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Effectiveness of four tonometers in measuring intraocular pressure following femtosecond laser–assisted LASIK, SMILE and transepithelial PRK

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Running Head

IOP measurement following 3 forms of refractive surgery

Abstract

Purpose: To test the performance of 4 tonometers in estimating intraocular pressure (IOP) after 3 forms of refractive surgery.

Setting: Eye Hospital, WenZhou Medical University, China.

Design: Prospective case series.

Methods: Patients matched for preoperative age, corneal thickness and myopic correction enrolled for femtosecond laser–assisted laser in situ keratomileusis (FS-LASIK), small-incision lenticule extraction (SMILE), or transepithelial photorefractive keratectomy (TransPRK) were included in the study. For each patient, 4 measurements of IOP were obtained preoperative and 3 months postoperative, using the Goldmann applanation tonometer (GAT-IOP), the Dynamic Contour Tonometer (DCT-IOP), corneal-compensated IOP (IOPcc) from the Ocular Response Analyzer, and biomechanically-corrected IOP (bIOP) from the Corvis ST. Overall corneal stiffness was also estimated based on the stiffness parameter (SP-A1) provided by the Corvis ST.

Results: The study included 144 eyes of 144 patients. Among the 3 procedures, the smallest variances between preoperative and postoperative IOP estimates and SP-A1 values were observed with the TransPRK, followed by SMILE and FS-LASIK. In the TransPRK group, no significant differences were observed in both bIOP (-0.18±1.63 mmHg) and DCT-IOP (-0.64±2.34 mmHg), while they were larger and significant in GAT-IOP (-1.78±2.29 mmHg) and IOPcc (-2.77±1.84 mmHg). In FS-LASIK and SMILE groups, while there were similar significant reductions in IOP after surgery, these reductions were still lower in bIOP and DCT-IOP than in GAT-IOP and IOPcc.

Conclusions: The bIOP and DCT-IOP were the least affected IOP estimates between the 3 refractive surgery procedures considered. It was evident that TransPRK produced significantly smaller reductions in IOP readings than did FS-LASIK and SMILE.

Introduction

Since the times of radial keratotomy, the measurement of intraocular pressure (IOP) after refractive procedures has remained a concern [1]. It is known that IOP estimates are affected by corneal thickness, shape and biomechanics [2-5], therefore it is expected that after tissue removal and separation in laser procedures, tonometry would produce lower IOP readings [6]. And since the biomechanical impact varies from one surgical procedure to another, their subsequent effect on IOP readings would also differ [7, 8].

The Goldmann applanation tonometer (GAT), introduced in the 1950s, is still the reference standard and the most widely used tonometer worldwide [9]. The influence of corneal thickness and biomechanics on GAT-IOP measurements has led to several methods to correct its values after refractive procedures [10-12]. The methods are often based on population analyses and have resulted in corrections that ranged widely between 0.7 and 7.1 mmHg for each change in central corneal thickness of 100 μm, and between 0.12 and 0.50 mmHg for a change in age of 10 years [2, 13, 14]. These wide variations have encouraged efforts to develop alternative, and possibly more accurate, tonometry techniques, a notable example of which is the PASCAL Dynamic Contour Tonometer (DCT) (Ziemer Ophthalmic Systems AG). Unlike the GAT, the DCT has a curved tip, which allows the cornea to assume its natural shape when the pressure is the same on both sides [15]. The success of the DCT in reducing the effect of corneal stiffness on its IOP readings, compared with the GAT, has been evident in several earlier studies [16-21].

Other tonometry devices, based on the noncontact, air-puff principle, have also been developed, including the Ocular Response Analyzer (ORA, Reichert Ophthalmic Instruments) and the Corvis ST (CVS) (OCULUS Optikgerate GmbH). Both tonometers produce IOP measurements that are intended to be less affected by corneal biomechanics relative to GAT [22, 23]. This study sought to evaluate these new devices in a systematic simultaneous assessment that considered their performance and the effect the corneal biomechanical changes caused by femtosecond laser-assisted LASIK (FS-LASIK), small-incision lenticule extraction (SMILE) and transepithelial PRK (TransPRK) on their IOP estimates.

