

Comparison of ultrasonic pachymetry, with a new optical biometry and tono-pachymetry

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Abstract

The aim of this study was to compare the measurements of central corneal thickness (CCT) using the CT-IP tonopachymetry and AL-Scan optical biometry with those obtained with ultrasound (US) pachymetry. In this prospective study, CCTs were measured in 100 eyes of healthy subjects with the CT-IP tonopachymetry, AL-Scan optical biometry and US pachymetry, and the results were compared. The mean CCT taken with the CT-IP, AL-Scan optical biometry and US pachymetry were $514.1 \pm 34.96 \mu\text{m}$, $540.00 \pm 29.57 \mu\text{m}$ and $542.53 \pm 31.2 \mu\text{m}$, respectively. There were high correlations between CCT readings using US pachymetry and AL-Scan optical biometry ($r=0.949$, $p=0.001$), between US pachymetry and CT-IP tonopachymetry ($r=0.851$, $p<0.001$) and between AL-Scan optical biometry and CT-IP tonopachymetry ($r=0.859$, $p<0.001$). Both AL-Scan optical biometry and CT-IP tonopachymetry are quick, non-contact devices that are easy to use and are reliable alternatives to US pachymetry for measuring CCTs.

Keywords: Cornea, pachymetry, corneal central thickness

Introduction

The measurement of central corneal thickness (CCT) has a crucial role in both the diagnostic and therapeutic assessment of ocular pathologies; therefore, it has become increasingly important in ophthalmic practice. This measurement is required for refractive surgery preoperative evaluations to prevent postoperative corneal ectasia and also is an indicator of corneal endothelial function [1-3]. Intraocular pressure (IOP) is a criterion for the diagnosis of glaucoma and is commonly assessed using applanation tonometry which is based on the Imbert-Fick law. Increased corneal thicknesses lead to falsely high estimations of IOP, whereas low corneal thicknesses may result in misdiagnosed and untreated glaucoma [4,5]. Therefore, measuring CCT has become a standard practice for the evaluation and management of glaucoma. There are various instruments utilizing different principles that can measure CCT, including ultrasound, specular microscopy, optical coherence tomography, tonopachymetry, interferometry, confocal microscopy and corneal topography [6-9].

Currently, ultrasound (US) pachymetry is the most commonly used method for corneal thickness measurements. However, it has the disadvantage of direct

contact of the probe with the cornea with topical anaesthesia, which may influence the CCT measurement. Furthermore, it may damage the corneal epithelium and increase the risk of infection; it is dependent on the experience of the examiner, which can influence the reliability of the measurements [10,11]. Nowadays, noncontact instruments have become more popular to overcome this disadvantage.

AL-Scan (Nidek Gamagori, Japan) is a new noncontact optical reflectometer and keratometer, which uses an 830 nm superluminescent diode as a source. A rotating Scheimpflug camera is used to measure CCT. CT-IP tonopachymetry (Topcon, Tokyo, Japan) is a fully-automated noncontact tonometer and pachymeter that provides measurement of intraocular pressure and CCT. To the best of our knowledge, this was the first study that was designed to compare the CCT measurements obtained using recently marketed, AL-Scan optical biometry and CT-IP tonopachymetry with ultrasonic pachymetry.

Methods

This prospective study analysed the measurement of 100 right eyes of healthy subjects that was conducted at the Department of Ophthalmology, Dumlupinar University School of Medicine. The purpose of the study was explained and informed consent obtained from all subjects. The study was approved by the local ethics committee and conformed to the tenets of the Declaration of Helsinki. The exclusion criteria for this analysis were any eyes with measurement failure and corneal diseases, corneal

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astigmatism greater than 3 diopters, or any history of laser or intraocular surgery within the previous six months.

First, we measured CCT for each patient with AL-Scan optical biometry. The patient's chin was positioned on the chin rest and the forehead against a headband. It used 3-D autotracking and autofocus, which provided the operator with the most ease, comfort and accuracy for all measurements. The 3-D autotracking tracked any eye movements on the X–Y–Z planes to ensure accurate alignment of the eye. Once correct alignment was achieved, the autofocus immediately captured the image and data. Next, the CT-1P tonopachymetry was used to measure the corneal thickness. The inclinedly emitted light from a narrow slit in the cornea is reflected by the front and backside of the cornea. The reflected light was brought in by the line sensor. The corneal thickness was measured according to the interval between the front and backside reflection images on the line sensor. Finally, US pachymetry was used to measure the corneal thickness.

