Thin flap laser in situ keratomileusis: Analysis of contrast sensitivity, visual, and refractive outcomes

Rosario Cobo-Soriano, MD, PhD, Miguel A. Calvo, MD, Jaime Beltrán, MD, Fernando L. Llovet, MD, Julio Baviera, MD

Purpose: To analyze refractive, visual, and contrast sensitivity outcomes of laser in situ keratomileusis (LASIK) performed under thin flaps (less than 100 μm), and compare them with those of conventional thicker flaps.

Setting: Clínica Baviera, Instituto Oftalmológico Europeo, Madrid, Spain.

Methods: This retrospective study comprised 280 consecutive eyes that had LASIK for myopia using the Moria LSK-One microkeratome and the Technolas 217C excimer laser. Efficacy, predictability, and contrast sensitivity indicators were compared between 3 groups of flap thickness: thin (<100 μm, n = 105), medium (100 to 129 μm, n = 122), and thick (>130 μm, n = 53).

Results: Refractive results were excellent and comparable between the 3 groups; however, visual outcomes—measured as efficacy, postoperative evolution of uncorrected visual acuity, and contrast sensitivity—test were significantly better in the thin flap group. Efficacy results were 92.9%, 91.0%, and 81.0% in the thin, medium, and thick flap groups, respectively ($P < .05$), and the rate of enhancements was 0%, 2.3%, and 5.6%, respectively. With regard to contrast sensitivity, changes between preoperative and postoperative values at month 3 of follow-up, the thin flap group achieved the preoperative levels at 3 spatial frequencies (3, 6, and 18 cycles per degree), while the thicker flap groups maintained lower than preoperative levels at more than 2 spatial frequencies. When comparing contrast sensitivity values between the 3 groups, the thin flap group also obtained the best results at lower spatial frequencies.

Conclusions: Thin flap LASIK is a safe technique to correct myopic defects since it blends the advantages of surface and lamellar procedures (minimal debilitation of corneal biomechanical architecture with the rapid and comfortable visual recovery of lamellar approaches). Moreover, it achieves excellent refractive outcomes, a lower rate of enhancements, and a good visual performance with better contrast sensitivity test results.

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Historically, thin flaps have been classified as a complication of laser in situ keratomileusis (LASIK)[1–4] since they are considered as predisposing to flap folds and postoperative irregular astigmatism with increasing risk for loss of best corrected visual acuity (BCVA) and poorer quality of vision. The best flap thickness has traditionally been considered to be 130 μm to 160 μm.

Recently, after the cumulated experience on hundreds of thousands of LASIK procedures, this concept has been reconsidered and several practitioners have begun to defend the importance of leaving a greater amount of residual corneal bed. Several circumstances have changed the views on this concept: (1) increasing reports of delayed iatrogenic corneal ectasia associated with the LASIK technique[5–8] (not previously reported with photorefractive keratectomy [PRK] in spite of the extreme myopic corrections performed); (2) a better knowledge of corneal biomechanics due to the contribution of elevation topography (Orbscan), with reports

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of greater forward protrusion of the posterior face of the cornea associated with a thinner posterior residual stromal bed[9,10]; (3) modern laser software and current trends toward enlarging the diameter of laser ablations (thus producing deeper stromal tissue subtraction) to provide a wider functional optical zone and minimize nocturnal visual quality disturbances; and (4) aberrations induced by deep lamellar keratectomies when considering wavefront-based and customized ablations.[11,12]

The above-mentioned disadvantages of LASIK stem from a renewed interest in surface ablation techniques such as PRK, laser-assisted subepithelial keratectomy (alcohol-assisted epithelial flap),[13] and epi-LASIK (mechanical epithelial flap) to eliminate the destabilizing corneal cut and to preserve a valuable stromal bed. Despite the fact that these new techniques have improved PRK postoperative healing and have shown excellent results, some disadvantages persist: discomfort, mean healing time from 3.6 to 6.0 days requiring bandage contact lenses, useful vision achieved no earlier than 1 week, destruction of Bowman's membrane, and a higher risk for haze requiring long-term studies.[14]

