
To lift or recut: Changing trends in LASIK enhancement

Roy S. Rubinfeld, MD, David R. Hardten, MD, Eric D. Donnenfeld, MD, Raymond M. Stein, MD, Douglas D. Koch, MD, Mark G. Speaker, MD, PhD, Joseph Frucht-Pery, MD, Anthony J. Kameen, MD, Gerald J. Negvesky, MD

Purpose: To report serious complications caused by recutting laser in situ keratomileusis (LASIK) flaps for enhancement and reconsider the current preferred method of LASIK enhancement.

Setting: Multiple surgeon practices.

Methods: This retrospective noncomparative nonconsecutive case series comprised LASIK patients in the private practices of 9 experienced refractive surgeons and those reported in a survey of refractive surgeons. Case histories, refractions, corneal topographies, slitlamp photographs, and measurements of uncorrected and best corrected (BCVA) visual acuity after recutting LASIK flaps were collected. Surveys of refractive surgeons and an analysis of changing practice trends among the authors and these surgeons were assessed.

Results: In 12 cases, significant loss of BCVA and subjective visual difficulties resulted from recutting LASIK flaps. Most surveyed surgeons had changed their practice from recutting to lifting flaps even 9 to 10 years postoperatively with good results.

Conclusion: Recutting flaps for enhancement should be avoided unless other alternatives are unavailable.

J Cataract Refract Surg 2003; 29:2306–2317 © 2003 ASCRS and ESCRS

Residual refractive errors commonly occur after laser in situ keratomileusis (LASIK). Surgical management of these residual errors by excimer laser photoablation (enhancements) can be performed by lifting the flap, by cutting a new flap, or by surface ablation. Considering the current popularity of LASIK, if enhancements are required in only 10% of cases, tens or possibly hundreds of thousands of LASIK enhancement procedures will be performed every year in the United States alone. Although we believe that most surgeons perform enhancements by lifting flaps, many textbooks, courses, and journal articles suggest that enhancements can be routinely performed by recutting LASIK flaps 3 or more months after the primary LASIK procedure.^{1–11}

In this paper, we report the first series of serious complications induced by recutting flaps for routine LASIK enhancement. We propose that the serious nature of these complications and the results of a survey of experi-

enced refractive surgeons warrant reevaluation of the advisability of recutting flaps for LASIK enhancement.

Patients and Methods

Case histories of patients with complications after recutting LASIK flaps were collected from 9 refractive surgeons. Each contributor reviewed the patient's chart to collect standardized information about the case. Fifty refractive surgeons affiliated with TLC Vision were surveyed via an Internet questionnaire. Four e-mail reminders were sent to the surgeons to encourage completion of the survey. The survey questions are shown in Figure 1.

Summary of Cases

Twelve eyes of 12 patients developed significant complications following flap recutting for enhancement of previous LASIK surgery. The mean age of the patients at the time of the initial LASIK surgery was 37.8 years \pm 7.7 (SD) (range 24 to 47 years). The mean preoperative spherical equivalent (SE) was -6.23 ± 0.78 diopters (D) (range -3.75 to -9.00 D)

in the 10 myopic eyes and $+4.69 \pm 1.68$ D (range $+3.50$ to $+5.88$ D) in the 2 hyperopic eyes. All patients had a best corrected visual acuity (BCVA) of 20/20; normal pachymetry; and symmetrical, unremarkable topographies before surgery. After the initial procedure, the mean best spectacle-corrected visual acuity (BSCVA) was 20/20 (range 20/20 to 20/25) and the mean SE was 0.33 ± 2.02 D. Before enhancement, no eye lost 2 or more lines of BSCVA.

In 4 eyes, flaps were recut with the microkeratome used in the initial procedure but with a thicker plate. Five eyes were recut with the same microkeratome and the same plate, and 1 eye was recut with a different microkeratome with the same plate depth. Complete data were not available for 2 eyes. Six eyes in the series were right eyes and 6, left eyes. After enhancement by recutting, the mean uncorrected visual acuity (UCVA) was 20/63 (range 20/30 to 20/400), the mean SE was -0.49 ± 1.68 D, and the mean refractive cylinder was $+1.48 \pm 1.02$ D. The mean time to recutting after the primary LASIK procedure was 11.5 months (range 5.5 to 26.0 months). Seven eyes lost 2 or more lines of BSCVA; however, all patients had visually significant complaints such as monocular diplopia, glare, loss of contrast sensitivity, ghosting, and poor quality of vision. The details of the 12 cases are given in Table 1. Selected cases are reported below.

Case 1

A 45-year-old woman had uneventful bilateral LASIK for moderate myopia. A 160 μm plate was used with the Automated Corneal Shaper[®] microkeratome (Bausch & Lomb Surgical), and a Visx laser was used for the ablation. Postoper-

Accepted for publication September 4, 2003.

From Washington Eye Physicians and Surgeons (Rubinfeld), Chevy Chase, Maryland, Georgetown University Medical Center (Rubinfeld) and Washington Hospital Center (Rubinfeld), Washington, DC; Minnesota Eye Consultants (Hardten) and University of Minnesota (Hardten), Minneapolis, and Regions Medical Center (Hardten), St. Paul, Minnesota; and Manhattan Eye, Ear and Throat Hospital (Donnenfeld), New York, New York, USA; Bochner Eye Institute (Stein) and University of Toronto (Stein), Toronto, Ontario, Canada; Cullen Eye Institute, Baylor College of Medicine (Koch), Houston, Texas, and New York Eye and Ear Infirmary, New York Medical College (Speaker), New York, New York, USA; Hadassah University Hospital (Fruchtpery), Jerusalem, Israel; Greater Baltimore Medical Center (Kameen), Baltimore, Maryland, and Pocono Eye Associates (Negvesky), East Stroudsburg, Pennsylvania, USA.

Presented in part at the annual meetings of the American Academy of Ophthalmology and the International Society of Refractive Surgery, New Orleans, Louisiana, USA, November 2001.

None of the authors has a proprietary interest in any product mentioned.

Reprint requests to Roy S. Rubinfeld, MD, Washington Eye Physicians & Surgeons, Suite 950, 5454 Wisconsin Avenue, Chevy Chase, Maryland 20815, USA.

1. In the typical enhancement patient, in 2002 what % do you recut a new flap for the enhancement, and what % do you lift the existing flap for the enhancement.
Recut ___% Lift ___%
2. In the typical enhancement patient, in 1998 did you generally recut a new flap for the enhancement or lift the existing flap for the enhancement.
Recut ___% Lift ___%
3. If you changed your % of recuts or lifts from 4 years ago to now, why did you make that change?
Cost ___ Complications I've seen or heard of ___ Ability to further enhance in the future ___
Other reason _____
4. Have you ever experienced a severe problem with recutting a new flap?
Yes ___ No ___
If yes, describe approximate % of cases and the complication.

5. Have you ever experienced a severe problem with lifting an existing flap?
Yes ___ No ___
If yes, describe approximate % of cases and the complication.

