Management of postkeratoplasty ametropia: IntraLASIK after penetrating keratoplasty

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PURPOSE. *The authors describe a technique of laser in situ keratomileusis (LASIK) for the management of postkeratoplasty ametropia using a femtosecond laser for flap creation.*
METHODS. *The first step was the placement of a disposable suction fixation ring to ensure that it was well-centered on the graft. The applanation cone was applied; the border of the flap was adjusted according to the edge of the graft. The hinge was at the 12 o'clock position; the mean flap diameter was 7.93 mm and the flap depth was 113.33 µm. The flap creation was made with the IntraLase femtosecond laser in a raster pattern. Twenty minutes after the flap creation, it was lifted and the treatment was completed with the Allegretto Wavelight excimer laser.*
RESULTS. *Three patients were treated with this technique and no significant intraoperative or postoperative complications were observed.*
CONCLUSIONS. *IntraLASIK is a promising and accurate procedure for the correction of postkeratoplasty ametropia and astigmatism. (Eur J Ophthalmol 2008; 18: 877-85)*

KEY WORDS. *IntraLASIK, Penetrating keratoplasty, Postkeratoplasty ametropia, Postkeratoplasty astigmatism*

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INTRODUCTION

In the past 30 years, achieving optical clarity in corneal grafts has improved significantly due to developments in microsurgical techniques and eye banking (1, 2). However, astigmatism and ametropia are still unwanted and incalculable results of penetrating keratoplasty (PKP), particularly in patients with keratoconus, due to low visual acuity, disabled binocular visual function, and patient dissatisfaction in the late postoperative period (3-5). Astigmatic and myopic ametropia continues to be a severe problem in 8 to 20% of eyes that cannot be corrected by spectacles or contact lenses (5-7).

There are several methods for the surgical management of postkeratoplasty astigmatism, including incisional relaxation techniques such as arcuate, transverse, and trapezoidal keratotomies and/or compression sutures, as well as wedge restrictions, but these methods frequently lead to irregular astigmatism with unsatisfactory and unpredictable results (8-12). Photorefractive keratectomy (PRK) remains a possibility for reducing postkeratoplasty astigmatism and myopia; however, there is a risk for haze and refractive regression (13). Because of the disadvantages of these methods as well as the rapid, painless, and accurate correction of laser in situ keratomileusis (LASIK), this has become the preferred refractive method for performing surgical correction of refractive errors after PKP (14, 15).

Standard LASIK performed with a mechanical microkeratome has dramatically improved the postoperative management of keratoplasty patients (16-18). However, recently published reports about the femtosecond laser flap creation show advantages over mechanical microkeratome flap creation such as flap thickness predictability, flap uniformity, and preservation of epithelial integrity (19, 20).

The purpose of this study is to examine the efficacy of LASIK for the correction of postkeratoplasty ametropia and astigmatism using a femtosecond laser for flap creation.

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METHODS

We present three cases (two male, one female) with postkeratoplasty ametropia that were treated successfully using the femtosecond laser (IntraLase FS Laser, IntraLase Corp., Irvine, CA) for flap creation. The primary corneal disease leading to PKP was keratoconus in all patients. All three patients were spectacle or contact lens intolerant. The refraction was stable for at least 3 months before surgery, and all eyes had at least two manifest or cycloplegic refractions 2 or more weeks apart.

The preoperative examination included uncorrected visual acuity (UCVA), manifest refraction, best spectacle-corrected visual acuity (BSCVA), cycloplegic refraction, intraocular pressure (IOP), slit lamp, and fundus examinations. Postoperative follow-up examinations were performed at 1 and 7 days, 1 month, and then every 3 months for each year.

Corneal topography was performed with the Orbscan II corneal topography (Bausch & Lomb), Pentacam (Oculus), and the Allegretto Wave Topolyzer (Oculus); ultrasound corneal pachymetry was also measured (Sonogage Cornea Scan II 5). All keratoplasty sutures were removed at least 3 months before IntraLASIK. There were no signs of late wound dehiscence or neovascularization at the time of surgery.

