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Comparison of Ultrasound and Scheimpflug Methods for Central Corneal Thickness

Tulay Karacan Ersekerci[1*], Rasit Kilic[2], Sebile Ustun Comcali[2], Abdi Bahadır Cetin[2] and Yasin Cakmak MD[2]

[1]Department of Ophthalmology, Finike Goverment Hospital, Antalya, Turkey.
[2]Department of Ophthalmology, Numune Hospital, Sivas, Turkey.

Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: The central corneal thickness (CCT) of healthy individuals was measured with an ultrasonic pachymeter (UP) and the Scheimpflug imaging system (SIS) and the results were compared to evaluate the agreement between the two methods in this study.
Materials and Methods: The 61 subjects who had no ocular pathology or systemic disease except blepharitis were included in the study. CCT measurements of all subjects were performed with the UP (Sonomed 300P Pacscan) and SIS (Nidek Optical biometer AL-Scan) devices and the results were compared. The t test and the Bland-Altman plot were used as the statistical methods.
Results: The study sample consisted of 61 cases including 20 males and 41 females. The mean age was 41.8±12.4 (20-58) years for the males and 46.2±9 (24-60) years for the females with no statistically significant difference (*P*=0.116). The mean CCT measurement of all the 61 subjects was 544.5±31 µm in the right eyes and 547.3±33 µm in the left eyes with UP, 530.7±27.6 µm in the right eyes and 531.6±25.5 µm in the left eyes with SIS. The CCT in the SIS results was an average of 13.8 µm thinner than the UP results in the right eye, 15.7 µm in the left eye and this difference

**Corresponding author: Email: drtke@yahoo.com;*

was statistically significant (p=0.001 in right and left eyes). A high degree of agreement was found between the two methods with the Bland-Altman plot.
Conclusion: A high degree of agreement was found between SIS and UP regarding CCT measurements and the mean SIS results were 13.8 µm and 15.7 µm thinner than the UP results in the right eyes and left eyes respectively.

Keywords: Central corneal thickness; Scheimpflug imaging; ultrasonic pachymeter; glaucoma.

1. INTRODUCTION

Central corneal thickness (CCT) measurement is an important parameter in ophthalmology. It is widely used in planning refractive surgery, in the diagnosis, treatment, and follow-up of some corneal disorders, and in the diagnosis of glaucoma by performing corrected intraocular pressure measurements [1-5]. Instruments measuring corneal thickness work according to ultrasonic or optical principles. The ultrasonic methods are ultrasonic pachymetry and ultrasonic biomicroscopy. The optical methods include slit lamp pachymetry, specular microscopy, screening corneal topography, confocal microscopy, optical coherence tomography, and Scheimpflug imaging [3,6,7].

Ultrasonic pachymetry is the gold standard in terms of reliability and accuracy for central corneal thickness measurement. It is a contact test performed with topical anesthesia. The optical SIS is a non-contact CCT measurement method.

Non-contact methods are preferred for central corneal thickness measurement in opthalmology departments. We measured the CCT in healthy individuals with the SIS and UP methods and compared the results to evaluate the agreement between the two techniques.

2. MATERIALS AND METHODS

Cases who presented to our clinic and had no pathology except blepharitis that did not cause dry eye or any symptom were included in the study. We evaluated the 122 eyes of 61 subjects who accepted to participate voluntarily after they were informed on the procedures within the scope of the study. Those with any systemic disease and cases with a history of ocular surgery were excluded. The study was planned and conducted in accordance with the Helsinki Declaration. A consent form was obtained from all participants.

Central corneal thickness measurements were first taken via SIS (Nidek Optical Biometer AL-Scan). After the subject sat down in front of the device, measurements were performed with the subject looking at the fixation point. We only obtained one CCT measurement with SIS as the repeatabilityis good [8]. CCT measurement was performed with the UP (Sonomed 300P Pacscan) method at the second stage of the study. Each eye was administered one drop of 0.5% proparacaine hydrochloride (Alcaine®, Alcon) as the topical anesthetic drop before the measurements. The subject was made to focus on an object in front while at the sitting position and the probe touched the center of the cornea perpendicularly. Five consecutive measurements were taken. The procedure was repeated for the other eye. The mean of the measurements was accepted as the CCT.

The ultrasonic pachymetry measurement results were classified as the UP results and the Scheimpflug imaging system measurement results as the SIS results and the results were compared between the two groups. The data were evaluated with the Bland-Altman plot and independent and paired samples t test. A p value was smaller than 0.05 was accepted as statistically significant.