Patients and Methods

One hundred forty-four eyes of 144 myopes, (26.3±5.2 years, range 17-42) including 55 men and 89 women, who underwent refractive surgery in the Eye Hospital of WenZhou Medical University were included in this prospective study. They included 50 eyes that underwent

FS-LASIK, 50 that underwent SMILE and 44 that underwent TransPRK. The patients were selected to ensure that the 3 treatment groups had almost the same means and ranges in age, central corneal thickness and refractive correction. The study followed the tenets of the Declaration of Helsinki. It was approved by the Institutional Review Board of the Eye Hospital of Wenzhou Medical University. Informed consent was provided by all participants to use their data in research.

Surgical parameters, including refractive error correction (REC), optical zone diameter (OZD), ablation depth (AD), and residual stromal bed thickness (RSB), were recorded from surgery planning/treatment printouts. REC was converted into a corrected mean spherical equivalent (cMSE). Mean curvature power in the central 3 mm of the anterior surface (Km) and central corneal thickness (CCT) was measured with a Pentacam (OCULUS Optikgerate GmbH) and RSB ratio was defined as RSB divided by presurgery CCT. One eye per patient was selected to match the 3 treatment groups in cMSE and CCT, in addition to age, in order to avoid these variables acting as confounding factors in the statistical analyses.

IOP and biomechanical measurements

Each participant was submitted to IOP measurements using 4 tonometers: the GAT (AT900, Haag-Streit), the DCT, the ORA (model SW-5000), from which the corneal-compensated IOP (IOPcc) was recorded and the CVS (software version 6.08r19), from which the biomechanically-corrected IOP (bIOP) was recorded. The CVS exam additionally provided the stiffness parameter at first applanation (SP-A1), which has been shown in earlier studies to offer a good measure of overall corneal stiffness [24]. The stiffness parameter (SP-A1) was calculated as:

$$\text{SP-A1} = (\text{adjAP1} - \text{bIOP}) / (\text{A1DeflAmp}) \qquad \text{Eq 1}$$

where Adj AP1 is the adjusted air puff pressure at first applanation, and A1 DeflAmp the defection amplitude at first applanation [25]. Since earlier studies have demonstrated a significant positive correlation between SP-A1 and the ORA parameters corneal hysteresis [CH] and corneal resistance factor [CRF], for the sake of simplicity SP-A1 was chosen as the single estimate of corneal stiffness" [26].

All exams were by a single experienced examiner (WH), with the patient in a sitting position and in a single clinic visit, in the same half-day session (morning 08:30-11:30 or afternoon 01:30-04:30) to minimize diurnal effects [27]. In compliance with the eye hospital guidelines, IOP exams were carried out after the topography measurements. The noncontact tonometers (ORA and CVS) were used before the contact tonometers (GAT and DCT). However, the order of measurements taken with ORA and CVS and with GAT and DCT was random to avoid bias toward one specific tonometer [28]. Noncontact IOP measurements were repeated with 3 minute intervals until 3 readings with less than 2 mmHg difference between the highest and lowest values were obtained. Contact measurements were carried out with topical anaesthesia using Alcaine 0.5% applied 20 minutes after completion of all noncontact measurements. In case of GAT, fluorescein was applied with a fluorescein strip (JinMing Con., Ltd.). Each contact tonometer was used twice with a pause of at least 5 minutes between measurements. Data were collected preoperatively and 3 months after surgery.

Surgical techniques

In the FS-LASIK procedure, the lamellar flap was created using a femtosecond laser (Ziemer Ophthalmic Systems AG). The flaps had a superior hinge, their maximum thickness ranged between 95 and 110 µm, and diameter between 8.5 and 9.0 mm. Tissue ablation was performed using a Amaris 750Hz excimer laser (Schwind eye-tech-solutions). In the TransPRK procedure, the epithelium and stroma were ablated in a single step using the aberration-free mode of the Amaris laser. The SMILE procedure was performed using the VisuMax femtosecond laser (Carl Zeiss Meditec AG). It involved removing a stromal lenticule, leaving a 120 µm-thick cap. The postoperative care was similar for the 3 procedures: 1 drop of tobramycin/dexamethasone (Tobradex) was instilled at the surgical site. A bandage contact lens (Acuvue Oasy, Johnson & Johnson Vision) was placed on the cornea and kept for 1 day after FS-LASIK, or for 5 to 7 days after TransPRK and until complete corneal re-epithelisation. Following this period, fluorometholone 0.1% (Flumetholon) and topical levofloxacin 0.5% (Cravit) were applied 4 times a day for 1 week. The fluorometholone dosage was then tapered each subsequent week until it was stopped 1 month after FS-LASIK and SMILE. In the TransPRK group, the fluorometholone dosage was tapered each subsequent 2 to 3 weeks and stopped 2 to 3 months after surgery.

