

Laser Intraström Keratoplasty—Case Report

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ABSTRACT

PURPOSE: To evaluate the feasibility of correcting high hyperopia by means of intraström laser in situ keratomileusis procedures and lamellar keratoplasty underwnt laser intraström keratoplasty. Her preoperative uncorrected visual acuity (UCVA) was 20/300 and best spectacle-corrected visual acuity (BSCVA) was 20/100 with a refraction of +8.00 -1.00 x 130°. Corneal topography showed a highly irregular corneal surface. Central corneal thickness was 398 µm. Lenticule preparation included mechanical de-epithelialization of a human donor eye, keratectomy with a microkeratome, user-designed software combining a photorefractive keratectomy (PRK) treatment for +8.00 D sphere, an ablation zone of 7.0 mm, and a circumferential cut (internal diameter of 6.5 mm) for tissue ablation. Implantation involved re-lifting the flap, positioning the lenticule onto the corneal bed, and repositioning of the flap.

METHODS: A female patient with high hyperopia and irregular astigmatism resulting from multiple laser in situ keratomileusis procedures and lamellar keratoplasty underwnt laser intraström keratoplasty. Her preoperative uncorrected visual acuity (UCVA) was 20/300 and best spectacle-corrected visual acuity (BSCVA) was 20/100 with a refraction of +8.00 -1.00 x 130°. Corneal topography showed a highly irregular corneal surface. Central corneal thickness was 398 µm. Lenticule preparation included mechanical de-epithelialization of a human donor eye, keratectomy with a microkeratome, user-designed software combining a photorefractive keratectomy (PRK) treatment for +8.00 D sphere, an ablation zone of 7.0 mm, and a circumferential cut (internal diameter of 6.5 mm) for tissue ablation. Implantation involved re-lifting the flap, positioning the lenticule onto the corneal bed, and repositioning of the flap.

RESULTS: The operation was uneventful as was the early postoperative follow-up. BSCVA improved to 20/50 with +1.00 -2.25 x 120° at 2 months postoperatively. Corneal topography showed a more regular cornea with increased curvature in all meridians. Central corneal thickness increased to 600 µm.

CONCLUSION: Laser intraström keratoplasty may be an option for correcting high hyperopia and irregular astigmatism in eyes with a thin corneal bed. [*J Refract Surg* 2004;20:79-84]

In recent years we have witnessed the rapid development of surgical methods to correct myopia, hyperopia, and astigmatism. Although most patients who undergo refractive surgery are elective first time patients, there are also increasing numbers of patients with secondary iatrogenic hyperopia and astigmatism after complicated laser treatments who have decreased residual corneal thickness. At present, refractive surgeons have a variety of techniques to manage complications after corneal laser surgery.¹⁻¹³ Keratoplasty, together with epikeratoplasty and keratomileusis, was introduced by Barraquer during the 1980s, but due to the complexity of the procedure and equipment, the inaccuracy of refractive results, postoperative complications, and delayed visual rehabilitation¹, it is rarely performed today, even after recent studies of laser lenticule lathing.² Another alternative with promising but inconclusive results¹¹⁻¹³ are artificial lenses made of various materials (flint glass, polymethylmethacrylate, polysulfone, and hydrogel) that are implanted in the stroma.

None of these techniques successfully treat irregular astigmatism or high hyperopia, due to the impossibility of performing photoablation on a cornea with a very thin corneal bed).¹⁴ With this case report, we demonstrate a technique for correcting high hyperopia in a patient after multiple complicated corneal laser surgeries.

PATIENT AND METHODS

A 42-year-old white female was referred to our clinic to correct high irregular compound hyperopic astigmatism resulting from earlier laser in situ keratomileusis (LASIK) procedures by different ophthalmologists. Initially, she had best spectacle-corrected visual acuity (BSCVA) of 20/20 in both eyes and underwent a simultaneous bilateral LASIK for OD +4.00 diopters (D) and OS +4.50 D in November of 1996. The outcome was BSCVA of 20/200 and spherical refraction of +5.00 D.

