Original Article

Laser *in-situ* keratomileusis for refractive error following radial keratotomy

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Aim: To evaluate the safety and efficacy of laser *in-situ* keratomileusis (LASIK) in eyes with residual/ induced refractive error following radial keratotomy (RK). **Design:** Retrospective study. **Materials and Methods:** A retrospective analysis of data of 18 eyes of 10 patients, who had undergone LASIK for refractive error following RK, was performed. All the patients had undergone RK in both eyes at least one year before LASIK. Parameters like uncorrected visual acuity (UCVA), best-corrected visual acuity (BCVA), contrast sensitivity, glare acuity and corneal parameters were evaluated both preoperatively and postoperatively. **Statistical Software:** STATA-9.0. **Results:** The mean UCVA before LASIK was 0.16±0.16 which improved to 0.64 ± 0.22 (P < 0.001) after one year following LASIK. Fourteen eyes (out of 18) had UCVA of ≥ 20/30 on Snellen's acuity chart at one year following LASIK. The mean BCVA before LASIK was 0.75 ± 0.18. This improved to 0.87 ± 0.16 at one year following LASIK. The mean spherical refractive error at the time of LASIK and at one year after the procedure was –5.37 ± 4.83 diopters (D) and –0.22 ± 1.45D, respectively. Only three eyes had a residual spherical refractive error of ≥ 1.0D at one year follow-up. In two eyes, we noted opening up of the RK incisions. No eye developed epithelial in-growth till 1 year after LASIK. **Conclusion:** LASIK is effective in treating refractive error following RK. However, it carries the risk of flap-related complications like opening up of the previously placed RK incisions and splitting of the corneal flap.

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Laser *in-situ* keratomileusis (LASIK) is an effective procedure in the management of refractive errors following corneal surgeries.[1-4] LASIK is known to be a safe refractive surgical procedure, with good refractive efficacy and predictability and is associated with rapid visual recovery with minimal risk of complications. Prior to the advent of excimer laser, radial keratotomy (RK) was the most widely performed surgical technique to correct myopic refractive error. However, RK was not as predictable as the refractive surgeries performed by excimer laser, thereby frequently giving rise to under and over-corrections.[5,6]

The purpose of this study was to evaluate the safety and efficacy of LASIK by Chiron Technolas 217 (Bausch and Lomb, Salt Lake City, Utah) in eyes with residual/induced refractive error following RK. LASIK was considered in these eyes only when there was significant anisometropia or intolerance to contact lens.

Materials and Methods

A retrospective analysis of data of 18 eyes of 10 patients, who had undergone LASIK for refractive error following RK, was performed. All the patients had visually significant myopia and/or astigmatism at the time of LASIK. Those patients were included who had undergone RK in both the eyes at least one year before (25.1 ± 10.83 months; range: 13–44 months) and no other ocular surgery was performed after the RK procedure. Again, those patients were included who had a stable refraction for at least six months and a stable topographic pattern in at least two consecutive monthly maps before LASIK. Sixteen eyes of nine patients had eight radial scars on the cornea corresponding to the keratotomy incisions, while two eyes of one patient had 16 incisions owing to two RK enhancement procedures. Patients wearing soft contact lenses were asked to stop wearing them 15 days before the scheduled date for LASIK procedure. Those who were on rigid gas permeable contact lenses were asked to stop using them a month prior. Preoperative evaluation included the measurement of the uncorrected visual acuity (UCVA), best-corrected visual acuity (BCVA), cycloplegic refraction, contrast sensitivity on Cambridge charts, glare acuity, slit lamp biomicroscopy, indirect ophthalmoscopy, ultrasonic pachymetry, applanation tonometry and videokeratography.

In each eye, LASIK was performed using standard protocol. Surgery was performed under topical anesthesia (0.5% proparacaine). The Hansatome microkeratome (Chiron Vision, Claremont, CA) was used to create a superiorly hinged lamellar flap. In the Hansatome head cutting a 180-micron flap was used in all the eyes. A 9.5 mm suction ring was applied in 12 eyes while in six eyes an 8.5 mm suction ring was used. The intraocular pressure (IOP) generated after activation of the suction was measured with the Barraquer tonometer. The flap was cut only if on applanation of the cornea, the central mire was equal to or within the circular mark etched on the tonometer (indicating a pressure of equal to or more than 65 mmHg). Standard surgical technique was used and the Chiron Technolas 217 excimer laser (Chiron Vision, Claremont, CA) was used for stromal ablation. The optic zone diameter was between 5–6 mm in all the eyes and a minimal residual stromal

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bed thickness of at least 250 microns was left after laser ablation in all the eyes. The target refraction was emmetropia in all the operated eyes.