The surgical procedure and postoperative treatment regimen was the same for each patient. The disposable suction fixation ring was placed. Our goal was to attempt to center the flap on the same diameter and dimensions of the previous corneal transplant saving the transplant edge. The applanation cone was applied; the applanated cornea was aligned via software to center the flap diameter on the graft as visualized on the computer screen. The lamellar corneal flap was prepared with the IntraLase femtosecond laser. The flap parameters selected for each patient are listed in Table I; the flap parameters of Case 3 are different because the femtosecond laser used in this case was different. We observed that the formation of the applanation meniscus did not differ from a standard myopic LASIK procedure, but at the end of the successful applanation the foreseen flap diameter had to be shifted over the graft via software in case of slightly decentered transplants.

The flap diameter and position was adjusted so that the flap edge was congruent with the graft margin and the flap diameter was almost identical to or slightly smaller than the previous graft diameter. After flap creation, 20 minutes rest time was given to let all the bubbles dissipate. The flap was lifted with a spatula and the stromal bed was measured with ultrasound pachymetry. A standard excimer laser ablation was performed using an Allegretto Wave excimer laser (WaveLight Laser Technologie AG). The bed was irrigated with balanced salt solution and the flap repositioned. All operations were performed by one surgeon (R.B.K.).

A wavefront-guided treatment was not performed, as it was not recommended by the laser manufacturer in

TABLE I - THE FLAP PARAMETERS OF EACH PATIENT

Case	Method	Diameter (mm)	Depth (μm)	Hinge	Hinge angle	Bed energy	Spot separation	Line separation	Side cut energy	Side cut angle (degree)	Pocket enable
1	Raster	8.0	110	Superior	50	3.0	10	11	2.20	65	off
2	Raster	8.0	100	Superior	50	3.0	10	11	2.20	65	off
3	Raster	7.8	130	Superior	55	2.10	10	12	2.50	70	off

TABLE II - PRE- AND POSTOPERATIVE VISUAL AND REFRACTIVE RESULTS OF THE THREE PATIENTS

Case	Preoperative visual acuity			Attempted correction	Late postoperative visual acuity		
	UCVA	BSCVA	Refraction		UCVA	BSCVA	Refraction
1	20/400	20/50	+3.0 –8.50 x 175º	+2.50 –5.50 x 175º	20/100	20/30	+1.50 –4.75 x 170º
2	20/400	20/50	–4.0 –6.50 x 70º	–3.50 –4.50 x 70º	20/80	20/30	+0.50 –3.50 x 70º
3	20/2000	20/200	–4.25 –6.00 x 75º	–3.0 –5.0 x 75º	20/100	20/40	–1.75 –2.25 x 80º