In fact, lamellar techniques are still the main refractive procedure due to their greater degree of refractive stability and predictability with higher corrections, rapid visual recovery time, less significant postoperative discomfort, and decreased rate of haze complications. Nevertheless, controversies concerning the advantages and disadvantages of lamellar versus surface approaches[14,15] have led to an intermediate technique, thin flap LASIK, which brings together the advantages of both approaches.

Thin flap LASIK involves creating intended regular thin flaps (from 60 μm to 100 μm) instead of a conventional flap to leave a thicker posterior residual stromal bed. This conservation of posterior tissue allows safer correction of relatively higher levels of myopia; preserves biomechanical integrity, especially in thinner corneas; decreases the risk for corneal ectasia; and allows a larger diameter laser ablation optical zone to minimize unwanted scotopic visual symptoms. Thin flap LASIK should not be confused with unintended irregular thin flaps with damage to Bowman's layer due to intraoperative complications, such as poor suction, irregular oscillation speed, or damaged microkeratome blades.

Several surgeons have defended this technique and have published their experience (RT Lin, "Thin Flaps May Decrease the Risk of Post-LASIK Ectasia," Ocular Surg News, July 15, 2002; 20:17; M Lipner, "The Best Flap Ever; the Skinny on the Thin-Flap LASIK," EyeWorld, August 2003; 8:35; M Lipner, "Making the Case for thin Flaps," EyeWorld, October 2002; 7:45–47).[16–19] Microkeratomes including the MK-2000 (Nidek), Automated Corneal Sharper (Bausch & Lomb), SKBM (Alcon), and LSK-One (Moria) have reported keratectomies in the sub-100 μm range, even as low as 60 μm to 70 μm.

Ours is a private ophthalmologic institution with 22 centers located throughout Spain and a staff of 70 ophthalmologists who perform an annual volume of more than 16 000 refractive surgical procedures. We have been working on thin flap LASIK since 1999 and have acquired wide experience (more than 15 000 cases) in this procedure. We have developed a school for training in the use of manually guided microkeratomes (LSK-One) and in performing intentional thin flaps with routinely intraoperative pachymetry to preserve a posterior corneal bed greater than 300 μm. These manual microkeratomes can create different thicknesses of the flaps depending on the manually guided advancing speed. We take advantage of this versatility to customize flap thicknesses according to the degree of myopia, corneal central pachymetry, pupil size, and laser ablation optical zone. We combine 3 variables: advancing speed, the use of 100 μm versus 130 μm footplates, and the use of different blade thicknesses to obtain thin flaps (<100 μm) or medium flaps (from 100 μm to 130 μm). We consider a flap greater than 130 μm as an unintended thick flap, even in cases with no micron compromise.

Recent debates and controversies on this subject in ophthalmologic journals and electronic media have led

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From the Clínica Baviera, Instituto Oftalmológico Europeo, Madrid, Spain.

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Reprint requests to Rosario Cobo-Soriano, MD, PhD, C/Marquesa Viuda de Aldama 52, chalet no. 10, 28109, Madrid, Spain. E-mail: rosario@fcobo.e.telefonica.net.

us to transmit our experience and results of thin flap LASIK and to publish our prevalence of iatrogenic corneal ectasia since 1999 (the point at which we began to control and measure flap thickness and to perform intraoperative pachymetry), which is 0.008% (7 of 85 556 eyes).

