COMPARISON OF OPTICAL COHERENCE REFLECTOMETRY AND ULTRASOUND CENTRAL CORNEAL PACHYMETRY

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ABSTRACT

In 50 eyes of 25 patients we prospectively measured the central corneal thickness (CCT) comparing the OLCR (Optical Low Coherence Reflectometry) pachymeter with the contact ultrasound pachymeter. The OLCR system was mounted on to a Haag-Streit slit lamp. Every single measurement was the result of 5 scans. With the contact ultrasound Sonomed pachymeter we performed 5 separate measurements and calculated the mean.The correlation between the two measurements was excellent (r = 0.99). The mean standard deviation (SD) of the measurements taken with the non-contact OLCR pachymeter was significantly lower than with the contact ultrasound pachymeter, 0.49 μm and 4.71 μm respectively ($p < 0.01$).
The variability of the CCT measurements taken with the non-contact OLCR pachymeter is significantly lower than the variability of the CCT measurements taken with the contact ultrasound pachymetry.

RÉSUMÉ

L'épaisseur de la cornée centrale a été mesurée de façon prospective chez 50 yeux de 25 patients en comparant le pachymètre optique OLCR (Optical Low Coherence Reflectometry) au pachymètre échographique. Le pachymètre OLCR était monté sur un biomicroscope de Haag-Streit. Chaque mesure isolée était le résultat de 5 scans. Nous avons comparé chaque mesure du pachymètre OLCR avec la moyenne de 5 mesures prises avec le pachymètre Sonomed.
La corrélation entre les deux techniques était excellente (r=0.99). La déviation standard moyenne de la pachymétrie optique (0.49 μm) était significativement plus basse que la déviation standard moyenne de la pachymétrie échographie (4.71 μm) ($p<0.01$).
La variabilité des mesures de l'épaisseur de la cornée centrale prises avec le pachymètre OLCR non-contact est significativement plus basse que la variabilité des mesures de l'épaisseur de la cornée centrale prises avec le pachymètre échographique contact.

KEY WORDS

Pachymetry, central corneal thickness, contact ultrasound pachymetry, optical low coherence reflectometry.

MOTS-CLÉS

Pachymétrie, épaisseur cornéenne centrale, pachymètre échographique contact, pachymètre optique.

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INTRODUCTION

Measurement of corneal thickness is an essential element of glaucoma clinics and of corneal refractive surgery. The central corneal thickness (CCT) measurement is essential in patients attending for glaucoma assessment to avoid misclassification resulting from the relationship between CCT and tonometric pressure (2,4-6,13). To avoid complications such as corneal ectasia after in situ keratomileusis and perforation in radial and astigmatic keratotomy, accurate corneal thickness measurements are important (1,10,12,16). Currently, measurements of corneal thickness are primarily performed with ultrasound pachymetry. However, differences in corneal thickness measurements are reported among ultrasound pachymeters (11,17). Optical Low Coherence Reflectometry (OLCR), a recently developed optical ranging technique, is reported to enable fast, noncontact measurements of corneal thickness with micrometer precision (3,7,14,15).

The aim of this study is to compare the variability of CCT measurements taken with the non-contact OLCR pachymeter versus the contact ultrasound pachymeter.

METHODS

Twenty-five healthy volunteers (50 eyes) with no history of corneal disease, ocular surgery, or contact lens use were recruited for the study. A single investigator made all the measurements of corneal thickness in both eyes using a non-contact Optical Low Coherence Reflectometry (OLCR) pachymeter (Haag-Streit, Switzerland) and a contact ultrasound Sonomed pachymeter (Micropach, Model 200P, USA). Before the measurements, all subjects received an anterior segment examination to ensure that no ocular disease existed and that the cornea was clear. In all subjects, measurements were made first by optical pachymetry and then by ultrasound pachymetry. The order of measurement was chosen because optical pachymetry is noncontact whereas ultrasound pachymetry may disturb the corneal surface temporarily during the procedure. Five separate, sequential measurements were performed with the contact ultrasound pachymeter and the average of these 5 readings was calculated. The investigator was masked from the results of the OLCR pachymeter when measuring the CCT with the ultrasound pachymeter.

The OLCR unit is a prototype and was developed jointly by Schwind and Haag-Streit (Köniz, Switzerland). Optical pachymetry consists of measuring the oblique section of the cornea by means of a split prism and aligning the split images so that the epithelial layer coincides with the endothelial layer. The electric signals are processed and recorded with a personal computer. Patient data and measurement data are monitored on a computer screen (7).

The OLCR system was mounted on a Haag-Street slit lamp. The OLCR measurements were done with the subject in a seated position, as usual for cornea observation. The subject kept both eyes open and fixated on the measurement beam. Five single measurements were automatically averaged by the OLCR software. The OLCR system automatically measured the standard deviation (SD) of the measurement.

Ultrasound pachymetry uses high-frequency sound waves to detect the epithelial and endothelial layers, both of which are highly reflective surfaces. Knowing the velocity of sound in corneal tissue, the distance between the 2 reflecting surfaces can be calculated by detecting the time lapse between reflected sound waves from the 2 surfaces. For ultrasound pachymetry, the cornea was anesthetized with topical oxybuprocain 0.4%. The subject was then placed in a face-up position and asked to look at a fixation target in the distance while the ultrasound probe was aligned perpendicular to the centre of the cornea and applanated gently on the cornea. The probe was sterilized with alcohol in between patients.

Statistical Analysis

We correlated the mean CCT measurements of both pachymeters using the Pearson correlation coefficient. We compared the mean CCT values and the SD of all the measurements taken with both instruments. A two-tailed paired *t* test was used to compare the mean CCT values measured with the 2 pachymeters. A F test was used to determine the statistical significance of the difference in the variances (SD^2) between the two pachymeters. For both statistical tests, a *p* value less than 0.05 was considered the level of significance.

