

Comparison of Corneal and Anterior Chamber Parameters following Myopic laser in situ keratomileusis and photorefractive keratectomy by Pentacam as A New Imaging Technique

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Abstract

Purpose: To compare changes in posterior corneal elevation, anterior chamber depth (ACD), anterior chamber volume (ACV) and corneal volume (CV) after laser in situ keratomileusis (LASIK) and photorefractive keratectomy (PRK) for low to moderate myopia by pentacam imaging

Methods: In this prospective comparative case series, 105 consecutive myopic eyes randomly scheduled for LASIK (n=59) or PRK (n=46) in Farabi Eye Hospital, underwent pentacam imaging. Posterior corneal elevation, ACD, ACV and CV changes before and 6 months after operation were evaluated.

Results: Mean posterior displacement was $4.55 \pm 4.12 \mu\text{m}$ (range: -4 to +18 μm) and $3.9 \pm 4.5 \mu\text{m}$ (-4 to +21 μm) in LASIK and PRK treated eyes, respectively ($P > 0.05$). The ACV, ACD and CV were decreased in both groups but the reduction of these parameters pre and postoperatively in each group and between two groups was not statistically significant ($P > 0.05$).

Conclusion: There was no significant difference in posterior corneal displacement, ACD, ACV and CV between LASIK and PRK treated eyes.

Keywords: Cornea, Anterior Chamber, Myopia, Laser in Situ Keratomileusis, Photorefractive Keratectomy, Pentacam

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Introduction

Laser in situ keratomileusis (LASIK) and photorefractive keratectomy (PRK) are the most common applied ablative refractive surgeries. The result of these procedures depends in part on wound healing and corneal curvature changes after surgery. Although most corneal changes occur within the anterior corneal surface, presumed posterior corneal surface changes can affect the outcome of these procedures.¹⁻⁴ However, its significant increase in the context of regression of laser correction may induce overdiagnosis of postrefractive surgery ectasia. PRK differs from LASIK in lack of creation of a corneal flap leading to a less changes of corneal biomechanics. This is in favor of less reports of keratectasia after PRK.⁵

Many authors have reported increased posterior corneal elevation after ablative refractive surgery. As these changes in posterior corneal shape might be considered as an early marker of corneal ectasia, it seems to be important to be evaluated in postoperative state of patients who have undergone refractive surgery.¹⁻¹⁶

Although most reports of posterior corneal elevation changes are based on Orbscan (Bausch & Lomb, Rochester, NY) measurements, the pentacam (Oculus, Wetzlar, Germany) is another instrument that has recently been used to assess such changes. The pentacam uses a rotating Scheimpflug camera to provide three-dimensional scanning of the whole anterior segment of eyes and captures direct images of the posterior corneal surface and is claimed to show accurate measures of the posterior cornea and the anterior chamber. The second important challenging issue was the role of the refractive surgery techniques (LASIK or PRK) in postoperative posterior corneal bulging leading to the changes of posterior corneal elevation, anterior chamber depth (ACD), anterior chamber volume (ACV).

To address these debates, this study was performed to measure these parameters by a new imaging system (Pentacam, Oculus, Wetzlar, Germany) and compare them between LASIK and PRK operated eyes in a matched group of patients by a prospective design.

Methods

One hundred and five myopic eyes (59 eyes underwent LASIK and 46 eyes underwent PRK) enrolled in this prospective study. Informed consent was obtained from all patients before including in the study. Patients selected for the study met the following inclusion criteria: age ≥ 20 years, documented stable refraction for at least 1 year, corneal thickness ≥ 480 μm for PRK and ≥ 500 μm for LASIK, spherical equivalent refraction ≤ 8 diopters (D) of myopia, refractive astigmatism ≤ 3.00 D, residual stromal bed of 420 μm for PRK and 260 μm for LASIK and best spectacle corrected visual acuity (BSCVA) $\geq 20/20$. Exclusion criteria were: a history of prior refractive or cataract surgery, keratoconus, collagen vascular disease, and diabetic retinopathy.