3. RESULTS

The study consisted of 20 males and 41 females for a total of 61 healthy individuals. The mean age was 44.8±10.3 (20-60) years for all cases, 41.8±12.4 (20-58) years for males and 46.2±9 (24-60) years for females with no statistically significant difference between the males and females (P=0.116). The mean CCT measurement for all 61 subjects was 544.5±31 µm in the right eyes and 547.3±33 µm in the left eyes with UP, 530.7±27.6 µm in the right eyes and 531.6±25.5 µm in the left eyes with SIS. CCT was 13.8 µm and 15.7 µm thinner on average in the SIS results in the right eyes and left eyes respectively and this difference was statistically significant (P=0.001 in both eyes).

UP and SIS measurement results are seen around the equality line in Figs. 1 and 2. Figs. 3 and 4 present the Bland-Altman plot demonstrating good agreement between the UP and SIS methods for measurement of CCT and the 95% limits of agreement.

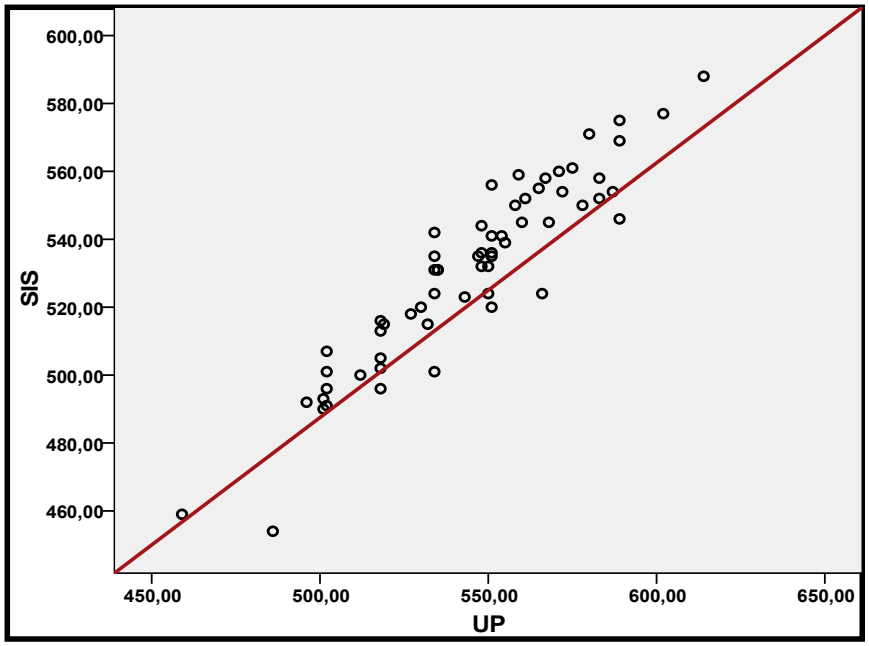

Fig. 1. Distribution of CCT measurements with US and SIS around the equality line in right eyes

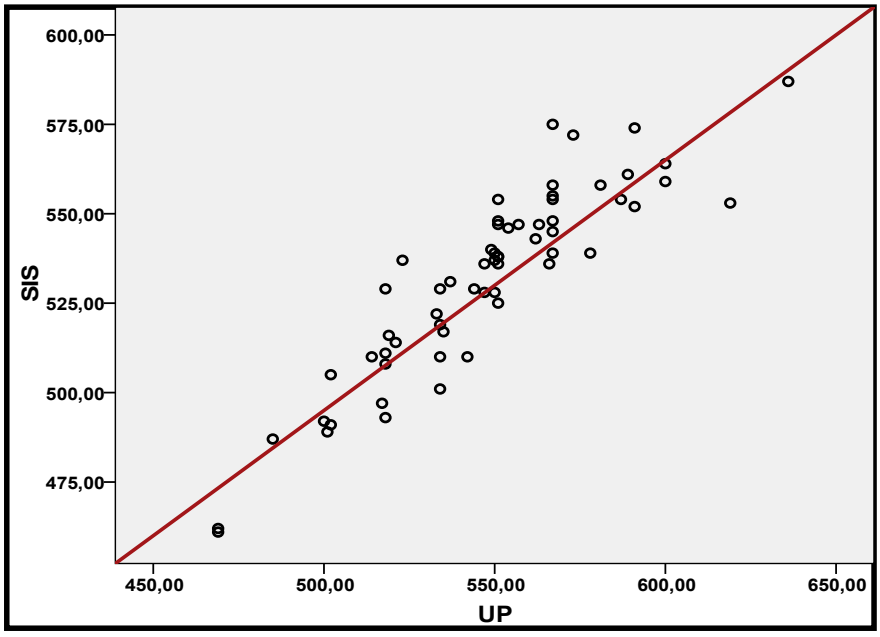

Fig. 2. Distribution of CCT measurements with US and SIS around the equality line in left eyes

