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ORIGINAL RESEARCH

Intraocular pressure measurements with Goldmann applanation tonometry and dynamic contour tonometry in eyes after IntraLASIK or LASEK

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Background and methods: Myopic photorefractive surgery induces a reduction in central corneal thickness, which may lead to underestimation of intraocular pressure. This retrospective clinical study compared intraocular pressure measurements obtained by Goldmann applanation tonometry (GAT) and dynamic contour tonometry (DCT-Pascal) in eyes undergoing myopic intralaser-assisted in situ keratomileusis (IntraLASIK) or laser-assisted subepithelial keratomileusis (LASEK).

Results: Of a total of 51 eyes, 21 underwent LASEK and 30 underwent IntraLASIK. By GAT, mean preoperative intraocular pressure was 16.2 ± 1.99 mmHg and postoperatively was 10.84 ± 1.45 mmHg. By DCT, mean preoperative intraocular pressure was 15.9 ± 2.08 mmHg and postoperatively was 16.1 ± 2.3 mmHg. Both preoperative and postoperative differences between measurements made by GAT and DCT were found to be statistically significant ($P < 0.04$ and $P < 0.01$, respectively). GAT and DCT readings were unaffected by type of surgery ($P = 0.74$ and $P = 0.46$, respectively).

Conclusion: Postoperative GAT measurements were lower than those obtained by DCT. The difference between preoperative and postoperative DCT measurements was minimal, so DCT may be preferable for the measurement of intraocular pressure in eyes undergoing myopic IntraLASIK or LASEK.

Keywords: intraocular pressure, Goldmann applanation tonometry, dynamic contour tonometry, intralaser-assisted in situ keratomileusis, laser-assisted subepithelial keratomileusis

Introduction

Laser-assisted in situ keratomileusis (LASIK) is a common photorefractive procedure. A novel modification of the procedure is intralaser-assisted in situ keratomileusis (IntraLASIK), in which the corneal stromal flap is created using a laser beam rather than a mechanical microkeratome. Laser-assisted subepithelial keratomileusis (LASEK) is a method in which the flap is created by dissecting the cornea up to the level of Bowman's membrane, so the flap consists of epithelium alone. The latter procedure is thought to be better tolerated by thin corneas, and a recent study showed stable long-term results in corneas thinner than 500 µm that underwent LASEK, after a 10-year follow-up.[1] Because both methods entail laser ablation of the corneal stroma, the central corneal thickness is necessarily reduced, and that reduction has been previously associated with changes in intraocular pressure measurements.[2]

Measurement of intraocular pressure is a major diagnostic tool in glaucoma. Goldmann applanation tonometry (GAT, Haag Streit, Koeniz, Switzerland) is the gold

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standard for measuring intraocular pressure.[3] The accuracy of GAT seems to be influenced by central corneal thickness, corneal curvature, corneal rigidity, and corneal deformability (hysteresis).[4–6] Previous studies have shown that intraocular pressure measured by GAT may be overestimated in thick corneas and underestimated in thin corneas.[2] Central corneal thickness seems to play a substantial role in the measurement of intraocular pressure by GAT, and may modulate the management of patients with glaucoma.[7]

Dynamic contour tonometry (DCT-Pascal, SMT Swiss Microtechnology AG, Port, Switzerland) is a digital contact method of intraocular pressure measurement that is apparently independent of factors such as central corneal thickness or corneal curvature.[8,9] The objective of this study was to assess the difference in intraocular pressure measurement obtained by GAT or DCT in eyes undergoing either IntraLASIK or LASEK.

Materials and methods

Design

This retrospective clinical study was conducted in accordance with the Declaration of Helsinki and approved by the local ethics committee. We retrieved information about patients who underwent bilateral LASEK or IntraLASIK for correction of myopia. Patients included in the study had had intraocular pressure measurements performed preoperatively and at least 6 months postoperatively using GAT and DCT. DCT provides a quality index with its intraocular pressure reading. This quality index is considered reliable when it is ≤3, as was the case in this study. Only measurements performed by an experienced glaucoma specialist were valid, and no correction algorithms were used for the postoperative measurement of intraocular pressure. Further, GAT and DCT were calibrated according to the manufacturer's guidelines. Because local clinical protocol dictates that intraocular pressure should be measured with at least a 5-minute interval between GAT and DCT, data collected from the two devices were unbiased by one another. Only measurements obtained from right eyes were included for statistical analysis.

Other data collected were best-corrected visual acuity, ultrasound central corneal thickness, keratometry, details of slit lamp biomicroscopy, and dilated fundus examinations. Central corneal thickness was estimated using an ultrasound-based pachymeter (Accupach V, Accutome, Malvern, PA). Local protocol requires central corneal thickness measurements to be performed only after measurement of intraocular pressure. For maximal precision, it is customary in our clinic to average the results of three measurements. Corneal curvature was estimated using an automatic keratometer (Topcon KR8000, Topcon, NJ). The average was recorded as a single corneal curvature measurement. Exclusion criteria were known ophthalmological disorders, corneal irregularities, patients who did not complete 6 months of follow-up, and incomplete data documentation in the patient files.