Pentacam imaging was used to evaluate posterior corneal elevation, ACD, ACV and corneal volume (CV) before and 6 months after refractive surgery.

The Nidek EC-5000 was used for all procedures, and the Moria CB microkeratome was used for creation of LASIK flaps. The PRK patients had alcohol-assisted epithelial removal. All surgeries were performed by expert ophthalmologists in excimer Laser Vision Correction Center of Farabi Eye Hospital.

Pentacam software version 1.09 (Oculus, Inc.) was used for imaging preoperatively and 6 months postoperatively. The thinnest cornea in the central 4.0 mm was recorded as the thinnest central corneal thickness (CCT) reading. Residual bed thickness (RBT) was estimated using the thinnest CCT reading and subtracting the non-nomogram-adjusted ablation depth and the nominal flap thickness of 160 μm . Variables included the preoperative and postoperative central posterior corneal elevation, ACD measured from the endothelium, ACV and CV.

Changes in the central posterior corneal surface was determined by subtracting the postoperative elevation data from the preoperative elevation data based on the maximum difference in the 4.0 mm zone (difference map).

The reference best-fit sphere (BFS) was determined by the central 8.0 mm zone of the preoperative maps. The difference in elevation was pre and postoperative displacement of

the posterior corneal surface. Postoperative anterior elevation readings carried minus signs, denoting depressions resulting from the ablation. We selected posterior elevation difference (PED), in which the central corneal elevation value is subtracted between the two examinations (t1-t2) using the same BFS reference.^{4,6}

Statistical analysis

All data were collected in an Excel database and transferred to SPSS (SPSS for Windows, version 15.0, SPSS Inc, Chicago, IL, USA) for data analysis. The pre and postoperative difference for each variable was analyzed using paired T-tests. Pearson correlation analyses were used to assess the difference between individual measurements for each patient. A P-value<0.05 was considered to indicate a significant difference.

Results

A total of 105 myopic eyes were examined with Oculus pentacam before and 6 months after refractive surgery. The mean age of the patients was 25.5±4.8 years (range 20-40 years) in LASIK group and 24.2±3.7 years (range 20-37 years) in PRK group. The mean preoperative spherical equivalent refraction was -3.38±1.26 D (range -1.62 to -6.00 D) in LASIK group and -3.25±1.33 D (range: -1.12 to -5.87 D) in PRK group (Table 1).

The mean preoperative CCT was 545±17.5 µm (range: 512-527) and 532±23.3 µm (range: 488-581 µm) in LASIK and PRK eyes, respectively. The RBT was 346±21 µm (range: 312-389 µm) in LASIK eyes and 483±25.7 µm (range: 437-544 µm) in PRK

eyes postoperatively. The mean of ablation depth in LASIK eyes was 56.8±20.61 µm and 56.64±21.8 µm in PRK eyes (Table 2).

After surgery, there was a mean decrease in ACD reading of 3.16±0.27 µm (2.71-3.66 µm) in LASIK eyes and 3.2±0.3 µm (2.7-3.8 µm) in PRK eyes (P=0.5). ACV was also decreased in LASIK and PRK groups (3.2±0.26 mm³) in LASIK group and -3.24±0.29 µm³ in PRK group), CV was also decreased in two groups but the reduction of these parameters (ACD, ACV, CV) was not statistically significant (Table 3).

The mean difference in preoperative and postoperative posterior corneal surface elevations was small in LASIK and PRK groups. The mean posterior central displacement in LASIK eyes was 4.55±4.12 (range: -4 to + 18 µm) and in PRK eyes was 3.9±4.5 µm (range -4 to +21 µm). Anterior and posterior central and maximum corneal surface elevation displacement after LASIK and PRK are shown in Table 4.

