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Changes in Central Corneal Thickness and Endothelial Cell Count after Lasik

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Authors' contributions

This work was carried out in collaboration between all authors. Authors SHK and STQ conceived of the study and participated in its design. Author SN participated in the design of the study. Author AN participated in the study design and coordination. Author KK performed the statistical analyses. All authors read and approved the final manuscript.

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Short Research Article

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ABSTRACT

Purpose: To compare the pre and postoperative endothelial cell counts and central corneal thickness in patients undergoing laser *in situ* keratomileusis (LASIK) for the treatment of myopia.
Study Design: Prospective study.
Place and Duration: This hospital based study was carried out at the LASIK Centre in the Postgraduate Department of Ophthalmology, Government Medical College, Srinagar for a period of one and a half year (from April 2014 to October 2015).
Materials and Methods: A series of 53 patients (100 eyes) with myopia between -1 and -8.25D and upto -2.75D of myopic astigmatism were included in the study. These patients underwent LASIK using Carl Zeiss Meditec AG's MEL 80 (Germany) laser. Central corneal thickness and endothelial cell counts were measured before and 1 day, 1 week, 1 month and 3 months after LASIK using non contact specular microscopy. Age and refractive error were also recorded.

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Results: The mean age of the patients was 26.9±4.71 years (range 19 to 36 years). The study included 30(56.6%) males and 23(43.4%) females. A total of 100 eyes were operated.47 patients underwent LASIK in both eyes while only one eye was operated in 6 patients. At the end of 3 months, the mean spherical equivalent of refraction was -0.24±0.369 compared to a preoperative mean of -4.81±2.053. The preoperative central corneal thickness ranged from 442 to 590 microns with a mean of 515.7 microns ± 36.4 and endothelial cell count ranged from 2365 to 3578 cells per mm^2 with a mean of 2874.6 cells per mm^2 ± 225.14. At 1 day, 1 week, 1 month and 3 months after LASIK, mean CCT was recorded as 414.5±48.5, 406.7±47.9, 411.3±48.1 and 418.3±48 respectively. No significant correlation was found between age, refractive error and mean CCT. The mean endothelial cell count was recorded as 2867.1±218.14, 2865.6±212.64, 2864.8±207.64 and 2861.3±201.48 at 1 day, 1 week, 1 month and 3 months after LASIK.
Conclusion: There was a significant decrease in central corneal thickness in the immediate postoperative period. It continued to decline till 1 week after the surgery and then increased over time in the late postoperative period. However no significant change was observed in endothelial cell counts in the postoperative period.

Keywords: Central corneal thickness; endothelial cell counts; myopia; non-contact specular microscope; laser in situ keratomeliusis (LASIK).

ABBREVIATIONS

LASIK : Laser in situ Keratomileusis
CCT : Central Corneal Thickness
ECC : Endothelial Cell Count
MSE : Mean Spherical Equivalent
UCVA : Uncorrected Visual Acuity
BCVA : Best-corrected Visual Acuity
SD : Standard Deviation

1. INTRODUCTION

Laser *in situ* keratomileusis (LASIK) has become the most popular refractive procedure performed today because of its safety, efficacy, quick visual recovery, and minimal patient discomfort [1]. Laser *in situ* keratomileusis (LASIK) combines the precision of excimer laser photoablation with the advantages of an intrastromal procedure that maintains the integrity of Bowman's layer and the overlying corneal epithelium. Alterations in corneal thickness and curvature during LASIK can affect the refractive stability in the postoperative period. LASIK has been known to be associated with a rare but visually debilitating refractive instability called ectasia. It is recommended that at least 250 µm of residual corneal stromal tissue should be left after ablation so as to prevent ectasia [2].

An intact and healthy corneal endothelium is important for maintenance of corneal clarity and function. During various surgical procedures of the cornea, care should be taken that this non regenerative cell layer is not adversely affected [3]. A number of corneal surgeries such as radial keratotomy have been known to be associated with a decrease in endothelial cell count postoperatively [4]. Various studies conducted in the past have evaluated the effects of photoablation on epithelial and stromal thickness, keratocyte density and corneal nerve regeneration, but the long-term effect on the corneal endothelium has not been fully elucidated [5,6,7]. There have been conflicting reports regarding the short term effects of photoablation on the corneal endothelium with most studies finding no significant effect [8,9].

The aim of the present study is to determine the changes in central corneal thickness (CCT) and endothelial counts in patients following LASIK surgery.