The patient looked straight ahead and the probe was placed perpendicular to the centre of the cornea. After the instillation of topical anaesthesia with proparacaine hydrochloride ophthalmic solution, five consecutive measurements with US pachymetry were taken, and the mean value of these five measurements was used as CCT reading.

Statistical analyses were performed using SPSS software for Windows, version 16.0 (SPSS Inc., Chicago, Illinois, USA). The paired t-test was used to compare the mean CCT values of each pair of instruments. Pearson's correlation coefficient test was used to assess the correlation between the methods. P values of <0.05 were considered statistically significant. The Bland–Altman analysis was used for interdevice comparisons of CCT measurement with a mean difference of ± 1.96 standard deviation of the difference, and the 95% limits of agreement was defined as the mean difference between instruments.

Results

One hundred eyes of 100 healthy subjects were included in this study. The demographic data and CCT measurement of studied subjects were shown in table 1 and 2.

Table 1. Demographic data of the study population

Age (year)	
Mean $\pm$ SD	60.54 $\pm$ 7.98
Range	35–75
Gender	
Male	56 (56%)
Female	44 (44%)

Table 2. CCT measurement of studied subject with US pachymetry, AL-Scan optical biometry and CT-1P tonopachymetry

	CCT (μ m)	Range
US pachymetry	542.53 $\pm$ 31.2 μ m	470–604 μ m
AL-Scan optical biometry	540.00 $\pm$ 29.57 μ m	475–594 μ m
CT-1P tonopachymetry	514.16 $\pm$ 34.96 μ m	428–598 μ m

CCT measured using US pachymetry was significantly higher than that measured with both optical biometry and tonopachymetry (paired t-test, $p=0.011$ and $p<0.001$). The values obtained with optical biometry were significantly higher than those measured with tonopachymeter (paired t-test, $p<0.001$). There were high correlations between CCT readings using US pachymetry and optical biometry (Pearson correlation coefficient $r=0.949$, $p=0.001$), US pachymetry and tonopachymeter (Pearson correlation coefficient $r=0.851$, $p<0.001$) and optical biometry and tonopachymeter (Pearson correlation coefficient $r=0.859$, $p<0.001$). The Bland–Altman plot shows excellent agreement (Figure 1,2 and 3).

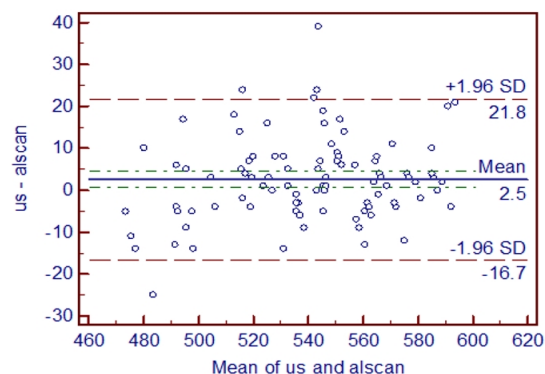


Figure 1. The Bland–Altman plot of central corneal thickness as measured using AL-Scan optical biometry versus ultrasound (US) pachymetry for both calculated as mean ± 1.96 SD (N=100 eyes).

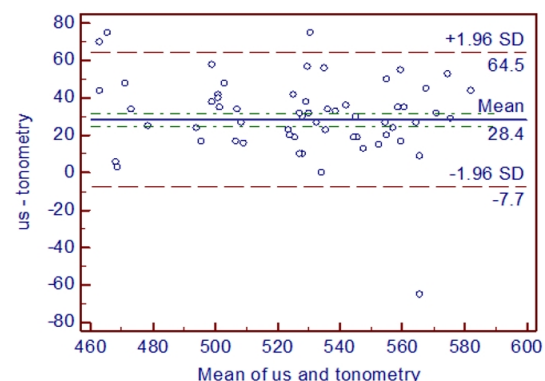


Figure 2. The Bland–Altman plot of central corneal thickness as measured using CT-1P Tonopachymetry versus ultrasound (US) pachymetry for both calculated as mean ± 1.96 SD (N = 100 eyes).