UCVA = Uncorrected visual acuity; BSCVA = Best spectacle-corrected visual acuity

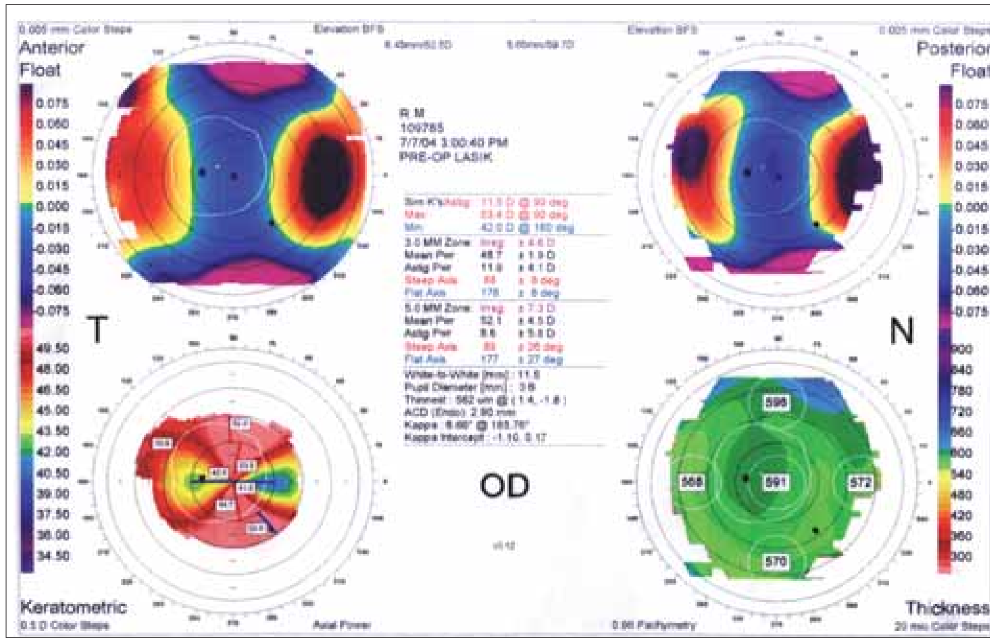

Fig. 1 - *Preoperative topographic map of Case 1.*

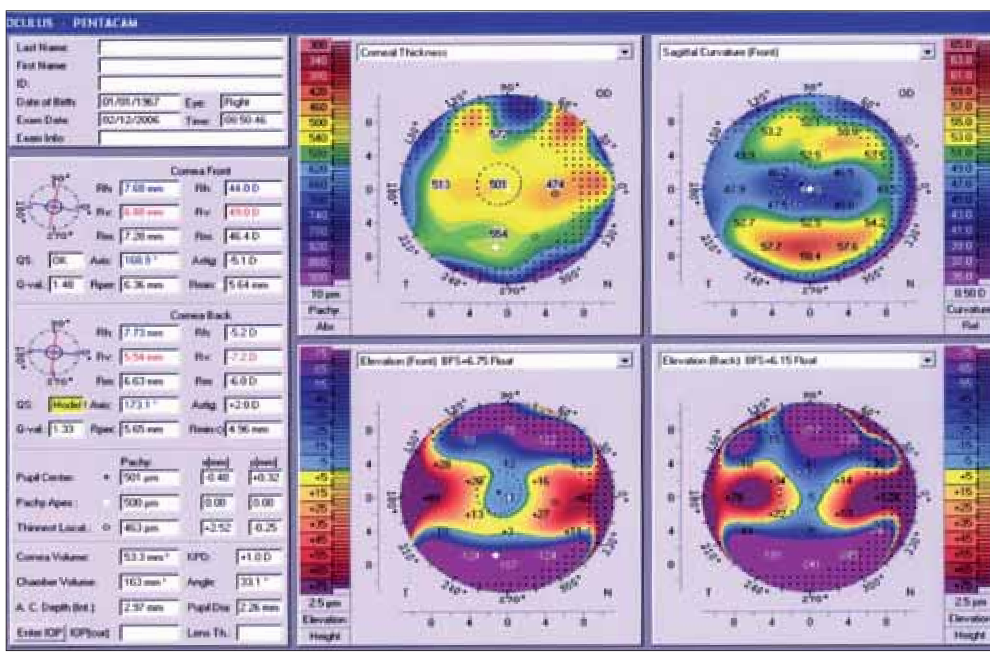

Fig. 2 - *Postoperative (2 years) topographic map of Case 1.*

eyes with an astigmatic error of over –2.0 D, which all three patients had.

RESULTS

The preoperative and late postoperative UCVA, BSCVA, manifest refraction, and attempted refractive correction values are documented in Table II. No significant intraoperative or postoperative complications such as corneal wrinkles, epithelial ingrowth, or graft rejection were observed. A short presentation of each case is demonstrated below.