2. MATERIALS AND METHODS

This study was conducted at the LASIK Centre in the Postgraduate Department of Ophthalmology, Government Medical College, Srinagar for a period of one and a half year (from April 2014 to October 2015).

2.1 Inclusion Criteria

Patients were enrolled if they met the following criteria: Age> 18 years, preoperative cycloplegic spherical refraction between -1.00D and -8.25D of myopia and upto -2.75D of myopic astigmatism, a stable refraction (change<0.5D per year) for at least 1 year, preoperative BCVA $\geq$ 6/9, sufficient corneal thickness for full correction with residual stromal thickness of at least 250 micron remaining beneath LASIK flap.

Informed written consent was obtained from all the patients in local language.

2.2 Exclusion Criteria

Patients were excluded from the study if they had a history of any ocular disease or intraocular surgery, keratoconus or forme fruste keratoconus (as detected by corneal topography), connective tissue disorder, pregnancy or severe dry eye syndrome.

2.3 Preoperative Assessment

A proper history regarding the type of treatment used previously was taken. Patients using contact lenses were instructed to remove (soft contact lenses 2 weeks and rigid contact lenses 4 weeks) before their preoperative examination as well as before surgery. The preoperative examination included: Assessment of UCVA and BCVA, slit lamp biomicroscopy, specular microscopy, non-contact tonometry, fundus evaluation, autokeratometry, corneal topography and corneal pachymetry. CCT in both eyes was measured with a non-contact specular microscope (SP-1P, Topcon corporation, Tokyo, Japan). In the non-contact specular microscopy study, the subject was positioned with his or her chin in a cup, and the forehead was placed against a headband. CCT and endothelial cell density were measured simultaneously. Three readings were obtained for each eye and the mean was considered for further analyses.

2.4 Procedure

LASIK was performed at a single center using the Moria One Use-plus microkeratome (Moria Surgicals, France) which created a flap of 9 mm to 9.5 mmin diameter with an intended thickness of 110 µm. Subsequent photoablation was conducted with the Carl Zeiss meditec AG's MEL 80 (Germany) excimer laser.

All eyes were treated in a routine manner with optical zone diameters ranging from 6.0 mm to 7.0 mm.

2.5 Postoperative Treatment Protocol

Post-operative treatment consisted of moxifloxacin 0.5%, dexamethasone 0.1% (Milflox DM-Sun Pharmaceuticals India) drops four times daily for 1 week; and artificial tears (Tears Naturale II – Alcon Belgium) every hour at day 1 and 2, and four to six times a day thereafter for a duration of 2 to 10 weeks.

2.6 Follow up Examination

Patients were examined at 1 day, 1 week, 1 month and 3 months following surgery. In all cases specular microscopy was performed on each visit postoperatively. The Topcon SP 1 Pspecular microscope (Topcon corporation, Tokyo, Japan) was used. It is a non-contact, specular microscope which counts the endothelial cells per mm^2 in the centre of the cornea and measures the central corneal thickness. All measurements were made by the same ophthalmologist.

2.7 Statistical Analysis

SPSS (version 20.0) and Microsoft excel were used to carry out the statistical analysis of data. Continous variables were summarized as mean and standard deviation and categorical variables as percentage. Data was presented by bar diagrams and pie charts. Normality analysis was performed using the Kolmogorov-Smirnov (K-S) test. Paired -t test was used for comparison of pre and post LASIK central corneal thickness, mean endothelial cell count and refraction. P value less than 0.05 was considered statistically significant.

3. OBSERVATIONS AND RESULTS

A total of 53 patients (100 eyes) with myopia were included which were in the age group of 19 to 36 years. In our series, 56.6% (30 patients) were males and 43.4% (23 patients) were females.

Table 1. Mean central corneal thickness with standard deviation (Pre and Post LASIK)

	Mean central corneal thickness ± Standard deviation
PRELASIK (Baseline)	515.7±36.4
1 day	414.5 ±48.5
1 week	406.7 ±47.9
1 month	411.3 ±48.1
3 months	418.3 ±48.0

79.24% (42) patients used spectacles while 20.75% (11) depended on contact lens for myopic correction before LASIK. The flat K (K1) values ranged from 40.71D to 47.48D with a mean value of 43.97D ± 1.54 SD. The steep K (K2) values ranged from 40.75D to 48.48D with a mean value of 44.04D ± 1.62SD. The mean preoperative spherical refraction was of -

4.58±2.03D and mean cylinder was -0.46 D ±0.656D. The mean spherical equivalent of refraction was -4.81D ±2.053D (range -0.875D to -9D).