Statistical Analysis

Statistical analysis was accomplished using the R Core Team, a language and environment for statistical computing (2016 version, R Foundation for Statistical Computing https://www.R-project.org/). The one-sample Shapiro-Wilk test was used to check the normality of distribution of the continuous variables. Comparisons between the 3 surgery methods were made with one-way analysis of variance (ANOVA) or Kruskal-Wallis according to the normality test. The differences between the preoperative and postoperative measurements were assessed with the parametric paired t-test or with the non-parametric Wilcoxon signed-rank test. Pairwise comparisons were adjusted with the Bonferroni correction. Bland-Altman plots were used to evaluate the level of agreement between the preoperative and postoperative IOP measurements [29]. A *P* value of less than 0.05 was considered indicative of statistical significance.

Results

The baseline patient characteristics are shown in Table 1. No significant differences were observed in the baseline age, Km, CCT, cMSE, OZD, and SP-A1 between the 3 surgery groups. However, statistical differences were present in each pairwise comparison ($p < 0.050$) in AD, flap/cap thickness and RSB.

Analysis of the IOP and SP-A1 measurements in preoperative and postoperative stages is shown in Table 2. There was no significant difference in the preoperative IOP estimates for corneas undergoing FS-LASIK, SMILE and TransPRK for either GAT, DCT or bIOP (p= 0.531, 0.730, 0.990, respectively). Conversely, the differences were significant in the IOPcc estimates within the 3 surgery groups ($p < 0.001$).

When considering the difference of IOP between pre-surgery and post-surgery the comparative analysis showed that the differences between pre-surgery and post-surgery bIOP and DCT-IOP, (ΔbIOP and ΔDCT-IOP), presented the smallest reductions compared with ΔGAT-IOP and ΔIOPcc. Figure 1 illustrates the differences within the groups.

When considering each surgery, all 4 IOP estimates showed a significant decrease in IOP values in FS-LASIK and SMILE. Conversely, in TransPRK group no significant difference between preoperative and postoperative IOP was observed in bIOP (p= 0.678) and DCT (p= 0.262). The SP-A1 reduction was statistically significant in all 3 surgery groups with this reduction being highest in FS-LASIK, intermediate in SMILE and lowest in TransPRK.

Pairwise comparisons showed no difference in SP-A1 reductions between FS-LASIK and SMILE ($p = 0.106$) but both sets of reductions were statistically different than TransPRK ($p < 0.010$). Even though the RSB ratio was lower (higher tissue ablation) in SMILE than in FS-LASIK (0.57±0.04 vs 0.64±0.03), the reductions in GAT-IOP and IOPcc were higher in the FS-LASIK group ($p = 0.041$ and $p < 0.001$, respectively). This difference between the 2 procedures was not as evident in DCT-IOP and bIOP ($p = 0.069$ and $p = 0.051$, respectively). The distribution in SP-A1 is illustrated in Figure 2, and the relation between RSB ratio and reduction in IOP is shown in Figure 3.

The Bland-Altman plots (Figure 4) showing the mean differences (Δ = postoperative - preoperative IOP values) and the 95% limits of agreement (LoA) for each IOP estimate and for each surgical technique are illustrated in Figure 3. The smallest differences are found in bIOP, followed closely by DCT. On the other hand, GAT and IOPcc exhibited both the largest postoperative-preoperative IOP differences and the highest LoA.

