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Changes in preoperative corneal measurements following same-day intraocular pressure testing with rebound tonometry

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Abstract

Purpose: To evaluate the extent to which rebound tonometry affects corneal surface properties and preoperative corneal measurements.

Setting: Four cornea specialty private practices.

Design: Prospective case series.

Methods: Visual acuity testing, corneal topography, keratometry, and grading of corneal staining were performed on both eyes of 60 randomly selected, previously scheduled patients. Technicians then performed rebound tonometry on one randomly selected eye only. Immediately following, intraocular pressure measurement, corneal topography, keratometry, and corneal staining were repeated on both eyes.

Results: None of the 60 study eyes developed increased staining scores following intraocular pressure testing with the Icare ic100. For corneal staining, mean keratometry, and total corneal cylinder, no statistically significant difference was found from the first measurement to the second measurement between the study eyes and control eyes.

Conclusion: Rebound tonometry with the Icare ic100 may be used on any patient at any time during the exam without affecting the results of other tests, allowing clinicians to test intraocular pressure prior to preoperative cataract or refractive surgery measurements on the same day. This may allow for significant improvement in patient flow in the office and save patients from the cost and time of extra visits.

Keywords: cataract surgery, corneal measurements, Icare ic100, rebound tonometry, refractive surgery, same day intraocular pressure testing

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Introduction

Goldmann applanation tonometry (GAT) has long been considered the gold standard method of obtaining intraocular pressure (IOP).[1] However, in some settings and with certain patient populations, GAT is impractical, which has led to the development of alternative methods of measuring pressures. In particular, patients presenting for preoperative assessment for refractive surgery or cataract procedures create scheduling challenges as applanation tonometry performed shortly before biometric procedures such as keratometry could affect the validity of the measurement.[2] Specifically, studies show it is prudent to wait at least 20 minutes before measuring the corneal curvature.[2] In fact, corneal topography-based Sim K showed substantial steepening of the cornea in the first 5 minutes and a significant difference from baseline in the 10- to 15-minute time interval after both gonioscopes.[2]

Furthermore, due to the force that is necessary to flatten the cornea beneath the Goldmann tip, instillation of topical anesthetics is required before measurements can be obtained. This, as well as the need for fluorescein dye, may make it necessary for

cataract surgeons to schedule an additional preoperative visit, because these drops can interfere with other necessary preoperative tests.

Typically, when a patient presents for an exam, is found to have a cataract, and wishes to proceed with surgery, the patient needs to return at a later date to obtain the preoperative measurements from a cornea that has not been altered. However, if clinicians could test IOP and preoperative cataract or refractive surgery measurements on the same day, this would allow for significant improvement in patient flow in the office and it would save patients from the cost and time of extra visits.

For this reason, alternative IOP measurement tools that can be used on any patient at any time during the exam without affecting the results of other tests would be desirable in busy surgical settings, as this may allow for significant improvement in patient flow in the office and save patients from the cost and time of extra visits. To that end, this investigation evaluated the extent to which rebound tonometry affects corneal measurements to determine whether this method of testing could be employed as a substitute to GAT when performing a comprehensive preoperative cataract or refractive surgery workup.

The accuracy of rebound tonometry was not assessed here, as earlier research shows that rebound tonometry can be used without topical anesthesia[3] and is in close agreement with GAT in the majority of patients.[4] Rebound tonometry is based on making a moving object collide with an eye while monitoring the motion parameters of the colliding object.[4,5] IOP is calculated based on impact duration and maximum deceleration, or duration or maximum deceleration.[3,4] The higher the IOP, the shorter the duration of the impact.[3,4,6]

This study utilized the Icare ic100 (Icare, Helsinki, Finland), a hand-held portable rebound tonometer. Testing time with the ic100 is approximately 15 seconds per eye.

Patients and methods

Design

This was a prospective randomized clinical study and an exploratory study. This research adhered to the tenets of the Declaration of Helsinki. The Mount Carmel Institutional Review Board approved the study protocol (170608-1), and all patients provided written informed consent to participate.

