft. Worth, TX) four times per day for 2 months and to taper it during postoperative months 3 and 4.

The correction of a residual refractive error and the correction of irregular astigmatism was undertaken in two eyes at 6 months after transplantation using topography-guided LASIK (ORK-software, Multiscan, Schwind, Kleinostheim, Germany) and a lift of the donor cornea. At 6 months after automated lamellar keratoplasty, manifest refraction as well as corneal topography had stabilized.

RESULTS

Surgery was uneventful in all 10 eyes. In two eyes, the graft epithelium was loose and edematous and was removed during the operation. At day 1 after surgery, the graft was swollen with prominent edges in all eyes. The four sutures were removed after healing of the epithelium and disappearance of stromal edema, which occurred within 6 days in all eyes. In no eye were additional sutures necessary. Eight eyes displayed residual donor epithelium healing lines at months 1 and 3, which were interpreted as epithelial rejection lines. In 7 of the 10 eyes a central steepening was apparent at months 1 and 3, which decreased within 6 months after surgery. In one eye at 3 months after surgery, a sterile infiltrate occurred in the interface that healed under topical corticosteroid therapy within 1 week.

Visual acuity results are listed in the Table. Visual acuity recovered within the first month after surgery but best spectacle-corrected visual acuity (BSCVA) was limited by the multifocal cornea. Visual rehabilitation to a BSCVA of 20/40 or better was achieved in 7 of 10 eyes. On average, BSCVA improved from 20/200 ± 20/200 to 20/40 ± 20/100 (P<.05).

Case Report

A 42-year-old female patient received bilateral simultaneous LASIK for myopic astigmatism in a local laser center. Preoperative BSCVA was 20/20 OU. According to the operative report, a cutting error occurred in the left eye. The flap had an irregular form and was incomplete. After manual flap completion, a 3.50-D laser treatment for correction of myopia was performed. Postoperative BSCVA was never better than 20/100 and when the patient was referred to our department on postoperative day 21, visual acuity was count fingers. The flap was edematous and epithelial ingrowth had led to melting of the flap (Fig 1). We removed the primary flap by completing the original cut, cleaned the wound bed carefully by means of a hockey knife, and performed an anterior lamellar keratoplasty with a microkeratome.

After removal of the four sutures, BSCVA was 20/100 and improved to 20/60 at 1 month and 20/30 at month 3 after keratoplasty. BSCVA did not improve further and a topography-guided laser treatment was performed at month 6 including an uncomplicated lift of the donor disc. One month after this re-operation, uncorrected visual acuity was 20/25 (+1).

A second eye demonstrates the effect of automated anterior lamellar keratoplasty in a cornea after hyperopic Ho:YAG laser thermalkeratoplasty and hyperopic PRK, where all previous attempts to remove the apical scar failed (Fig 2). Here, BSCVA improved from 20/100 preoperatively to 20/50 at 1 month postoperatively.

DISCUSSION

The key findings of this study are that in eyes with visually significant complications after lamellar refractive surgery, automated anterior lamellar keratoplasty led, within a reasonable rehabilitation time, to a visual acuity of 20/40 in 70% of the eyes. Further improvement might be obtained by re-operations using computer-assisted ablation (topography or wavefront-guided).

By the middle of the last century, anterior lamellar keratoplasty was a popular and frequently used method in corneal surgery. However, in the 1960s, anterior lamellar keratoplasty was replaced by penetrating keratoplasty. This tendency was accelerated by the growing knowledge of the molecular events leading to graft rejection and the development of improved surgical instrumentation and techniques.[4]

LASIK and PRK, however, are lamellar techniques and therefore the majority of problems after refractive surgery occur at the anterior surface of the cornea: scarring after PRK, cutting errors during LASIK, and recurrent epithelial ingrowth after LASIK with melting of the flap.[1,2] In some cases, those conditions cannot be managed other than by keratoplasty.

We suggest that in these cases, anterior lamellar keratoplasty rather than penetrating keratoplasty should be envisaged for the following reasons.[5] First, the corneal endothelium is not transplanted, resulting in fewer rejections and less rigid selection criteria for donor material. Second, anterior lamellar keratoplasty is less invasive than penetrating keratoplasty, thus reducing complications. In the case of iatrogenic keratectasia, however, where the biomechanical stability of the residual stroma is insufficient for anterior lamellar keratoplasty, penetrating keratoplasty until recently represented the technique of choice. A new alternative for managing iatrogenic keratectasia may be deep lamellar keratoplasty, where a significant part of the corneal stroma is replaced by donor stroma while the recipient's endothelium and Descemet's membrane are preserved.[6]

Until recently, lamellar keratoplasty was technically difficult to perform and optical rehabilitation, one of the main goals, was not always achieved. Furthermore, the manual preparation of the lamellae (donor and recipient) often caused irregularities of the interface with subsequent consequences on postoperative healing and vision. The approach presented here may help overcome these problems since the manual preparation of the surface-parallel cuts is markedly improved by a standardized technique and reproducible thickness of donor and recipient lamellae is achieved. This standardization significantly shortens postoperative rehabilitation by allowing suture removal after only a few days.

Another advantage of automated anterior lamellar keratoplasty in the management of complications after refractive surgery is the possibility of a laser re-treatment by lifting the flap to correct for any residual refractive error or irregular astigmatism that is reducing the patient's visual acuity. Here the remaining superficial suture serves as an artificial hinge, allowing a lift of the donor disc similar to the re-lift performed in repeat LASIK. Although the superficial suture might induce some amount of corneal astigmatism, we believe that its function as a hinge is more important for the procedure than its astigmatism-inducing effect. The additional laser ablation may be performed as a topography-guided ablation in gross irregularities or as wavefront-guided ablation for fine-tuning of corneal optics.[7] The two lifts and laser retreatments performed at 6 months after surgery were uneventful and resulted in an improvement in BSCVA to 20/30 in both eyes.

We suggest that anterior lamellar keratoplasty with a microkeratome may be used for surface problems of the cornea and particularly problems after LASIK and PRK; the procedure is easy to perform using the same cutting technique as for LASIK. Furthermore, sutures can be removed after only a few days and later refractive reoperation facilitates additional visual rehabilitation. In this small series, we did not encounter problematic rejections of transplanted lamellae. However, such rejections have been reported to be rare.[4] Therefore, longer follow-up and a larger number of eyes are required to estimate the effective clinical value of this procedure.

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