Discussion

To correct refractive error and enable the ocular optical system to focus light on the retina, refractive surgery changes corneal shape by removing part of stromal tissue, leading to considerable reductions in overall corneal stiffness and possible underestimations in IOP measurement. Four commonly-used tonometers, the contact Goldmann applanation tonometer and the Dynamic Contour Tonometer, and the noncontact Ocular Response Analyzer and the Corvis ST, were assessed in this study to quantify and compare the effects of refractive surgical procedures on their IOP estimates in a Chinese adult population. The results demonstrated that the bIOP and the DCT-IOP were less affected than GAT-IOP and

IOPcc, and that TransPRK caused smaller reductions in IOP readings by all 4 tonometers than both FS-LASIK and SMILE. The study also pointed at slightly more effect of FS-LASIK than SMILE on IOP measurements, particularly in GAT-IOP and IOPcc, even though the tissue loss in SMILE was larger.

Two recent meta-analyses investigated the biomechanical changes in different surgical procedures. Guo et al. used the corneal biomechanical assessment provided by the ORA and found that the reduction in corneal biomechanics was greater with FS-LASIK than SMILE, in agreement with the present study, and although non-statistically significant, PRK/laser-assisted subepithelial keratectomy (LASEK) showed less decrease in corneal biomechanics than SMILE [8]. Similarly, Rævdal et al. observed higher reductions in corneal viscoelastic properties following LASIK compared with SMILE in nonrandomised studies [30].

The stiffness parameter was developed to facilitate the interpretation of the corneal deformation parameters produced by the Corvis ST. The SP-A1 allows evaluating how individual parameters respond to the decrease in corneal resistance to deformation [25]. It was observed that the reduction in SP-A1 was smaller in TransPRK than in SMILE and FS-LASIK. One limitation to this analysis is that even though the patients had been matched for age, CCT and the cMSE, the amount of tissue removed was not the same among the procedures and the SMILE cap depth was bigger than the FS-LASIK flap depth. The SMILE group presented the highest values of depth of tissue removed, which can increase the reduction in the SP-A1. Further, the significantly less stiffness reduction in TransPRK than in the other two procedures supports the fact that the IOP readings in this group were the least influenced by surgery.

The absence of statistical difference in SP-A1 between FS-LASIK and SMILE is in accordance with the similar reductions in bIOP, DCT-IOP and GAT-IOP ($p > 0.051$). The IOPcc presented different behaviour. It was the estimate that was the most reduced among the 4 procedures and no statistically significant difference was found between SMILE and TransPRK, -3.08±1.53 mmHg and -2.77±1.84 mmHg, respectively ($p = 0.128$). This behaviour can be partially explained by the fact that the IOPcc was the only measurement that was significantly lower in the preoperative of the SMILE group compared with LASIK and TransPRK ($p < 0.001$).

Analysing the relationship between the RSB ratio and the reduction in IOP estimates, it is observed that in GAT-IOP and IOPcc the reduction was higher in FS-LASIK than in SMILE, even with SMILE presenting the lowest RSB ratios. This difference was not evident in bIOP or DCT-IOP. For all 4 estimates, the TransPRK IOP reduction was significantly less than with the other 2 procedures. These differences suggest that the higher biomechanical impact caused by FS-LASIK was more prominent in GAT-IOP and IOPcc estimates, while the bIOP and DCT-IOP estimates were less affected.

Similar reductions in IOP readings in patients undergoing refractive surgery procedures are reported in the literature. In a large cohort of 174,666 cases, Schallhorn et al. found a significantly higher reduction in IOP estimate from preoperative to postoperative in LASIK cases compared to PRK [7]. They found that the reduction in IOP using noncontact tonometry after LASIK was on average 0.94 mmHg higher than after PRK. This result is in accordance with this study, in which the mean difference between preoperative and postoperative stages was higher in FS-LASIK than PRK for all 4 tonometers. The highest mean difference was in GAT-IOP (1.60 mmHg) and the lowest in bIOP (1.03 mmHg). Larger reductions in IOP measurement were also found after SMILE compared with a procedure that was comparable to PRK (without stromal flap creation, LASEK) as reported by Yu et al [31]. At 3 months postoperatively, the average IOPcc was 1.40 mmHg higher in the LASEK group. Similarities in IOP reduction after SMILE and LASIK were also found by Li et al [22], where a mean reduction of approximately 3 mmHg in IOPcc was observed, similar to that found in this study.