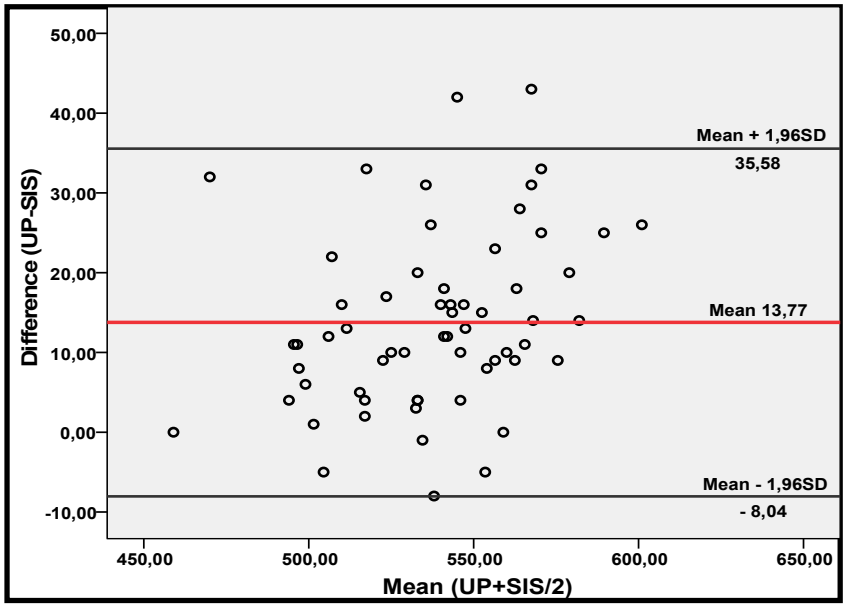

Fig. 3. Distribution graph of difference from the mean of measurements with the UP and SIS methods in right eyes

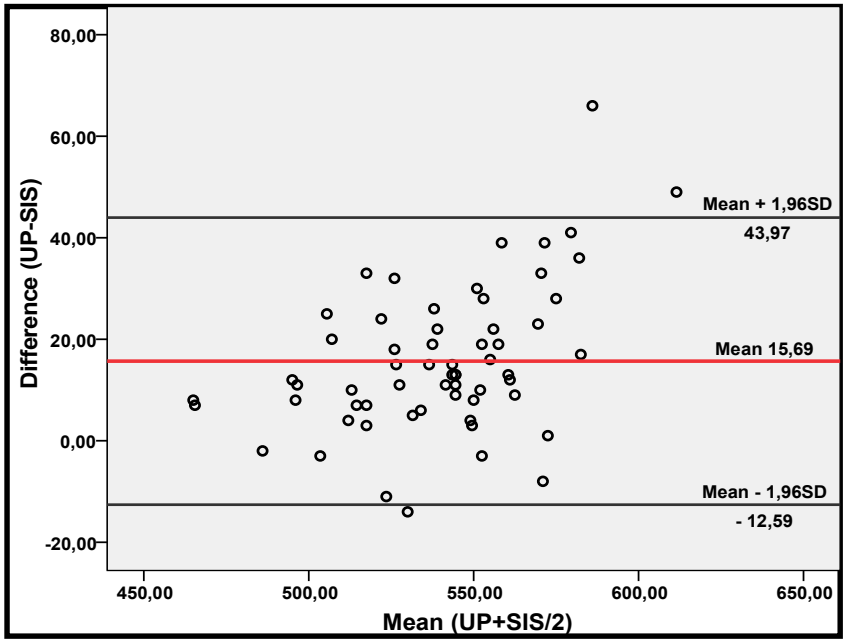

Fig. 4. Distribution graph of difference from the mean of measurements with the UP and SIS methods in left eyes

4. DISCUSSION

Central corneal thickness has a very important place in diagnosis and treatment follow-up in ophthalmology. Even a small change in CCT may change the treatment strategy and affect the refractive surgery decision. UP is currently the most widely used method for CCT measurement.

Although it has advantages such as being cheap, reliable and practical, the need to use topical anesthesia before the measurement, and the possibility of causing cross-infection or creating a corneal defect due to the contact method of measurement are its disadvantages. It is also possible for measurements to vary because of excessive compression of the cornea, the measurement not being performed at the exact center, and tear film layer changes in repeated measurements [3,9-11].