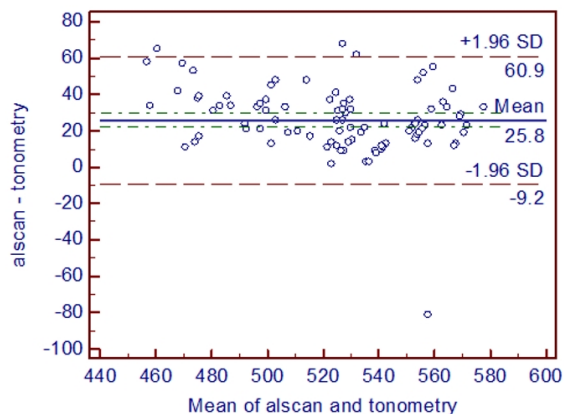


Figure 3. The Bland–Altman plot of the central corneal thickness as measured using CT-1P Tonopachymetry versus AL-Scan optical biometry for both calculated as mean ± 1.96 SD (N = 100 eyes).

Discussion

Accurate measurement of CCT has become important with the rapidly increasing popularity of corneal refractive surgery, particularly for the selection of a surgical technique [12]. It has also become a standard component in glaucoma evaluation. IOPs that are measured using a conventional tonometer are higher in eyes with a thicker cornea; a thin CCT may lead to the misdiagnosis of normal tension glaucoma [13-15]. Our previous study determines that IOP increased by 0.29 mmHg for each 10 μ m increase in CCT [16]. Therefore, new noncontact pachymetry systems have recently become available. The comparison of a new measurement technique with an established one is often required to see whether the new one agrees sufficiently well with the old one, leading to replacement of the old or whether the two methods could be interchangeably used. AL-Scan optical biometry and CT-1P tonopachymetry were recently marketed in the worldwide. To the best of our knowledge this was the first study that was compared them with conventional ultrasonic pachymetry which is gold standard method for CCT measurement.

Lomoriello et al reported the mean CCT measured using NT530P tonopachymetry was 13- μ m statistically thinner than US pachymetry [17]. Garcia-Resua et al also found that the mean CCT was 20.66- μ m lower using the same tonopachymetry system compared with US pachymetry [18]. However, the underestimation detected by these two reports was less than the difference that was observed in our study (mean underestimation: 28.37 μ m that used varied tonopachymetry instruments).

There have been many reports regarding CCT measurement using the Scheimpflug-base system; in some reports, the average measured 7- μ m was thinner than the measurement using US pachymetry [18-20]. Other studies found that the average measured 5- μ m was thicker than that obtained using US pachymetry [21-23]. Rainer et al

reported that the mean CCT measured with partial coherence interferometry was significantly thinner than that measured with US pachymetry [24]. In another study by Nemeth et al. showed that CCT measured with partial coherence interferometry was more reliable and reproducible than CCT measured by US pachymetry [25]. Huang et al found that AL-Scan optical biometry had comparable result with IOL Master in CCT measurement with excellent reproducibility and repeatability [26]. In this study, CCT measured using AL-scan optical biometry (using Scheimpflug-base system) was thicker than the one measured using the tonopachymetry (25.84 μ m); however, the difference from US pachymetry was too small (2.53 thinner). Therefore, it can be used as a good option to assess the corneal health.

Many authors have claimed that US pachymetry may lead to false results because of topical anaesthetics, the indentation of the cornea, inaccurately placement of the US probe and different speeds of sound in various parts of the cornea. The US probe may apply an applanation force to the cornea, which may displace the 7–30- μ m thick tear film and may also thin the corneal epithelium; this may lead to an indistinctly thinner CCT [27,28]. We are not sure why this disparity occurred in our study.

It is known that every 20- μ m difference in CCT from the population mean (approximately 542 μ m) leads to a 1-mmHg difference between the actual IOP and IOP measured with applanation tonometry [29]. CT-1P tonopachymetry reported thinner CCT measurements than other two devices; however, this difference was not clinically significant. The 28.37- μ m difference in CCT provided an actual IOP that was approximately 1.5-mmHg lower. This difference increase in the thinner cornea. The main advantage of tonopachymetry was to provide an adjusted IOP so it could be used in busy clinics.

The results of our study showed that CCT measurements obtained with AL-Scan optical biometry and CT-1P tonopachymetry were comparable to US pachymetry; however, the thinner measurement using CT-1P tonopachymetry should be taken into consideration, particularly in normotensive glaucoma and advanced glaucoma patients.

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