6. In 2002, do you typically make an initial flap that is large enough to lift for both myopic and hyperopic enhancements?
Yes ___ No ___
7. In 1998, did you typically make an initial flap that was large enough to lift for both myopic and hyperopic enhancements?
Yes ___ No ___
8. What is the oldest lamellar flap you have lifted successfully for an enhancement?
<1 year 2 years 3 years 4 years 5 years 6 years 7 years
8 years 9 years 10 years 11 years 12 years

Figure 1. (Rubinfeld) Survey sent to 50 refractive surgeons.

atively, the patient's left cornea developed mild to moderate diffuse lamellar keratitis (DLK) and epithelial ingrowth, which were treated with topical corticosteroid drops, lifting the flap, and removing the epithelium. At 5.5 months, the left eye remained somewhat myopic. The UCVA was 20/50 and the BSCVA, 20/20.

An enhancement procedure was performed using the same microkeratome with a 180 μm plate to cut a deeper flap. After the microkeratome pass, a subtle, thin, opalescent membrane was observed in the bed; it was carefully repositioned without the use of saline solution and refloating. The repositioning appeared satisfactory, and a small myopic laser treatment was applied. The flap was then carefully replaced. The appearance of the flap under the operating microscope was excellent, and the slitlamp examination 30 minutes after surgery showed excellent flap position.

Table 1. Summary of 12 cases with complications after flap recutting.

Case	Pre-LASIK MRx	Pre-Enhancement MRx	Microkeratome	Plate Depth (μm), Suction Ring Size (mm) (Initial Procedure/Enhancement)	Post-Enhancement MRx
1	-8.00 +1.75 \times 100	-1.75 +1.75 \times 92	ACS	160/180	Pl +3.25 \times 10
2	+3.50 sphere	+2.25 sphere	Hansatome	180, 9.5/180, 9.5	+1.50 +0.50 \times 10
3	-8.50 +2.75 \times 110	+0.50 +1.00 \times 60	ACS	180/180	Too irregular to obtain
4	-8.50 sphere	-5.00 +1.00 \times 50	Unknown	Unknown	-5.50 +1.00 \times 58
5	-6.25 +0.25 \times 80	-1.00 sphere	Hansatome	160, 8.5/180, 9.5	-0.25 +1.00 \times 132
6	-6.00 +0.50 \times 160	-1.25 +0.50 \times 75	CB	160/180	-1.50 +1.50 \times 155
7	-10.25 +2.50 \times 100	-1.00 sphere	Hansatome	160, 8.5/180, 9.5	+1.25 +0.50 \times 5
8	-3.75 sphere	-1.25 +0.50 \times 135	Hansatome	160, 9.5/160, 9.5	-0.25 +1.00 \times 135
9	+5.50 +0.75 \times 13	+2.50 +1.25 \times 171	Hansatome (initial procedure)/ ACS (enhancement)	160/160, 9.5	-0.25 +1.75 \times 43
10	-4.50 sphere	+0.75 +1.25 \times 40	Hansatome	Unknown/180, 9.5	-1.50 +.75 \times 170
11	-6.50 +1.00 \times 90	-1.00 +0.75 \times 85	Hansatome	180, 8.5/180, 9.5	-2.00 +1.50 \times 45
12	-5.25 +0.75 \times 15	-1.75 sphere	Hansatome	180, 8.5/180, 9.5	-1.75 +3.50 \times 105

One day after the enhancement procedure, a linear discontinuity or crease was noted in the anterior corneal stroma, oriented obliquely and superotemporally on slitlamp examination. The UCVA and BSCVA were 20/400. There was some flap edema, although the flap position was excellent. Topical corticosteroids (prednisolone phosphate) were applied every hour for several days. No significant improvement in BCVA was noted during 1 week of this treatment. Two weeks after the enhancement procedure, the flap was lifted and attempts were made to reposition the thin lamellar tissue. Despite the surgical procedure and continued treatment with topical prednisolone phosphate, 19 months later the patient had severe irregular astigmatism of 8.0 D (Figure 2) and a UCVA of 20/40 with severe ghosting, diplopia, and extremely poor subjective quality of vision. Slitlamp examination using retroillumination (Figure 3) demonstrated a linear lamellar discontinuity in the area of irregular astigmatism noted on postoperative topography. The final refraction in the left eye was plano +3.25 \times 10, which yielded a poor-quality BCVA of 20/40 to 20/30.

Subsequent attempts to surgically repair the patient's irregular astigmatism included flap elevation, removal of the stromal sliver, and phototherapeutic keratectomy (PTK) (Figures 4 and 5), but there was no improvement in BSCVA.

Case 3

A 46-year-old woman had uneventful bilateral LASIK for moderate myopia with an Automated Corneal Shaper microkeratome using a 180 μm plate and the Visx Star laser. The patient had bilateral LASIK enhancement for residual

myopia 12 months after the primary procedure. A new flap was created using the same microkeratome and plate, and the same laser was used for the ablation. A subtle tag of peripheral corneal tissue was noted at the time of the procedure but did not appear clinically significant. Postoperatively, the patient complained of poor vision in the right eye. The

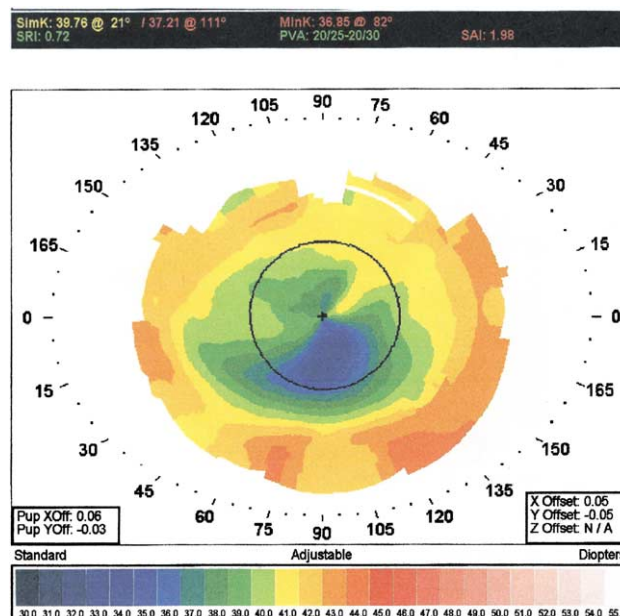


Figure 2. (Rubinfeld) Axial topographic map of Case 1 showing severe irregular astigmatism after recutting for enhancement.

Table 1. (cont).

