ELSEVIER

Comparison of Two Procedures: Photorefractive Keratectomy Versus Laser In Situ Keratomileusis for Low to Moderate Myopia

Jae Bum Lee, Jae Sung Kim,
Chul-Myong Choe, Gong Je Seong and Eung Kweon Kim

Institute of Vision Research, Department of Ophthalmology, Yonsei University College of Medicine, Seoul, Korea

Purpose: A prospective study was conducted to compare the effectiveness, safety, and stability of photorefractive keratectomy (PRK) and laser in situ keratomileusis (LASIK) for correction of low to moderate myopia.

Methods: Forty-five patients with a manifest refraction (PRK, -4.54 ± 0.80; LASIK, -4.82 ± 1.10) from -1.50 to -6.00 diopters (D) were treated and followed-up for 6 months. In each case, 1 eye received PRK and the other LASIK. The first eye treated, and the surgical method used in the first eye, were randomized. Uncorrected and corrected visual acuity, manifest refraction, corneal haze, and topographic analysis of ablation decentration were examined.

Results: The uncorrected visual acuity was 20/20 or better in 35 PRK eyes (77.8%) and 28 LASIK eyes (62.2%) at 6 months (P = .107). At 6 months, 28 eyes (62.2%) that received PRK showed a spherical equivalent of within ± 0.5 D as compared with 24 eyes (53.4%) that received LASIK (P = .393). The amount of ablation decentration was 0.37 ± 0.25 mm in PRK eyes and 0.49 ± 0.38 mm in LASIK eyes at 3 months (P = .36).

Conclusions: In our study, PRK and LASIK were found to be similarly effective and predictive of correction in low to moderate myopia. PRK has the advantage of less ablation decentration and is safer than LASIK, so we recommend PRK for eyes with low to moderate myopia. **Jpn J Ophthalmol 2001;45:487–491** © 2001 Japanese Ophthalmological Society

Key Words: Ablation decentration, LASIK, low to moderate myopia, PRK.

Introduction

Since the 193-nm excimer laser was introduced to the ophthalmology field, its applications to the treatment of myopia, astigmatism, and hyperopia have been increasing.[1–4] Photorefractive keratectomy (PRK) is believed to be a very safe corrective procedure for low to moderate myopia. However, postoperative pain, corneal haze, and myopic regression are known problems of PRK.[5] Laser in situ keratomileusis (LASIK) may be a procedure preferred to PRK, particularly in cases with a high degree of myopia. However, epithelial ingrowth, corneal flap-related complications, and corneal ectasia are recognized as shortcomings of LASIK.[6–8] Some authors have reported promising results with LASIK for the correction of high myopia.[9,10] However, in low to moderate myopia, it is still a point of contention and its use depends on the individual surgeon's preference. Therefore, to discern the efficiency and safety differences between the procedures, we compared the results of PRK in 1 eye and LASIK in the contralateral eye, performed on patients who had a low to moderate level of myopia ranging from -1.50 D to -6.00 D.

Materials and Methods

Forty-five patients with myopia (90 eyes) were enrolled in this study between January 1999 and September 1999. All the patients had received a full ex-

Received: August 18, 2000

Correspondence and reprint requests to: Jae Bum LEE, MD, Department of Ophthalmology, Yonsei University College of Medicine, Yongdong Severance Hospital, 146-92 Dogok-Dong, Kangnam-Ku, 135-270, Seoul, Korea

Jpn J Ophthalmol 45, 487–491 (2001)

Published by Elsevier Science Inc.

0021-5155/01/$–see front matter
PII S0021-5155(01)00406-3

Jpn J Ophthalmol
Vol 45: 487–491, 2001

planation of the procedures and informed consent was obtained before surgery. Each patient received PRK in 1 eye and LASIK in the other eye by the same surgeon (JBL). The first eye treated, and the surgical method used in the first eye, were randomized. The time interval between the procedures in both eyes was 2 weeks in all patients. The preoperative corrected visual acuity of all patients was 20/20 or better. Each patient received preoperative ophthalmic examinations that included slit-lamp microscopy, fundus examination, cycloplegic and manifest refraction, corneal keratometry, corneal topography, central corneal thickness, and Goldmann tonometry. Patients having systemic or ocular diseases such as diabetes mellitus, connective tissue disease, amblyopia, corneal disease, cataract, glaucoma, and retinal disease were excluded from the study.

