Retinal Nerve Fiber Layer Thickness Change after Photorefractive Surgery

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Abstract

Purpose: to analyze the retinal nerve fiber layer (RNFL) change after photorefractive surgery.

Methods: Forty-four eyes of 29 patients had RNFL measured by scanning laser polarimetry (SLP) before and after photorefractive surgery. Patients were divided in 3 groups: PRK group (10 eyes), low myopic LASIK group (17 eyes) and moderate myopic LASIK group (17 eyes). Pre and postoperative mean RNFL thickness (total and per quadrant) and 14 SLP parameters were compared with the Wilcoxon and Mann-Whitney tests.

Results: In the PRK group, total mean and inferior mean thickness decreased after surgery. Five parameters were changed after the procedure. In the low myopic LASIK group all mean RNFL thickness decreased and 4 parameters changed after surgery. In the moderate myopic LASIK group all mean RNFL thickness decreased and 5 parameters were changed after surgery. The mean decrease in the RNFL thickness seen in both LASIK groups were statistically different from PRK group (P<0.01).

Conclusion: Our results show that RNFL thickness decreases after photorefractive surgery as measured by SLP.

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Drs. Flank and Kasahara share equal responsibility in the preparation of the manuscript.

INTRODUCTION

Subtle anatomic changes in the neural rim and the retinal nerve fiber layer (RNFL) are believed to precede visual field changes in glaucoma patients. In order to objectively evaluate changes in the RNFL, new methods have been developed. Scanning laser polarimetry (SLP) is one of these new technologies and it has been used in the diagnosis and follow-up of glaucomatous patients and suspects.[1,2,3,4,5] SLP works based on the principle that polarized light passing through the RNFL (a birefringent medium) undergo a measurable phase shift proportional to the thickness of the tissue.

Recent reports suggest that laser-assisted in situ keratomileusis (LASIK) can interfere with SLP measurements by affecting corneal birefringence, an intrinsic tissue property. [6,7,8,9]

The purpose of this study is to analyze the RNFL changes after photorefractive surgery and to compare proportional changes between LASIK and photorefractive keratectomy (PRK).

MATERIAL AND METHODS

Forty-four eyes of 29 patients scheduled for refractive surgery at the Sao Paulo Eye Hospital were enrolled. All surgeries were performed by 2 surgeons (JM and FM) from January to June, 2001. Patients were informed about the risks of the procedure and signed informed consent. The

procedures followed were in accordance with the Helsinki Declaration of 1075, as revised in 1983. All patients were white, 16 (55.1%) were male and 13 (44.9 %) female. They were divided in 3 groups, according to the surgical technique and degree of myopia in PRK, LASIK I (low myopic) and LASIK II (moderate myopic).

The PRK group comprised 10 eyes of 5 patients. The mean age group was 38.8 ± 8.8 years (range, 26 to 48), mean preoperative spherical equivalent was -1.9 ± 0.4 diopters (range, -1.00 to -2.75), and the mean tissue ablation was 32.2 ± 16.0 μm (range, 9 to 59). The low myopic group comprised 17 eyes (10 patients) with mean preoperative spherical equivalent up to - 4.00 diopters (- 2.53 ± 0.9, range - 0.75 to - 4.00). The mean age was 32.9 ± 6.8 years (range, 24 to 50), and the mean tissue ablation was 49.7 ± 11.0 μm (range, 28 to 58). The moderate myopic group comprised 17 eyes (14 patients) with preoperative spherical equivalent from - 4.25 diopters and up (- 7.19 ± 1.88, range, - 5.00 to -10.00). The mean age was 33.2 ± 7.7 years (range, 21 to 47), and the mean tissue ablation was 90.5 ± 20.0 μm (range, 66 to 133).

Preoperatively all patients underwent a complete ophthalmologic examination including, refractometry, biomicroscopy, aplanation tonometry, indirect ophthalmoscopy, pachimetry, corneal topography, and retinal nerve fiber layer analysis with the scanning laser polarimeter (GDx ® version 2.0.08, Laser Diagnostic Technology, San Diego, CA, USA).

