ORIGINAL RESEARCH

Laser in situ keratomileusis enhancement for correcting residual refractive error

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Abstract

Aim: To study the results of laser in situ keratomileusis (LASIK) enhancement for residual refractive error.

Patients and methods: 121 eyes of 101 patients had LASIK enhancement done after a previous LASIK procedure. The average time after initial surgery was 121.2 ± 56.2 days (range, 83 to 433 days). The patients were divided into 4 groups according to their refraction: group I, -1.0 to -5.0 D (4 eyes); group II, -5.1 to -10.0 D (57 eyes); group III, -10.1 to -15.0 D (44 eyes); and group IV, >15.0 D (16 eyes). The mean pre-LASIK spherical equivalent of each group was: group I, -3.70 ± 1.01 D (range, -2.50 to -4.63 D); group II, -7.82 ± 1.47 D (range, -5.13 to -9.88 D); group III, -12.20 ± 1.44 D (range, -10.13 to -14.88 D); and group IV, -20.60 ± 3.40 D (range, -15.25 to -27.50 D). The mean pre-LASIK enhancement spherical equivalent of each groups was: group I, +0.97 ± 0.89 D (range, -0.13 to +2.00 D); group II, -1.15 ± 1.22 D (range, -4.63 to +2.13 D); group III, -2.22 ± 0.99 D (range, -3.88 to -0.50D); and group IV, -6.62 ± 3.52 D (range, -11.88 to +0.25 D). The spectacle corrected visual acuity before the first laser in situ keratomileusis was 20/40 or better for 111 eyes (92%), apart from 6 eyes in group III and 4 eyes in group IV. Patients were followed at 1 day, 1 week, 1 month, 3 months, 6 months, and 12 months.

Results: Eighty five eyes (71%) were followed up at 3 months and 12 months, and 79 eyes (65.3%) at 6 months after LASIK enhancement. The mean spherical equivalent at 3 months for group I was +0.440 ± 0.800D (range, -0.125 to +1.000 D); for group II, -1.170 ± 0.880 D (range, -2.875 to +0.875 D); for group III, -1.120 ± 1.450 D (range, -3.750 to +2.000D); and for group IV, -3.630 ± 3.330 D (range, -11.000 to +0.250 D). At 12 months, the mean spherical equivalent was + 0.310 ± 0.440 D (range, 0 to + 0.625 D) for group I; -0.200 ± 1.030 D (range, –2.750 to +2.250 D) for group II; -0.550 ± 1.040 D (range, -4.375 to +1.250 D) for group III; and -1.950 ± 2.130 D (range, -7.000 to +0.500 D) for group IV. The post-LASIK enhancement uncorrected visual acuity improved in 110 eyes (91%), reduced 1 line in 2 eyes, 2 lines in 2 eyes, and no change in 7 eyes. Among the 85 eyes followed up at 12 months, 66 eyes (78%) had uncorrected visual acuity of 20/40 or better. At 12 months follow-up, no eye had spectacle corrected visual acuity of less than 20/40.

Conclusions: Laser in situ keratomileusis enhancement is effective in reducing the residual refractive error and improving the uncorrected visual acuity after laser in situ keratomileusis.

Key words: Laser in situ keratomileusis, Myopia

Introduction

Laser in situ keratomileusis (LASIK) for surgical correction of myopia is gaining acceptance as a versatile refractive surgical procedure. Quick visual rehabilitation, minimal postoperative discomfort, and absence of postoperative corneal haze are some reasons for LASIK's popularity over other

refractive procedures. The reported predictability of LASIK has been promising.[1-3] Nevertheless, as with any refractive procedure, enhancement will be indicated in some cases. One of the advantages of LASIK is that a repeat procedure may be readily and accurately performed.[4] In this study, the results of a series of patients with LASIK enhancement were evaluated.

Patients and methods

121 eyes of 101 patients had LASIK enhancement done from September 1996 to February 1998 at the Department of Ophthalmology at the Hong Kong Sanatorium & Hospital. The mean age of the 63 women and 38 men was 36.83 years (range, 21.00 to 65.00 years). 103 eyes (85.0%) had previously worn contact lenses, with soft lenses in 48 eyes (40.0%), gas permeable lenses in 40 eyes (33.0%), and hard lenses in 15 eyes (12.4%).