Timing of Enhancement (Mo)	Postop Complications	Post-Transection Surgical Interventions	Final UCVA	Final BSCVA
5.5	DLK, ingrowth, irreg. astig.	Flap relifting, tissue repositioning, tissue excision, PTK	20/40	20/30 ⁻²
7.0	Irreg. astig.	None	20/30	20/30 ⁺³
12.0	Irreg. astig.	Flap relifting, tissue repositioning × 2	20/200	20/200
12.0	Irreg. astig.	None	20/400	20/60
6.0	Irreg. astig.	None	20/50	20/25
13.0	Irreg. astig., ingrowth	Flap relifting, removal of ingrowth	20/80	20/50
9.0	Irreg. astig.	None	20/50	20/30
12.0	Irreg. astig., striae	Flap relifting, hyperthermic treatment of striae	20/40	20/25
26.0	Irreg. astig.	None	20/40	20/40
9.0	Striae	None	20/60	20/50
22.0	Irreg. astig.	None	20/60	20/60
5.0	Irreg. astig.	None	20/50	20/30

BSCVA = best spectacle-corrected visual acuity; DLK = diffuse lamellar keratitis; Ingrowth = epithelial ingrowth; Irreg. astig. = irregular astigmatism; MRx = manifest refraction; PTK = phototherapeutic keratectomy; UCVA = uncorrected visual acuity

UCVA and BSCVA were 20/200 with complaints of glare and diplopia.

Slitlamp examination of the right eye with retroillumination through a dilated pupil revealed a 5.0 mm oblique ridge in the center of the pupil. The flap in the right eye was lifted, and a rolled edge of thin lamellar tissue was found in the bed corresponding to the ridge seen on slitlamp illumination. The edge was unrolled and the flap replaced and meticulously repositioned. The patient's vision did not improve, and the ridge was present on retroillumination slitlamp examination (Figure 6). Two weeks later, a second attempt was made to smooth the bed in the right eye without success. Irregular astigmatism was visible on topography (Figure 7). The Snellen visual acuity and subjective visual quality remained unchanged. A rigid, gas-permeable (RGP) contact lens was fitted, which provided the patient with 20/20 visual acuity.

Case 4

A 46-year-old woman had bilateral LASIK for moderate myopia outside the U.S. The type of microkeratome and laser were not known. Postoperatively, the patient had flap edema and haze that were treated with prednisolone acetate drops and sodium chloride 5% drops and ointment. The edema and haze cleared but the left eye regressed; the BCVA was 20/20 with $-5.00 +1.00 \times 50$.

One year after the LASIK procedure, the surgeon recut the flap and noted a "fillet" of tissue in the stromal bed, which was noted to be "wrinkled" after the microkeratome pass. Additional laser treatment was applied, although surgical

details are unavailable. Two and a half years after the enhancement procedure, haze and scarring were visible in the left eye (Figure 8) and a linear discontinuity in the flap could be seen on retroillumination slitlamp photographs. Topography revealed 8.0 D of irregular astigmatism over the visual axis (Figure 9), and the patient's subjective visual acuity remained

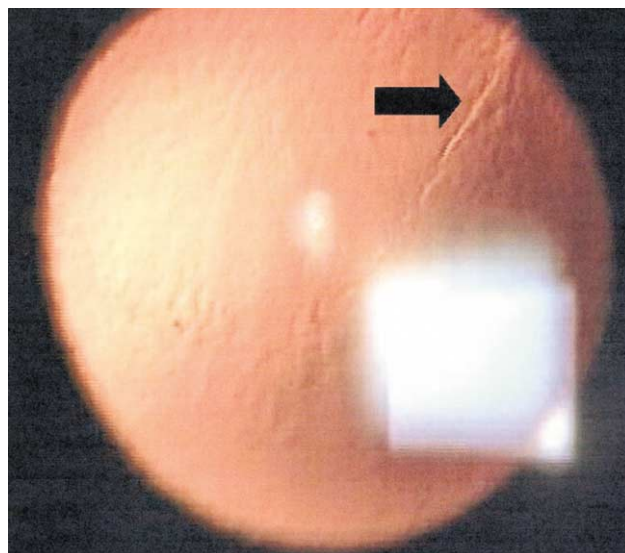


Figure 3. (Rubinfeld) Retroillumination slitlamp photograph of Case 1. Note the discrete, semicircular discontinuity in the stroma (arrow) caused by a sliver of stroma produced by recutting the flap.

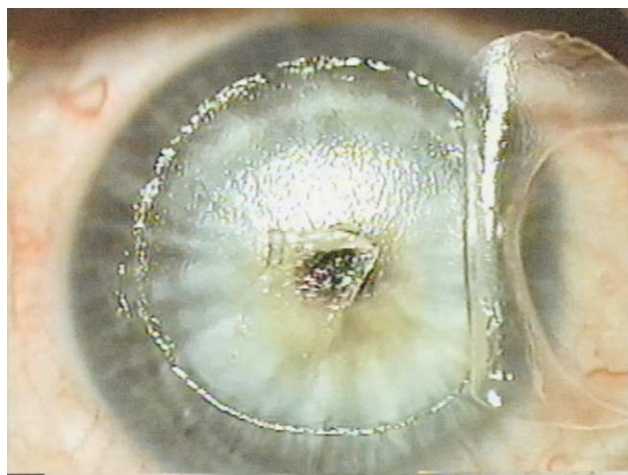


Figure 4. (Rubinfeld) Lamellar sliver of stromal tissue found on elevation of the flap in Case 1. This lamellar tissue was induced by recutting the flap, and it could not be accurately repositioned (courtesy of Lee T. Nordan, MD).

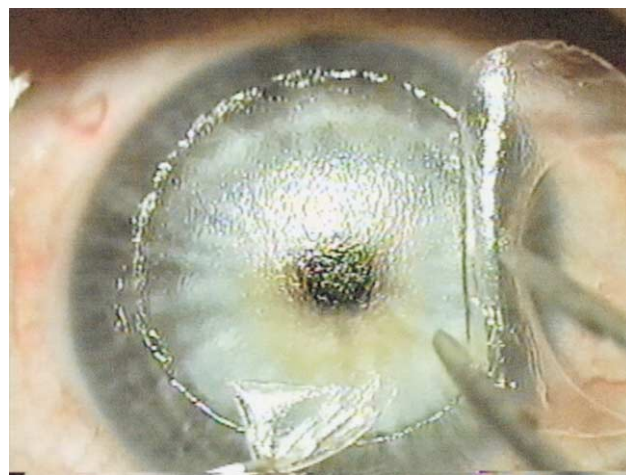


Figure 5. (Rubinfeld) Surgical removal of lamellar stromal tissue described in Figure 4 (courtesy of Lee T. Nordan, MD).

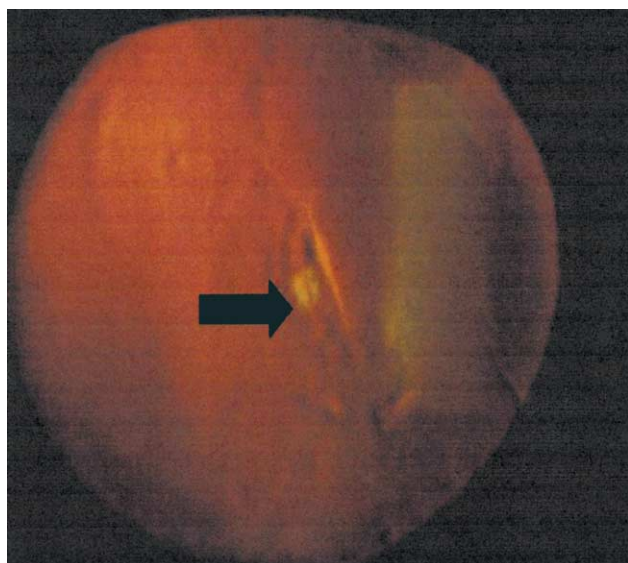


Figure 6. (Rubinfeld) Retroillumination slitlamp photograph of folded stromal sliver (arrow) under the LASIK flap in Case 3.