Randomly selected, previously scheduled patients of the principal investigator's and co-investigators' own practices meeting the age requirement of 18–65 were asked at the time of their eye examination if they would be willing to participate. Testing was also made available to practice employees. Fifteen patients were included from each of the four sites. Figure 1 outlines the step-by-step approach employed during the study.

The primary objective of this study was to evaluate whether rebound tonometry would induce corneal changes that could impact preoperative cataract and refractive surgery pretesting.

Corneal testing

In all four practices, corneal topography was obtained with the Pentacam (Oculus Arlington, Washington). The IOL Master (Zeiss Dublin, CA) was used for keratometry. Corneal staining with fluorescein was performed on all eyes. One drop of saline was placed on a fluorescein strip and then applied to each eye in the inferior fornix. Staining was scored according to the Oxford scale.[7] These three measures were obtained twice on all 60 patients (120 eyes) – once before rebound tonometry and again on both eyes, following unilateral rebound tonometry.

IOP testing

Following visual acuity, corneal topography, keratometry, and corneal staining, technicians performed rebound tonometry on one randomly selected eye only using the portable Icare ic100 tonometer. No drops or anesthetics were employed, as these are not required for testing with the Icare tonometer.[4]

The Icare tonometer utilizes a lightweight (26.5 mg), stainless steel probe. The probe measures 50 mm long and is 1.4 mm in diameter.[3,4,8,9] The disposable probe is repelled horizontally and gently touches the cornea at low speed (0.25–0.30 m/s). The probe's rebound from the cornea (which occurs at a distance of 4–8 mm), induces a voltage in the solenoid, which is converted to a digital signal.[3,4,8,9] Measurement takes place in 0.1 seconds, with corneal reflex occurring after 0.2 seconds. When the measurement button is pressed, the tonometer takes six readings, discarding the highest and the lowest. The remaining four readings are averaged.