Finally, and with regard to refractive and visual performance of thin flap LASIK, we have no reason to suspect irregular corneal astigmatism or a poorer quality of vision since patients do not complain of visual disturbances and we obtain excellent uncorrected visual acuity (UCVA) and BCVA, comparable with results of conventional thicker flap LASIK. Studies of LASIK performed under thin flaps are scarce and focus on the viewpoint of anatomic corneal changes, including confocal microscopy findings and postoperative flap complications. We have been unable to find studies that analyze the repercussion of these microscopic findings on visual performance. We undertook a retrospective and controlled study of thin flap LASIK for myopia based on functional results and compared the results with those in 2 control groups (medium flap and thick flap) by investigating refractive and visual results including the contrast sensitivity, which is a more sensitive evaluation of visual function that better characterizes visual outcomes after LASIK.

Patients and Methods

All consecutive patients who had uneventful LASIK for myopia (spherical myopia, simple, or compound myopic astigmatism) during the 7-month period from January to July 2003 performed by 2 surgeons (R.C.S., M.A.C.) were retrospectively reviewed. One hundred forty-four patients met the study inclusion criteria: (1) preoperative BCVA $\geq$0.7 (amblyopic eyes excluded to obtain greater accuracy in contrast sensitivity test results); (2) Planoscan software (Zyoptix eyes excluded to compare homogeneous groups and to avoid bias by type of laser ablation); and (3) patients who had the complete preoperative and postoperative data (including contrast sensitivity). The study sample included 280 eyes (141 right, 139 left). The mean age of the patients was 32.5 years $\pm$ 7.2 (SD) (range 21 to 58 years). Afterward, the eyes were divided into 3 groups according to intraoperative flap thickness: thin flap ($<$100 μm), medium flap (100 μm to 129 μm), and thick flap ($\geq$130 μm) (105, 122, and 53 eyes, respectively).

All patients had stable refraction for 1 year before the procedure and gave written informed consent.

Patients were studied under the same standard preoperative protocol: UCVA, subjective correction with and without cycloplegia, BCVA, biomicroscopy, tonometry, binocular ophthalmoscopy, ultrasonic pachymetry (DGH Technology Inc.), keratometry, corneal topography (Orbscan, Orbtek Inc.), and contrast sensitivity (CSV-1000, Vector Vision).

The surgical procedure involved presurgical anesthesia with topical eyedrops of tetracaine hydrochloride 0.01% supplemented with oral sedation (alprazolam 0.25 mg). The keratectomies were performed using the Moria LSK-One microkeratome (Microtech). Intraoperative pachymetry was performed in all cases (ultrasonic pachymeter, DGH Technology, Inc.) after the flap was lifted, and flap thickness was calculated by subtracting stromal bed thickness from total central corneal thickness.[24] The Technolas Keracor 217C excimer laser (Bausch & Lomb) with the PlanoScan program was used in all cases. (Patients treated with Zyoptix software were also excluded.)

Follow-up was on the first day, first week, and first and third months after surgery. Postoperative treatment involved topical tobramycin–dexamethasone eyedrops for 1 week and lubricant tears for several months.

The CSV-1000 contrast sensitivity test is a self-standardized vision-testing instrument with photo-cell circuitry that senses external light over a wide range of ambient illumination, and continually monitors and calibrates the instrument light level, providing a constant luminance level of 85 candelas/mm that ensures accurate results in different examinations. For each examination, 4 spatial frequencies (3, 6, 12, and 18 cycles per degrees [cpd]) are tested with 8 sequences per spatial frequency. The CSV-1000 is operated by wireless remote control so that each row of the instrument can be individually lighted for easy viewing by the patient. The test was performed preoperatively and at the third month postoperatively with the best optical correction and the same room luminance conditions.

Postoperative results were classified as follows:

1. *Refractive outcome.* Predictability indicators such as the percentage of eyes that achieved a postoperative spherical equivalent (SE) within $\pm$1.00 D and $\pm$0.50 D, and the percentage of eyes with postoperative defocus equivalent $\leq$1.00 D (defined as the spherical equivalent defect plus one half of cylinder defect in absolute values) were used; this parameter represents more accurately the reality of the residual refractive defect since it does not underestimate the residual astigmatism such as the spherical equivalent.
2. *Visual outcome.* Efficacy was represented as the percentage of eyes with a difference between postoperative UCVA and preoperative BVCA $\geq$0 lines of Snellen visual acuity. Safety was defined as the percentage of eyes with loss of $\geq$1 line between preoperative and postoperative BCVA.