Briefly, the surgical technique for LASIK involved the creation of a corneal flap (160 μm or 180 μm, at the surgeon discretion) with the Hansatome® (Bausch & Lomb Surgical, Claremont, CA, USA). A flying-spot ablation was performed on corneal stroma with the Technolas Keracor 117 C excimer laser (Bausch & Lomb Surgical, Claremont, CA, USA), using a variable optical zone (4.5 mm to 6.0 mm) individualized for each eye. The corneal flap was then repositioned, the interface irrigated with balanced saline solution and let it air dry for at least 3 minutes. A bandage contact lens was placed in the operated eye for at least 12 h and the patient was instructed to use tobramicin 0.3% and dexamethasone 0.1% (Tobradex®, Alcon Laboratories, INC., Fort Worth, TX, USA) q.i.d. for 1 week.

The PRK procedure started with a removal of the previously demarcated corneal epithelium to a diameter of 7.0 mm. A flying-spot laser ablation was done with the Technolas Keracor 117 C excimer laser (Bausch & Lomb Surgical,

Claremont, CA, USA) and a bandage contact lens was placed. Postoperatively, patients were instructed to take tobramicin 0.3% and dexamethasone 0.1% (Tobradex®, Alcon Laboratories, INC., Fort Worth, TX, USA) q.i.d. for 3 days and diclofenac 0.1% (Voltaren®, Novartis Ophthalmics, Duluth, GA, USA) q.i.d. for 24 h. On postoperative day 3, the bandage contact lens was removed and patients started using fluoromethasone 0.1% (Florate®, Alcon Laboratories, INC., Fort Worth, TX, USA) q.i.d. for one month.

SLP was repeated from one to 10 weeks after the surgical procedure. Three good quality pictures were taken from each eye by the same operator and the mean of the 3 was used for analysis. In the mean image, a ellipse set at 1.75 times the disk diameter was drawn concentric to the disk margin. The preoperative image was set as reference.

Pre and postoperative values of mean RNFL thickness (total and per each of the 4 quadrants) and SLP parameters included in the GDx® software version 2.0.08 (symmetry, superior ratio, inferior ratio, superior/nasal, maximum modulation, average thickness, ellipse modulation, ellipse average, superior average, inferior average and superior integral) were compared. Definition of each parameter has been described elsewhere.[10] Wilcoxon test was used to compare pre and postoperative data within the groups and Mann-Whitney test was used to compared the ⍙% values of each group (⍙% = pre - postoperative / pre X 100). A P value of less than 0.05 was considered to be statistically significant.

RESULTS

Table 1 shows the mean pre and mean RNFL thickness difference among PRK group, LASIK I (low myopic) group and LASIK II (moderate myopic) group. All quadrants showed statistically significant difference for LASIK I and LASIK II groups, whereas, for the PRK group, mean total and mean inferior quadrant showed significant difference.

Figure 1

Table 1: Mean pre and postoperative retinal nerve fiber layer thickness.

	PRK			LASIK I			LASIK II		
	Pre (μm)	Post (μm)	P*	Pre (μm)	Post (μm)	P*	Pre (μm)	Post (μm)	P*
Total	55.2 (10.3)	53.1 (9.3)	.01	66.1 (12.9)	57.7 (9.9)	.01	64.8 (11.4)	57.9 (9.6)	.001
Superior	62.0 (13.9)	60.0 (14.1)	NS	77.6 (15.4)	68.7 (11.8)	.02	71.1 (12.4)	61.8 (9.6)	.001
Inferior	69.9 (12.9)	66.1 (12.7)	.01	79.0 (16.0)	69.8 (14.3)	.02	78.7 (14.8)	70.7 (14.4)	.001
Temporal	27.9 (6.6)	26.8 (6.4)	NS	36.6 (9.6)	29.2 (6.1)	.01	42.3 (11.8)	34.8 (10.8)	.01
Nasal	38.5 (5.4)	35.7 (5.7)	NS	47.9 (11.7)	38.6 (6.8)	.01	48.6 (13.2)	43.2 (10.1)	.01

LASIK I: low myopic group LASIK II: moderate myopic group mean (standard deviation) Pre: preoperative Post: postoperative NS: not significant P* : Wilcoxon

Table 2 shows the pre and postoperative differences of all SLP parameters among 3 groups. Average thickness, ellipse average and inferior integral were statistically different for the 3 groups.

Figure 2

Table 2: Mean pre and postoperative parameters.