After 4 years and seven enhancements, the patient was referred to our service in December 2000. Her uncorrected visual acuity (UCVA) was

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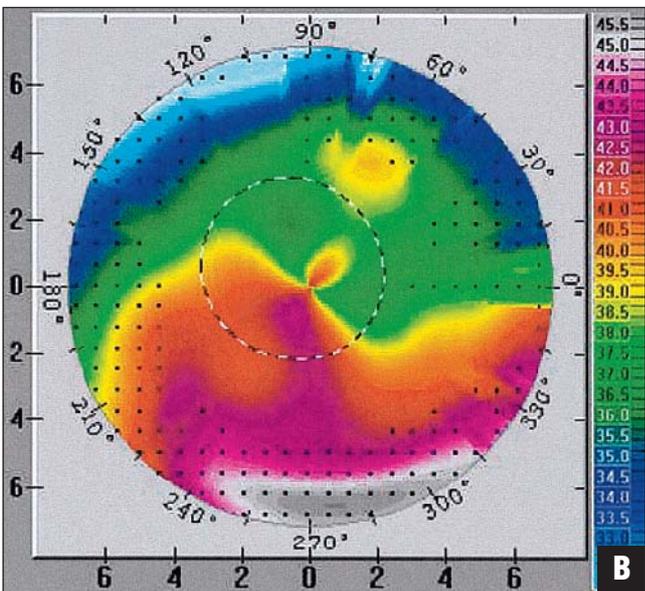
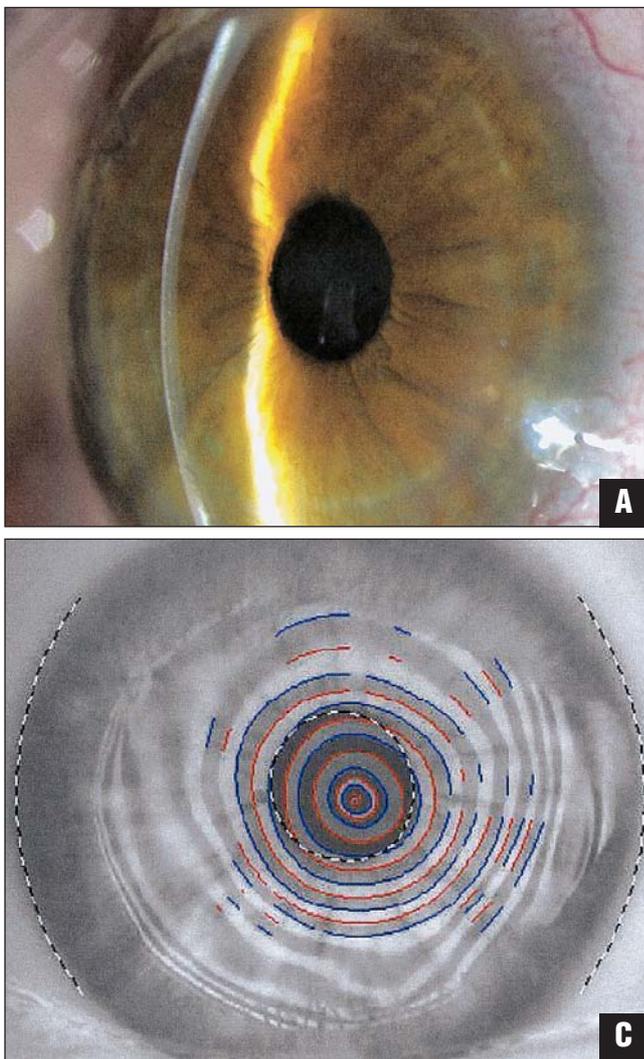


Figure 1. Preoperative data before laser intrastromal keratoplasty: **A)** slit-lamp; **B)** corneal topography; **C)** videokeratography.