The central corneal thickness ranged from 442 to 590 microns with a mean of 515.7 microns ±36.43 and endothelial cell count ranged from 2365 to 3578 cells per mm2 with a mean of 2874.6 cells per mm2± 225.14.

The CCT showed a significant decrease at 1 day following the surgery (414.5 microns ± 48.5, p value <0.05). It continued to decline till 1 week after the surgery (406.7 microns ± 47.9, p value <0.05) and subsequently increased at 1 month (411.3 microns ± 48.1) and 3 months (418.3 microns ± 48) postoperatively.

Table 2. Mean endothelial cell count with standard deviation (Pre and Post LASIK)

	Mean endothelial cell count ± Standard deviation
Baseline	2874.6±225.14
1 day	2867.1±218.14
1 week	2865.6±212.64
1 month	2864.8±207.64
3 months	2861.3±201.48

The mean endothelial cell count showed a decrease from preoperative value of 2874.6 cells per mm^2±225.14 to 2861.3 cells per mm^2±201.48 at the end of 3 months after the surgery which was clinically and statistically non-significant (p value >0.05).

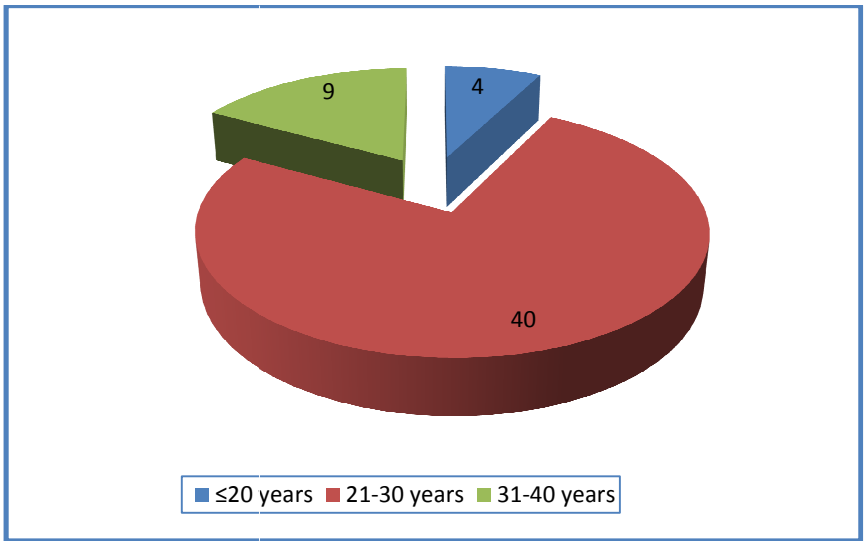

Fig. 1. Age distribution of patients

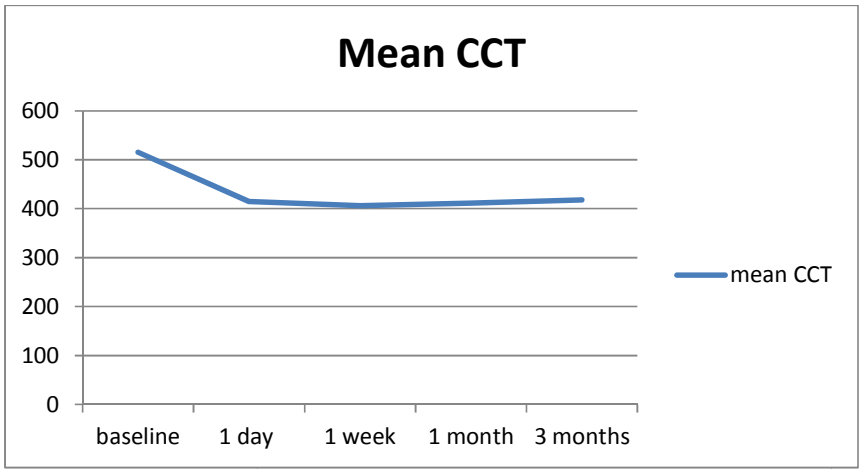

Fig. 2. Mean central corneal thickness (Pre and Post LASIK)

