Corneal Thickness Measurements With the Topcon SP-2000P Specular Microscope and an Ultrasound Pachymeter

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Objective: To compare the reproducibility of measurements obtained with a new pachymetry instrument, the Topcon specular microscope (Topcon SP-2000P; Topcon America Corp, Paramus, NJ), with those obtained by ultrasound pachymetry.

Methods: Corneal thickness was measured in 40 eyes of 40 patients 3 times each with the Topcon SP-2000P and an ultrasound pachymeter (DGH 500; DGH Technology Inc, Exton, Pa) by 2 separate investigators. Comparisons included average thickness as measured by each instrument, average thickness for each instrument as measured by each investigator, and differences in thickness due to corneal abnormalities.

Results: Mean corneal thickness measured by the Topcon instrument was significantly less (32 µm; \(P<.001\)) than the mean value obtained with the ultrasound pachymeter. Similarly, mean values obtained with the 2 instruments by the 2 investigators were significantly different (\(P<.001\) and \(P<.008\) for investigators 1 and 2, respectively), with the Topcon value less than the ultrasound value in both cases. Both instruments detected abnormalities in corneal thickness equally well. However, the measurements obtained with the Topcon instrument by the 2 investigators were more consistent (no significant difference \([P = .32]\)) than those obtained with the ultrasound unit (difference was significant \([P = .02]\)).

Conclusions: The new noncontact Topcon specular microscope provides measurements of corneal thickness that are somewhat less than those of ultrasound pachymetry, but that seem to be more consistent from one operator to another, possibly as a result of the elimination of observer bias induced by probe placement required by the ultrasound unit. This consistency may be important in the comparison of measurements by different operators over time in patients being followed up after refractive surgery or other therapeutic interventions.


Corneal thickness, as measured by pachymetry, is a sensitive indication of the health of the cornea. Measurement of corneal thickness is useful for the diagnosis of disease, determining the effectiveness of medical and surgical treatment (especially refractive surgery), and the evaluation of contact lens wear. Because repeated measurements over time may not be made by the same person, precision independent of operator is important.

One of the most common approaches to corneal pachymetry is ultrasound. Ultrasound pachymeters require corneal contact and use the Doppler effect to determine thickness. As corneal pachymetry has become fully integrated into the diagnostic armamentarium of the ophthalmologist, however, new and more sophisticated pachymeters have been described and evaluated.\(^1,2\) New methods for measuring intraocular distances in vivo include an opto-electronic system that measures retinal thickness by calculating the separation between anterior and posterior intersections;\(^3\) dual-beam partial coherence interferometry,\(^4\) which can measure distances between several anterior segment structures; and optical coherence tomography,\(^5,6\) which is used to measure the thickness of anterior and posterior segments.\(^5,6\)

The Topcon SP-2000P specular microscope (Topcon America Corp, Paramus, NJ) is a new noncontact optical instrument that provides pachymetric measurements and specular microscopy simultaneously. Measurement of corneal thickness requires differential focusing on the epithelial and endothelial surfaces, which also allows for evaluation of endothelial cell density. With this instrument, thickness measurements can be made on both the central and peripheral cornea.
MATERIALS AND METHODS

We measured central corneal thickness in 1 eye each of 40 patients as part of their clinical examination at the LSU Eye Center, New Orleans, La. Two investigators made 3 separate, sequential readings with the Topcon unit and an ultrasound pachymeter (DGH 500; DGH Technology Inc, Exton, Pa). Eyes with normal corneas, as well as eyes with pathological conditions, including post–penetrating keratoplasty symptoms, uveitis, postphacoemulsification symptoms, Fuchs’ dystrophy, pigmented guttata, anterior chamber intraocular lenses, dry eye syndrome, myopia, and corneal graft failure, were evaluated. Because each patient under study was already scheduled for ultrasound pachymetry, no informed consent was required by the institutional review board for the inclusion of a less-invasive (noncontact Topcon device) form of the same diagnostic assessment.

For ultrasound pachymetry, the cornea was anesthetized with topical proparacaine hydrochloride. The patient was required to look straight ahead while the pachymeter probe was lightly placed on the center of the cornea, as located visually by the investigator. The probe was sterilized with alcohol after each patient.

For Topcon pachymetry, the patient was positioned with his or her chin in a cup and forehead against a headband, similar to the positioning for slit-lamp examination. Corneal thickness and endothelial cell density were measured while the patient focused on a fixation light in the instrument. For this study, only central corneal thickness, which was determined by patient fixation, was used.