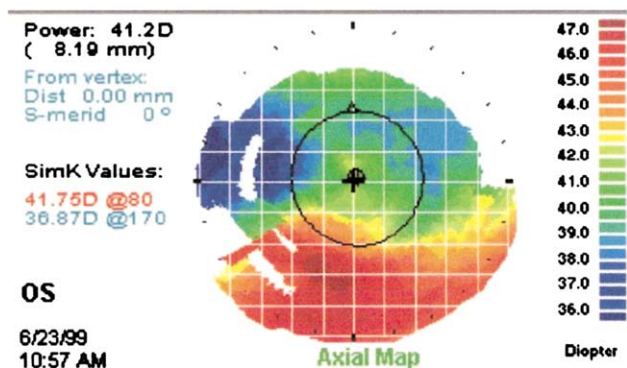


Figure 7. (Rubinfeld) Axial topographic map of irregular astigmatism in Case 3 induced by flap recutting.

extremely poor. The UCVA was 20/400, and the BSCVA was 20/60 with $-5.50 + 1.00 \times 58$. The patient complained of severe glare, diplopia, and poor contrast and quality of vision. An RGP contact lens improved the vision in this eye to 20/30, but the patient was contact lens intolerant.

Case 6

A 37-year-old man had uneventful bilateral LASIK for moderate myopia with a manual CB microkeratome (Moria) using a 160 μm plate and the Visx Star laser. Thirteen months postoperatively, an enhancement was performed in the right eye for residual myopia. The surgeon recut the flap with the CB microkeratome using a 180 μm depth plate. The procedure was complicated by multiple lamellar slivers involving the flap and bed. The patient was referred for consultation and further management.

Three weeks after the complication occurred, the UCVA in the right eye was 20/80 and the BSCVA was 20/60 with a refraction of $+0.25 + 1.50 \times 175$. On slitlamp examination, there appeared to be striae manifested by a few visible lines in the flap; these were thought to be slivers of displaced corneal tissue. The flap was lifted, and an attempt was made to reposition the corneal slivers. One week later, the BCVA was 20/40⁻ with a refraction of $-1.75 + 1.75 \times 155$.

Three and a half months later, a focal area of epithelial ingrowth that extended 2.0 mm was noted. Over the next 9 months, the epithelial ingrowth progressed. At this time, multiple focal areas of epithelial ingrowth extending to the pupil were noted (Figure 10). The outer flap edge was lifted in the operating room, but the epithelial cells were not located at this interface (Figure 11). The flap was then repositioned. One month later, the patient was brought back to the operating room and the inner flap edge was lifted and the epithelial cells gently removed with a spatula. One month later, a relatively clear interface was noted but the BSCVA was

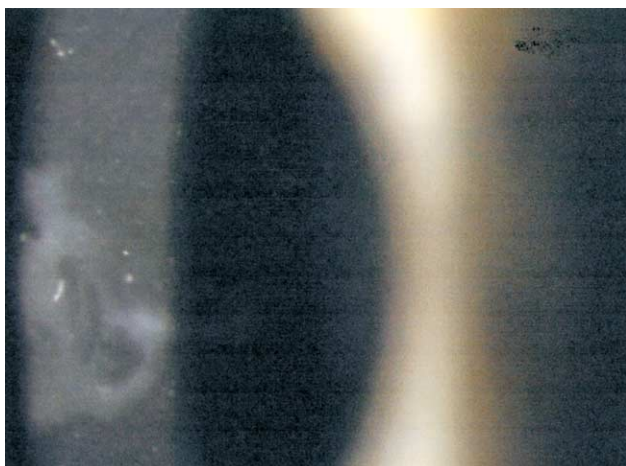


Figure 8. (Rubinfeld) Slitlamp photograph of haze present in cornea of Case 4 2.5 years after a microkeratome transected the original flap plane during recutting for enhancement.

20/50 with $-1.50 +1.50 \times 155$. The patient complained of glare, diplopia, and poor quality of vision. One year later, the BSCVA remained 20/50 secondary to irregular astigmatism. The patient is considering a lamellar graft.

Case 7

A 30-year-old man had bilateral LASIK for moderate to high myopia. The procedures were performed using a Hansatome® microkeratome (Bausch & Lomb Surgical) with an 8.5 mm ring and a 160 μm plate. The ablation was performed with a Nidek excimer laser.



Figure 10. (Rubinfeld) Slitlamp photograph of multiple focal areas of epithelial ingrowth extending to the pupil in Case 6.

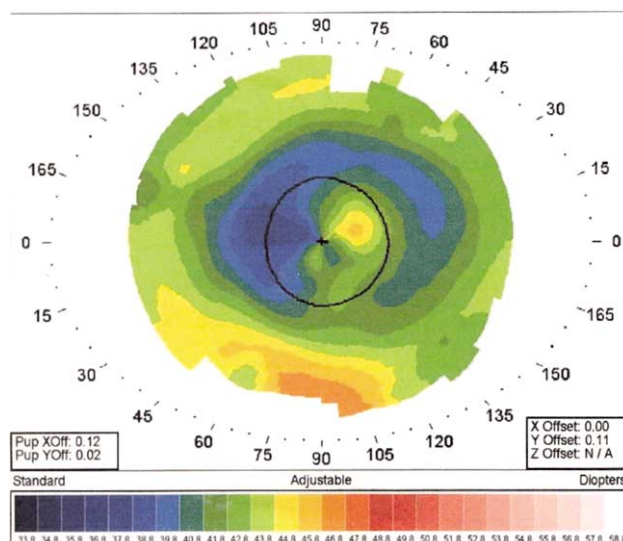


Figure 9. (Rubinfeld) Axial topography demonstrating 8.0 D of irregular astigmatism caused by recutting the flap in Case 4.

Nine months postoperatively, an enhancement was performed for residual myopia by cutting a new flap using the Hansatome with a 180 μm plate and a 9.5 mm suction ring. Upon elevating the flap, the surgeon noted separation of a shallow flap from the deeper flap, creating 2 corneal flaps. The thin interface flap was repositioned carefully (Figure 12), and excimer laser ablation was performed. After saline irrigation and repositioning with Weck-cel® sponges (Medtronic Solan), the superior flap was laid down on top of the interface lamellar tissue. A bandage contact lens was applied and left in place for 3 days.