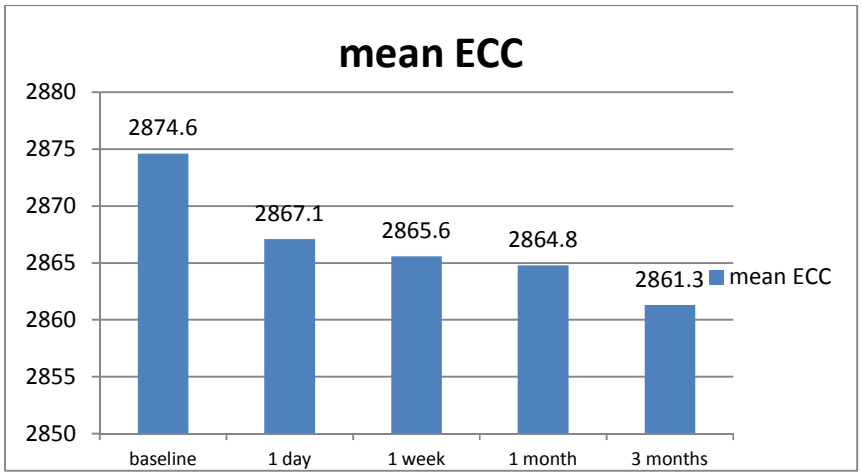

Fig. 3. Mean endothelial cell count (Pre and Post LASIK)

Table 3. Comparison of Pre LASIK refraction with Post LASIK refraction in studied eyes

Refraction parameters		Mean	SD	Multiple comparisons		
				Comparison	t-value	P-value[@]
MSE	Baseline (1)	-4.81	2.053	1 vs 2	24.41	<0.001*
	1 week (2)	-0.31	0.400	1 vs 3	24.63	<0.001*
	1 month (3)	-0.25	0.329	1 vs 4	25.95	<0.001*
	3 months (4)	-0.24	0.369	3 vs 4	0.81	0.420[#]

**Statistically significant difference (P-value<0.05); [#]Statistically non-significant difference (P-value>0.05)*

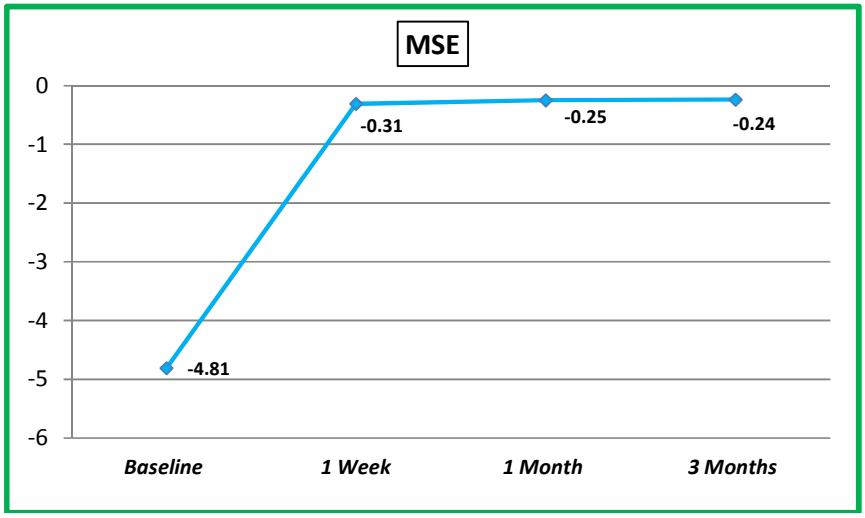

Fig. 4. Comparison of Pre LASIK refraction with Post LASIK refraction in studied eyes

The mean manifest spherical equivalent (MSE) of refraction changed from -4.81 ±2.053 at baseline to -0.31±0.400 at first week, -0.25±0.329 at 1 month and then to- 0.24±0.369 at 3 months following the surgery.

No significant correlation was found between changes in CCT, age and changes in spherical equivalent in the postoperative period.

4. DISCUSSION

This study evaluated the changes in central corneal thickness and endothelial cell count following LASIK using the non contact specular microscope. Non-contact specular microscopy is a commonly used method for measurement of corneal thickness. It is an ideal technique for measuring the corneal thickness after any

refractive surgery due to its advantages including noninvasiveness, ease of operator use, and good examiner-independent reproducibility [10].