Photorefractive Keratectomy Procedure

The procedure was done under topical anesthesia with proparacaine hydrochloride 0.5%. We used an excimer laser (Keratome II®; Coherent-Schwind, Neuostheim, Germany). At the completion of the surgery, a drop of ofloxacine 0.3% (Ofloxacine®; Sam-il Pharmacy, Seoul, Korea) and a drop of diclofenac 0.1% (Optanac®; Sam-il Pharmacy) were administered and a therapeutic contact lens (Hypa day®, diameter 14.2 mm, BC 8.7 mm; Chonan, Korea) was applied to the eye. After the epithelium had healed, Ofloxacine and fluorometholon 0.1% (Fluorometholon®, Sam-il Pharmacy) were administered four times a day and gradually tapered over 4 months.

Laser In Situ Keratomileusis Procedure

In the LASIK procedure, a microkeratome (Automated Corneal Shaper®; Chiron Vision, Claremont, CA, USA) was used. We used a number 160 thickness plate, which produced a cut 160 μm in thickness; the intended stromal bed thickness was at least 250 μm. This cut was followed by a midstromal ablation by the laser. Subsequent to the surgery, a drop of Ofloxacine 0.3% and a drop of diclofenac 0.1% were instilled. Ofloxacine and prednisolone 0.125% (Optilon®; Chonggundang Pharmacy, Seoul, Korea) were administered four times a day beginning 1 day after surgery and continuing for 1 week. We gradually tapered these over a 1-month period.

Following surgery, the uncorrected and corrected visual acuity and manifest refraction were measured at 1, 3, and 6 months after surgery, and the complications in both PRK and LASIK eyes were also recorded. From the difference map of topography (Orbscan®; Orbtek, Salt Lake City, UT, USA), ablation decentration from the pupil center was calculated. This was done by placing the cursor at the center of the ablation zone; from the screen, decentration from the pupil center was measured off in millimeters.

Subepithelial corneal haze levels were detected by slit-lamp examination and subjectively graded according to Hanna's method[11] at 6 months after PRK and LASIK surgery. Subepithelial haze was graded from 0 to 4 as follows: 0: totally clear; 0.5: a faint corneal opacity seen only by oblique indirect illumination; 1: an opacity of minimal density seen with difficulty with direct and diffuse illumination; 2: an easily visible opacity; 3: a denser opacity that significantly decreased the visualization of intraocular structures such as the iris and retina; and 4: an opaque cornea. Paired *t*-tests were used to compare the pre-operative data. Chi-square tests were used to compare the uncorrected visual acuity 20/20 or better and mean spherical equivalent refractions within ±0.5 diopter (D) at 6 months after surgery. Values of $P < .05$ were considered statistically significant.

Results

In both the PRK- and LASIK-treated eyes, there was no statistically significant difference in spherical equivalent, average keratometry, intraocular pressure, or central corneal thickness between the 2 eyes before surgery (Table 1). The mean preoperative spherical equivalent refraction was −4.54 ± 0.80 D (range, −1.50 to −6.00 D) in the PRK eyes and −4.82 ± 1.10 D (range, −1.75 to −6.00 D) in the LASIK eyes. The mean preoperative amount of astigmatism was 0.73 ± 1.08 in PRK and 0.87 ± 1.21 in LASIK eyes. At 6 months, it was 0.34 ± 0.83 in PRK and 0.54 ± 0.71 in LASIK eyes, respectively.