	PRK			LASIK I			LASIK II		
Parameter	Pre	Post	P*	Pre	Post	P*	Pre	Post	P*
symmetry	0.86 (0.15)	0.92 (0.14)	.01	0.98 (0.09)	0.94 (0.13)	NS	0.93 (0.09)	0.91 (0.27)	NS
sup. ratio	2.58 (0.71)	2.55 (0.57)	NS	2.49 (0.37)	2.59 (0.38)	NS	2.32 (0.59)	2.2 (0.42)	NS
inf. ratio	2.94 (0.59)	2.76 (0.48)	.05	2.56 (0.44)	2.78 (0.47)	NS	2.48 (0.61)	2.48 (0.61)	NS
sup/nasal	1.98 (0.33)	2.09 (0.4)	NS	2.13 (0.32)	2.2 (0.35)	NS	2.12 (0.43)	2.05 (0.42)	NS
max. mod.	1.99 (0.6)	2.04 (0.59)	NS	1.65 (0.43)	1.88 (0.42)	NS	1.66 (0.55)	1.72 (0.41)	NS
ellip. mod.	3.33 (0.62)	2.99 (1.23)	NS	2.87 (0.9)	3.18 (0.57)	NS	2.81 (0.61)	2.95 (0.65)	NS
avrg. thick	52 (8.69)	49.9 (8.26)	.05	62 (12.8)	54.3 (9.23)	.01	60.4 (10.0)	54.5 (7.7)	.001
ellip. avrg	55.3 (10.4)	53 (9.43)	.05	66.2 (12.9)	57.8 (9.95)	.02	64.7 (11.3)	57.9 (9.6)	.001
sup. avrg	62 (13.9)	59.5 (14.2)	NS	77.1 (14.8)	68.7 (11.8)	.05	71.1 (12.3)	61.8 (9.6)	.001
inf. avrg	69.9 (12.6)	66.1 (12.7)	.01	79.1 (16.1)	69.9 (14.2)	.03	78.8 (14.8)	70.8 (14.3)	.001
sup. integ	0.18 (0.03)	0.17 (0.03)	NS	0.2 (0.03)	0.19 (0.03)	NS	0.27 (0.36)	0.16 (0.02)	.001

LASIK I: low myopic group LASIK II: moderate myopic group mean (standard deviation) Pre: preoperative Post: postoperative NS: not significant P* : Wilcoxon

Table 3 shows the comparison of the mean pre and postoperative change of RNFL thickness (Δ%) among groups. Mean total and 3 of the 4 quadrants (except nasal) were statistically different between PRK and LASIK I. No difference was found between LASIK I and LASIK II.

Figure 3

Table 3: Mean pre and postoperative differences of retinal nerve fiber layer thickness among groups.

	PRK (Δ%)	LASIK I (Δ%)	P*	LASIK II (Δ%)	P†
Total	3.59	11.84	.01	10.49	NS
Superior	3.35	10.73	.01	12.75	NS
Inferior	5.41	11.31	.05	10.2	NS
Temporal	3.27	17.85	.05	17.21	NS
Nasal	6.81	17.24	NS	10.19	NS

Δ%: (Pre - Post) / Pre P*: Mann-Whitney between PRK group and low myopic group P† : Mann-Whitney between low and moderate myopic groups NS: not significant

Table 4 shows the comparison of the mean pre and postoperative change (Δ%) of SLP parameters. Symmetry, inferior ratio, average thickness and ellipse average were statistically different between PRK and LASIK I groups. Between LASIK I and LASIK II, all differences, except integral superior, were not significant.

Figure 4

Table 4: Mean pre and postoperative differences of parameters among groups.