Our study showed that the CCT values decreased significantly 1 day following LASIK and continued to decline till 1 week after the surgery. However after 1 week, the thickness increased as observed at 1 month and 3 months after the surgery. Ming-Hui et al. [11] showed a similar trend in their study as corneal thickness changed from a preoperative value of 531.6 ± 24.3 µm to 431.4 ± 38.4 µm, 422.6 ± 3 7.8 µm, 427.2 ± 38.0 µm and 434.4 ± 38.2 µm at 1 day, 1 week, 1 month and 3months after the surgery respectively.

A significant decrease in central corneal thickness in the immediate postoperative period is because of thinning of the stroma, which is the basis of the procedure. Besides this, various other processes including resorption of fluid introduced by intraoperative irrigation, biomechanical hydration shift, epithelial thickness modulation in response to laser ablation, and interface reflectivity changes may also have been responsible for the decline in CCT. Peng et al. [12] studied the effect of surface photorefractive keratectomy and laser *in situ* keratomileusis on the corneal endothelium. They observed that injury to the epithelium can lead to loss of underlying keratocytes from apoptosis. The remaining keratocytes respond by generating new glycosaminoglycans and collagen. This keratocyte activation is strongest at 1 to 2 weeks, and persists until 3 months after LASIK surgery [13]. This could cause the increase in posterior stromal thickness, thus explaining the increase in CCT seen in the later postoperative period.

In 1999, Wang et al. [2] found that changes in corneal curvature following refractive surgeries depend on a number of factors. They observed that the posterior corneal bulge is correlated with residual corneal bed thickness. There is an increased risk of ectasia if the residual corneal bed is thinner than 250 µm. In our study, the microkeratome blade created a flap of 110 µm in thickness, so the residual stromal bed was nearly 331 µm. There were no cases of ectasia reported till the last follow up period.

In our study, no significant loss in endothelial cell count was observed at the end of 1 week, 1month and 3 months after LASIK. These results are comparable with various other studies which showed no effect of LASIK with a microkeratome on endothelial cell loss above that of age-related physiologic cell loss [3,14,15]. Kato et al. [16] retrospectively analyzed 779 eyes after myopic LASIK with a microkeratome and found that endothelial loss at 5 years was 1.2%, which is within the range of physiologic cell loss. Mirza Jamil et al. [17] in their study showed that at four months post LASIK mean ECC was found to be 2435.78 ± 113.79 compared to a preoperative value of 2464.76 ± 109.64. There was a less than 1% loss in endothelial cell count before and 4 months after LASIK which was clinically and statistically non significant (P=0.1). However, Perez-Santonja et al. [18] found an improvement in ECC and morphology after photoablative refractive surgery. This was attributed to cessation of contact lens wear which is known to induce morphologic changes in the corneal endothelium.

Excimer laser surgery may induce endothelial cell injury by various mechanisms including mechanical trauma by shock waves, thermal damage and increased intraocular pressure induced by the suction ring [19,20]. However most of these changes are transient and do not lead to any significant endothelial damage in the long term.

The results of various keratorefractive surgeries are exquisitely dependent on the process of corneal healing. In this study, the mean preoperative spherical equivalent of refraction was -4.81±2.053D which reduced significantly to a mean value of -0.25±0.329D and -0.24 ±0.369D (p value <0.001) at the end of 1 month and 3 months respectively. Significant regression which seems to be reported with higher frequency after high-myopia correction was not observed in our study. Epithelial or subepithelial and stromal hyperplasia leads to corneal steepening which has been implicated in the etiology of refractive regression in the late postoperative period [21].

Thus, the evaluation of corneal changes after the keratorefractive procedures is important as it may help in better understanding of the corneal healing responses after the surgery which in turn may be used to obtain more satisfactory results. The importance of the findings in our study also relates to the use of corneas that have received LASIK or PRK as donor tissue. The finding of no difference in endothelial cell loss after keratorefractive surgery compared to normal suggests that corneas after keratorefractive surgery can be suitable for posterior lamellar keratoplasty [14]. However an important limitation of this study is the smaller number of

eyes evaluated and a short follow up period. Hence, further studies with larger sample size and longer periods of follow up are needed to substantiate these findings.

5. CONCLUSION

In conclusion, there was an initial decrease in central corneal thickness till 1 week following the surgery and subsequently it increased over time. However, there was no clinically or statistically significant loss of endothelial cell count up to three months after laser *in situ* keratomileusis.

ETHICAL APPROVAL

Institutional ethical approval was obtained prior to the study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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