3. *Contrast sensitivity.* Differences in mean values for each spatial frequency between flap thickness groups and between preoperative and postoperative results in each group were measured. For statistical analysis, the values in logarithm units, as recommended in the CSV-1000 norms, were used.
4. *Statistical analysis.* Group differences in continuous variables were tested using the paired and unpaired Student *t* test and analysis of variance (ANOVA) with Bonferroni correction. Chi-square and Fisher exact tests were used for comparing percentages between independent groups. Statistical differences were considered significant when the *P* value was less than 0.05.

Results

In all 280 eyes, the mean preoperative refractive values were as follows: sphere −3.87 ± 2 D (range 1 to −11.0 D), cylinder −0.84 to 0.8 D (range 0 to −4.0 D), and spherical equivalent (SE) −4.29 ± 1.9 D. The mean BCVA was 0.97 ± 0.06 (range 0.7 to 1.0); 94.8% of eyes had a BCVA ≥0.9. The mean K-value was 43.69 ± 1.50 D (range 40.25 ± 47.25 D). The mean Orbscan mesopic pupil diameter was 4.26 ± 0.67 mm (range 3.0 to 6.0 mm) and the mean pachymetry, 550.46 ± 32.30 μm (range 485 to 650 μm).

Table 1 shows the preoperative patient data by group. There were no significant differences in any parameter except the K-values (steeper corneas had thickest flaps) and total pachymetry (thicker corneas had thicker flaps).

In all 280 eyes, the mean intraoperative values were as follows: mean ablation optical zone 5.86 ± 0.16 mm (range 5.0 to 6.8 mm), ablation depth 76.9 ± 27.7 μm, flap thickness 107.4 ± 22.0 μm (range 60 to 185 μm),

Table 1. Preoperative data in the 3 groups.

Parameter	Thin Flap Group n = 105	Medium Flap Group n = 122	Thick Flap Group n = 53	*P* Value*
Age, y				
Mean (SD)	31.6 (6.7)	33.45 (7.2)	32.2 (7.4)	.13
Range	21 to 51	21 to 58	21 to 58	
Mean BCVA (SD)	0.98 (0.07)	0.98 (0.06)	0.97 (0.08)	.6
Sphere, D				
Mean (SD)	−3.89 (2.30)	−3.76 (1.84)	−3.98 (1.95)	.7
Range	0 to −11.0 D	0 to −10.5 D	0 to −9.0 D	
Cylinder, D				
Mean (SD)	−1.00 (0.65)	−0.99 (0.79)	−0.73 (0.71)	.06
Range	0 to −3.0 D	0 to −4.0 D	0 to −3.0 D	
SE, D				
Mean (SD)	−4.30 (2.00)	−4.21 (1.75)	−4.4 (1.98)	.8
Range	0 to −11.5 D	−1 to −10.8 D	−1 to −9.38	
K-value				
Mean (SD)	43.48 (1.4)	43.6 (1.5)	44.34 (1.45)	<.01
Range	40.25 to 47	40.5 to 47.25	40.75 to 47.25	
Pachymetry, μm				
Mean (SD)	536.28 (30)	553.26 (28)	570.2 (33.8)	<.01
Range	490 to 625	485 to 625	515 to 650	
Pupil diameter, mm				
Mean (SD)	4.29 (0.65)	4.22 (0.63)	4.28 (0.8)	.7
Range	2.8 to 5.9	2.5 to 5.6	2.5 to 6.0	

SE = spherical equivalent
*ANOVA test

Table 2. Intraoperative data in the 3 groups.