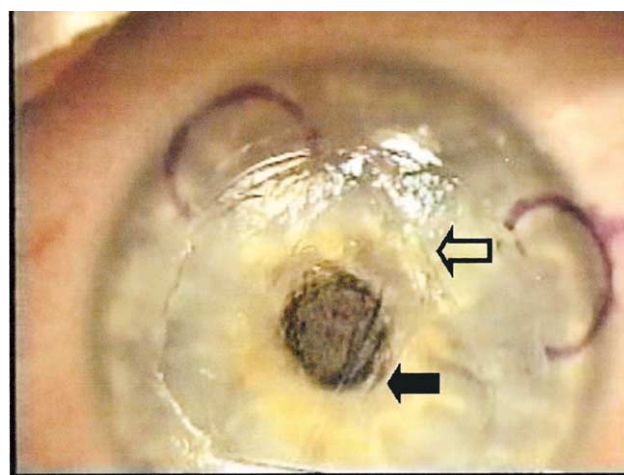


Figure 11. (Rubinfeld) Operating microscope photograph taken after lifting the outer flap to remove epithelial ingrowth in Case 6. The epithelial cells were not located at this interface. Folds (closed arrow) in a stromal sliver of recut tissue were discovered instead. The open arrow indicates the edge of the lamellar sliver of stromal tissue.



Figure 12. (Rubinfeld) Operating microscope photograph of thin, irregular sliver of stromal tissue observed after recutting the flap for enhancement in Case 7. The surgeon was attempting to reposition the thin lamellar tissue.

Ten weeks after the enhancement procedure, the patient was referred for consultation. He complained of glare, light sensitivity, and poor quality of vision with spectacle correction. The UCVA was 20/50, and the BSCVA was 20/30⁺² with +1.25 +0.50 × 5. On retroillumination, interface folds were visible in the transected flap (Figure 13); corneal topography showed irregular astigmatism. The patient continued to have difficulty with night driving and was fit with an RGP contact lens that improved the BCVA to 20/20⁻ and improved but did not eliminate the glare.

Case 9

A 39-year-old white woman had uneventful bilateral LASIK for high hyperopia with a Technolas 116 laser (Bausch & Lomb Surgical). An Automated Corneal Shaper microkeratome with a 160 μm plate was used. Twenty-six months postoperatively, the UCVA in the right eye had regressed to 20/50 with residual hyperopic astigmatism.

An enhancement procedure was performed in the right eye using a 160 μm plate on a Hansatome microkeratome and a 9.5 mm suction ring. After the microkeratome pass, the flap was lifted with a spatula and a thin piece of free tissue approximately 1.0 mm wide was seen; it had folded edges extending peripherally outside the pupil. The edges were repositioned with a spatula, and the laser procedure was started. During laser application, a piece of free tissue suddenly dislocated from the central region of the stroma and disappeared from the field, apparently as a consequence of the laser shock wave. The flap was then repositioned without complication.

Following enhancement, the BSCVA was reduced to 20/50 with +1.00 -1.00 × 10. Computerized topography

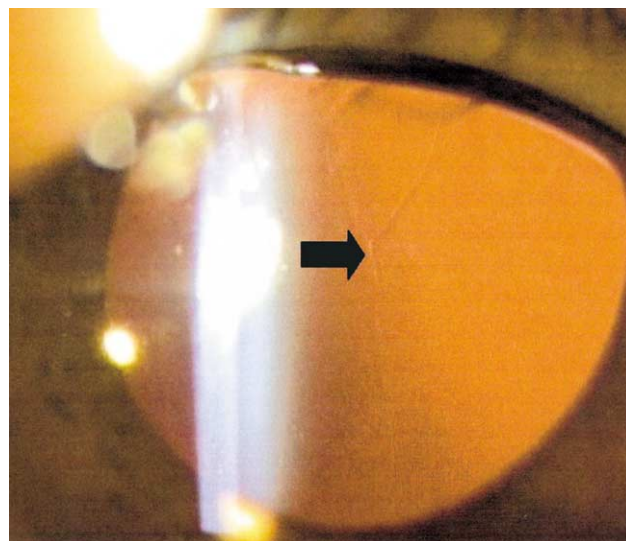


Figure 13. (Rubinfeld) Retroillumination slitlamp photograph of interface folds (arrows) visible in the transected flap in Case 7.

revealed marked irregular central corneal astigmatism (Figure 14). Twenty-four months post enhancement, the BSCVA in the right eye remained 20/40⁻ with a correction of -0.25 +1.75 × 43 and the topography continued to demonstrate a highly irregular central corneal surface.

Refractive Surgeon Survey

Fifty refractive surgeons were surveyed about their enhancement techniques and experience. Twenty-eight surgeons responded, and these results are presented in Figures 15 to 19. On average, the surgeons recut flaps 18% of the time in 1998; this was reduced to 1% in 2002. The major

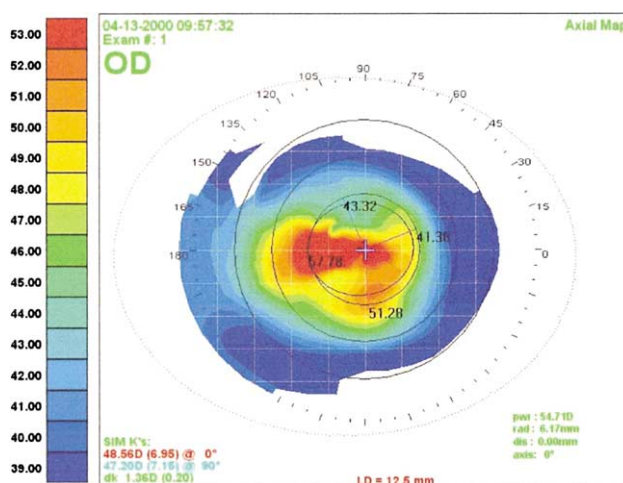


Figure 14. (Rubinfeld) Axial topography demonstrating marked irregular central corneal astigmatism in Case 9.

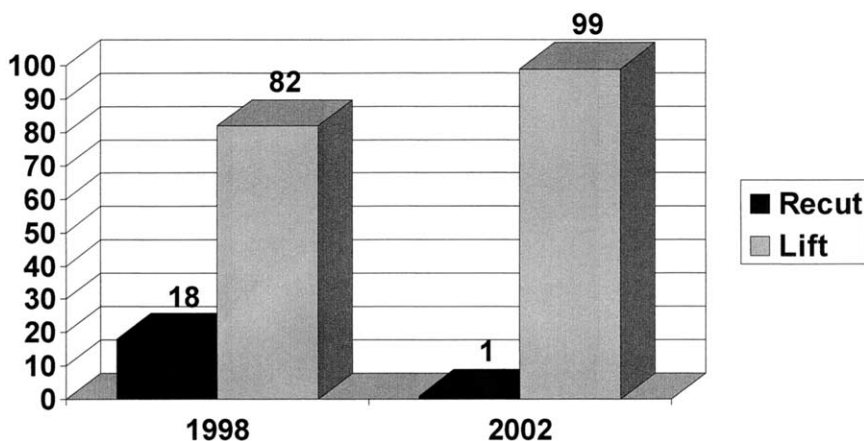


Figure 15. (Rubinfeld) Mean percentage of recutting and lifting enhancement procedures performed in 1998 and 2002 by survey respondents.