Statistical analysis

The statistical analysis was performed using the Statistical Package for the Social Sciences software version 15.0 (SPSS Inc, Chicago, IL). Continuous variables were analyzed using the two-tailed Student's *t*-test. Pearson correlations were used to assess the relationship between preoperative and postoperative GAT and DCT intraocular pressure measurements. A Bland-Altman plot was prepared using Microsoft Excel 2010.

Results

The right eyes of 51 patients were included in this study. Twenty-one eyes underwent LASEK and 30 underwent IntraLASIK. The patients ranged in age from 19 to 45 years (mean 26.61 ± 5.87 years). The mean spherical equivalent prior to surgery was −5.25 ± 1.49 diopters (D).

Mean preoperative central corneal thickness was 562.31 ± 22.61 μm overall, 553 ± 25.16 μm in the LASEK group, and 568.83 ± 18.37 μm in the IntraLASIK group; as expected, the preoperative central corneal thickness was lower for the LASEK group ($P < 0.01$). Mean postoperative central corneal thickness was 471.71 ± 38.18 μm overall, 456.19 ± 49.34 μm for the LASEK group, and 482.57 ± 23.18 μm for the IntraLASIK group ($P = 0.01$). Corneal curvature was higher in the LASEK group at 45.04 ± 1.5 D versus 43.66 ± 1.2 D for IntraLASIK ($P < 0.001$). Additional demographical data are presented in Table 1.

The mean preoperative intraocular pressure reading was 16.2 ± 1.99 mmHg for GAT and 15.9 ± 2.08 mmHg for DCT. The difference in preoperative intraocular pressure measurements between the two devices was found to be statistically significant for the LASEK and IntraLASIK groups combined ($P < 0.04$). Intraocular pressure values measured by DCT tended to be lower than those measured by GAT by 0.3 ± 1.00 mmHg. Postoperative DCT readings tended to be higher than GAT readings. Mean DCT readings were 16.1 ± 2.3 mmHg and mean GAT readings were 10.84 ± 1.45 mmHg, with a difference between measurements of 5.26 ± 1.98 mmHg ($P < 0.001$). The postoperative

Table 1 Patient characteristics

	IntraLASIK (mean ± SD)	LASEK (mean ± SD)
Age (years)	27.4 ± 6.36	25.48 ± 5.04
Gender	13 males, 17 females	13 males, 8 females
Preop spherical equivalent (D)	–4.87 ± 1.12*	–5.79 ± 1.79
Preop CCT (µm)	568.83 ±18.37*	553 ± 25.16
Postop CCT (µm)	482.57 ± 23.18*	456.19 ± 49.34
Preop corneal curvature (D)	43.66 ±1.2*	45.04 ±1.5
Postop corneal curvature (D)	39.52 ± 1.4	40.25 ± 1.74
Preop GAT (mmHg)	16.43 ± 2	15.86 ± 2.03
Postop GAT (mmHg)	10.9 ± 1.4	10.76 ± 1.55
Preop DCT (mmHg)	16.23 ± 1.7	15.43 ± 2.49
Postop DCT (mmHg)	16.32 ± 1.91	15.79 ± 2.79

Note: *Statistically significant ($P < 0.05$).
Abbreviations: CCT, central corneal thickness; D, diopter; SD, standard deviation; GAT, Goldmann applanation tonometry; DCT, dynamic contour tonometry; IntraLASIK, intralaser-assisted in situ keratomileusis; LASEK, laser-assisted subepithelial keratomileusis; preop, preoperative; postop, postoperative.

disagreement between DCT and GAT measurements is demonstrated by a Bland-Altman plot in Figure 1.

When comparing the difference between preoperative and postoperative measurements obtained by GAT, intraocular pressure readings were higher prior to surgery by 5.35 ± 1.85 mmHg ($P < 0.01$). With DCT, postoperative measurements were higher by 0.2 ± 0.54 mmHg ($P < 0.01$).

We compared the effect of modality of surgery on intraocular pressure measurements obtained by GAT and DCT prior to and after surgery. For that purpose, we compared the preoperative–postoperative difference in measurements between the two modalities of surgery. Mean intraocular pressure for IntraLASIK measured by GAT was 16.43 ± 2.0 mmHg preoperatively and 10.9 ± 1.4 mmHg postoperatively. For LASEK, the mean preoperative measurement was 15.86 ± 2.03 mmHg versus 10.76 ± 1.55 mmHg postoperatively. Thus, there was no statistically significant difference in the amplitude of change in preoperative versus postoperative GAT intraocular pressure measurement between IntraLASIK and LASEK ($P = 0.74$). The mean DCT preoperative intraocular pressure measurement for IntraLASIK eyes was 16.23 ± 1.7 mmHg versus 16.32 ± 1.91 mmHg postoperatively. The mean DCT preoperative reading for LASEK eyes was 15.43 ± 2.49 mmHg versus 15.79 ± 2.79 mmHg. Therefore, DCT was also unaffected by modality of surgery ($P = 0.46$).