The patients were divided into 4 groups according to their pre-LASIK refractions:
- group I (-1.00 to -5.00 D) included 4 eyes with a mean spherical equivalent (SE) of -3.70 ± 1.01D (range, -2.50 to -5.00 D)
- group II (-5.10 to -10.00 D) included 57 eyes with a mean SE of -7.82 ± 1.47 D (range, -5.13 to -9.88 D)
- group III (-10.10 to -15.00 D) included 44 eyes with a mean SE of -12.20 ± 1.44 D (range, -10.13 to -14.88 D)
- group IV (>15.00 D) included 16 eyes with a mean SE of -20.60 ± 3.40 D (range, -15.25 to -27.50) [**Table 1**].

The mean pre-enhancement SE of each group was
- group I, +0.97 ± 0.89 D (range, -0.13 to +2.00 D)
- group II, -1.15 ± 1.22 D (range, -4.63 to +2.13 D)
- group III, -2.22 ± 0.99 D (range, -3.88 to -0.50 D
- group IV, -6.62 ± 3.52 D (range, -11.88 to +0.25D) [**Table 2**].

111 eyes (92%) had a spectacle corrected visual acuity (SCVA) of 20/40 or better, apart from 6 eyes in group III and 4 eyes in group IV before the first LASIK.

The initial LASIK surgeries were performed using topical anesthesia of 0.4% oxybuprocaine 1 drop every 10 minutes for 30 minutes before surgery. The cornea was marked with gentian violet using a corneal marker with 3.0 and 10.5 mm rings linked by a pararadial line. The suction ring was centered around the outer marking line and the vacuum pump was turned on. Intraocular pressure (IOP) was verified to be greater than 65 mm Hg with a Barraquer tonometer. A corneal flap was created with the Chiron Automatic Corneal Shaper (Chiron, Claremont, USA). The flap thickness was 160 μm or 130 μm. Creation of the flap was followed by photoablation with 50 Hz planoscan excimer laser (Chiron 217, Doranch, Germany). After stromal ablation, the flap's posterior surface was irrigated with balanced salt solution, and the flap was repositioned to its original location. After waiting for 4 minutes to allow flap stromal bed adherence, 0.3% tobramycin eyedrops were instilled. No contact lens was used.

Most enhancement surgeries were performed at least 3 months after the initial LASIK. For most patients, the flap was lifted instead of being re-cut when the enhancement was performed. The minimum residual corneal thickness after the enhancement should be 220 μm or the patient would be excluded from the study. The pre-enhancement examination included manifest refraction, slit lamp biomicroscopy, funduscopy, uncorrected visual acuity (UCVA), SCVA, IOP, and Orbscan (Orbtech, Salt Lake City, USA).

For some patients, surgery was individually tailored according to possible regression. Sometimes bilateral enhancements were performed in the same session, while at other times they were done sequentially. The postoperative medications were 0.3% tobramycin and 0.1% fluorometholone eyedrops 4 times a day for the first week, which were then reduced gradually. Patients were advised to avoid direct pressure to the eye for 12 weeks.

Patients were followed up at 1 day, 1 week, 1 month, 3 months, 6 months, and 12 months. The UCVA, SCVA, IOP, and manifest refraction after enhancement were recorded at every visit. Patients also completed 4 questionnaires at 1 week, 1 month, 3 months, and 6 months after surgery to evaluate patient satisfaction.

Table 1. Pre-laser in situ keratomileusis mean refraction (D; ± SD) and number of eyes with spectacle corrected visual acuity (SCVA) ≥20/40.

	Group I (n = 4)	Group II (n = 57)	Group III (n = 44)	Group IV (n = 16)
Refraction	-3.07 ± 1.01	-7.82 ± 1.47	-12.20 ± 1.44	-20.60 ± 3.40
SCVA ≥20/40	4 (100%)	57 (100%)	38 (86.4%)	12 (75%)

Table 2. Mean refraction (D; ± SD) pre- and post-enhancement.