The most significant advantages of optical measurement methods are that they do not contact the cornea, do not require topical anesthetics, can perform repeatable rapid measurements, and the result is not affected by the person performing the measurement. They are also preferred because they eliminate the mechanical problems caused by indentation [12].

SIS is an optical, non-contact method used to investigate the anterior segment. This technique creates a 3-dimensional image by taking many anterior segment images from different angles in a few seconds using the Scheimpflug camera system and also performs anterior chamber depth and CCT measurements [2,13,14].

There are many studies in the literature comparing corneal thickness measurement methods. UP was shown to measure CCT thicker than other methods in certain studies and thinner in other studies. Al-Mezaine et al. [14] found a mean CCT value of 552.4±37 µm with SIS (Pentacam) and 544.1±35.4 µm with UP. Al-Mezaine et al [15] found the mean CCT of patients who had undergone LASIK surgery to be 522±42.2 µm with SIS and 516.2±40.6 µm with UP in another study. In contrast, Cioline et al. [16] measured mean CCT as 506±29.5 µm with SIS and 505±31.7 µm with UP and concluded that these 2 methods can be used alternatively in LASIK patients. Buyuk et al [17] compared SIS and UP methods in healthy eyes and eyes with keratoconus and measured a mean CCT in keratoconus patients of 480.18±33.6 µm with SIS and 465.67±34.5 µm with UP while the mean CCT in healthy eyes was 573.8±35.7 µm with SIS and 563.58±30.9 µm with UP. Results with the SIS were thicker than those with UP both in the eyes with keratoconus and the healthy eyes. The reason for the lower measurements with UP than with non-contact methods could the lateral displacement of the 7-30 micron tear film layer with the probe contacting the cornea and the epithelial thinning due to the larger amount of pressure [18].

In response to these studies, Lackner et al. [19] compared SIS (Pentacam), Orbscan and UP for CCT measurements. The mean measurements were 542±29 µm with SIS and 552±32 µm with UP. They found that the results obtained with the SIS were 9.8 µm lower than with UP and showed that the repeatability of the measurements taken with the SIS was higher while the user-related error was minimum. O'Donnell et al. [20] measured CCT values as 528±45 µm with SIS and 534±47 µm with UP in a similar study. In conclusion, there is a high degree of agreement between the SIS method and UP and the CCT is measured thicker with the SIS method in some studies and UP in others. This difference may not be significant for glaucoma specialists but could be quite important for refractive surgeons. Incorrect measurements in refractive surgery could lead to excessive tissue removal from the stromal bed and iatrogenic keratectasia [21,22].

The effect of anesthetic drops, the impossibility of taking a measurement from the exact center of the cornea and the site of the reflection from the cornea posterior surface not being completely clear, and the reflection location between Descemet's membrane and the anterior chamber instead of the posterior surface of the cornea were stated as the reasons for the higher CCT measurements with the ultrasonic method in some studies [11,18]. The mean CCT measurement results were530.7±27.6 µm in the right eyes and 531.6±25.5 µm in the left eyes with SIS method and 544.5±31 µm in the right eyes and 547.3±33 µm in the left eyes with UP method in our study, similar to these findings. Mean CCT was 13.8 µm thinner in the right eye, 15.7 µm thinner in the left eye in the SIS results than the UP results and the difference was statistically significant. We believe the reasons for the thicker CCT measurements with ultrasonic pachymetry were the effect of topical anesthetic drops and the reflections being beyond Descemet's membrane.

Correlation analysis is usually used in studies conducted to evaluate the agreement between different methods [23]. However, correlation analysis is a test of the hypothesis that there is no relationship between the two methods and it is therefore unnecessary to test whether the two methods designed to measure the same value are related. A high degree of correlation can be shown even if the two methods have weak agreement. The degree of correlation is dependent on the distribution width of the sample results. The correlation is higher in samples with

a large distribution width [23]. Taking these problems into account, the Bland-Altman method was thought to be more appropriate as it reveals the measurement differences of two methods objectively and the clinician can decide on the acceptability level of the differences for the evaluation of an alternative method [23]. The data in this study were evaluated with the Bland-Altman analysis and a high degree of agreement was found between the SIS and UP methods.

5. CONCLUSION

We think that SIS can be used as a an alternative to UP, the gold standard, as the CCT measurements do not require topical anesthesia, and the technique does not require contact, can be easily applied and is repeatable. The two methods show a statistically high degree of agreement. However, CCT measurements with SIS can be thinner or thicker than measurements with UP, a fact that should especially be taken into account by refractive surgeons.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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