20/125 with an autorefractometer (Automatic Refractor/Keratometer model 599, Humphrey Instruments - Karl Zeiss, Jena, Germany) of $+6.75 -5.25 \times 170^\circ$ with highly irregular corneal topography (Keratograph type 70600 with customized software version, Oculus, Wetzlar, Germany) and gross flap irregularities and folds. Her central ultrasonic corneal thickness (Pachymeter SP-2000, Tomey Corp., Nagoya, Japan) was $286 \mu\text{m}$, 2-mm peripheral superior was $277 \mu\text{m}$, inferior was $300 \mu\text{m}$, temporal was $296 \mu\text{m}$, and nasal was $271 \mu\text{m}$. Automated lamellar keratoplasty with complete removal of the original flap in the right eye was performed using a commercially available microkeratome (Berlin, Schwind Inc., Kleinostheim, Germany) with a flap thickness of $130 \mu\text{m}$ and a diameter of approximately 9 mm. The lamella was sutured onto the corneal bed using eight single sutures (X suture at the 11 o'clock position) com-

bined with a running 10-0 monoylon suture. The outcome was a transparent graft with minimal striae, but with some small epithelial ingrowth islands diagnosed in January 2001; UCVA was 20/160 and did not improve with corrective lenses.

In March 2001, she presented with UCVA of 20/300, BSCVA of 20/200 (pinhole 20/40), and $+8.00 -1.00 \times 130^\circ$; autorefractometer was $+8.75 -1.87 \times 131^\circ$, central corneal thickness was $398 \mu\text{m}$, superior was $446 \mu\text{m}$, inferior was $432 \mu\text{m}$, and temporal and nasal were $445 \mu\text{m}$. Slit-lamp microscopy showed a transparent flap with some folds, islands of epithelial ingrowth inferiorly, X-suture at 11 o'clock as a pseudo-hinge, and corneal topography showed high irregular corneal astigmatism (Fig 1). After having ethical commission board approval and the patient's consent, laser intrastromal keratoplasty was performed on the right eye in April 2001.

Laser Intrastromal Keratoplasty

Step 1—The stromal lenticle was prepared the day before surgical implantation. The entire fresh donor bulbus (36 hours post mortem) was positioned onto the eye holder and filled with balanced salt solution (BSS) through the optical nerve to restore normal intraocular pressure. The donor eye had no prior history of any ocular disease or operation and showed negative serological results for HIV, HBs-Ab, and HCV-Ab. The procedure was initiated with mechanical de-epithelialization using a hockey knife. Lamellar microkeratotomy was performed by

Table
Clinical Data Before and After Laser Intraströmical Keratoplasty

Time	UCVA	BSCVA	BSCVA (Pinhole)	Manifest Refraction (D)	Corneal Thickness* (Pachymetry; μm)
Before LASIK	20/300	20/200	20/40	+8.00 -1.00 x 130°	Central: 398; Superior: 446; Inferior: 432; Temporal: 445; Nasal: 445
After LASIK					
1 day	Count fingers	20/300	---	-2.00 sphere	---
2 days	20/300	20/100	---	-1.00 -2.00 x 120°	---
15 days	20/200	20/100	20/80	+0.25 -1.75 x 120°	Central: 652; Superior: 598; Inferior: 713; Temporal: 622; Nasal: 697
30 days	20/125	20/80	20/60	+1.25 -2.00 x 130°	Central: 610; Superior: 566; Inferior: 698; Temporal: 607; Nasal: 676
60 days	20/125	20/70	20/50	+1.00 -2.25 x 120°	Central: 600; Superior: 559; Inferior: 677; Temporal: 600; Nasal: 660

*Central and displaced by 2 mm

using a commercially available microkeratome (Berlin, Schwind Inc., Kleinostheim, Germany) with a hinged flap of a thickness of 130 μm and a diameter of 9.5 mm. The cornea of the donor eye was then ablated with a regular spherical correction of +8.00 D (optical zone 7.0 mm) using a scanning-spot excimer laser (Allegretto Wave, WaveLight Laser Technologie AG, Erlangen, Germany). A customized scanning software algorithm was used to create a circumferential cut with internal diameter of 6.5 mm. The lenticule was then removed from the stromal bed and positioned into a sterile shallow recipient filled with Optisol-GS (Chiron Ophthalmics, Irvine, CA). Total lenticule preparation time was approximately 20 minutes; the lenticule preparation procedure had been previously established in fresh enucleated pig eyes. In addition, reproducibility and accuracy of lenticule shape were verified by a surface profiling system.¹⁵