	Group I	Group II	Group III	Group IV
Pre-enhancement	+0.970 ± 0.890	-1.150 ± 1.220	-2.220 ± 0.990	-6.620 ± 3.520
Post-enhancement				
3 months	+0.440 ± 0.800	-1.170 ± 0.880	-1.120 ± 1.450	-3.630 ± 3.330
6 months	+0.625 ± 0.880	-0.520 ± 1.160	-0.840 ± 1.210	-2.460 ± 3.130
12 months	+0.310 ± 0.440	-0.200 ± 1.030	-0.550 ± 1.040	-1.950 ± 2.130

Table 3. Number of eyes with spectacle corrected or uncorrected visual acuity ≥20/40 at 3, 6, and 12 months.

	Group I [No. (%)]	Group II [No. (%)]	Group III [No. (%)]	Group IV [No. (%)]
Spectacle corrected visual acuity				
3 months	2 (100)	38 (100)	28 (97)	16 (100)
6 months	2 (100)	38 (100)	29 (100)	15 (94)
12 months	2 (100)	38 (100)	29 (100)	16 (100)
Uncorrected visual acuity				
3 months	2 (100)	25 (66)	15 (52)	6 (38)
6 months	2 (100)	33 (87)	20 (70)	6 (38)
12 months	2 (100)	32 (84)	24 (83)	8 (50)

Table 4. Number of eyes with different visual acuities at 12 months follow-up.

	Group I		Group II		Group III		Group IV	
	UCVA	SCVA [No. (%)]	UCVA	SCVA [No. (%)]	UCVA	SCVA [No. (%)]	UCVA	SCVA [No. (%)]
≥20/20	1 (50)	1 (50)	19 (50)	29 (76)	10 (34)	22 (76)	0	1 (6)
<20/20 to ≥20/25	1 (50)	1 (50)	7 (18)	8 (21)	8 (28)	5 (17)	2 (13)	5 (31)
<20/25 to ≥20/40	0	0	6 (16)	1 (3)	6 (21)	2 (7)	6 (37)	10 (63)
<20/40	0	0	6 (16)	0	5 (17)	0	8 (50)	0

Abbreviations: UCVA = uncorrected visual acuity; SCVA = spectacle corrected visual acuity.

Results

Of 3165 eyes that had LASIK performed between July 1996 and October 1997, one hundred and twenty one eyes (3.8%) of 101 patients had LASIK enhancement for residual refractive error between September 1996 and February 1998. Eighty five eyes (71%) had follow up at 3 and 12 months, and 79 eyes (65%) at 6 months. The mean post-enhancement SE of the different groups at 3, 6, and 12 months are shown in **Table 2**.

The pre-enhancement UCVA was 20/40 or better in 40 eyes (33%), 20/30 in 11 eyes, and 20/25 in 4 eyes. The post-enhancement UCVA improved in 110 eyes (91%), showed no change in 7 eyes, lost 1 line in 2 eyes, and lost 2 lines in 2 eyes. The 4 eyes that lost visual acuity had some complications during or after the enhancement. Among the 85 eyes with follow up at 12 months, 66 eyes (78%) had a final UCVA of 20/40 or better. At 12 months follow-up, no eyes had SCVA of less than 20/40 (**Tables 3 and 4**). Failed suction occurred in 4 eyes and 1 eye had uneven bed during enhancement. Two eyes had flap revision due to epithelial ingrowth and 4 eyes had trace corneal scarring post-operatively. At 3 months follow-up, 29 eyes of 15 patients (12%) were dissatisfied with the vision improvement. In 22 eyes, the pre-LASIK SE was larger than 8 D and the patients noted halos, fogginess, or glare. Three eyes had complications of uneven bed, shallow ridge, or intrastromal epithelization. In these patients, the UCVA was 20/20 in 18 eyes, 20/25 in 4 eyes, 20/30 in 3 eyes, and 20/40 in 4 eyes.

Discussion

Refractive correction of high myopia is a controversial and difficult clinical problem. At present, there is no completely satisfactory surgical procedure to correct high myopia.[5] The limitation of predictability and regression of any refractive procedures can result in residual refractive error.[6] Retreatment after the initial surgery is common for high myopia.[1] In this study, 3.8% of the eyes had enhancement done after the initial LASIK.

Whether a patient needs an enhancement or not is mainly based on the patient's satisfaction with the original result. Enhancement should be considered only if the patient has complaints about the visual outcome.