At 1 week, 12 PRK eyes (26.7%) and 21 LASIK eyes (46.7%) could see 20/20 or better without correction. At 6 months, the uncorrected visual acuity was 20/20 or better in 35 PRK eyes (77.8%) and 28 LASIK eyes (62.2%) but this data showed no statistical significance ($P = .107$) (Table 2). Table 3 summarizes the refractive results during follow-up. At 6 months after surgery, 28 eyes (62.2%) that had received PRK showed a spherical equivalent of within ±0.5 D as compared with 24 eyes (53.4%) that received LASIK ($P = .393$). Furthermore, 39 eyes (86.7%) that received PRK showed a spherical equivalent of within ±1.0 D as compared with 38 eyes (84.5%) that received LASIK.

Table 1. Preoperative Characteristics of Patients

	PRK*	LASIK†	*P*-Value
Sex (men/women)	25/20	25/20	
Pre-op spherical equivalent (diopter)	−4.54 ± 0.80	−4.82 ± 1.10	0.11
Pre-op K reading (diopter)	43.8 ± 0.8	43.7 ± 0.7	0.88
Pre-op IOP‡ (mm Hg)	14.0 ± 2.6	13.4 ± 2.4	0.30
Pre-op central corneal thickness (μm)	558.5 ± 29.5	556.1 ± 36.9	0.57

*PRK: Photorefractive keratectomy.
†LASIK: Laser in situ keratomileusis.
‡IOP: Intraocular pressure.

Corneal haze scores for the LASIK-treated eyes were zero in all examinations. Throughout the follow-up, PRK produced lower levels of subepithelial haze than did LASIK. At 6 months, 38 PRK-treated eyes (84.4%) had zero or +0.5 subepithelial haze; 6 eyes (13.3%) had +1 subepithelial haze; and 1 eye (2.2%) had +2 subepithelial haze. The amount of ablation decentration was 0.37 ± 0.25 mm in the PRK eyes and 0.49 ± 0.38 mm in the LASIK eyes at 3 months ($P = .36$).

As for complications, in PRK, corticosteroid-induced elevated intraocular pressure (21 mm Hg or higher) was seen in 1 eye and in another eye, epithelial healing was delayed until 6 days after surgery. In LASIK, epithelial ingrowth was seen in 3 eyes and in 1 eye, the ingrowth was removed mechanically at 3 weeks following surgery. Stopping of microkeratome in the middle of the pass in 1 eye, free cap in 1 eye, and interface foreign body in 2 eyes were seen. No other adverse reactions, such as microbial keratitis, endophthalmitis, corneal perforation, or corneal ectasia occurred in any patients in this study.

Discussion

Trokel and Srinivasan experimented with corrective surgery for myopia using an excimer laser,[12] and PRK on the human eye was first successful in 1988.[13] Since then, PRK has been widely applied because of its precise predictability.[14] However, such predictability is decreased in cases of high myopia, and its effects are limited because of corneal haze and myopic regression.[15] Owing to the development of the microkeratome and improvements in surgical procedures, LASIK has recently been used more frequently for the correction of high myopia greater than −6.0 D. However, the use of LASIK to correct myopia of less than −6.0 D is controversial.

In moderate to high myopia, Hersh et al[16] reported that there was a greater tendency toward undercorrection in LASIK-treated eyes. From their data, at 6 months after PRK, 19.1% and 66.2% eyes demonstrated visual acuity of 20/20 and 20/40 or better, respectively, while after LASIK, 26.2% and 55.7% eyes were 20/20 and 20/40 or better. In low to moderate myopia, Wang et al[5] reported that 83% of LASIK-treated eyes had an uncorrected visual acuity of better than 20/20 at 1 year after surgery as compared with 72% of PRK-treated eyes.

The results of our study demonstrated that 77.8% of the PRK eyes had an uncorrected visual acuity of better than 20/20 at 6 months as compared with 62.2% of LASIK eyes. Additionally, when within ± 0.50 D, even though it was not statistically significant ($P > .05$), PRK eyes were 62.2% and LASIK eyes, 53.4%, showing that PRK-treated eyes achieved better results; this differed from previous reports. In the present study, although the improvement in uncorrected visual acuity was more rapid in LASIK than in PRK, the final visual outcome showed no difference at 6 months after surgery (Table 2).