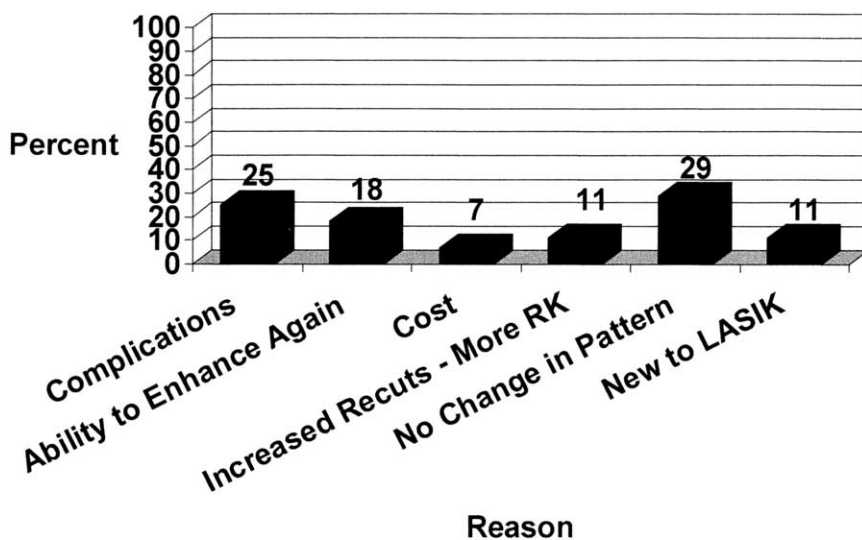


Figure 16. (Rubinfeld) Reasons survey respondents had changed their percentage of recutting and lifting procedures from 4 years earlier.

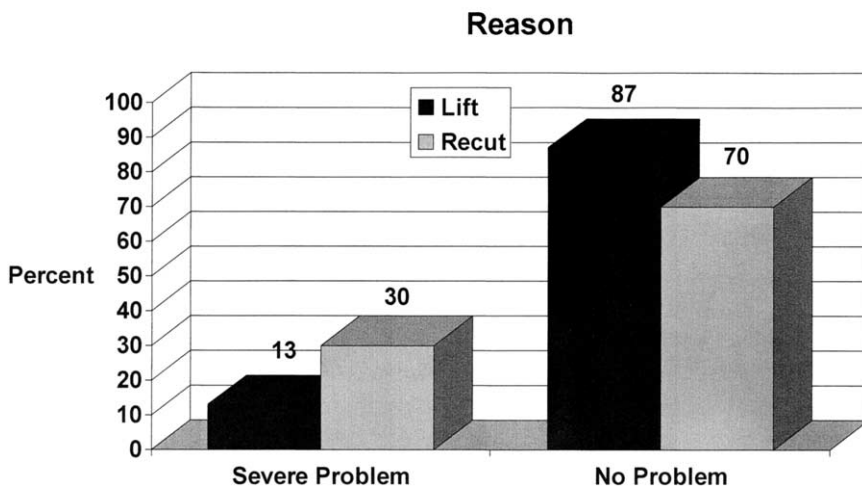


Figure 17. (Rubinfeld) Percentage of survey respondents who had experienced a severe problem when lifting or recutting a flap.

reasons for changing from recutting to lifting were personal complications with the recutting technique, discussions with other surgeons who had experienced complications with the recutting technique, or the ability to enhance again by lifting the flap if needed. In 1998, most surgeons did not create an initial flap large enough for a hyperopic enhancement if they were treating a myopic eyes; however, most indicated that

they currently often made an initial flap that was large enough for hyperopic or myopic treatment. Of the respondents, 13% had encountered a severe problem with a flap lifting enhancement and 30% with a recutting enhancement, while most had not encountered a problem with either technique. Some surgeons in the study had successfully lifted flaps 9 years after primary LASIK.

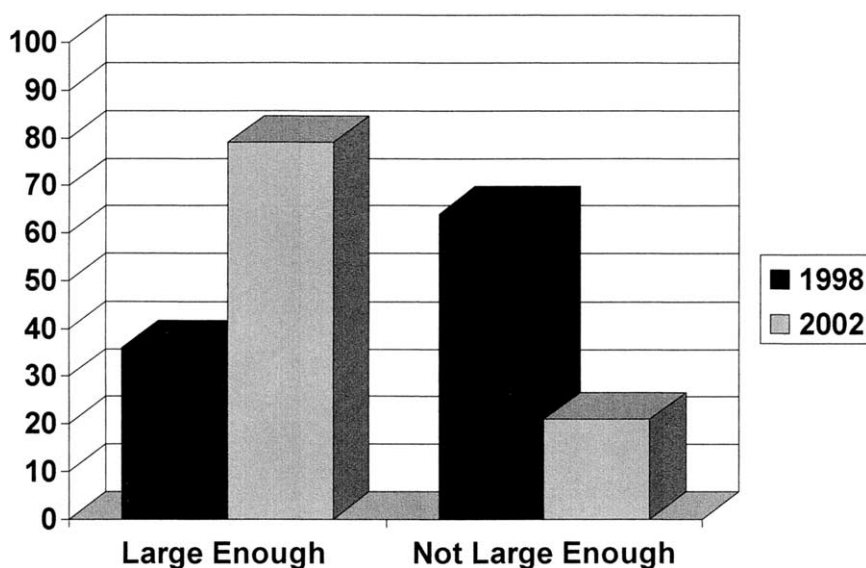


Figure 18. (Rubinfeld) Percentage of survey respondents who made the initial flap large enough to lift for myopic and hyperopic enhancements in 1998 and 2002.

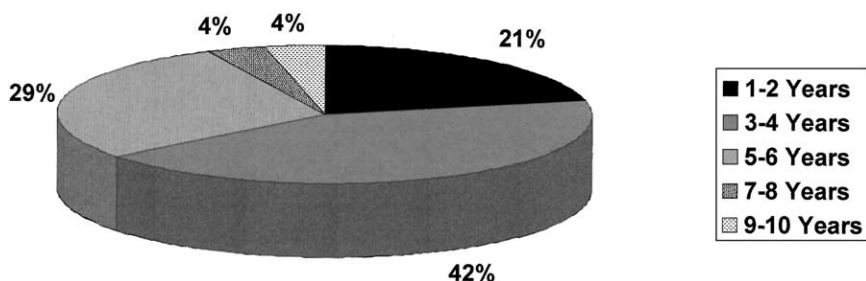


Figure 19. (Rubinfeld) Latest time survey respondents successfully lifted a lamellar flap for enhancement.

Discussion

Although lamellar refractive surgery is nearly 50 years old, it remains a field in evolution. Techniques, indications, and instrumentation should be and are constantly undergoing change and reevaluation to produce the best possible results. This process of continuous improvement in outcomes and safety is important in all fields of surgery but is perhaps even more critical in elective procedures such as LASIK.