UCVA is the main criteria used to assess the effectiveness of a refractive procedure.[2] Some studies of LASIK to correct high myopia show that between 45% and 71% of eyes have a UCVA of 20/40 or better after surgery, with better results in eyes with lower myopia.[7,8] In the enhancement groups reported in this study, the pre-enhancement UCVA was 20/40 or better in 40 eyes (33%), 20/30 in 11 eyes, and 20/25 in 4 eyes. After enhancement, the UCVA was 20/40 or better at 12 months in 78% of eyes. From **Table 3**, it can be seen that the higher the myopia is, the lower is the UCVA.

Knorz et al reported that LASIK provides stability of manifest refraction and UCVA, as well as a high degree of patient satisfaction, without significant visual loss in patients with myopia up to -10 D.[8] Results may still be acceptable in patients with myopia up to -15 D, but the rate of visual loss is higher, and patient satisfaction is lower. For myopia greater than 15 D, accuracy and patient satisfaction were sufficiently poor to advise against the use of LASIK. In addition, patients with astigmatism correction were less pleased with the results than were patients who received spherical corrections only. In this study, there were 60 eyes (50%) with SE greater than 10.1 D and 16 eyes (13%) greater than

15.0 D. Among the 19 eyes (16%) whose UCVA was less than 20/40 post-enhancement, the original SE was greater than -10.1 D in 13 eyes (68%) and astigmatism was greater than 1.0 D in 7 eyes.

Guell and Muller reported that night vision was slightly impaired for 23% of patients 6 months after LASIK.[6] Perez-Santonja et al reported that night halos and starbursts occurred in 29% and 31% of eyes, respectively, at 6 months.[3] These symptoms improved with time, the night halos were related to small ablation diameters. In the patients in this study, 12% patients were dissatisfied with the vision at 3 months post-enhancement follow-up, with most patients experiencing halos, fogginess, or glare. Since their initial SE was mostly larger than 8 D, the ablation diameters were relatively smaller.

Eduardo and Maurice reported that enhancement refractive procedures should always be considered in terms of the benefit to risk ratio of improving uncorrected vision versus compromising the best corrected vision.[4] At 12 months post-enhancement, 19 eyes of our patients had UCVA less than 20/40. Eight of them belonged to group IV. One advantage of LASIK is repeatability and most of the enhancements were done without re-cutting the flaps. In conclusion, the results of this study have indicated that LASIK enhancement is effective for reducing the residual refraction and improving the final uncorrected visual acuity.

References

1. *Salah T, Waring GO III, el Maghraby A, et al. Excimer laser in situ keratomileusis under a corneal flap for myopia of 2 to 20 diopters. Am J Ophthalmol 1996;121:143-155.*
2. *Pallikaris IG, Siganos DS. Excimer Laser in situ keratomileusis and photorefractive keratectomy for correction of high myopia. J Refract Corneal Surg 1994;10:498-510.*
3. *Perez-Santonja JJ, Bellot J, Claramonte P, Ismail MM, Alio JL. Laser in situ keratomileusis to correct high myopia. J Cataract Refract Surg 1997;23:372-385.*
4. *Eduardo M, Maurice J. The Martines enhancement technique for correcting residual myopia following LASIK. In: Machat JJ, editor. Excimer laser refractive surgery; practice and principles. Thorofare: Slack Inc.; 1996:409-411.*
5. *Helmy SA, Salah A, Badawy TT, Sidky AN. Photorefractive keratectomy and laser in situ keratomileusis for myopia between 6.00 and 10.00 diopters. J Cataract Refract Surg 1996;2:417-421.*
6. *Guell JL, Muller A. Laser in situ keratomileusis (LASIK) for myopia from -7 to -18 diopters. J Cataract Refract Surg 1996; 12:222-228*
7. *Lynn MJ, Waring GO III, Carter JT. Combining refractive error and uncorrected visual acuity to assess the effectiveness of refractive corneal surgery. J Refract Corneal Surg 1990;6:103-109.*
8. *Knorz MC, Wiesinger B, Liermann A, Seiberth V, Liesenhoff H. Laser in situ keratomileusis for moderate and high myopia and myopic astigmatism. Ophthalmology 1998;105: 932-940.*