Case 1

A 40-year-old man had PKP in 1999 in the left eye, and in 2001 in the right eye for keratoconus. The right eye had

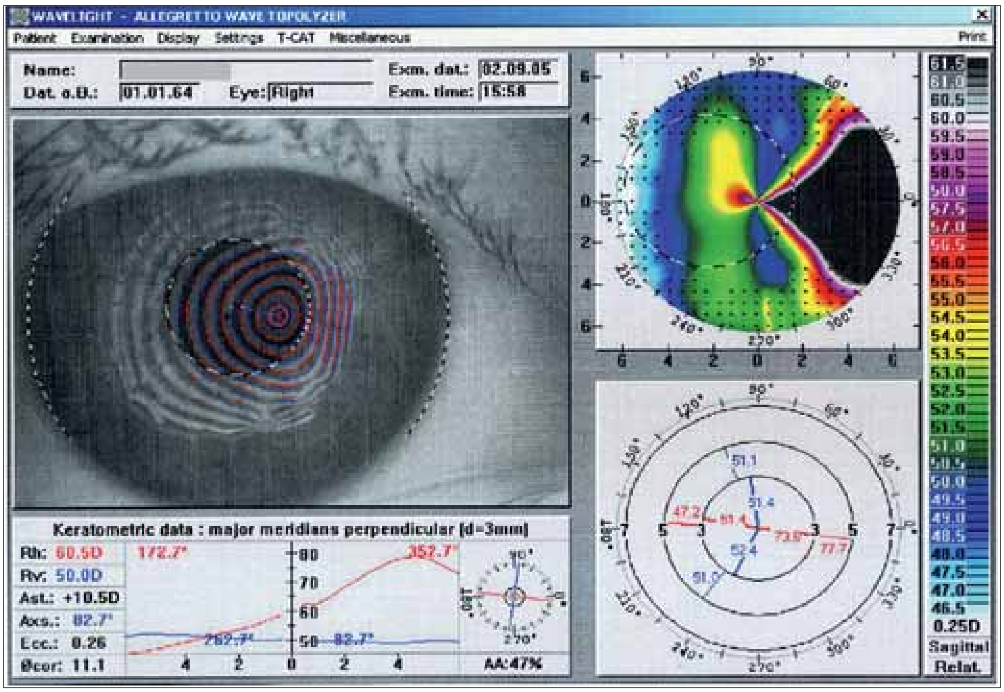

Fig. 3 - *Preoperative topographic map of Case 2.*

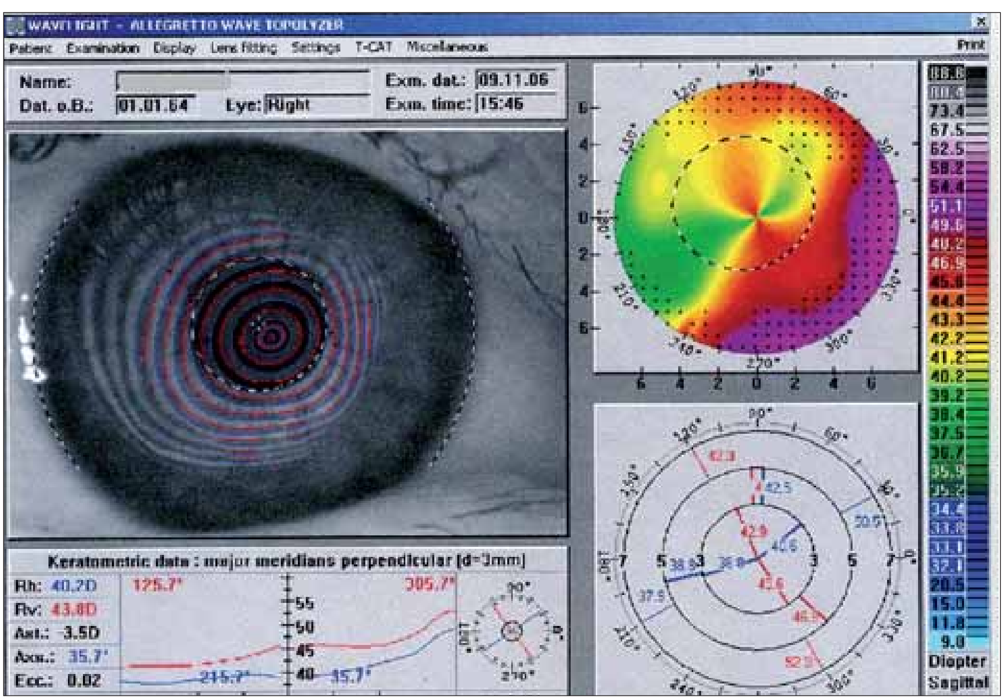

Fig. 4 - *Postoperative (14 months) topographic map of Case 2.*

multiple graft rejection episodes during the postoperative period, all successfully treated with topical steroids. Twenty-four months later, the single running suture in the right eye was removed. The slit-lamp examination revealed a clear graft, no signs of cataract, and normal fundus findings. The IOP was within normal ranges at all examinations. After suture removal, the patient had high mixed astigmatism that could not be fully corrected with contact lenses or spectacles. The preoperative autorefraction was +5.50 –10.0 x 175°. The preoperative UCVA was 20/400 and BCVA was 20/50 with +3.0 –8.50 x 175º. The attempted correction was +2.50 –5.50 x 175º. The preoperative corneal pachymetry of the graft was 590 µm. The ablation depth was 79 µm, the optical zone was 6.50 mm, with a total treatment zone of 8.90 mm. After 18 months of follow-up, the postoperative autorefraction was +2.50 –5.50 x 170º, the postoperative UCVA was 20/100, and BCVA was 20/30 with +1.50 –4.75 x 170º. The pre- and post-IntraLASIK topographies are shown in Figures 1 and 2.

Case 2

The second patient was a 38-year-old woman who had PKP in 2003 in the right eye. Twenty months later, the single running suture of the right eye was removed. The ophthalmologic examination revealed a clear graft, normal anterior and posterior segment findings, and IOP was normal. Preoperative autorefraction was –4.25 –6.75 x 70°. The preoperative UCVA was 20/400 and