Parameter	PRK (Δ%)	LASIK I (Δ%)	P*	LASIK II (Δ%)	P†
Symmetry	-7.79	3.95	.001	3.96	NS
Sup. ratio	-0.6	-5.54	NS	1.96	NS
Inf. ratio	5.59	-10.58	.05	-3.41	NS
Sup./nasal	-6.23	-3.94	NS	2.58	NS
Max. modulation	-5.65	-18.18	NS	-11.53	NS
Ellipse modulation	9.36	-19.37	NS	-8.42	NS
Average thickness	3.89	11.32	.01	9.27	NS
Ellipse average	3.86	11.89	.01	10.36	NS
Sup. average	4.24	10.08	NS	12.79	NS
Inf. average	5.53	11.21	NS	10.15	NS
Sup. integral	3.54	-11.57	NS	15.58	.05

Δ%: (Pre - Post) / Pre P*: Mann-Whitney between PRK group and low myopic group P† : Mann-Whitney between low and moderate myopic groups NS: not significant

DISCUSSION

This study is the only that compared PRK and LASIK changes in SLP results. The results of this study concur with previous publish studies. Gürses-Özden et al. found that total mean RNFL and superior, inferior, temporal and nasal mean RNFL were thinner after LASIK in 13 eyes.[6] Tsai et al., evaluating 35 eyes, noted the postoperative integrals and averages of RNFL thickness were statistically significantly lower than preoperative values in all quadrants, except in the temporal one.[8] Roberts et al. noted that six of 12 retinal nerve fiber layer thickness measurements showed significant change in 30 eyes, one week after LASIK.[9] However, there was no correlation with corneal ablation depth for all parameters. In a larger series of patients, Kook et al. found the mean postoperative retardation values of all sectors and of the superior, temporal, inferior and nasal sectors showed reduced RNFL thickness.[7]

The SLP (version 2.0.08) measurements is influenced by corneal and crystalline lens birefringence. In order to neutralize corneal polarization effect caused by the 3 mm diameter central cornea, SLP uses a built-in anterior-segment-compensating device fixed at corneal polarization axis of 15 nasally downward.[10] However, considerable intraindividual and interindividual variability exists and the linear relationship between corneal polarization axis and RNFL retardation parameters is responsible, in part, for the wide distribution of RNFL thickness as generated by SPL.[11]

Most authors agree that RNFL thickness changes after LASIK is caused by the structural changes determined by ablation of tissue from the anterior stroma in central cornea.[6,7,8,9] Such ablation affects the form-birefringent properties of the cornea to a point to change RNFL thickness measurements by SLP. It is unlikely that the transient elevated IOP during the microkeratome pass caused true nerve fiber loss. Although reaching values over 50 mmHg, the IOP elevation lasts less than 30 seconds. Besides, the time period between the surgery and the second SLP measurement, which was one or two weeks in some patients, seems too short to allow apoptosis of the retinal ganglion cell take place causing axon loss and be noticed by means of SLP. Nevertheless, Bushley et al. report a case of visual field defect associated with LASIK.[12] The near superior altitudinal defect correlated with an infero-temporal notch. They believe that increased IOP associated with the microkeratome ring used during LASIK may have precipitated optic nerve head ischemia and visual field defect. This case is an exception to the rule and highlights the importance of discussing this unusual complication in glaucomatous patients.

Choplin et al. found no significant effect of excimer laser PRK on RNFL thickness measurements in a group of 13 patients with moderate myopia.[13] In their study, the pre and postoperative RNFL thickness measurements were not compared. Conversely, in our study, we found total mean and inferior RNFL thinning in the PRK group and 5 parameters changed after the procedure. The SLP measurements changes in PRK patients suggests that RNFL thinning does not represent true loss.

In our study we decided to compare the RNFL changes seen after refractive surgery according to the surgical technique. LASIK seemed to cause more thinning in the RNFL and SLP parameters changes than PRK. When comparing low and moderate myopic groups only one parameter (superior integral) was different between groups, whereas no difference was found in the RNFL thickness measures suggesting that the amount of corneal tissue ablation does not influence the retardation measurements. This is in agreement with Roberts et al. that found no correlation with corneal ablation depth for all parameters.[9]

A new version of SLP with variable corneal polarization compensation (VCC) is now available. Weinreb et al. compared the ability of SLP to discriminate between healthy and glaucomatous eyes with fixed corneal polarization magnitude and VCC.[14] The authors noticed that VCC can improve the ability to discriminate between healthy and glaucomatous eyes. Even though the correction for corneal polarization compensation with VCC looks promising, whether these measurements can be influenced by photorefractive surgery, or not, is yet to be determined.

In conclusion, our study shows that both PRK and LASIK can influence SPL measurements. This effect is most probably caused by structural changes in the corneal stroma as a result of excimer laser ablation.

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