While the difference in visual outcomes was statistically insignificant, more PRK-treated eyes than LASIK eyes achieved an uncorrected visual acuity

Table 2. Uncorrected Visual Acuity Following Photorefractive Keratectomy (PRK) and Laser In Situ Keratomileusis (LASIK)

	1 Week		1 Month		3 Months		6 Months	
	PRK	LASIK	PRK	LASIK	PRK	LASIK	PRK	LASIK
Visual Acuity	n(%)	n(%)	n(%)	n(%)	n(%)	n(%)	n(%)	n(%)
≥20/20	12(26.7)	21(46.7)	33(73.3)	26(57.8)	38(84.4)	32(71.1)	35(77.8)	28(62.2)
20/25–20/30	18(40)	16(35.6)	7(15.6)	12(26.7)	4(8.9)	11(24.4)	8(17.8)	14(31.1)
20/50–20/70	13(28.9)	8(17.8)	5(11.1)	7(15.6)	3(6.7)	2(4.4)	2(4.4)	3(6.7)
≤20/100	2(4.4)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)
Total	45	45	45	45	45	45	45	45

Table 3. Distribution of Refraction After Photorefractive Keratectomy (PRK) and Laser In Situ Keratomileusis (LASIK) in Same Patient*

Spherical Equivalent Refraction (D)	1 Month		3 Months		6 Months	
	PRK (n = 45)	LASIK (n = 45)	PRK (n = 45)	LASIK (n = 45)	PRK (n = 45)	LASIK (n = 45)
+2.0 to +1.6	1(2.2)	1(2.2)	1(2.2)	0(0.0)	0(0.0)	0(0.0)
+1.5 to +1.1	2(4.4)	1(2.2)	1(2.2)	1(2.2)	1(2.2)	1(2.2)
+1.0 to 0.6	7(15.6)	6(13.3)	4(8.9)	3(6.7)	2(4.4)	2(4.4)
+0.5 to 0.1	8(17.8)	5(11.1)	7(15.6)	4(8.9)	6(13.3)	3(6.7)
0 to −0.5	15(33.3)	15(33.3)	19(42.2)	19(42.2)	22(48.9)	21(46.7)
−0.6 to −1.0	9(20.0)	14(31.1)	9(20.0)	13(28.9)	9(20.0)	12(26.7)
−1.1 to −1.5	3(6.7)	3(6.7)	4(8.9)	5(11.1)	5(11.1)	5(11.1)
−1.6 to −2.0	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(2.2)
Mean (D)	0.0	−0.3	−0.4	−0.5	−0.5	−0.6
Range (D)	−1.1 to +1.9	−1.2 to +1.8	−1.4 to +1.6	−1.5 to +1.4	−1.5 to +1.4	−1.7 to +1.3
SD	0.8	0.6	0.7	0.5	0.8	0.5

*Values are numbers of eyes, with percentages in parentheses, except for mean, range, and SD.
†D: Diopters, SD: standard deviation.

of 20/20 or better at 6 months after surgery. The possible causes for these results can be speculated as follows. First of all, the ablation decentration was less following PRK than LASIK. This may be due to the patient having difficulty in seeing the fixation light through an irregular corneal stroma after the corneal flap was flipped during the LASIK procedure.[17] Secondly, there was more irregular astigmatism following LASIK than following PRK. Although we could not measure the irregular astigmatism from the topography, in LASIK, when the flap is placed at its original position following laser ablation, the corneal flap does not precisely return to its exact original position. We are able to observe a small contraction of the corneal flap towards the hinge, producing a small gap along the flap edge after surgery. Thus, irregular astigmatism tends to develop, which cannot be ignored.

Thirdly, prior to surgery, particularly in PRK, preliminary detailed and sufficient patient education was conducted, which included explanations of postoperative check-ups as well as precise application of the steroid eyedrops. That might have reduced the degree of corneal haze and myopic regression after PRK.