BCVA was 20/50 with –3.50 –6.50 x 70º. The attempted correction was –3.50 –4.50 x 70º. The preoperative corneal pachymetry of the graft was 557 µm. The ablation depth was 115 µm, the optical zone was 6.50 mm, and the treatment zone was 9.0 mm. After 14 months of follow-up, the postoperative autorefraction was +0.50 –3.50 x 70°. The postoperative UCVA was 20/80 and BCVA was 20/30 with +0.50 –3.50 x 170º. Figures 3 and 4 demonstrate the preoperative and postoperative (14 months) topographic results of this case.

Case 3

The third patient was a 35-year-old man who had PKP in 1995 in the right eye at another hospital. The sutures had already been removed. The ophthalmologic examination revealed a clear graft, normal anterior and posterior segment findings, and normal IOP. The preoperative autorefraction was –4.50 –9.25 x 73°. The preoperative UCVA was 20/2000 and BCVA was 20/200 with –4.25 –6.0 x 75º. The attempted correction was –3.0 –5.0 x 75º. The preoperative corneal pachymetry of the graft was 633 µm. The ablation depth was 108 µm, the optical zone was 6.0 mm, and the treatment zone was 8.50 mm. The postoperative autorefraction was –2.25 –2.75 x 82°. The postoperative UCVA was 20/100 and BCVA was 20/40 with –1.75 –2.25 x 80º. Figure 5 shows the flap lifting stage of the operation; the placement of the LASIK flap is within the corneal graft. Figures 6 and 7 demonstrate the pre- and postoperative topographies of this patient.

The manifest refraction was always lower than the autorefraction in all eyes preoperatively and in two eyes postoperatively. There were no lost lines of UCVA or BSCVA at the late postoperative period. All three patients were satisfied with the visual outcome of the operation despite some residual refractive error.