We divided our patients in 3 groups based on posterior corneal displacement in LASIK and PRK groups: group 1: -4 to +4 µm, group 2: +4 to +11 µm and group 3: > +11 µm. Only 4 eyes in LASIK group and 3 eyes in PRK groups had forward posterior corneal displacement of >11 µm (Table 5).

The difference in the mean posterior corneal displacement between the LASIK and the PRK eyes was not statistically significant (P>0.05). In our study, there was no association between the preoperative CCT, RBT and ablation depth with the change in posterior corneal elevation for either the LASIK or the PRK group.

Table 1. Mean age, mean correction (spherical equivalent)

Group	N	Mean age	P-value	Mean correction	P-value	Range
LASIK	59	25.5±4.8y	>0.05	-3.38±1.26D	>0.05	-1.62 to -6.00 D
PRK	46	24.2±3.7y	>0.05	-3.25±1.33D	>0.05	-1.12 to -5.87 D

LASIK: Laser in situ keratomileusis
PRK: Photorefractive keratectomy

Table 2. Thinnest preoperative central corneal thickness measurement, ablation depth and Residual bed thickness

Group	N	Mean CCT±SD	Mean RBT±SD	Mean ablation depth µm
LASIK	59	545±17.5	346±21	56.8±20.61
PRK	46	532±23.3	483±25.7	56.64±21.8

CCT: Central corneal thickness
RBT: Residual bed thickness
LASIK: Laser in situ keratomileusis
PRK: Photorefractive keratectomy

Table 3. Preoperative and postoperative anterior chamber depth, Anterior chamber volume, CV (Mean±SD µm)

Group	Anterior chamber depth			Anterior chamber volume			Corneal volume		
	Preoperative	Postoperative	Difference	Preoperative	Postoperative	Difference	Preoperative	Postoperative	Difference
	ACD	ACD'	Diff	ACV	ACV'	Diff	CV	CV'	Diff
LASIK	3.22±0.26	3.18±0.27	0.04±0.04	208±29.2	204±29.6	4.13±6.7	60.4	60.2	-0.16
PRK	3.28±0.27	3.23±0.29	-0.05±0.09	214±31.2	207±33	-7±8.7	59.01	58.17	-0.8

ACD: Anterior chamber depth
ACV: Anterior chamber volume
CV: Corneal volume
LASIK: Laser in situ keratomileusis
PRK: Photorefractive keratectomy

Table 4. Anterior and posterior central and maximum corneal surface elevation displacement

Group	Mean±SD µm			
	Ant-CED	Ant-MED	Post-CED	Post-MED
LASIK	-17.6±9.3	-18.15±9.3	+4.55±4.12	6.45±12.02
PRK	-17.26±11.6	-17.4±11.9	+3.9±4.5	5.56±12.35

CED: Central elevation displacement
MED: Maximum elevation displacement
LASIK: Laser in situ keratomileusis
PRK: Photorefractive keratectomy

Table 5. Categorization of posterior corneal elevation changes after laser in situ keratomileusis and Photorefractive keratectomy in 3 groups

Group	I	II	III
Posterior CE	-4- +4 µm	+4- -11 µm	>11 µm
LASIK (N: 59)	37 (62.9%)	18 (30.5%)	4 (6.8%)
PRK (N: 46)	31 (67.4%)	12 (26.1%)	3 (3.5%)

CE: Corneal elevation
LASIK: Laser in situ keratomileusis
PRK: Photorefractive keratectomy

Discussion

The goal of refractive surgery is to create emmetropia by altering the shape of the cornea. The two techniques most commonly used today are PRK and LASIK.⁶