All the patients were prescribed ciprofloxacin (0.3% four times daily) and fluorometholone (0.1% four times daily) eye drops for four weeks and tear supplements four times daily for six weeks in the postoperative period. Routine postoperative examinations were scheduled at day one, one week, one month, three months, six months and one year after the surgery. All the patients came regularly as per the follow-up schedule. The UCVA, BCVA, refraction, contrast sensitivity, glare acuity, pachymetry and corneal topography were performed at all follow-up visits and any post-operative complication was noted.

The data of all the patients were entered and analyzed on an excel spreadsheet. All the entries were checked for any possible keyboard error. Preoperative and one-year postoperative measurements were summarized by mean and standard deviation. Changes following surgery within each group were assessed using paired't' test. *P*-value lesser than 0.05 was considered as statistically significant.

Results

The mean age of the patients was 26.9 ± 6.36 years and seven (out of 10) patients were females.

The mean UCVA before LASIK was 0.16 ± 0.16 which improved to 0.64 ± 0.22 ($P < 0.001$) at one year following LASIK [Fig. 1]. Fourteen eyes (out of 18) had a UCVA of ≥20/30 on Snellen's acuity chart at one year following LASIK. The mean BCVA before LASIK was 0.75 ± 0.18. This improved to 0.87 ± 0.16 at one year following LASIK procedure [Fig. 2]. The mean contrast sensitivity before LASIK was 21.88 ± 4.13. This value reduced to 14.47 ± 2.63 after one year following laser. The mean glare acuity before, and at one year after LASIK were found to be 0.56 ± 0.31 and 0.39 ± 0.22 respectively. Visual acuity recorded in the morning and in the evening were the same.

The mean refractive error for which RK was performed was –7.0 ± 1.5 diopters (D). Only two eyes had associated cylindrical element of –1.50 D and –2.0 D [Table 1]. The mean spherical refractive error at the time of LASIK was –5.37 ± 4.83 D. Thirteen eyes (out of 18) had associated cylindrical error at the time of LASIK procedure. The mean myopic cylindrical error at the time of LASIK was –1.40 ± 0.86 D (n=9) and the hyperopic astigmatism was + 4.0 ± 1.58 D (n=4). Two eyes, in which RK enhancements were performed, had a high cylindrical error of +3.0 D at 90° and +5.0 D at 120°. The mean spherical refractive error following LASIK was – 0.22 ± 1.45 [Table 2]. The mean myopic cylindrical error following laser was –1.10 ± 0.33 D (n=5), while the mean hyperopic astigmatism was +1.83 ± 0.94 D (n=3). Only three eyes had a post-LASIK spherical refractive error of > –1.0 D. However, eight eyes had some amount of cylindrical errors of which, five eyes had > ± 1.0 D of cylindrical error, which included those two eyes in which RK enhancements were done earlier. The mean spherical equivalent preoperatively was –5.40 ± 5.28, which improved to 0.52 ± 0.92, 0.54 ± 0.97 and 0.48 ± 0.99 at three months, six months and one year, respectively [Fig. 3].

The mean central corneal thickness as measured by ultrasonic pachymetry was 534.38 ± 34.07 before LASIK. The mean keratometry in these eyes before LASIK was 40.81 ± 2.45 D, which reduced to 38.51 ± 3.56 D at one year following laser. The mean anterior corneal elevation on Orbscan topography system was 10.75 ± 4.34 before LASIK, which changed to 5.88 ± 5.21 at one year following laser. The mean posterior corneal elevation on Orbscan topography system was 37.41 ± 10.03 before LASIK; the same was 59.82 ± 8.81 at the end of one year following LASIK procedure.

The mean optic zone for excimer laser ablation was 5.64 ± 0.41 mm. The mean corneal stromal ablation by excimer laser was 89.87 ± 28.62 microns.

