The Comparison of Corneal Thickness Measurement : Ultrasound *versus* Optical Methods

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Abstract

Purpose : To compare the measurement of central corneal thickness between ultrasonic and optical techniques in normal Thai myopic eyes.

Method : In this prospective study, the ultrasonic and optical pachymeter were employed to measure the central corneal thickness in 100 eyes of normal myopic volunteers. Corneal thickness was compared using the paired Student *t*-test. The correlation of central corneal thickness between the two groups was assessed by linear regression analysis.

Results : The difference of mean central corneal thickness between ultrasound (554.4 $\pm$ 27.50 μm) and optical (581.1 $\pm$ 22.62 μm) pachymetry was statistically significant in the normal myopic eyes ($p = 0.001$). Both methods possessed a highly significant linear correlation ($r = 0.90$, $p = 0.001$)

Conclusions : The optical measurement of central corneal thickness in normal myopic eyes is, on average, 27 μm greater than ultrasonic pachymeter measurement.

Key word : Central Corneal Thickness, Ultrasonic Pachymetry, Optical Pachymetry

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The measurement of central corneal thickness (CCT) is an essential tool for corneal health evaluation. Accurate corneal thickness measurements are important in managing corneal diseases such as keratoconus[1]. With the recent heightened interest in keratorefractive surgical procedures, including photorefractive keratectomy and laser in situ keratomileusis, which require precisely measured incursions into the cornea, pachymetry has provided an informative evaluation and has become increasingly important[2].

Various techniques have been evaluated in order to obtain the most reliable, practical, and reproducible pachymetry tool in clinical practice[3-5]. To date, clinical measurement of CCT has been primarily

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by ultrasonography or optical methods[6]. All methods possess advantages and disadvantages. Ease of use and patient comfort are important concerns, but the accuracy of the measurement is also critical.

The purpose of this study was to compare corneal thickness measurements between the optical (Orbscan) method and the ultrasonic pachymetry in normal myopic eyes.

METHOD

Methodology

This prospective study was performed in 50 subjects (100 eyes) at the Department of Ophthalmology, Faculty of Medicine, Chiang Mai University, Chiang Mai, Thailand from January 2001 to December 2001. All patients provided written informed consent.

All eyes had a best-corrected visual acuity of 6/6 or better. Two subjects who wore soft contact lenses were asked to remove them 2 days before measurement. Inclusion criteria for subjects in the present study were good ocular health, no history of ocular disease, and central fixation as demonstrated by ophthalmoscopy.

The central corneal thickness measurement was performed using the Orbscan Corneal Topography (optical method) and followed by ultrasonic pachymetry. The subject was asked to place his/her forehead into the white headband of the Orbscan. When the subject's head was determined to be at the correct level by aligning their eyes with the alignment ends on the forehead piece, the head strap was placed around the back of the head. The subject kept both eyes open and fixated on the fixation light. Three optical (Orbscan) measurements were performed then the mean CCT was averaged. Then, ultrasonic pachymetry was repeated 10 times at the center of the cornea, and the mean values were recorded.

Instrumentation

The Orbscan corneal topography system (Orbscan II®, Bausch & Lomb Surgical, Salt Lake City, UT, USA) is topography that measures anterior and posterior corneal elevation, surface curvature, and corneal thickness using a scanning-slit mechanism. The optical acquisition head scans the eye using slits projected at a 45-degree angle. Pachymetry is determined from the difference of elevation between the anterior and posterior surfaces in 9 circles of 2.0 mm diameter. This instrument also indicates the thinnest point of the cornea and marks its distance from the visual axis and its quadrant location.

Immediately after the Orbscan measurements, the cornea was anesthetized with topical benoxinate hydrochloride 0.4 per cent (Ciba Vision Ltd., Hettingen, Switzerland) and the CCT was measured by ultrasonic pachymetry (Paxis®, Quantel Medical, Clermont-Ferrand, France). The subjects were asked to observe a fixation target during measurement to ensure optimal alignment and centration of the ultrasonic probe. The probe was sterilized and applied as perpendicularly as possible to the central cornea. Slit-lamp examination was then performed to ensure that no corneal damage had resulted from pachymetry.

Statistical analysis was performed using paired Student *t*-test and Pearson correlation coefficient. A p-value less than 0.05 was considered statistically significant.

RESULTS

There were 28 men (56 eyes) and 22 women (44 eyes) included in the study. The mean age $\pm$ SD was 26.4 years $\pm$ 11.2. The range of myopia was -0.50 to -12.00 diopters. The mean CCT using ultrasonic pachymetry was 554.4 $\pm$ 27.50 μm and using Orbscan pachymetry was 581.1 $\pm$ 22.62 μm. Central corneal thickness values of the two methods were statistically significantly different ($p = 0.001$).