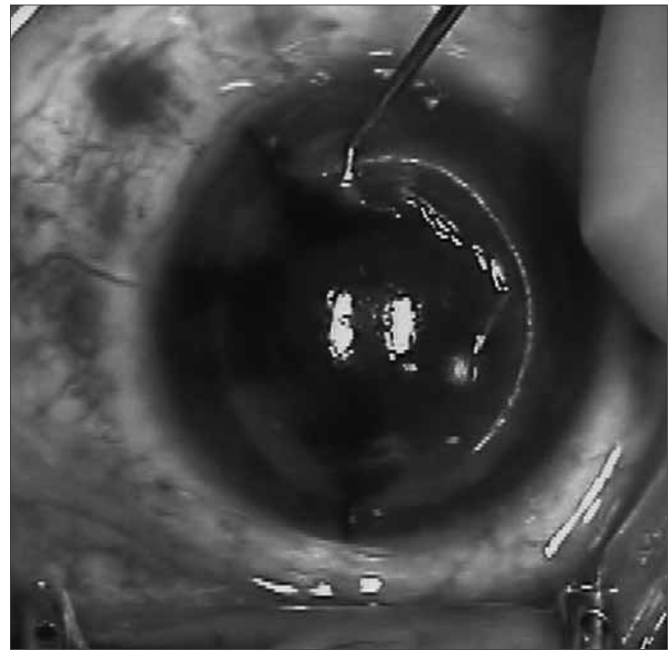

Fig. 5 - *Flap lifting stage of Case 3, demonstrating the placement of the LASIK flap well within the corneal graft.*

DISCUSSION

The preferred method in postkeratoplasty ametropia has been LASIK using the mechanical microkeratomes (16, 17). However, Hardten et al caution that the major disadvantage of LASIK is the risk of complications related to the creation of the lamellar flap (18). These complications include decentered and free flaps, irregular edges and surfaces, and buttonhole perforations and, therefore, extreme vigilance in patient selection is required (19). Further, epithelial trauma and epithelial defects that might occur during the preparation of the flap with mechanical microkeratome on a cornea without previous surgery can be associated with problems such as patient discomfort, photophobia, delayed visual recovery, epithelial ingrowth, and diffuse lamellar keratitis.

The IntraLase femtosecond laser is an infrared (1053 nm) scanning pulse with an accuracy of ±5 µm based upon