Step 2—The prepared lenticule was stored for 12 h at +4°C. Immediately prior to surgery it was rinsed with BSS and stored in a BSS-filled corneal graft holder for approximately 10 minutes. After applying topical anesthesia (oxybuprocaine chloride 0.4%, Ciba Vision, Novartis Intl AG, Basel, Switzerland), the patient's corneal lamella (flap) was marked and lifted using the 11 o'clock X-suture as an artificial hinge. The epithelial ingrowth islands were scraped off the stromal bed and from the rear side of the lamella. Then the lenticule was taken out of the holder and positioned on the stromal bed. Centration of the lenticule with respect to the center of the pupil was performed using a BSS irrigated cannula; the lamella was then repositioned using the same cannula, carefully irrigating the posterior surface of the lamella. A soft bandage

lens was placed for the first 2 days. Follow-up examinations were carried out at 1, 2, 14, 30, and 60 days. Antibiotic treatment was started with ofloxacin 0.3% (Floxal, Chauvin, Montpellier, France) four times per day and fluoromethalone 0.1% (FML Liquifilm, Allergan AG, Lachen, Switzerland) three times per day and gradually diminished over 3 weeks.

RESULTS

Lenticule preparation and implantation as well as early postoperative follow-up were uneventful. Preoperative and postoperative clinical data are listed in the Table. Slit-lamp microscopy data are presented in Figure 2; the sudden increase on the first postoperative day and constant decrease of corneal thickness in the later follow-up period are evident in this figure.

At postoperative day 1, the patient reported pain due to a peripheral erosion (nasal, inferior) with a width of approximately 0.7 mm. This gap was assumed to be a result of a corresponding short flap phenomenon. The cornea showed inter-lamellar inflammation with slight fibrinous reaction and edema of the stroma, lenticule, and both eyelids (Fig 3). The patient reported a foggy image (UCVA was count fingers) and a BSCVA of 20/300. Autorefractometry, corneal topography, and pachymetry were not obtainable.

At day 15 after laser intraströmical keratoplasty, UCVA improved to 20/200 and BSCVA to 20/100 (with pinhole 20/80); refraction was +0.25 -1.75 x 120°. There was a slight epithelial ingrowth inferiorly and temporally that stopped at the lenticule margins.