Different attempts to correct GAT-IOP readings after laser refractive surgery have been discussed in the literature. De Bernardo et al. studied GAT measurements obtained preoperative and postoperative PRK,[12] and observed a similar behaviour to that found in this study with an average IOP reduction of approximately 2 mmHg and a wide LoA (from -7 to 3mmHg). They compared several correction formulas, and obtained the best result with Rashad's method [32], with an average reduction of approximately 1 mmHg and LoA from -3.25 to 0.99 mmHg. Even though this correction was successful in reducing the difference in IOP between preoperative and post-TransPRK, the differences were still higher than those obtained in our study with the relatively newer tonometry methods, bIOP and DCT (-0.18±1.63 mmHg, $p = 0.678$ and -0.64±2.34 mmHg, $p = 0.262$, respectively). In another related study, Lee et al. found no statistical difference in bIOP before and after TransPRK in cases with or without accelerated crosslinking ($p > 0.101$) [33, 34], supporting the expectation that bIOP, and also DCT, were less affected by CCT and the stiffness reductions induced by TransPRK. On the other hand, IOPcc presented reductions (-2.77±1.84 mmHg) that were even higher than those observed with GAT in the TransPRK group, even though the LoA was narrower with IOPcc.

The reductions in IOP readings observed both in FS-LASIK and SMILE, whereas higher than those observed in TransPRK were still low especially for bIOP (less than 1.5 mmHg) and for DCT (less than 2.2 mmHg), both statistically significant ($p< 0.050$). These results are in line with a study by Fernandez et al. that reported a significant reduction in bIOP by an average of 1.4 mmHg ($p< 0.010$) after SMILE. They are compatible with the findings by Sales-Sanz et al. including a reduction in postoperative DCT-IOP of 1.29 mmHg in LASIK cases ($p= 0.036$) [35, 36]. Chen et al. found smaller differences with non-statistically significance between the preoperative and postoperative reading of bIOP in FS-LASIK and SMILE. [23]. A similar result was also reported by Lee et al. before and after FS-LASIK [34].

One limitation of the study could be a possible IOP mis-estimation due to the consecutive application of different tonometers [1, 37-39]. The interval adopted in the study of at least 3 minutes between consecutive measurements and the random order followed within the contact and noncontact tonometer groups are expected to have helped reduce any possible bias. This expected is supported by an observation made by Tejwani et al. that there was no influence of sequential measurements using GAT, DCT, ORA and Corvis with 5-minute intervals [40]. Another study limitation was the diurnal fluctuations of the true IOP. Despite efforts to minimise their effects there is still the possibility that the variation observed between the pre-surgery and post-surgery measurements could have been affected by this physiological behaviour.

In conclusion, the bIOP and DCT-IOP estimates were the least influenced IOP measurements by FS-LASIK, SMILE and TransPRK refractive surgeries, while GAT-IOP and IOPcc were more considerably impacted. The effects were less pronounced in TransPRK, which caused the smallest reduction in corneal stiffness compared with FS-LASIK and SMILE.

WHAT WAS KNOWN

- Intraocular pressure (IOP) measurement will be influenced by corneal stiffness.
- Stiffness change varies from one surgical procedure to another.
- IOP measurement decreases after corneal refractive surgery.

WHAT THIS PAPER ADDS

- Biomechanically-corrected IOP and Dynamic Contour Tonometer IOP were the least affected by the stiffness change after refractive surgeries.
- Reductions in IOP measurements were different between 3 kinds of corneal refractive surgeries according to their level of reduction in corneal stiffness, lowest in TransPRK, then SMILE, and highest in FS-LASIK.

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Table Captions:

Table 1 –Baseline characteristics of different surgery groups.

Table 2 –Pre and Postoperative intraocular pressure and stiffness parameter estimates in corneas undergoing FS-LASIK, SMILE and TransPRK.

Figure Captions:

Figure 1 Variation of the 4 IOP estimates (differences postoperative between and preoperative values) in different surgical groups. *Pairwise comparisons with p> 0.05 (non-statistically significant differences)

Figure 2 Variation (postoperative-preoperative values) in stiffness parameter at first applanation (SP-A1) in different surgical groups. Error bars represent standard deviation values. Pairwise comparison revealed no differences between FS-LASIK and SMILE (p= 0.106) but the reduction in both groups were statistically higher than in TransPRK (p< 0.010).