Laser in situ keratomileusis enhancement is a commonly performed procedure. Many investigators have suggested that it might best be accomplished by recutting a new flap 3 to 12 months after the original procedure.¹⁻¹¹ Currently, the timing and choice of enhancement technique are areas of controversy in lamellar refractive surgery. Studies to determine the optimum approach to enhancement have been performed¹²⁻¹⁶ and are underway.

As more and more enhancements are performed, the question of whether to lift or recut becomes critical.

There are scattered reports of complications involving fragmented or transected flaps during recutting for enhancement,^{8,17,18} including 1 case of "flap maceration" and flap loss.¹⁵ This paper is the first reported series of vision-threatening complications associated with flap recutting for LASIK enhancement.

Several factors predispose to serious flap complications during recutting for enhancement. Foremost is the lack of reproducibility of corneal flap thickness, even when the same type of microkeratome is used.¹⁹⁻²² In one study, the mean flap thickness produced by a single microkeratome was $120.8 \pm 26.3 \mu\text{m}$. With variability of this magnitude, using a depth plate or setting 20 μm deeper for the second flap does not guarantee that transection of the original flap plane will not occur. In some cases, deeper plates or settings may not be available for recutting a second flap. Even if the actual cut is 20 μm deeper than the first, it is possible to disrupt the shallower lamellae.

Also, various vector forces make transection of the original plane possible when a different microkeratome is used for the recut.¹⁸ Another factor that contributes to variability in the depth of the microkeratome cut is the intensity and duration of microkeratome suction.²³

Corneal curvature and corneal thickness¹⁹ as well as surgeon translational velocity and turbine velocity²⁴ also affect the cutting depth of microkeratomers. The depth of cuts in the first eye are reported to be deeper than those in the second eye.²⁵ The net result of these multiple variables is an inherent risk for flap transection during recutting with all available mechanical microkeratomers.

In addition to these concerns, we believe there are other compelling reasons to avoid recutting flaps for enhancement whenever possible. In a recent study,¹⁶ lifting the original flap yielded statistically significantly better uncorrected vision and refractive stability 1 year after enhancement than recutting a new flap. Even if lifting and recutting provided the same refractive results, one means of choosing the better approach for patients needing enhancement might involve assessment of the severity of the intraoperative and postoperative complications associated with each of these surgical options. The potential complications of recutting flaps, as our report demonstrates, include transection of the original lamellar plane with potentially sight-threatening loss of BCVA. Transecting a flap is virtually impossible with blunt dissection compared with the use of a microkeratome blade. Potential problems associated with lifting flaps include the increased risks for epithelial ingrowth and DLK. It is also possible that subepithelial fibrosis, tearing the flap, and striae may occur at a higher rate with lifting than with recutting, although these theoretical concerns have not been demonstrated. The key issue is that most complications that may occur with flap lifting are generally reversible, self-limited, or treatable.

Another reason lifting may be preferred over recutting is the possibility of future enhancements. A significant number of patients having an enhancement may desire additional future surgery. If 2 lamellar planes have been cut, it may be difficult for the surgeon to determine which flap to lift in the next surgery. This likely increases the risk for buttonholing the flap or lamellar transection upon lifting a flap that has been recut. Similarly, confusion can result if epithelial ingrowth develops in an eye that has been recut for LASIK enhancement. It can be difficult or impossible to deter-

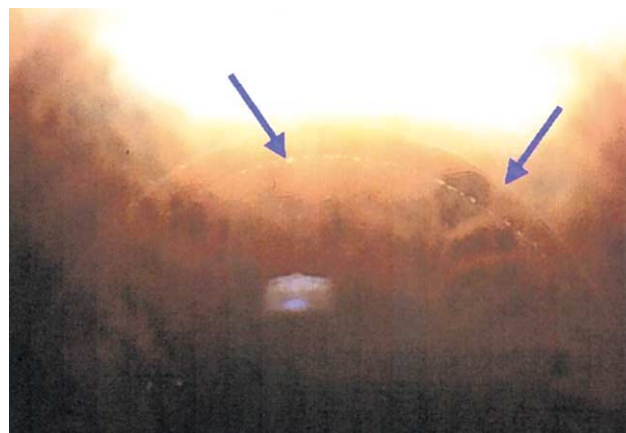


Figure 20. (Rubinfeld) Slitlamp photograph of correct placement of a recut incision. The recut flap incision (lower arrow) is peripheral to the initial flap incision (upper arrow) (courtesy of Stephen G. Slade, MD).

mine in which plane or lamellar incision the cells are located, as in Case 6. Similar confusion can result when striae occur in an eye that has been recut for enhancement. It may not be apparent in which lamellar flap plane the striae are present, as illustrated in another case in this series.

In all our cases (with the possible exception of Case 3), all appropriate guidelines for safe flap recutting were observed. These include using a deeper plate on the same type of microkeratome when possible, waiting at least 5 months after the primary procedure, and starting the cut “outside” the original flap, ie, between the first cut and the limbus (Figure 20). Despite adherence to commonly accepted guidelines by expert surgeons, these prudent precautions did not prevent recut complications that resulted in persistent loss of BCVA.

In rapidly evolving fields such as lamellar refractive surgery, it is not uncommon for leading surgeons to modify their techniques before publication of scientific papers or texts in a process of continuous evolution. The results of our survey demonstrate this evolution in that most respondents did not recut flaps or they had shifted their preferred enhancement technique from recutting to lifting (Figure 14). If lifting flaps whenever possible is preferable to recutting, several implications follow. First, as many of the surveyed surgeons described, flaps for most primary LASIK flaps should be large enough to allow the possibility of future hyperopic enhancement without the need for recutting. Although these larger flaps may carry a higher risk for bleeding

from neovascularization, induce more dry-eye symptoms, or be more difficult to lift many years after LASIK,⁸ we believe these risks are outweighed in many cases by the risks of recutting. As a corollary to this, in patients with preexisting flaps less than 9.0 mm in diameter, it may be preferable to perform hyperopic enhancements by lifting the flap and using small optical zones. Also, if recutting flaps is to be avoided, enhancements should be performed in a timely manner to minimize the need to lift flaps several years postoperatively.

Certain surgical techniques may optimize the success and reduce the risks of flap lifting. These include marking the flap edge at the slitlamp with a Sinskey-type hook and controlled tearing or capsulorhexis of the flap, taking care to produce clean edges with minimal epithelial disruption. Instilling a saline solution in the interface, similar to what the surgeon routinely uses for the microkeratome pass, may help reduce friction and improve the blunt lamellar dissection, especially in older flaps. Postoperative bandage contact lenses may also be helpful.