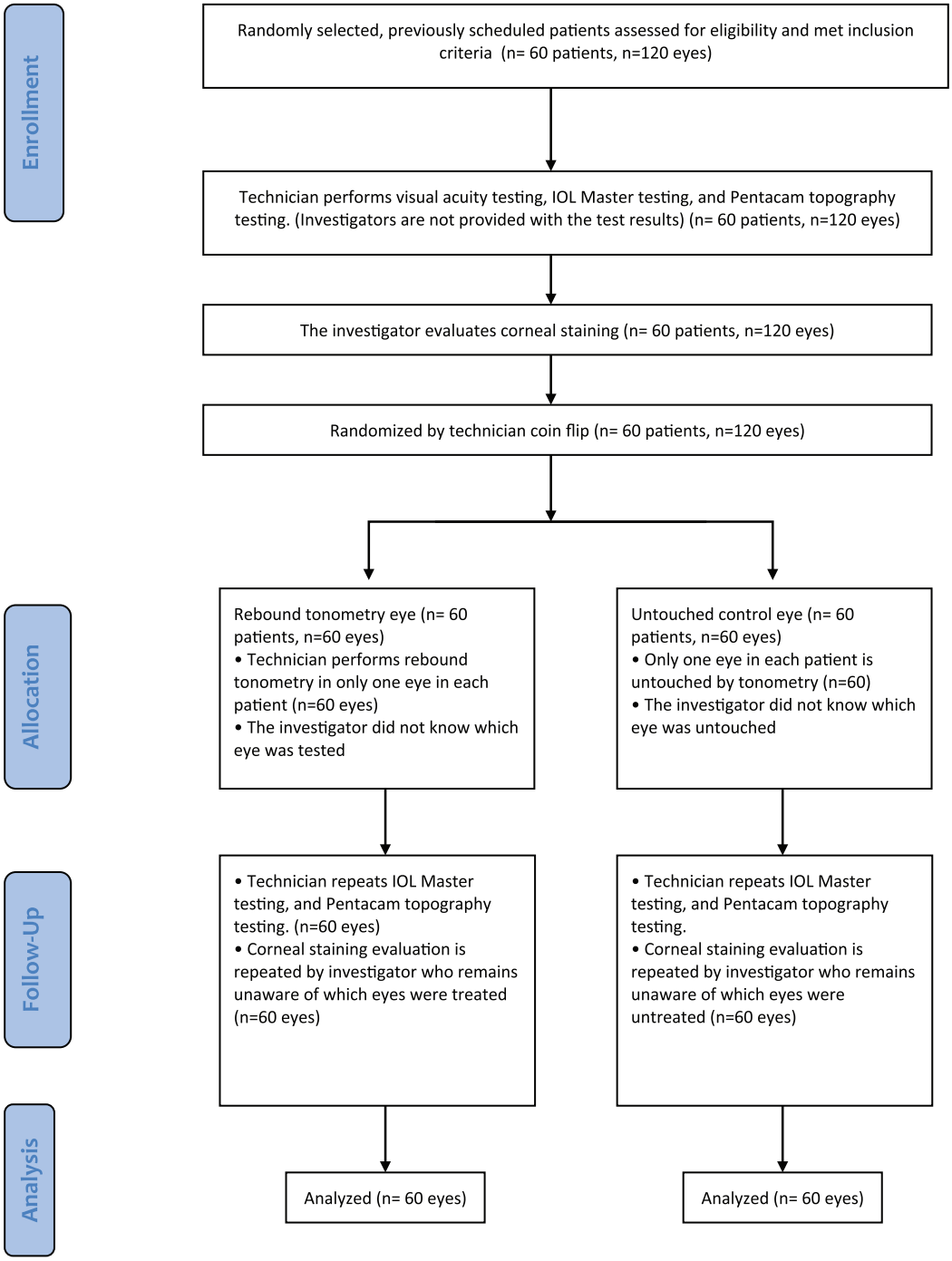

Figure 1. The step-by-step approach employed during the study. Fifteen patients were included from each of the four sites, for a total of 60 patients (120 eyes).

Immediately following unilateral IOP measurement with the ic100, corneal topography, keratometry, and corneal staining were repeated on both eyes.

Statistical analysis

Statistical analysis was performed using *t* test for unequal sample sizes and unequal variances. The objective is to estimate whether the average differences (post minus pre) is statistically different. To operationalize the *t* test, the team computed the difference in means for each variable (post minus pre) as well as the standard errors associated with each variable's mean. The *t* test compares the two distributions and provides a statistical significance for the difference.

Table 1. None of the 60 study eyes developed increased staining scores following IOP testing with the Icare ic100, and for both mean keratometry and total corneal cylinder, no statistically significant difference was found from the first measurement to the second measurement between the study eyes and control eyes.

N **= 60**						
Study	**PCKM**	**PC TotalCyl**	**IOLM KM**	**IOLM Total Cyl**	**Stain**	**IOP**
Avg Pre	43.647	0.840	43.697	0.901	0.233	14.900
SD	1.667	0.554	1.700	0.585	0.563	3.776
Avg Post	43.622	0.828	43.721	0.896	0.217	
SD	1.692	0.529	1.752	0.574	0.555	
Avg Diff	0.025	0.012	0.024	0.005	0.017	
Control	**PCKM**	**PC TotalCyl**	**IOLM KM**	**IOLM Total Cyl**	**Stain**	**IOP**
Avg Pre	43.600	0.882	43.728	0.917	0.250	
SD	1.784	0.662	1.780	0.742	0.541	
Avg Post	43.647	0.968	43.725	0.951	0.305	14.610
SD	1.777	0.655	1.776	0.724	0.561	4.131
Avg Diff	0.047	0.086	0.003	0.035	0.055	
Diff-in-diff	0.022	0.074	0.021	0.030	0.038	
p-value	0.962	0.634	0.963	0.861	0.790	

Avg Diff, average difference in absolute value between first and second measurement; Diff-in-Diff, difference in absolute value between the Avg Diff for the study eyes and the control eyes; IOLM KM, IOL Master mean keratometry; IOLM Total Cyl, IOL Master total corneal cylinder; IOP, intraocular pressure; PCKM, Pentacam mean keratometry; PC TotalCyl, Pentacam total corneal cylinder; *SD*, standard deviation.