LASIK and PRK have become a popular corneal refractive procedure. However, corneal ectasia is a serious complication of these procedures. This complication may be more in LASIK than PRK.⁵ Perhaps this may be related to more corneal weakening and change of corneal parameters such as posterior corneal curvature change. The first studies to evaluate posterior corneal elevation following ablative refractive surgeries were performed by Orbscan showing a significant forward bulge of the posterior corneal surface especially after LASIK.¹⁰⁻¹² In the case of regression of the refractive errors, the main concern of the surgeons is postrefractive surgery ectasia, an inevitable nightmare that was supported by high posterior corneal elevation found in Orbscan. It is proposed that Orbscan might overestimate the posterior corneal elevation due to the "noise" of the measurements and the inaccuracy of system realignment for the second measurement. Alternatively, it may be that Orbscan calculates the magnification ratio inaccurately or modifies the posterior corneal image after excimer laser surgery, even though the apparent image of the posterior cornea surface becomes smaller postoperatively.^{15,16}

There are 3 methods in analyzing posterior surface changes, as following: (1) float, in which the BFS was allowed to float with no alignment constraints applied to the reference sphere when being best-fit to the data surface, in this method, the BFS axis may be different from that of the viewing axis, (2) apex-fixed best-fit corneal curvature (ABC) method, also known as the center and pin alignment, in this method, the BFS is centered on the view axis and the sphere axis is made to coincide with the view axis, (3) posterior elevation difference (PED), in which the central corneal elevation value is subtracted between the two examinations (t1-t2) using the same BFS reference.^{4,6} The values given by the first two methods were in radius of curvature (mm) and by the third method in micrometers microns of elevation. PED method for analysis and

comparisons. We selected PED method for analysis and comparisons.

The anterior corneal surface is reshaped directly by refractive surgery and has been largely studied by corneal topography. The posterior corneal surface may also change, not from direct application of excimer laser but secondary to postoperative corneal thinning and decreased corneal resistance.^{1,2} There is a theoretic risk of iatrogenic keratectasia after LASIK and other forms of refractive surgeries that result in corneal weakening.² The posterior cornea appears to steepen after routine LASIK and PRK in eyes that do not have ectasia.^{2,8}

Studies using the Orbscan report a frequent forward shift in the posterior surface elevation of the cornea after LASIK.^{1,2,8-10} Baek et al found a mean forward shift of as much as $40.9 \pm 24.8 \mu\text{m}$ in a retrospective review of 196 eyes after LASIK.¹¹ Cairns et al, found a mean forward protrusion of approximately $20 \mu\text{m}$ in 115 post-LASIK eyes.¹²

Shimmura et al, suggest that slit-scan topography and pachymetry is powerful tools in the assessing of the anterior and posterior cornea and noticed posterior corneal protrusion may occur post-PRK eyes.¹³

Our study found a mean forward shift of only $4.55 \pm 4.12 \mu\text{m}$ in LASIK eyes and $3.9 \pm 4.5 \mu\text{m}$ in PRK group. Consistent with our study, Ciolino et al found a mean forward shift of only $2.64 \pm 4.95 \mu\text{m}$ in LASIK eyes with pentacam,¹ also Hashemi et al found a mean forward shift of only $2.5 \mu\text{m}$ with pentacam.¹⁰ It appears that Orbscan determines the posterior elevation above the BFS higher than the pentacam.¹⁴ One explanation for this observation is the difference in technology used to measure the cornea⁹ it has been reported that difference exists between pentacam and Orbscan devices regarding the measurement of posterior corneal elevation. Orbscan's mathematical reconstruction of the posterior cornea may lead to overestimating the posterior corneal elevation above the BFS. Furthermore, Hernandez-Quintela et al,⁶ Maloney¹⁵ and Ha¹⁶ suggest that Orbscan measurements may be a source of artificially observed ectasia by overestimating pre and postrefractive surgery posterior corneal

elevation. Therefore, pentacam's ability to image directly the posterior cornea could be a more accurate representation of the posterior corneal topography.¹⁷⁻²⁰

Conclusion

In conclusion, PRK and LASIK for correction of low to moderate myopia do not induce

statistically significant changes in posterior corneal surface detected by pentacam imaging. The reduction in ACD, ACV and CV was minimal and not statistically significant. Our findings also suggest pentacam to be a clinically acceptable instrument for measuring posterior corneal elevation, ACD, ACV and CV in virgin as well as laser-treated eyes.