In addition, occurrence of complications was lower in PRK than in LASIK. An increase in intraocular pressure was seen in 1 PRK eye, which was controlled with a β-blocker. In an eye that had a +2 grade corneal haze after PRK, the manifest refraction at 6 months was sph −0.50 = cyl −0.50, Axis 180°; the uncorrected visual acuity was 20/30 and the corrected visual acuity was 20/20. In LASIK eyes, in the eye that had an operation for epithelial ingrowth, the manifest refraction at 6 months was sph −0.25 = cyl −1.00, Axis 180°; the uncorrected visual acuity was 20/50 and the corrected visual acuity was 20/30 at 6 months. The manifest refraction of the free cap eye was sph −0.50 = cyl −2.00, Axis 150°; the uncorrected visual acuity was 20/70 and the corrected visual acuity was 20/50 at 6 months.

Conclusions

Although in this study PRK-treated eyes had a slower visual recovery in the early postoperative period and slightly more corneal haze that was not vision-threatening, the PRK procedure was safer than LASIK in low to moderate myopia cases. Careful selection of patients and sufficient education and understanding before surgery are considered necessary to achieve a good outcome.

References

1. Seiler T, Wollensak J. Myopic photorefractive keratectomy with the excimer laser. One-year follow-up. Ophthalmology 1991;98:1156–63.
2. Sher NA, Chen V, Bowers RA, et al. The use of the 193 nm excimer laser for myopic photorefractive keratectomy in sighted eyes. A multicenter study. Arch Ophthalmol 1991;109:1525–30.
3. Gartry DS, Kerr Muir MG, Marshall J. Excimer laser photorefractive keratectomy. 18-month follow-up. Ophthalmology 1992;99:1209–19.
4. Brancato R, Tavola A, Carones F, et al. Excimer laser photorefractive keratectomy for myopia: results in 1165 eyes. Italian Study Group. Refract Corneal Surg 1993;9:95–104.
5. Wang Z, Chen J, Yang B. Comparison of laser in situ keratomileusis and photorefractive keratectomy to correct myopia from −1.25 to −6.00 diopters. J Refract Surg 1997;13:528–34.
6. Kim HM, Jung HR. Laser assisted in situ keratomileusis for high myopia. Ophthalmic Surg Lasers 1996;27(5 Suppl):S508–11.
7. Marinho A, Pinto MC, Pinto R, Vaz F, Neves MC. LASIK for

high myopia. One year experience. Ophthalmic Surg Lasers 1996;27(5 Suppl):S517–20.

8. Wang Z, Chen J, Yang B. Posterior corneal surface topographic changes after laser in situ keratomileusis are related to residual corneal bed thickness. Ophthalmology 1999;106: 406–10.
9. 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.
10. Fiander DC, Tayfour F. Excimer laser in situ keratomileusis in 124 myopic eyes. J Refract Surg 1995;11(3 Suppl):S234–8.
11. Hanna KD, Pouliquen YM, Waring GO III, Savoldelli M, Fantes F, Thompsom KP. Corneal wound healing in monkeys after repeated excimer laser photorefractive keratectomy. Arch Ophthalmol 1992;110:1286–91.
12. Trokel SL, Srinivasan R, Braren B. Excimer laser surgery of the cornea. Am J Ophthalmol 1983;96:710–5.
13. McDonald MB, Liu JC, Byrd TJ, et al. Central photorefractive keratectomy for myopia: partially sighted and normally sighted eyes. Ophthalmology 1991;98:1327–37.
14. Kim JH, Hahn TW, Lee YC, Joo CK, Sah WJ. Photorefractive keratectomy in 202 myopic eyes: one year results. Refract Corneal Surg 1993;9(2 Suppl):S11–6.
15. Buratto L, Ferrari M. Photorefractive keratectomy for myopia from 6.00 D to 10.00 D. Refract Corneal Surg 1993;9(2 Suppl):S34–6.
16. Hersh PS, Brint SF, Maloney RK, et al. Photorefractive keratectomy versus laser in situ keratomileusis for moderate to high myopia. Ophthalmology 1998;105:1512–23.
17. Lee JB, Jung JI, Chu YK, Lee JH, Kim EK. Analysis of the factors affecting decentration in photorefractive keratectomy and laser in situ keratomileusis for myopia. Yonsei Med J. 1999;40:221–5.