Figure 3 Correlation of RSB ratio with reduction in IOP in different surgical groups. Error bars represent standard deviation values

Figure 4 Bland-Altman plots for agreement between IOP estimates obtained pre and postoperative in different surgical groups. The solid lines represent mean differences in IOP and the dashed lines represent the 95% LoA

Table 1 – Baseline characteristics of different surgery groups.

	FS-LASIK (n=50)				SMILE (n=50)				TransPRK (n=44)				
Characteristic	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	P Value
Km (D)*	43.19	1.56	39.1	47.49	43.44	1.50	40.00	47.94	43.51	1.74	35.34	46.47	0.4839
Age (y)	25.22	5.81	17	36	27.16	5.05	18	42	26.73	4.51	17	39	0.1529
CCT (μm)	544.74	18.46	498	572	544.76	19.59	512	591	540.18	24.29	503	618	0.1554
cMSE (D)	-5.94	1.78	-10.38	-1.75	-5.62	1.72	-9.38	-1.88	-5.78	2.10	-9.88	-2.25	0.6964
OZD (mm)	6.68	0.36	5.8	7.3	6.65	0.28	6	7.6	6.52	0.43	5.7	7.3	0.0956
AD (μm)	95.98	20.85	38	136	112.98	19.59	63	146	87.82	22.30	48	133	<0.0001
Flap/Cap (μm)	99.60	3.00	95	110	120.00	-	120	120	-	-	-	-	<0.0001
RSB (μm)	346.14	21.72	306	394	310.94	23.95	276	381	452.36	36.85	380.00	553.00	<0.0001
RSB/CCT	0.64	0.03	0.57	0.74	0.57	0.04	0.52	0.68	0.84	0.04	0.74	0.91	<0.0001
SP-A1 (mmHg/mm)	96.93	14.49	60.00	121.95	95.53	8.73	73.09	114.95	93.45	14.34	73.00	125.97	0.2835

AD = ablation depth; CCT = central corneal thickness; cMSE = corrected mean spherical equivalent; FS-LASIK = femtosecond laser–assisted laser in situ keratomileusis; OZD = optical zone diameter; RSB = residual stromal bed; SMILE = small-incision lenticule extraction; SP-A1 = stiffness parameter at the first applanation; TransPRK = transepithelial photorefractive keratectomy

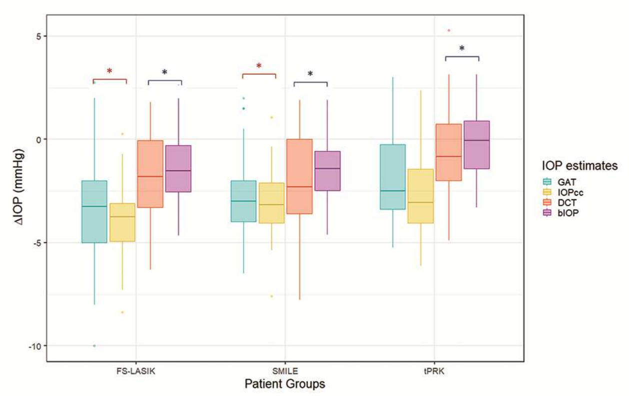
*Km: mean curvature power in the central 3 mm of the anterior surface;

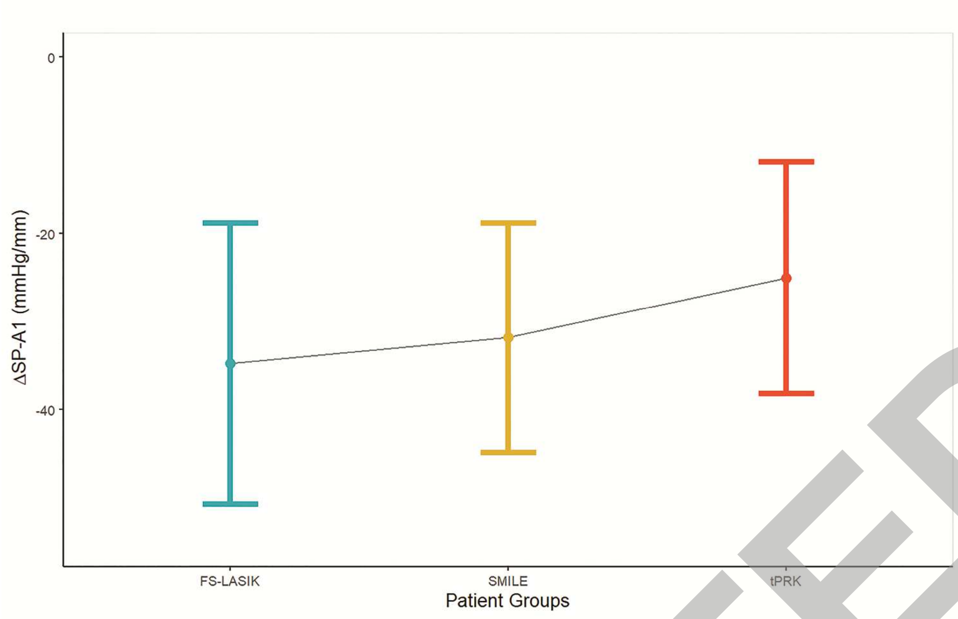
Table 2. Preoperative and postoperative IOP and stiffness parameter estimates in corneas undergoing FS-LASIK, SMILE, and TransPRK.