In two eyes in our study, opening up of previous incision (RK incision) was noted. In one of these a single incision opened up while in the other one, two incisions opened up in the form of a pie. In these eyes, copious irrigation was performed after stromal ablation to prevent implantation of any epithelium and a bandage contact lens (BCL) was placed after repositing the flap. The BCL was removed after three days. During the

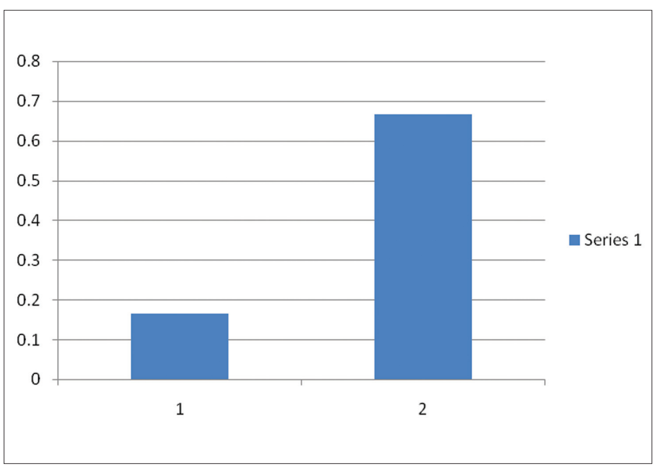

Figure 1: Uncorrected visual acuity before and after laser *in-situ* keratomileusis (1 = Pre-laser *in-situ* keratomileusis Uncorrected visual acuity, 2 = Post-laser *in-situ* keratomileusis Uncorrected visual acuity)

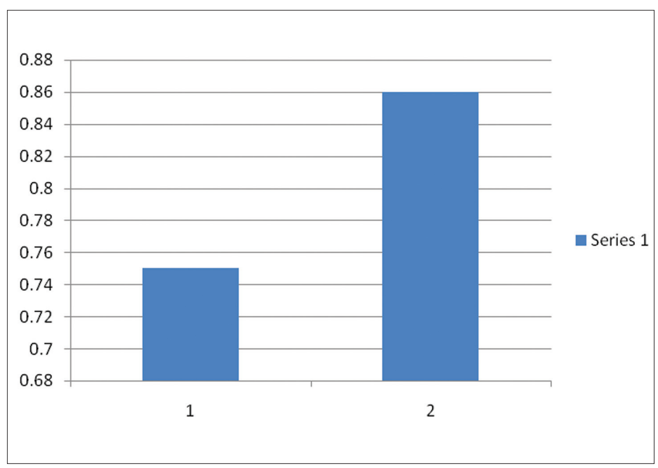

Figure 2: Best corrected visual acuity before and after laser *in-situ* keratomileusis (1 = Pre-laser *in-situ* keratomileusis best corrected visual acuity, 2 = Post laser *in-situ* keratomileusis best corrected visual acuity)

Table 1: Preoperative and postoperative (1 year) refractive status

Preoperative Spherical Equivalent	Preoperative UCVA*	Preoperative BCVA**	Postoperative Spherical Equivalent	Postoperative UCVA*	Postoperative BCVA**
–2.25	0.16	1	0	0.66	1
–2.0	0.66	0.66	–0.37	0.66	1
+1.0	0.25	0.5	–2.50	0.25	1
–14.0	0.008	0.66	–2.0	0.66	1
–13.0	0.008	0.66	–0.25	1	1
–10.75	0.008	0.66	0	0.66	0.66
–9.50	0.008	0.66	0	1	1
–3.50	0.25	1	–0.5	0.66	0.66
–3.0	0.25	1	–0.5	0.66	0.66
–1.37	0.33	0.66	–0.5	0.66	1
–0.9	0.33	0.66	–1.25	0.66	1
–13.0	0.008	0.66	–0.5	0.66	0.66
–6.37	0.05	1.2	–0.5	0.66	1
–7.50	0.03	0.66	0	0.66	1
–9.35	0.016	0.66	–2.0	0.5	0.66
–5.75	0.1	1	0	1	1
+1.50	0.33	0.66	+1.25	0.5	0.66
+2.50	0.16	0.66	+1.25	0.5	0.66

*UCVA: Uncorrected visual acuity, **BCVA: Best corrected visual acuity

Table 2: Mean spherical and cylindrical error before and after laser *in-situ* keratomileusis

	Pre-LASIK	Post-LASIK (1 year)	*P* value
Mean spherical error	–5.37 ± 4.83 D (range: –1.0 to –14.0)	–0.22 ± 1.45 (range: 0 to –2.0)	0.000
Mean cylindrical error			
Myopic	–1.40 ± 0.86 D (range: 0 to –3.0)	–1.10 ± 0.33 D (range: 0 to –1.5)	NS
Hyperopic	+ 4.0 ± 1.58 D (range: 0 to +6.0)	+1.83 ± 0.94 D (range: 0 to +2.5)	NS
Mean spherical equivalent	–5.40 ± 5.28 (range: +2.50 to –14.0)	–0.48 ± 0.99 (range: +1.25 to –2.37)	0.001