Parameter	Thin Flap Group n = 105	Medium Flap Group n = 122	Thick Flap Group n = 53	*P* Value*
Flap thickness, μm				
Mean (SD)	84.8 (10.0)	111.0 (8.4)	141.5 (14.0)	<.01*
Range	60 to 99	100 to 128	130 to 195	
Ablation depth, mm				
Mean (SD)	77.17 (30)	77.19 (26)	75.58 (27.2)	.9*
Range	30.2 to 146	29 to 134	30 to 146	
Stromal bed thickness, μm				
Preablation				
Mean (SD)	451.7 (30)	443.4 (28.5)	428.7 (36)	<.01*
Range	395 to 540	377 to 525	365 to 515	
Postablation				
Mean (SD)	370.2 (40)	363.6 (35)	355.36 (47)	.08*
Range	291 to 462	299 to 456	285 to 510	Thin/thick .04†
Optical zone, mm				
Mean (SD)	5.86 (0.20)	5.88 (0.19)	5.84 (0.20)	.4*
Range	5.3 to 6.8	5 to 6.8	5.2 to 6.5	

*ANOVA test
†Unpaired *t* test

preablation stromal bed 443.5 ± 31.0 μm (range 365 to 540 μm), and postablation stromal bed 364.6 ± 39.6 μm (range 295 to 510 μm).

Table 2 shows the intraoperative patient data by group. The stromal bed before and after ablation was significantly larger in the thin flap group than in the medium flap and thick flap groups.

In all 280 eyes, the mean refractive values at the third postoperative visit at a mean of 116.2 ± 26 days were as follows: sphere −0.06 ± 0.29 D, cylinder −0.26 ± 0.28 D, and SE −0.19 ± 0.30 D; 98.5% of eyes were within ±1.00 D of the SE, 91.78% were within ±0.50 D of the SE, and 96.7% were within ±1.00 D or less of the defocus equivalent. The mean UCVA was 0.96 ± 0.09. Figure 1 shows the UCVA from the first to the third week postoperatively by group.

Table 3 shows the preoperative and postoperative contrast sensitivity in all eyes. The contrast was statistically significantly worse at higher spatial frequencies.

Table 4 shows the preoperative and postoperative contrast sensitivity results by group. Results in the thin flap group were statistically significantly better than in the other 2 groups at 3 cpd and 6 cpd.

The thin flap group achieved the best results in the within-group difference between preoperative and postoperative contrast sensitivity, achieving preoperative levels at 3 frequencies. The medium and thick flap groups had lower than preoperative contrast sensitivity

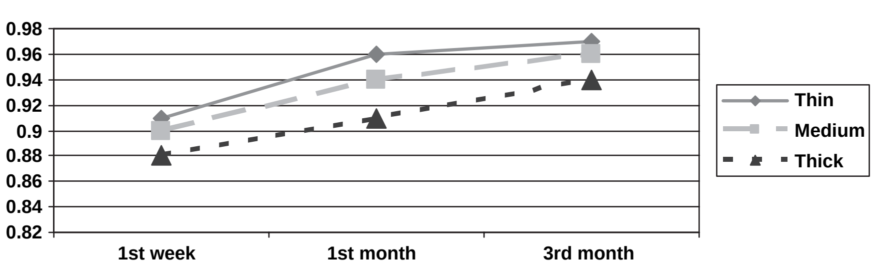

Figure 1. Comparison of postoperative evolution of UCVA (mean values) by flap thickness (μm).

Table 3. Preoperative and postoperative contrast sensitivity values in all 280 eyes at 3 months.

Frequency	Mean (SD) Preoperative	Postoperative	*P* Value*
3 cpd (row A)	1.56 (0.19)	1.56 (0.20)	.8
6 cpd (row B)	1.79 (0.22)	1.73 (0.20)	<.01
12 cpd (row C)	1.41 (0.27)	1.34 (0.20)	<.01
18 cpd (row D)	1.01 (0.27)	0.94 (0.20)	<.01

cpd = cycles per degree
*Paired *t* test

levels at more than 2 spatial frequencies at 3 months. Table 5 shows the *P* values for the within-group differences between preoperative and postoperative contrast sensitivity.