Results

Sixty patients (120 eyes) were included in the study. Average IOP was 14.90 mm Hg in the study group and 14.61 mm Hg in the control group (as measured following corneal measurements). None of the 60 study eyes developed increased staining scores following IOP testing with the Icare ic100 (0.23 pretest *versus* 0.22 posttest). No statistically significant difference was found from the first measurement to the second measurement between the study eyes and control eyes. There was a slight increase in staining in the control eyes (0.25 pretest *versus* 0.31 posttest), but this was not statistically significant. This may have been due to eye rubbing by the patient or the natural desiccation of the surface over the course of the exam. For both mean keratometry and total corneal cylinder, no statistically significant difference was found from the first measurement to the second measurement between the study eyes and control eyes, by Pentacam or IOL Master. The absolute value of change in mean keratometry was 0.0250 diopters in the study group and 0.0467 in the control group when measured with Pentacam ($p = 0.96$). The absolute value of change in mean keratometry was 0.0238 diopters in the study group and 0.0029 in the control group when measured with the IOL Master ($p = 0.96$).

The average total corneal cylinder measured by Pentacam was 0.84 D prior to rebound tonometry and 0.83 D following IOP measurement in the study group. The average total corneal cylinder measured by Pentacam was 0.88 initially and 0.97 on repeat testing in the control group ($p = 0.63$). When measured with the IOL Master, average total corneal cylinder in the study group was 0.90 D both before and after IOP measurements were performed. The average total corneal cylinder was 0.92 on initial testing and 0.95 on repeat testing in the control group ($p = 0.86$). The data are summarized in Table 1.

Discussion

Accurate intraocular lens power calculations are chiefly influenced by axial length and corneal power measurements,[10] both of which can be compromised if GAT is performed prior to corneal testing. Indeed, several corneal changes are induced as a result of anesthetic and fluorescein drops, and gonioscopy has been shown to temporarily steepen the central corneal surface.[2] This steepening is even more pronounced with the Goldmann lens, perhaps due to its more concave contact surface.[2] Simply put, however impractical it may be in terms of scheduling and practice flow, it may not be advisable to perform GAT prior to preoperative corneal measurements on the same visit. At a minimum, clinicians should wait 20 minutes before performing corneal testing.[2]

This being said, increasing time restraints are placed upon many ophthalmologists,[4] so the ability to test IOP and perform preoperative cataract or refractive surgery measurements on the same day would be a significant advantage. As such, we set out to determine whether Icare would enable us to remove a common practice barrier by proving to cause no corneal changes that would significantly affect preoperative cataract measurements.

As previous research has shown, the Icare tonometer is portable, requires no drops, and has been shown to be accurate in most situations when compared with GAT.[4] In this study, none of the study eyes developed increased corneal staining following IOP testing with the Icare ic100. Furthermore, no statistically significant difference was found from the first measurement to the second measurement between the study eyes or control eyes by Pentacam or IOL Master when measuring mean keratometry and total corneal cylinder.

The ability to confidently assess IOP on the same day that corneal measurements are recorded presents a meaningful benefit in terms of preoperative scheduling and can eliminate the burden on patients to return for additional visits. With the use of the Icare ic100 tonometer in the routine examination office flow, the surgeon may choose to immediately proceed with preoperative cataract measurements after the exam has been completed, with less concern of the applanation altering the accuracy of the measurements.

In addition, for patients requiring a corneal surface evaluation of any type, having Icare tonometry measurements obtained by a technician prior to the exam may not affect other aspects of the exam. Because the Icare does not require anesthetic drops, this test allows the opportunity for the physician to test corneal sensation after IOP checking is performed. Also, as the Icare does not require fluorescein stain, the physician may view the cornea without stain on the surface due to tonometry. Furthermore, if during the course of the exam, the physician decides that staining is needed, it can be applied without concern that the staining measurement will be altered by earlier applanation.

Authors' Note

These data have not been presented at any meeting.

Conflict of interest statement

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