RESULTS

Twenty-five healthy volunteers were recruited. All met the inclusion criteria. Both eyes of each volunteer were included in the study.

Figure 1 represents the correlation between the CCT values measured with the OLCR and the ultrasound pachymeter. The Pearson correlation coefficient was r = 0.99.

The mean CCT measured with the OLCR and the ultrasound pachymeter was 560.56 μm (95% confidence interval (CI), 560,42-560,70) and 565.65 μm (95% CI, 564,34-566,96) respectively. The mean SD of the measurements taken with the OLCR and the ultrasound pachymeter was 0.49 μm and 4.71 μm respectively ($p<0.01$).

DISCUSSION

The correlation between the CCT values measured with the OLCR and the ultrasound pachymeter was an almost perfect linear correlation. The Pearson correlation coefficient was r = 0.99.

The mean CCT measured with the OLCR pachymeter and the ultrasound pachymeter was 560.56 μm and 565.65 μm, respectively. Although the differences among the two pachymetry devices were within 5 μm, they were statistically significant ($p<0.01$). The mean CCT with the OLCR pachymeter was approximately 5 μm thinner than with the ultrasound pachymeter. These small differences are clinically less relevant in glaucoma clinics, but these can be relevant in refractive surgery. However, the reason for the significantly smaller measurements with the OLCR pachymeter remains unclear. A possible explanation could be the better

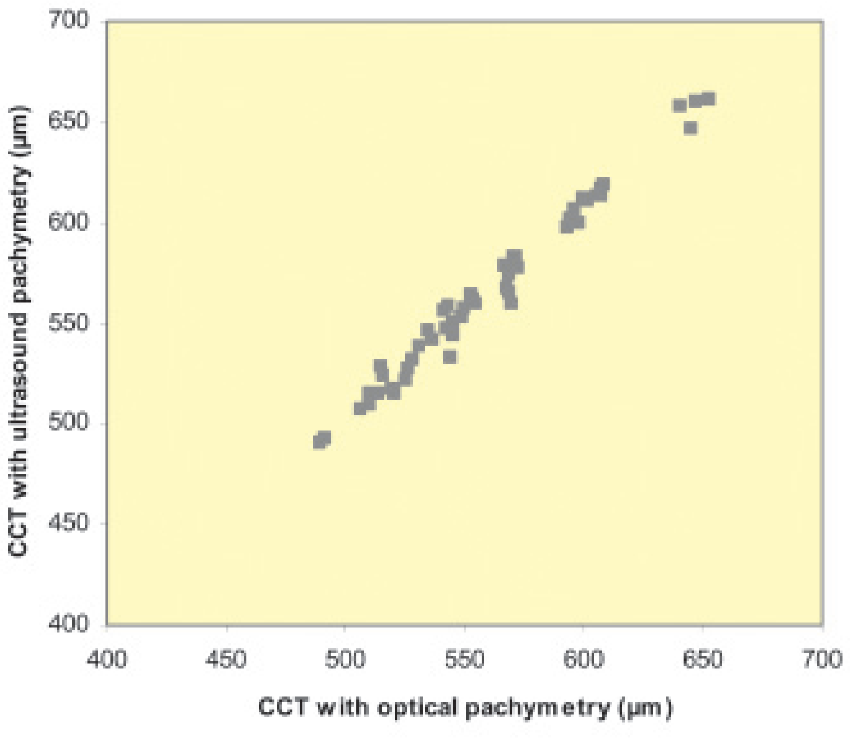

Figure 1. Correlation between the CCT values measured with the OLCR pachymeter and the ultrasound pachymeter. The Pearson correlation coefficient r =0.99.

central alignment with optical pachymetry. Manual probe placement of ultrasound pachymetry might be influenced by misalignment of the probe as the pachymeter lacks a fixation target for precise control of the patient's gaze.

The mean standard deviation of the measurements taken with the non-contact OLCR pachymeter was significantly lower than those taken with the contact ultrasound pachymeter: 0.49 and 4.70 μm respectively ($p<0.01$). The OLCR pachymeter was a more precise instrument. Nevertheless, the reproducibility of the measurements taken with the ultrasound pachymeter was relatively good, as reported in previous studies (8,9). The reason for the relatively good reproducibility might be that the measurements were performed sequentially within a short time by a single experienced examiner. Therefore, the error of measuring a different area of the cornea was minimized.

The OLCR pachymeter offers a high degree of comfort for the patient. It is a non-contact method with no need for anesthesia, and it ensures less risk of infection. Since all the values are computer generated and observator independent, the OLCR pachymeter has a lower intraobserver variability. The most commonly used ultrasonic systems today for measuring corneal thickness, use contact probes. Although accurate enough, these devices still leave room for improvement. In our experience, there are 2 major observer-dependent factors influencing ultrasound pachymetry readings: the probe should be placed exactly on the centre of the cornea and exactly perpendicular to the corneal surface. Contact probes also carry the additional risk of infection and of modifying, through pressure, the corneal thickness.

The OLCR pachymeter can be mounted on the slit lamp BQ 900®, BM 900®, BM 900®V or BC 900®. Tonometry correction, according to the pachymetry measurement, can be performed with the same device using a selectable slope (mmHg/10 μm) and zero-point (μm). Haag-Streit is cooperating with several excimer manufacturers so that the device can be built into, and used in parallel with, their excimer lasers.

CONCLUSION

The variability of the CCT measurements taken with the non-contact OLCR pachymeter is significantly lower than the variability of the CCT measurements taken with the contact ultrasound pachymeter.

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