Thirty days after implantation of the lenticule,

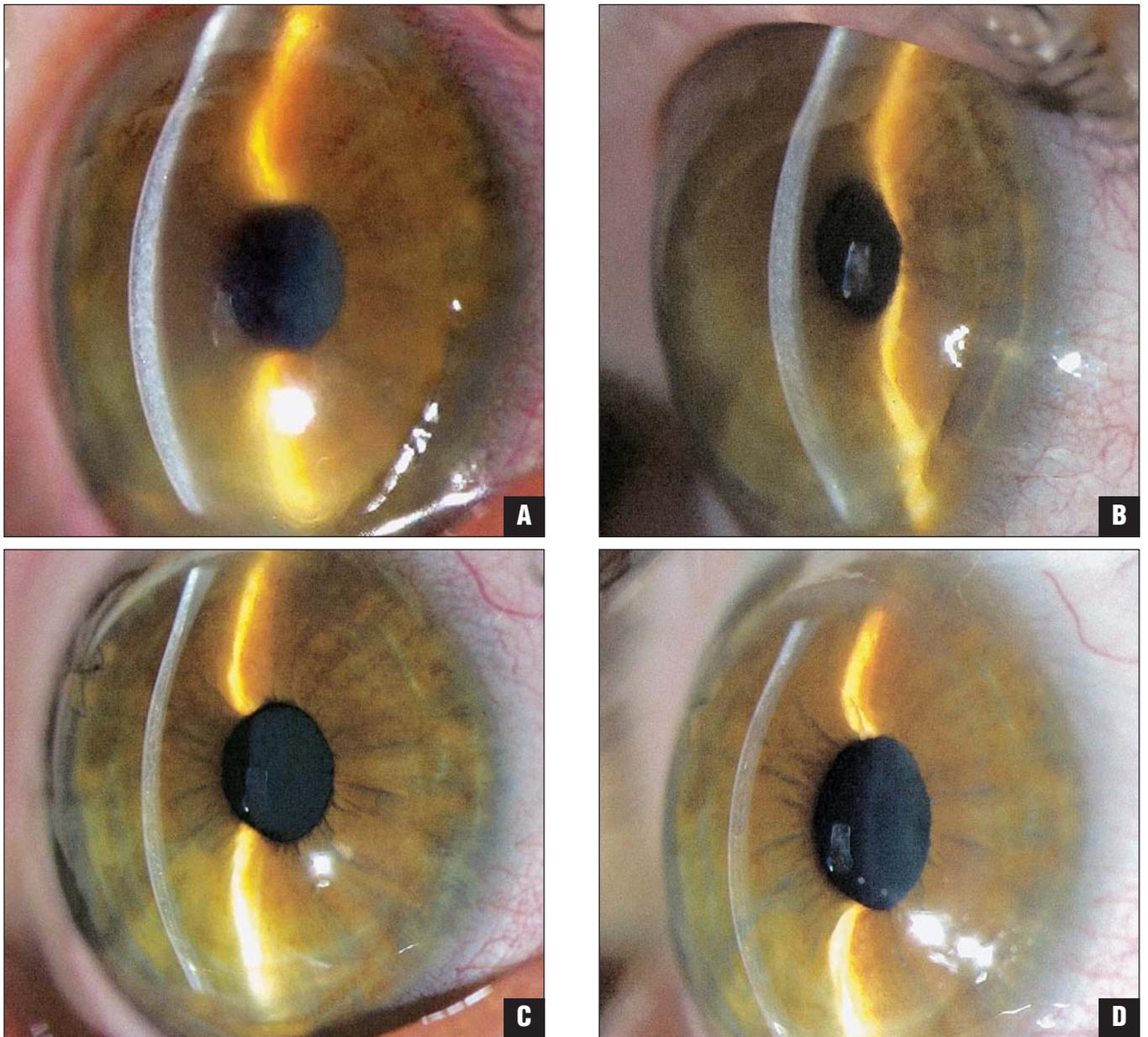


Figure 2. Slit-lamp microscopy after laser intrastromal keratoplasty at A) 1 day, B) 2 days, C) 2 weeks, D) 1 month.

UCVA improved to 20/125 and BSCVA to 20/80 (with pinhole 20/60); manifest refraction was +1.25 -2.00 x 130°. Corneal topography in Figure 4A shows a significantly steeper but more regular corneal front surface in comparison to preoperative corneal topography (Fig 1B); the videokeratograph after surgery (Fig 4B) can be compared with that prior to the surgery (Fig 1C).

Two months after implantation of the lenticule, UCVA and BSCVA were stable, and manifest refraction was virtually unchanged at +1.00 -2.25 x 120°. Corneal thickness was slightly less at every measurement point (Table).

DISCUSSION

The principal aim of performing laser intraström keratomileusis was to increase corneal thickness in order to bring it back into the treatable range of thickness using a lenticule that already has the shape of the attempted spherical correction. Adding more corneal tissue over the corneal bed is not expected to change the biomechanical properties of the cornea, ie, it is not meant to compensate for or stabilize iatrogenic keratoconus of the corneal bed, but rather is thought to be a sufficient addition to the corneal stroma to facilitate a more regular cornea, which can be ablated in the future, if needed.

The treatable limits of hyperopic correction described in the literature are between +15.00 and +19.00 D with keratoplasty, +12.00 D with keratomileusis¹⁶, and on the order of +15.00 D for

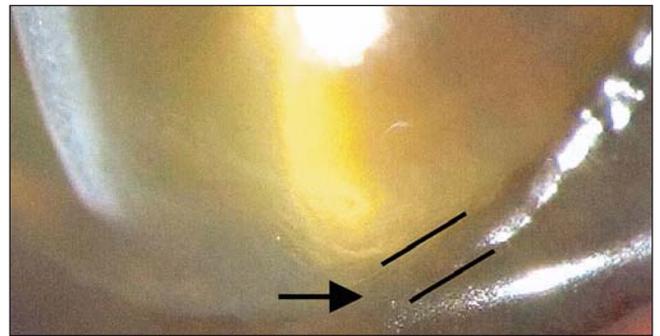


Figure 3. Biomicroscopic view of short flap phenomenon (space between two thin lines indicated by arrow) and corneal edema.

epikeratoplasty.¹⁷ The limiting factor is the quantity of tissue to be added to the cornea and the final corneal curvature. The limitations of laser intraström keratoplasty are unknown, but may be similar to those for keratoplasty, or perhaps higher; the lenticules prepared in our study were significantly thinner (150 µm) compared to the thick flaps used in keratoplasty, which are approximately 300 µm.