The Pearson correlation coefficient was performed on the results of optical (Orbscan) and ultrasonic pachymetry. The coefficient was 0.90 ($p = 0.001$), demonstrating that the two methods have a highly significant linear correlation (Fig. 1).

DISCUSSION

Several attempts have been made in order to evaluate central corneal thickness including ultrasonic pachymetry[7], optical slit-lamp pachymetry[8], and confocal microscopy[4,5]. Ultrasonic pachymetry is one of the common methods, which requires corneal contact and the Doppler effect to determine corneal thickness[9]. This technique has been used for over 30 years to assess and quantify ocular structures[10,11].

The Orbscan topography system is a modern, optical, scanning slit instrument. As the Orbscan measurement is based on a Scheimpflug-type slitlamp scanning system, the surface data point can be obtained from all surfaces of the anterior segment, i.e., from the anterior cornea to the anterior lens surface. It is, therefore, possible to create a true 3-D map from the anterior segment of the eye and calculate corneal thickness. This noninvasive device also provides information on

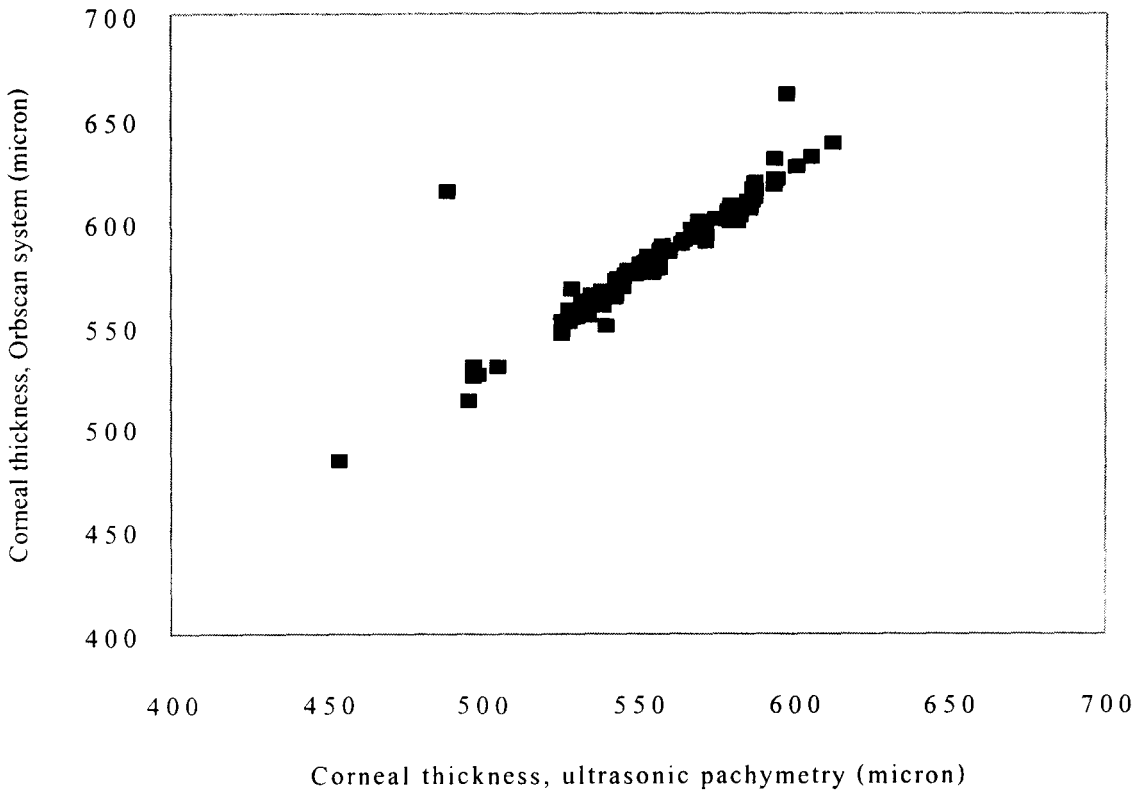

Fig. 1. Scattergram showing the correlation between ultrasonic and Orbscan pachymetry in normal Thai myopic eyes.

anterior corneal topography[12]. Theoretically, it can replace the existing computerized videokeratography and ultrasonic pachymetry by a single device if it proved to be accurate and reliable.