The measures of corneal thickness obtained from 1 eye of each subject by the 2 devices, and by each of the 2 investigators, were analyzed by a 3-level factorial analysis of variance. The diagnosis, investigator, and pachymeter device were the main effects in a reduced model in which the main effects and 2-way interactions of diagnosis and pachymetry type were analyzed. All P values reported are from protected t tests on least-square means from this analysis of variance. The α level for all comparisons was set at .05. All analyses were conducted using procedures from the Statistical Analysis System.

RESULTS

A total of 480 observations were included in the data set. However, only 437 observations were used in the statistical analysis because of missing values. The missing values were the result of the inability of the Topcon instrument to provide data from edematous or opaque corneas. For each comparison, only measurements of corneas available for both investigators and/or instru-

ments were used. Because not all 3 measurements in each examination were usable, a total of 222 ultrasound and 215 Topcon values were available for analysis.

DIFFERENCES BETWEEN DEVICES

The mean corneal thickness was 559.9 ± 5.5 µm (n = 222) as measured by the ultrasound unit and 528.3 ± 5.5 µm (n = 215) as measured by the Topcon unit. The Topcon unit measurements averaged 31.6 µm less than the ultrasound unit measurements; the difference was significant (P < .001) (Figure). The differences between the 2 devices were similar over the range of corneal thicknesses measured.

INTERACTION BETWEEN DEVICES AND CORNEAL DISORDERS

The differences in corneal thickness measurements between abnormally thick and thin corneas were not significantly different for the 2 devices (P = .99) (Figure).

INTEROBSERVER DIFFERENCES

As with the overall average values, the average Topcon and ultrasound values obtained by each investigator were different. For both investigators, the average value obtained with the Topcon unit was significantly less than the average value obtained with the ultrasound instrument (P < .001 and .008 for investigators 1 and 2, respectively) (Table).

The Topcon values were more consistent regardless of user; comparison of the measurements made with the Topcon unit by the 2 investigators showed no sig-
In this study, we compared corneal thickness measurements made with 2 instruments and by 2 investigators. We found that the Topcon specular microscope provided measurements that were, on average, 32 µm less than those from the ultrasound pachymeter. Other studies have documented the variability of different types of pachymetric data; corneal thickness measurements from a Haag Streit (Bern, Switzerland) optical pachymeter were also found to be significantly less than ultrasound pachymetric measurements. Despite the difference between the values provided by the instruments in our study, however, the similarities in the overall ranges and SEMs point to similar reproducibility for the 2 instruments.

The results indicated that the 2 instruments gave similar values in the measurement of corneas with various types of corneal abnormalities, where such measurements were possible. However, the comparison is limited by the fact that measurements of opaque or very edematous corneas with the Topcon instrument were inconsistent or, in some cases, unobtainable. Because the Topcon unit is an optical system and a reflection is required from the endothelial and epithelial surfaces, a severely distorted reflection, as in cases of severe edema, scarring, or pigmented endothelium, will result in an unreliably reading.

Importantly, we also found that values obtained in a given eye by 2 different investigators were more consistent for the Topcon instrument than for the ultrasound unit. Thus, the Topcon unit would be more useful for comparisons over time in situations where different physicians, nurses, or technicians examine the same patient. Multiple readings taken by different people are more consistent with the Topcon instrument because patient fixation is used to determine the center of the cornea. This rules out the observer bias with respect to probe placement that is introduced by the ultrasound pachymeter. Also, in our experience, if the ultrasound beam is not exactly perpendicular to the corneal surface, the reading will be higher than the true reading.

The Topcon instrument is easier to use than the ultrasound pachymeter. Although the investigator can repeatedly measure the corneal thickness in the same region by touching the cornea in the same location with the ultrasound probe, this method is inexact and can be difficult to accomplish because of the patient’s blinking. Also, the Topcon unit is more hygienic because it is non-contact. The ultrasound unit poses a possible risk of iatrogenic epithelial keratitis caused by the alcohol that is used to clean the tip of the probe. Additionally, with the Topcon unit, the patient need only sit at a machine similar to a slitlamp for 3 to 5 seconds.

In summary, the Topcon specular microscope is a reliable device for measuring corneal thickness. Reproducibility is similar to that of ultrasound pachymetry, the ease of use for the health care professional and the patient is greater, and there is less variability in measurements made by different people. The Topcon has the added advantage of providing endothelial cell densities. Limitations include unreliable measurements in optically dense or distorted corneas. Nevertheless, we believe this new device will have broad-based clinical applications in refractive surgery, medical and surgical therapeutics, and contact lens practice.

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