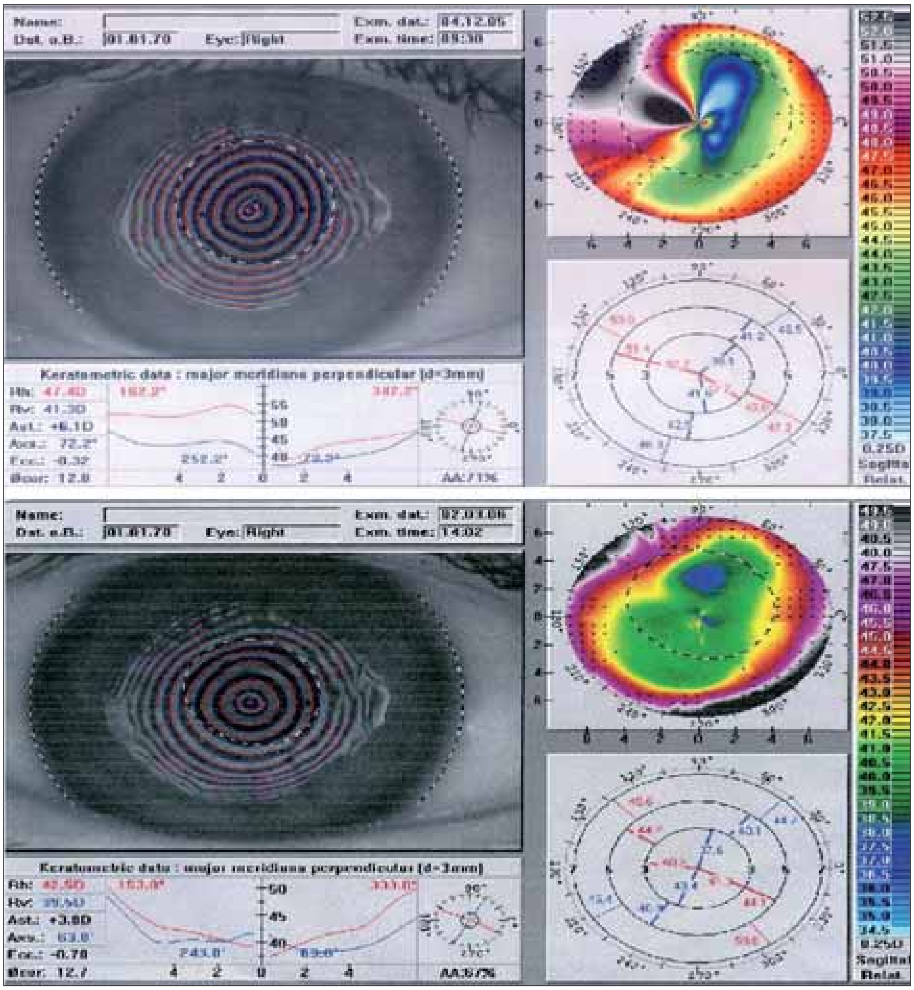

Fig. 6 - *Pre- and early postoperative topographic map of Case 3.*

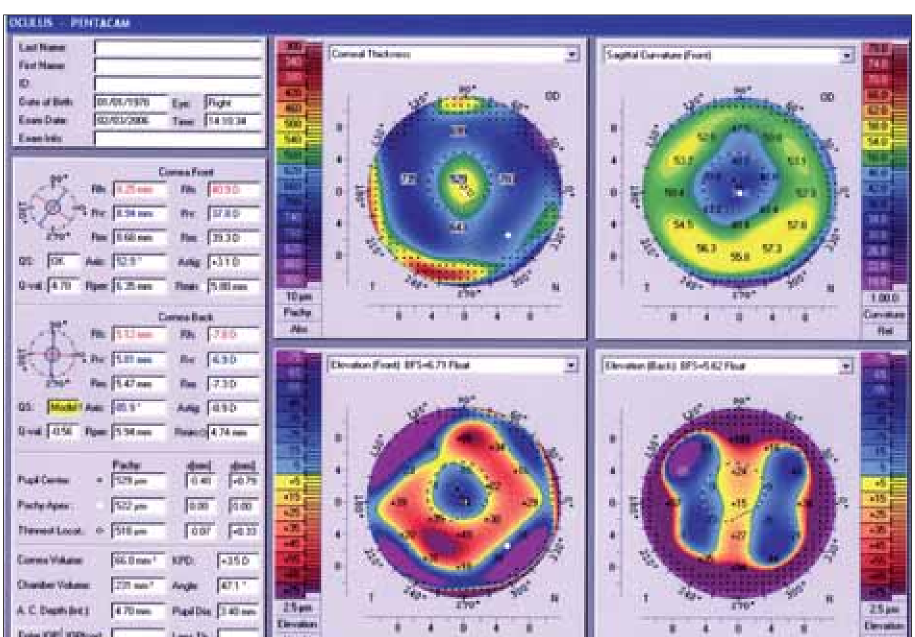

Fig. 7 - *Postoperative (15 months) topographic map of Case 3.*

the laser software and variation in the glass applanation plate thickness, enabling it to cut in the corneal stroma and create precise lamellar flaps for LASIK (20-22). This technology is capable of creating more predictable flap dimensions than current mechanical microkeratomes, and with the femtosecond laser, the abovementioned complications are fewer (19, 20). It was our choice to use this type of laser in the PKP patients.

There are several studies indicating the high success rate of LASIK treatment after PKP, some in one step and some in two, but in all these cases the corneal flap was created by a mechanical microkeratome (23, 24). Other randomized studies concerning standard LASIK have compared a mechanical microkeratome in one eye with femtosecond laser in the other eye (20-22).

Tran et al mention a case with epithelial ingrowth in the microkeratome group whereas none occurred in the femtosecond group (21). The risk of developing epithelial ingrowth can be devastating and might necessitate a new corneal transplantation; to reduce this risk we preferred the one-step procedure (25). A second reason for choosing the one-step procedure was that the attempted correction was much smaller than the manifest refraction in each case in order to avoid any possible overcorrection, which has not occurred in these three cases. IntraLASIK after PKP has several advantages compared to conventional LASIK treatment after PKP.

First, Durrie and coauthors' prospective contralateral eye study concludes that LASIK performed using the IntraLase femtosecond laser has better astigmatic outcomes than conventional LASIK with the Hansatome microkeratome. In this study, the Hansatome group had a higher postoperative residual spherical equivalent than in the IntraLase group (22).