Using the technique for laser intraström keratoplasty presented in this paper, manipulation of the corneal graft was minimal, as the entire lenticule preparation procedure took place in situ at the donor bulbus (Step 1). Instead of freezing and mechanical lathing the corneal lamella, a more precise excimer laser ablation was applied to the corneal tissue, without removing it until implantation. Under the surgical microscope, the lenticule appeared round and relatively transparent, with a

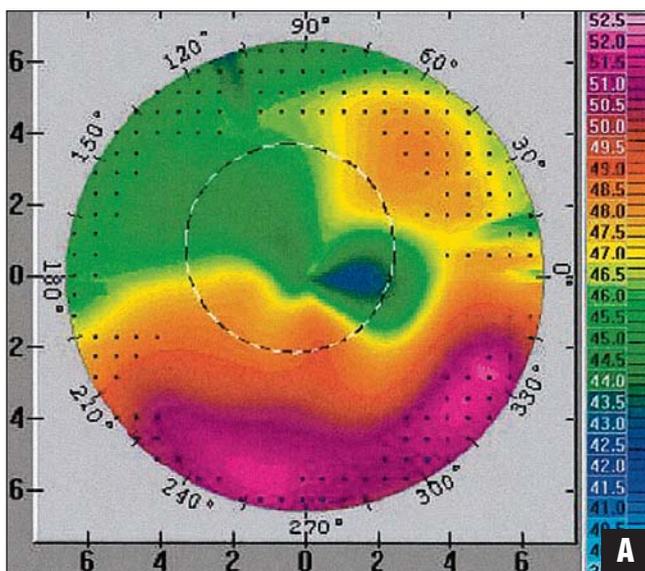


Figure 4. After laser intraström keratoplasty: **A)** corneal topography; **B)** videokeratography.

regular surface. A slight opacification was detected immediately after preparation, probably due to increased hydration. This opacity was absent the following day, after application of Optisol solution.

As expected, placing additional material beneath the flap resulted in a relatively short flap to cover the entire corneal bed, which led to a thin exposed area of corneal bed inferiorly, and to epithelial ingrowth. Stretching the flap over the lenticule during Step 2 of the laser intraströmical keratoplasty procedure resulted in a slightly smaller area, and the lenticule showed no displacement, even after several minutes of flap manipulation. This short flap phenomenon may explain the significant pain observed only in the immediate postoperative period after removing the contact lens; it was almost completely absent on the second day.

Interface problems such as corneal edema, epithelial ingrowth in a graft-host interface, and interface debris may occur after any lamellar refractive technique, but are infrequent. Lenticule edema was expected; reducing lenticule and corneal swelling (Fig 2), and epithelial healing over the small exposed area of stromal bed (short flap phenomenon) rather than the lenticule itself (as in epikeratoplasty) are probably responsible for the fast restoration of the normal anterior ocular surface.

Undercorrection or induced astigmatism, even irregular astigmatism, do not seem to be a serious problem after laser intraströmical keratoplasty because of the possibility of a secondary topography-guided treatment—re-lifting the flap and applying laser correction over the lenticule resting on the corneal bed, thus preserving the corneal bed tissue. In our patient, there was 1.00 D of induced astigmatism, preserving the original axis. The possibility of topography-guided treatment over donor corneal tissue may be an advantage over artificial material corneal inlays in which the laser-artificial tissue (laser-hydrogel) interaction has yet to be established. Our sutureless technique offers the assurance of re-lifting the flap without risk of unexpected corneal bed or cap behavior, which could eliminate the need for precise initial refractive correction.

Laser intraströmical keratoplasty may be a new method for correcting high hyperopia and irregular astigmatism in eyes with a thin corneal bed, usually after previous LASIK or PRK complications, as well as irregular astigmatism after penetrating keratoplasty or corneal trauma with irregular scars.

It might also be considered as a primary treatment for high hyperopia, if proven to be stable and predictable. Additional clinical evaluation of this new technique is required for determination of predictability, stability, and possible complications.

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