Table 6 shows the efficacy, predictability, and safety by group. Although the thin flap group had the best outcomes, the difference was statistically significantly only for efficacy. The efficacy in all eyes was 90%. Safety, measured as the percentage of eyes that lost 1 or more lines of Snellen visual acuity, was 1.4%; no eye lost 2 or more Snellen lines.

The percentage of enhancements at 3 months was 2.6% overall. It was 0% in the thin flap group, 2.3% in the medium flap group, and 5.6% in the thick flap group.

Discussion

The purpose of this study was to ascertain whether the historical concerns and stigma associated with thin flaps in LASIK surgery such as irregular astigmatism, flap folding, and interface alterations had a real and objective clinical repercussion on visual and refractive outcomes. Traditionally, a >130 μm flap has been recommended based on the belief that thin flaps are wrinkle prone as they tend to collapse to fit the central corneal bed and because they are more difficult to manipulate and position correctly.[20] Other studies of confocal microscopy in myopic LASIK have found higher postoperative cellular activation with increased reflectivity at the interface level associated with the thinnest flaps.[21,22] However, in recent years, there have been an increasing number of articles reporting positive experiences with thin/ultrathin flap LASIK. Yeo and Song[23] reported the clinical features in 27 eyes with an unintended thin corneal flap ≤100 μm, and found no statistical differences with the control group regarding postoperative anatomic complications such as interface debris, mild peripheral infiltration, superficial punctate keratitis, myopic regression, and decreased vision. Lin et al.[17] reported visual acuity and anatomic results in a large sample of ultrathin flap LASIK (from 45 to 130 μm) and found no significant anatomic complications. Turner (cited in Lin et al.) obtained similar visual outcomes with thin flaps. Chayet[16] introduced ultrathin flaps to his LASIK practice in 1998. Not only was he unable to find an increase in irregular astigmatism, he also noticed that visual rehabilitation was faster following thinner flaps. The present study shows that LASIK performed with regular thin flaps achieves excellent predictability results comparable with the results of conventional LASIK, better visual results measured as efficacy parameters, a more rapid visual postoperative recovery (Figure 1) consistent with Chayet,[16] a lower rate of enhancements, and a better contrast sensitivity acuity than LASIK with thicker flaps.

Anatomic Complications

This study aimed to evaluate only functional and visual results, but we did not find significant anatomic

Table 4. Contrast sensitivity: comparative analysis between groups.

Frequency	Preoperative Data, Mean (SD) Thin	Medium	Thick	*P* Value*	Postoperative Data, Mean (SD) Thin	Medium	Thick	*P* Value*
3 cpd	1.57 (0.18)	1.58 (0.18)	1.54 (0.16)	.35	1.60 (0.19)†	1.56 (0.17)	1.51 (0.15)	<.01
6 cpd	1.81 (0.21)	1.80 (0.20)	1.77 (0.16)	.40	1.77 (0.20)†	1.71 (0.19)	1.71 (0.20)	<.05
12 cpd	1.46 (0.25)	1.40 (0.26)	1.37 (0.25)	.07	1.39 (0.28)	1.32 (0.27)	1.30 (0.19)	.05
18 cpd	1.05 (0.26)	1.00 (0.30)	0.98 (0.26)	.20	0.99 (0.28)	0.91 (0.26)	0.92 (0.22)	.056

*ANOVA test
†Bonferroni test

Table 5. Contrast sensitivity *P* values, comparison of preoperative and postoperative results within groups.