A prospective study of corneal thickness measurements was performed using ultrasonic pachymetry and the optical (Orbscan) system. Statistical analysis showed that CCT measurements were, on average, 27 μm higher with the Orbscan than ultrasonic pachymetry in normal myopic eyes. Several studies have demonstrated measurement of corneal thickness using ultrasonic and optical system (Table 1) [2,6,9]. The results of Orbscan and ultrasonic pachymetry in the present study were comparable. The reason for the greater corneal thickness typically reported using the Orbscan has not been uncovered, and the error tends to be attributed to the Orbscan measurements since the ultrasonic method is considered the gold standard[8]. The possible explanation for the consistently higher corneal thickness measurement by Orbscan is the greater thickness of the tear film measured by this non-contact system[13]. Additionally, the ultrasonic method may underestimate corneal thickness through its contact with the ocular surface and the potential compression of the corneal tissue during measurement[6].

A highly significant linear correlation was found between the Orbscan and ultrasonic pachymetry. Yaylali et al[2] compared both techniques and concluded that, on average, the Orbscan overestimates the ultrasonic pachymetry values by 5.15 per cent. They stated that regression analysis might be used to determine equations that would enable direct conversion of measurements from one technique to the other. Chakrabarti et al[6] also showed that ultrasonic pachymetry measurement was 5.3 per cent higher with the Orbscan. The present study demonstrated that the Orbscan pachymetry measurement was 4.8 per cent higher than the ultrasonic measurement.

In conclusion, this study suggests that the Orbscan measurements of CCT in normal myopic eyes are, on average, 27 μm greater than ultrasonic

Table 1. Central corneal thickness measured by ultrasonic and Orbscan pachymetry with various studies.

Study	Number of eyes	Corneal thickness, ultrasonic pachymetry (μm) (mean ± SD)	Corneal thickness, orbscan pachymetry (μm) (mean ± SD)	P
Yaylali et al[2]	60	543.3 ± 7.49	571.3 ± 6.27	0.0048
Chakrabarti et al[6]	100	538.0 ± 36.70	566.6 ± 40.70	< 0.001
Fakhry et al[10]	20	527.7 ± 53.71	529.6 ± 54.53	< 0.001
The present study	100	554.4 ± 27.50	581.1 ± 22.62	0.001

pachymeter measurements and these two methods have a highly significant linear correlation. Although Orbscan is a noninvasive device and provides estimates of corneal thickness based on the whole cornea surface, it should be used in conjunction with ultrasonic pachymetry, particularly when measurement of CCT is critical as in keratorefractive surgery.

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การเปรียบเทียบการวัดความหนากระจกตาระหว่างวิธีอัลตราซาวด์และวิธีออปติคัล

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จุดมุ่งหมาย : เพื่อเปรียบเทียบความหนาของกระจกตาตรงกลางในคนไทยสายตาสั้นที่ปกติจากการวัดด้วยวิธีอัลตราซาวด์และวิธีออปติคัล

วิธีการ : เป็นการศึกษาไปข้างหน้าโดยวัดความหนาของกระจกตาตรงกลางของอาสาสมัครปกติที่สายตาสั้นจำนวน 100 ตาด้วยเครื่องมือวัดความหนากระจกตาแบบอัลตราซาวด์และแบบออปติคัล และเปรียบเทียบความหนากระจกตาจากสองวิธีนี้ด้วย paired Student *t*-test และศึกษาความสัมพันธ์ถดถอยเชิงเส้นตรงทางสถิติ

ผลการศึกษา : มีความแตกต่างอย่างมีนัยสำคัญทางสถิติของความหนาเฉลี่ยกระจกตาตรงกลางระหว่างวิธีวัดความหนากระจกตาแบบอัลตราซาวด์ (554.4 $\pm$ 27.50 ไมครอน) และแบบออปติคัล (581.1 $\pm$ 22.62 ไมครอน) ในคนสายตาสั้นที่ปกติ ($p = 0.001$) และการวัดทั้งสองวิธีมีความสัมพันธ์เชิงเส้นตรงอย่างมีนัยสำคัญทางสถิติ ($r = 0.90$, $p = 0.001$)

สรุป : ความหนากระจกตาตรงกลางของคนสายตาสั้นที่ปกติที่วัดด้วยวิธีออปติคัลจะหนากว่าวัดด้วยวิธีอัลตราซาวด์โดยเฉลี่ย 27 ไมครอน

คำสำคัญ : ความหนาตรงกลางกระจกตา, วิธีวัดความหนากระจกตาด้วยอัลตราซาวด์, วิธีวัดความหนากระจกตาด้วยออปติคัล

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