		FS-LASIK (n=50)				SMILE (n=50)				TransPRK (n=44)				
Tonometer	Measurement	Mean	SD	Min	Max	Mean	SD	Min	max	Mean	SD	Min	Max	P Value* (comparison among the groups)
GAT-IOP	Pre	13.39	2.26	7.5	18.5	13.13	1.88	8.50	17.75	12.90	2.19	8.50	17.50	0.5305
	Post	9.95	2.16	5.5	15	10.30	1.93	7.50	16.00	11.12	2.23	7.00	16.00	0.0289
	Δ	-3.38	2.76	-10	2.75	-2.83	2.08	-6.50	2.50	-1.78	2.29	-5.25	3.00	0.0139
	P value (pre vs post)	0.0000				0.0000				0.0003				
IOPcc	Pre	15.58	1.94	10.33	19.90	14.28	1.74	10.83	19.03	15.83	2.01	11.50	19.73	0.0002
	Post	11.64	1.65	7.93	15.87	11.19	1.74	8.37	17.33	13.11	2.29	8.70	19.87	0.0000
	Δ	-3.94	1.70	-8.37	0.27	-3.08	1.53	-7.60	1.07	-2.77	1.84	-6.13	2.37	0.0027
	P value (pre vs post)	0.0000				0.0000				0.0000				
DCT-IOP	Pre	17.35	2.26	12.35	21.5	17.26	2.54	13.13	22.83	16.96	2.70	10.65	24.5	0.7301
	Post	15.41	1.74	9.25	18.75	15.15	2.31	9.73	21.45	16.31	2.62	11.30	23.17	0.0436
	Δ	-1.87	1.95	-6.3	1.8	-2.11	2.27	-7.77	2.27	-0.64	2.34	-4.90	5.27	0.0035

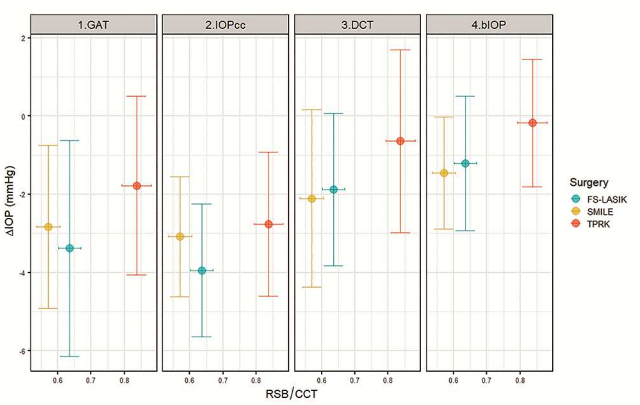
	P value (pre vs post)	0.0001				0.0000				0.2622				
bIOP	Pre	13.75	1.82	9.33	19.07	13.71	1.21	10.63	16.63	13.71	1.69	10.20	17.23	0.9903
	Post	12.53	1.78	8.80	17.27	12.25	1.79	8.57	16.73	13.53	2.23	8.30	19.37	0.0052
	Δ	-1.21	1.72	-4.67	2.63	-1.46	1.43	-4.62	2.03	-0.18	1.63	-3.30	3.57	0.0005
	P value (pre vs post)	0.0013				0.0000				0.6784				
SP-A1	Pre	96.93	14.49	60.00	121.95	95.53	8.73	73.09	114.95	93.45	14.34	73.00	125.97	0.2836
	Post	62.20	14.29	35.41	113.75	63.71	13.96	30.84	93.73	68.41	19.41	34.51	113.08	0.1519
	Δ	-34.74	15.97	-63.81	-8.11	-31.82	13.06	-65.95	-5.52	-25.03	13.14	-46.71	15.56	0.0291
	P value (pre vs post)	0.0000				0.0000				0.0000				