References

1. Ciolino JB, Belin MW. Changes in the posterior cornea after laser in situ keratomileusis and photorefractive keratectomy. *J Cataract Refract Surg* 2006;32(9):1426-31.
2. Konstantopoulos A, Hossain P, Anderson DF. Recent advances in ophthalmic anterior segment imaging: a new era for ophthalmic diagnosis? *Br J Ophthalmol* 2007;91(4):551-7.
3. Naroo SA, Charman WN. Changes in posterior corneal curvature after photorefractive keratectomy. *J Cataract Refract Surg* 2000;26(6):872-8.
4. Nilforoushan MR, Speaker M, Marmor M, et al. Comparative evaluation of refractive surgery candidates with Placido topography, Orbscan II, Pentacam, and wavefront analysis. *J Cataract Refract Surg* 2008;34(4):623-31.
5. Javadi MA, Mohammadpour M, Rabei HM. Keratectasia after LASIK but not after PRK in one patient. *J Refract Surg* 2006;22(8):817-20.
6. Hernández-Quintela E, Samapunphong S, Khan BF, et al. Posterior corneal surface changes after refractive surgery. *Ophthalmology* 2001;108(8):1415-22.
7. 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(2):406-9; discussion 409-10.
8. Ciolino JB, Khachikian SS, Cortese MJ, Belin MW. Long-term stability of the posterior cornea after laser in situ keratomileusis. *J Cataract Refract Surg* 2007;33(8):1366-70.
9. Vicente D, Clinch TE, Kang PC. Changes in posterior corneal elevation after laser in situ keratomileusis enhancement. *J Cataract Refract Surg* 2008;34(5):785-8.
10. Hashemi H, Mehravaran S. Corneal changes after laser refractive surgery for myopia: comparison of Orbscan II and Pentacam findings. *J Cataract Refract Surg* 2007;33(5):841-7.
11. Baek T, Lee K, Kagaya F, et al. Factors affecting the forward shift of posterior corneal surface after laser in situ keratomileusis. *Ophthalmology* 2001;108(2):317-20.
12. Cairns G, Ormonde SE, Gray T, et al. Assessing the accuracy of Orbscan II post-LASIK: apparent keratectasia is paradoxically associated with anterior chamber depth reduction in successful procedures. *Clin Experiment Ophthalmol* 2005;33(2):147-52.
13. Shimmura S, Yang HY, Bissen-Miyajima H, et al. Posterior corneal protrusion after PRK. *Cornea* 1997;16(6):686-8.
14. Quisling S, Sjoberg S, Zimmerman B, et al. Comparison of Pentacam and Orbscan IIz on posterior curvature topography measurements in keratoconus eyes. *Ophthalmology* 2006;113(9):1629-32.
15. Maloney RK. Editorial: Posterior corneal surface topographic changes after laser in situ keratomileusis are related to residual corneal bed thickness. *Ophthalmology* 1999;106:409-10.
16. Ha BJ, Kim SW, Kim SW, et al. Pentacam and Orbscan II measurements of posterior corneal elevation before and after photorefractive keratectomy. *J Refract Surg* 2009;25(3):290-5.
17. Nishimura R, Negishi K, Saiki M, et al. No forward shifting of posterior corneal surface in eyes undergoing LASIK. *Ophthalmology* 2007;114(6):1104-10.
18. Sun HJ, Park JW, Kim SW. Stability of the posterior corneal surface after laser surface ablation for myopia. *Cornea* 2009;28(9):1019-22.
19. Nishimura R, Negishi K, Dogru M, et al. Effect of age on changes in anterior chamber depth and volume after laser in situ keratomileusis. *J Cataract Refract Surg* 2009;35(11):1868-72.
20. Kim SW, Sun HJ, Chang JH, Kim EK. Anterior segment measurements using Pentacam and Orbscan II 1 to 5 years after refractive surgery. *J Refract Surg* 2009;25(12):1091-7.