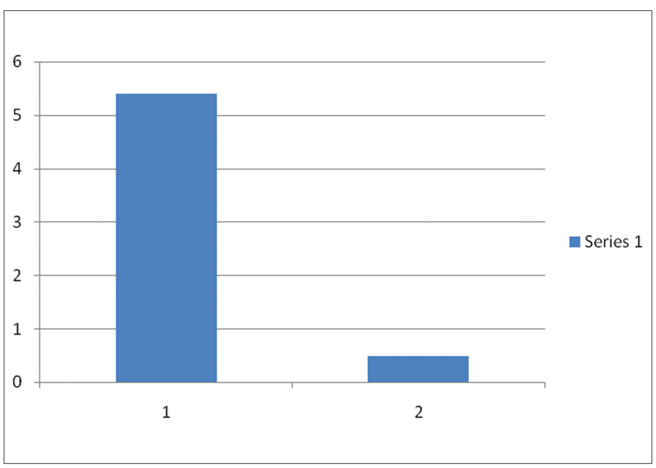

Figure 3: Mean spherical equivalent before and after laser *in-situ* keratomileusis (1 = Pre-aser *in-situ* keratomileusis mean spherical equivalent, 2 = Post aser *in-situ* keratomileusis mean spherical equivalent)

follow-up period of one year following LASIK, none of the eyes developed epithelial in-growth or any other sight threatening complication. The UCVA and BCVA in decimal in these eyes at one year following LASIK were 0.5 (20/40) and 0.66 (20/30), respectively and the contrast sensitivity on Cambridge charts was 130.66 ± 31.95.

Discussion

Residual myopia after RK may be due to a large optic zone, fewer incisions, shallow incisions or due to improper corneal response which is known to be variable in different individuals.[7]

Therapeutic strategies to correct refractive error following RK include spectacles, contact lenses, and resurgeries including re-deepening, extending existing RK incisions centripetally or centrifugally, placing additional RK incisions, or performing other keratorefractive procedures such as keratomileusis, epikeratophakia or excimer laser surgeries, which include photorefractive keratectomy (PRK) or LASIK.[5]

There has been a concern about flap complications in LASIK in eyes that have undergone prior RK and some have advocated performing PRK in these eyes. However, studies have shown that PRK is associated with a five to ten-fold increase in haze formation and at least 20% reduction in refractive predictability in RK-treated eyes.[5,8,9] Hence, we preferred LASIK over PRK in our study. However, a comparative evaluation of LASIK with surface ablation may provide the answer for an alternative procedure in such situations.

Another matter of concern is the flap realignment after stromal ablation in eyes with prior radial incisions in the cornea. Studies have reported splitting of the corneal cap into multiple pie-like segments during manipulation.[8,10] In our study, opening up of RK incision was noted in two eyes. However, the flaps were well settled in the postoperative period and no eye developed epithelial in-growth till one year following LASIK.

The present study highlights the safety of LASIK as there was an improvement in the mean BCVA. It can be considered as an effective procedure as there was a statistically significant improvement in the UCVA and 14 (out of 18) eyes did not require any refractive correction as they had UCVA of 20/30 or better on Snellen's acuity chart.

No diurnal fluctuation in the visual acuity was noted in any eye following LASIK. Diurnal fluctuation in visual acuity has been reported following RK, which is probably due to eyelid pressure during sleep, variations in IOP, corneal thickening secondary to night-time hypoxia and alteration in corneal topography.[11-13] However, no patient in our study complained of having diurnal fluctuation in visual acuity even in post-RK period.

In the present study, we observed that RK may result in development of astigmatism. Only two eyes had cylindrical error before RK, while 13 eyes (out of 18) had astigmatic error following RK at the time of LASIK. The occurrence of induced astigmatism has been reported previously following RK. In the prospective evaluation of radial keratotomy (PERK) study at five years, 15% of eyes had an increase in refractive astigmatism of one D or more.[14] The cylindrical error induced in this case following RK might be due to the irregular contractile forces emanating from the linear scars corresponding to the RK incisions. This may be partly corrected by creation of lamellar corneal flap and partly by stromal ablation. Topography-guided LASIK may be an effective option in correction of the spherical as well as astigmatic refractive error following corneal surgery. However, no significant advantage of topography-guided LASIK over conventional LASIK has been reported.[15]

The present study demonstrates that LASIK is reasonably effective in the correction of refractive error following RK. However, there are risks of flap-related complications in the form of opening up of the RK incisions and splitting of the flap.

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