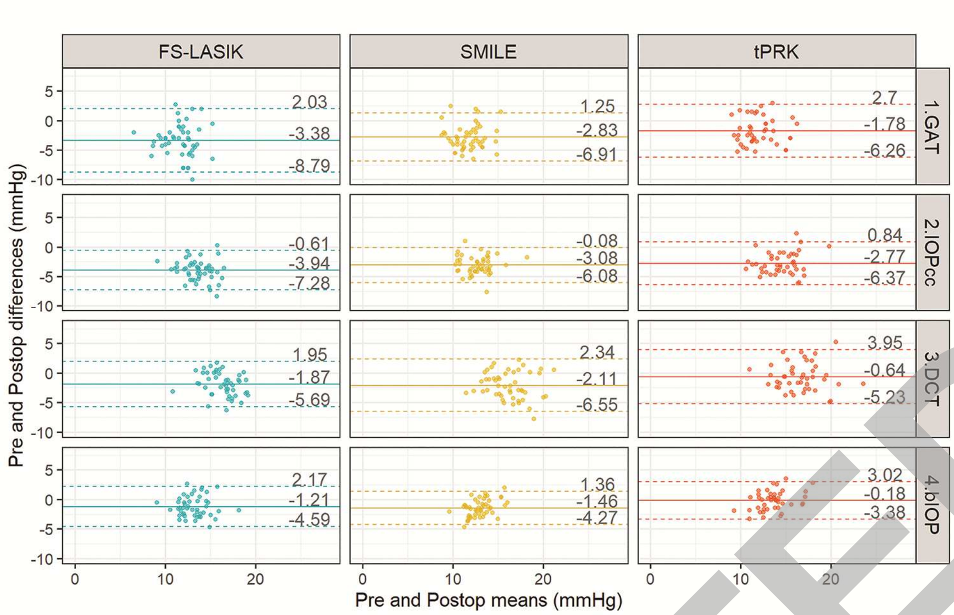
Δ = difference; bIOP = Corvis ST biomechanically-corrected IOP; DCT-IOP = IOP measured by Dynamic Contour Tonometry; FS-LASIK = femtosecond laser–assisted laser in situ keratomileusis; GAT-IOP = IOP measured by Goldmann applanation tonometry; IOP = intraocular pressure; IOPcc = ORA corneal-compensated IOP; post = post-surgery; pre = pre-surgery; SMILE = small-incision lenticule extraction; SP-A1 = stiffness parameter at first applanation provided by the Corvis ST; TransPRK = transepithelial photorefractive keratectomy


5
0
-5
-10
ΔIOP (mmHg)
*
*
*
*
*
FS-LASIK
SMILE
tPRK
Patient Groups
IOP estimates
GAT
IOPcc
DCT
bIOP



0
-20
-40
ΔSP-A1 (mmHg/mm)
FS-LASIK
SMILE
tPRK
Patient Groups


1.GAT
2.IOPcc
3.DCT
4.bIOP
ΔIOP (mmHg)
RSB/CCT
Surgery
FS-LASIK
SMILE
TPRK


FS-LASIK
SMILE
tPRK
1.GAT
2.IOPcc
3.DCT
4.bIOP
Pre and Postop differences (mmHg)
Pre and Postop means (mmHg)
2.03
-3.38
-8.79
1.25
-2.83
-6.91
2.7
-1.78
-6.26
-0.61
-3.94
-7.28
-0.08
-3.08
-6.08
0.84
-2.77
-6.37
1.95
-1.87
-5.69
2.34
-2.11
-6.55
3.95
-0.64
-5.23
2.17
-1.21
-4.59
1.36
-1.46
-4.27
3.02
-0.18
-3.38