Second, software centration of the corneal flap minimizes the potential for flap decentration. With a mechanical microkeratome, a precise cut of the graft is not possible: the flap edges may pass over the edge of the graft but the IntraLase femtosecond laser is capable of adjusting the flap diameter to be just the width of the original graft. There is no possibility of changing the biomechanics of the recipient cornea—in theory, with the mechanical microkeratome, the weakening of the peripheral corneal rim may cause ectasia or recurrence of the primary ectatic disease. Keratoconus recurrence is possible even years after a corneal transplantation and is probably related to incomplete excision of the cone (26, 27). Creating the flap only on the donor cornea seems more logical and safe compared to creating the flap with a mechanical microkeratome to avoid keratoconus recurrence.

Third, in terms of reliably creating thin flaps, as reported by Binder, the IntraLase femtosecond laser has a low standard deviation, compared with mechanical microkeratomes, and this is an advantage for a corneal graft in a keratoconus patient (19). In the same study, Binder also reports on the range of flap thicknesses achieved. The mean achieved flap thickness exceeded the attempted by 9.4 to 34.3 µm. The range for the attempted flap thicknesses of 90 µm (320 eyes) and 100 µm (140 eyes) was reported as 78–152 µm and 89–165 µm, respectively.

The predictability of the flap thickness could improve the safety of the procedure by avoiding iatrogenic ectasia (18, 28). As an example of the complications that might occur in a corneal graft, we refer to Mularoni et al, who described two buttonhole flaps in 15 PKP patients (29). Also with the IntraLase femtosecond laser it is possible to predictably adjust flap diameters to the exact width as the original graft and the hinge location and flap thickness, while eliminating the flap complication risks (21). Another advantage of femtosecond laser is that the flap-side cut is steeper than that of a flap edge created by a mechanical microkeratome, possibly providing a more accurate repositioning after flap lifting (18, 30).

We were aware of the risk of rupturing the transplant wound by increasing IOP during applanation, but knowledge of femtosecond laser applanation causing less IOP increase than the applanation of a microkeratome (35–40 mmHg versus 60–70 mmHg) was another reason why we preferred femtosecond laser assisted LASIK treatment (31). The fibrotic edge of the graft was also an additional safety factor for us for the prevention of a possible transplant wound rupture.

In one case (Case 3), the corneal thickness exceeded 630 µm, which suggests that there was some endothelial cell dysfunction though it did not lead to a risk of flap dislocation through.

The downside of one-step procedure could be a less accurate attempted correction because it has been demonstrated that just performing a flap alone with a mechanical microkeratome can alter the refractive status of the eye, by primarily changing the astigmatic error (16, 17). In this case, the host cornea may also be cut. Our hypothesis was to target a lower astigmatic value to manage a probable overcorrection and this has come true.

Perhaps the only disadvantage that can be mentioned with this method is that flap lifting is more difficult on a cornea with corneal graft. Following standard IntraLase femtosecond laser on a nonoperated cornea, flap lifting is easy and takes about a few seconds for an experienced surgeon. The fibrotic changes at the circumference of the graft hinder the usual rapid lifting maneuver. The surgeon must be cautious and patient during the lifting procedure; time must be given for the meticulous preparation and lifting of the flap, beginning at the margin.

A topographic, customized ablation (T-Cat) was not used because the autorefraction was higher than –6.00 D in all three cases and the manifest refraction was higher than –6.00 D in two of the cases. The laser manufacturer recommends against use of the T-Cat treatment in eyes with more than –6.00 D of astigmatism. The attempted corrections were intended to be lower than the manifest refraction in order to avoid extreme thinning of the corneal graft.

Our aim in treating these patients was to achieve a level of vision to allow them to perform normal daily activities comfortably. In conclusion, high astigmatism and ametropia is a serious, late, and complicated result of PKP. While we present the experiences of three patients here the use of IntraLASIK appears to be safe and efficient and warrants further study.

None of the authors has financial or proprietary interest in any material or method mentioned.

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