	P Value*		
Frequency	**Thin Flap**	**Medium Flap**	**Thick Flap**
3 cpd	.2	.2	.47
6 cpd	.16	<.01	<.05
12 cpd	<.05	<.01	<.01
18 cpd	.09	<.01	.12

*Paired *t* test

Table 6. Standard predictability and visual outcomes by flap thickness.

			Predictability (%)	
Flap Group	**Efficacy**	**Safety**	**±0.5 D**	**Defocus ≤1.0 D**
Thin	92.9%	0.95%	91.4%	97%
Medium	91%	0.8%	92.6%	97.5%
Thick	81%	3.7%	88.6%	94.3%
P value	<.05*	NS†	NS*	NS*

NS = not significant
*Chi square
†Fisher exact test

complications. In biomicroscopic terms, thin flaps usually have a more pronounced edge or slight microfolding that is evident with retroillumination, but these findings seem negligible and without clinical significance. Even extremely thin flaps with 10 to 20 μm of stroma under the epithelium have smooth stromal beds with no breaks in Bowman's membrane and no appearance of buttonhole or other complications.

Stromal Bed Thickness and Iatrogenic Ectasia

The true incidence of iatrogenic keratectasia after LASIK is still unknown and might not emerge until longer-term follow-up studies are conducted. The only reliable data from a large series were reported by Pallikaris and coauthors[6] with a prevalence of 0.66% (19 out of 2873 eyes) after a follow-up period of over 4 years. Several studies indicate that the amount of residual corneal thickness after ablation is a factor in the development of post-LASIK ectasia. Ou and coauthors[7] reported 3 eyes that developed iatrogenic keratectasia after LASIK with no preoperative evidence of subclinical keratoconus and calculated the residual corneal bed in 57 previous cases of keratectasia published in the literature. They calculated a range of residual stromal bed from 113 to 353 μm, with 51% of the reported cases under 250 μm. Other studies have emphasized that a low residual stromal bed is a significant risk for developing iatrogenic keratectasia.

We revised and collected all the cases with a diagnosis of iatrogenic keratectasia from the records of our institution since 1999 and reported a rate of 0.008%, which is negligible and significantly lower than published. We attribute our low rate of ectasia (more than 85 000 LASIK procedures during a 5-year follow-up period) to the exhaustive intraoperative control and measurements of flap and residual stromal bed thickness that is routinely performed by all the staff. While the etiology and biomechanical changes that induce keratectasia after LASIK remain unknown, it is necessary to minimize 1 of the risk factors we can control by maximizing the amount of residual stromal tissue.

Variables That Influence Flap Thickness

Numerous factors can affect flap thickness. We found a positive correlation with central corneal thickness, as did other studies,[24–28] and with preoperative keratometry, in contrast with findings of other authors who found no relationship[26] or an inverse relationship.[27] This controversy is probably due to differences in microkeratome features.

Change in Contrast Sensitivity

It is well known that functional vision changes occur following corneal refractive surgery. Several studies have demonstrated that myopic LASIK induces a significant decrease in contrast sensitivity test values, which is directly related to the degree of refractive error and the amount of corneal tissue ablated. This improves and usually returns to preoperative levels during a variable time of recovery, which ranges from 3 to 12 months later.[29–34] Our contrast sensitivity results showed a general depression at 6, 12, and 18 cpd spatial frequencies at 3 months post-LASIK, but when analyzing the results with regard to flap thickness, the thin flaps achieved better results when comparing the 3 groups and a more rapid recovery with 3 spatial frequencies that obtained the preoperative levels at that time.

Thin flap LASIK is a safe technique to correct myopic defects since it blends the advantages of surface procedures (minimal debilitation of corneal biomechanical architecture) with the rapid and comfortable visual recovery of lamellar approaches. It achieves excellent refractive and visual results, a lower rate of enhancements, and good contrast sensitivity results. To finalize, it is worth mentioning that the main reason for creating thinner flaps is to have stronger corneas with wider ablations that provide higher vision quality and not to extend the range of power correction.

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