If lifting for enhancement is found to be generally preferable to recutting after future analysis in large multicenter prospective trials, there will still be indications for recutting when lifting is not possible. These include a previous incomplete or thin flap, a primary flap too small for effective hyperopic treatment, an inability to relift because of extensive healing, previous radial keratotomy surgery, and previous recutting. In such circumstances, recutting using current techniques might be appropriate if one is careful to use the same type of microkeratome. With time, the availability of new microkeratomes might make recutting flaps safer and more consistent. There may also be a role for transepithelial PTK/photorefractive keratectomy when recutting is not possible, especially in cases of complicated primary flaps. Photorefractive keratectomy following lamellar surgery is not recommended because of the increased risk for corneal scarring.²⁷ The use of adjunctive mitomycin-C to prevent corneal scarring in patients who have had lamellar flaps may make surface ablation a preferable treatment option in some patients.²⁸

In some cases, recutting a flap for enhancement will remain a viable option. However, we hope surgeons keep several issues in mind: First, that the nearly unrecognized and relatively unreported potential complication of transection of the previous lamellar plane can

occur. Second, if it does occur, it may be so subtle and nearly invisible that careful, highly experienced surgeons may be initially unaware of the problem. Finally, if flap transection does occur, we recommend that the loose tissue segment be carefully replaced and repositioned if possible and further ablation be postponed, although it is not possible to determine whether doing so in our series would have altered the outcomes.

If it is not possible to smoothly reposition loose tissue segments caused by recutting, removal of the extra segment may prevent an elevated area in the region of the loose tissue segment. Typically, the cornea will remodel depressed areas more smoothly than elevated areas through epithelial hyperplasia. It may also be safer to avoid lifting a recut flap by sweeping a spatula under it, which may dislodge a sliver of transected tissue. A forceps might be used more safely to lift a recut flap by its edges. Similarly, great care should be used when introducing an irrigation cannula under a recut flap.

While we believe, based on the information presented, that lifting flaps for enhancement is generally preferable to recutting flaps, each patient and surgeon is different. This remains an individual choice to be made based on the available information and discussion with the patient to provide the optimal results in each case.

References

1. Pallikaris IG, Siganos DS. Laser in situ keratomileusis to treat myopia: early experience. *J Cataract Refract Surg* 1997; 23:39–49
2. Waring GO III, Carr JD, Stulting RD, Thompson KP. Prospective, randomized comparison of simultaneous and sequential bilateral LASIK for the correction of myopia. *Trans Am Ophthalmol Soc* 1997; 95:271–284
3. Lindstrom RL, Hardten DR, Chu YR. Laser in situ keratomileusis (LASIK) for the treatment of low, moderate, and high myopia. *Trans Am Ophthalmol Soc* 1997; 95:285–296; discussion, 296–306
4. Farah SG, Azar DT, Gurdal C, Wong J. Laser in situ keratomileusis: literature review of a developing technique. *J Cataract Refract Surg* 1998; 24:989–1006
5. Wilson SE. LASIK: management of common complications. *Cornea* 1998; 17:459–467
6. Stulting RD, Carr JD, Thompson KP, et al. Complications of laser in situ keratomileusis for the correction of myopia. *Ophthalmology* 1999; 106:13–20
7. Gimbel HV. Flap complications of lamellar refractive surgery [editorial]. *Am J Ophthalmol* 1999; 127:202–204

8. Machat JJ. Postoperative LASIK management. In: Machat JJ, Slade SG, Probst LE, eds, *The Art of LASIK*, 2nd ed. Thorofare, NJ, Slack, 1999; 257–259
9. Probst LE, Machat JJ. LASIK enhancement techniques and results. In: Machat JJ, Slade SG, Probst LE, eds, *The Art of LASIK*, 2nd ed. Thorofare, NJ, Slack, 1999; 233–234
10. Pérez-Santonja JJ, Ayala MJ, Sakla HF, et al. Retreatment after laser in situ keratomileusis. *Ophthalmology* 1999; 106:21–28; discussion by ME Whitten, 28
11. Martines E, John ME. The Martines enhancement technique for correcting residual myopia following laser assisted in situ keratomileusis. *Ophthalmic Surg Lasers* 1996; 27:S512–S516
12. Pérez-Santonja JJ, Bellot J, Claramonte P, et al. Laser in situ keratomileusis to correct high myopia. *J Cataract Refract Surg* 1997; 23:372–385
13. Yang B, Chen J, Wang Z. Enhancement ablation for the treatment of undercorrection after excimer laser in situ keratomileusis for correcting myopia. *Chin Med J* 1998; 111:358–360
14. Durrie DS, Aziz AA. Lift-flap retreatment after laser in situ keratomileusis. *J Refract Surg* 1999; 15:150–153
15. Domniz Y, Comaish IF, Lawless MA, et al. Recutting the cornea versus lifting the flap: comparison of two enhancement techniques following laser in-situ keratomileusis. *J Refract Surg* 2001; 17:505–510
16. Davis EA, Hardten DR, Lindstrom M, et al. LASIK enhancements; a comparison of lifting to recutting the flap. *Ophthalmology* 2002; 109:2308–2313; discussion by RS Rubinfeld, 2313–2314
17. Gimbel HV, Anderson Penno EE. *LASIK Complications; Prevention and Management*. Thorofare, NJ, Slack, 1999; 97
18. Peters NT, Iskander NG, Gimbel HV. Minimizing the risk of recutting with a Hansaome over an existing Automated Corneal Shaper flap for hyperopic laser in situ keratomileusis enhancement. *J Cataract Refract Surg* 2001; 27:1328–1332
19. Yildirim R, Aras C, Ozdamar A, et al. Reproducibility of corneal flap thickness in laser in situ keratomileusis using the Hansatome microkeratome. *J Cataract Refract Surg* 2000; 26:1729–1732
20. Kohnen T. Need for intraoperative measurement of corneal thickness during LASIK [editorial]. *J Cataract Refract Surg* 2000; 26:1695–1696
21. Maldonado MJ, Ruiz-Oblitas L, Munuera JM, et al. Optical coherence tomography evaluation of the corneal cap and stromal bed features after laser in situ keratomileusis for high myopia and astigmatism. *Ophthalmology* 2000; 107:81–87; discussion by DR Hardten, 88
22. Jacobs BJ, Deutsch TA, Rubenstein JB. Reproducibility of corneal flap thickness in LASIK. *Ophthalmic Surg Lasers* 1999; 30:350–353
23. Seo KY, Wan XH, Jang JW, et al. Effect of microkeratome suction duration on corneal flap thickness and incision angle. *J Refract Surg* 2002; 18:715–719
24. Kim YH, Choi J-S, Chun HJ, Joo C-K. Effect of resection velocity and suction ring on corneal flap formation in laser in situ keratomileusis. *J Cataract Refract Surg* 1999; 25:1448–1455
25. Gailitis RP, Lagzdins M. Factors that affect corneal flap thickness with the Hansatome microkeratome. *J Refract Surg* 2002; 18:439–443
26. Kapadia MS, Wilson SE. Transepithelial photorefractive keratectomy for treatment of thin flaps or caps after complicated laser in situ keratomileusis. *Am J Ophthalmol* 1998; 126:827–829
27. Carones F, Vigo L, Carones AV, Brancato R. Evaluation of photorefractive keratectomy retreatments after regressed myopic laser in situ keratomileusis. *Ophthalmology* 2001; 108:1732–1737
28. Majmudar PA, Forstot SL, Dennis RF, et al. Topical mitomycin-C for subepithelial fibrosis after refractive corneal surgery. *Ophthalmology* 2000; 107:89–94