Discussion

The objective of this study was to compare preoperative and postoperative intraocular pressure measurements obtained by GAT and DCT in eyes undergoing two types of keratorefractive procedure for the correction of myopia, ie, IntraLASIK or LASEK. Our main findings were that preoperative DCT measurements were lower than those obtained by GAT. GAT measurements were significantly lower postoperatively and DCT measurements were mildly elevated after surgery. However, the clinical significance of the latter finding is probably negligible, given that the amplitude of change was less than 0.5 mmHg.

The type of surgery did not influence either intraocular pressure measurement modality. The difference in preoperative and postoperative GAT or DCT measurements between the IntraLASIK and LASEK groups was insignificant.

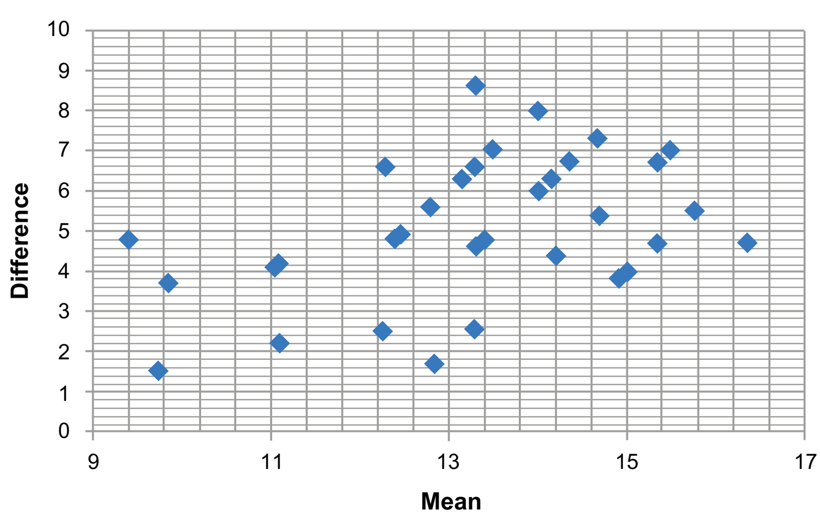

Figure 1 Bland–Altman plot demonstrating the high postoperative difference in measurement obtained by Goldmann applanation versus dynamic contour tonometry.
Note: All eyes were included (intralaser-assisted in situ keratomileusis and laser-assisted subepithelial keratomileusis groups combined).

We attribute this finding to the similar amount of stromal ablation associated with the two surgical procedures, regardless of composition of the corneal flap.

In a previous small study, postoperative intraocular pressure measured by GAT was significantly lower in both LASIK and LASEK groups.[10] Postoperative DCT measurements were not significantly altered. The type of procedure mainly affected corneal hysteresis, corneal resistance factor, and ocular response analyzer results. Similar to our study, LASEK corneas were thinner (lower central corneal thickness) prior to refractive surgery than those undergoing LASIK. However, in the referenced study, it was only when all eyes were pooled together that there was a moderate correlation between the percentage change in GAT and the percentage change in DCT. The results for DCT reported for this study are similar.

Another recent study assessed intraocular pressure measurements by GAT and DCT in a population of patients undergoing myopic photorefractive keratectomy, myopic LASIK, or hyperopic LASIK.[11] Preoperative GAT readings were lower in all groups. Postoperative GAT measurements in the photorefractive keratectomy group were lower, and at 6 months the mean reduction was −1.7 mmHg ($P < 0.05$). A similar trend was noted in the myopic LASIK group, with a mean reduction of −3.6 mmHg ($P < 0.05$) and in the hyperopic LASIK group (−1.1 mmHg, $P < 0.05$). Postoperative GAT measurements were lower than DCT measurements. No statistically significant differences were found between measurements obtained by DCT in any of the three groups. These results are also consistent with our results.

A further study found the difference in preoperative and postoperative GAT measurements to be greater than in DCT measurements from eyes undergoing myopic LASEK, which is again consistent with the results of our study.[12] Based on the results of the present study as well as previous ones, it seems that substantial reduction in postoperative central corneal thickness causes a significant underestimation of intraocular pressure measurement by GAT, whereas measurements obtained by DCT are apparently unaffected.

In conclusion, in this study of 51 eyes undergoing bilateral photorefractive surgery for the correction of myopia using either IntraLASIK or LASEK, measurements of intraocular pressures obtained by GAT and DCT were significantly different, with significant underestimation of postoperative intraocular pressure when using GAT. The type of surgery performed did not affect intraocular pressure measurement using either instrument. DCT was unaffected by central corneal thickness. Therefore, DCT may be more appropriate for the measurement of intraocular pressure after myopic IntraLASIK or LASEK.

Disclosure

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