Ophthalmology Research: An International Journal
5(4): 1-8, 2016, Article no.OR.26503
ISSN: 2321-7227

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Comparison between Ultrasonic Pachymetry and Scheimpflug Based Pentacam for Assessment of Central Corneal Thickness in Myopic Persons of Indian Sikh Origin

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Authors' contributions

This work was carried out in collaboration between all authors. Author RM designed the study. Author JM wrote the protocol and the first draft of the manuscript. Author LD managed the literature searches and helped in statistical analysis. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/OR/2016/26503
Editor(s):
(1) Tatsuya Mimura, Department of Ophthalmology, Tokyo Women's Medical University Medical Center East, Japan.
Reviewers:
(1) Engy Mohamed Mostafa, Sohag University, Sohag, Egypt.
(2) Dominika Wróbel-Dudzińska, Medical University, Lublin, Poland.
(3) Maged M. Roshdy, Ain Shams University, Cairo, Egypt.
(4) Tsung-Jen Wang, Taipei Medical University Hospital, Taiwan.
Complete Peer review History: http://sciencedomain.org/review-history/14843

Original Research Article

Received 21st April 2016
Accepted 20th May 2016
Published 31st May 2016

ABSTRACT

Aims: To compare the central corneal thickness (CCT) measurements between Ultrasound Pachymetry and by the Scheimpflug based Pentacam in myopic persons of Indian Sikh origin.
Methodology: In a prospective study, 100 eyes of 50 myopic persons of Indian Sikh origin (aged 16 to 45 years) were subjected to CCT measurement with two methods Ultrasonic Pachymetry and Pentacam HR. Pentacam HR readings were recorded first. CCT readings obtained by both the methods were compared and analysed statistically using unpaired t-test.
Results: Mean Pachymetry reading with Ultrasound Pachymeter was 557.9 (SD 9.727) micrometers and with Pentacam was 562.34 (SD 9.91) micrometers. The correlation coefficient (r) between measurements using both instruments was 0.974. There was a tendency of

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overestimation of CCT measurements with Pentacam with a statistically significant difference between both methods (P<0.001). However, the amount of overestimation seems to be of little clinical importance (4.44 µm). The mean difference was was -4.44 micrometers (95% LOA -0.108 to -8.77 micrometers).

Conclusion:

1. CCT measurements obtained with either the non contact Pentacam HR or contact Ultrasonic Pachymeter are close to each other with tendency of obtaining slightly higher readings with Pentacam HR.
2. Pentacam was more convenient to the patient with excellent agreement to the readings by Ultrasonic Pachymeter which is considered the gold standard method of CCT measurement.

Keywords: CCT; pachymeter; pentacam HR.

1. INTRODUCTION

Cornea is a transparent avascular tissue that measures 10-11 mm vertically and 11-12 mm horizontally. Central corneal thickness is 540.4 (SD 33.6) µm thick centrally on average, and thicker towards the periphery [1]. Cornea consists of following layers: non keratinized stratified squamous epithelium, Bowman's layer, stroma, Dua's layer, Descemet's membrane and endothelium. Measurement of the corneal thickness indirectly reflects endothelial function.

Measurment of central corneal thickness is performed for both diagnostic and therapeutic purposes. CCT allows determination of the amount of stromal ablation to minimize the risk of iatrogenic keratectasia in Laser Assissted In situ Keratomileusis (LASIK) surgery [2-4]. Analysis of corneal thickness in contact lens wearers is essential for monitoring any changes in the cornea. Knowledge of CCT is also necessary for accurate determination of intraocular pressure, because tonometer readings are dependent on corneal thickness to a certain degree. This has important implications in the management of glaucoma [5].

There are various ways of measuring corneal thickness. The most commonly used clinical method is Ultrasound Pachymetry (gold standard) and there are a number of published studies that address the reliability and repeatability of these measurement techniques [6-16]. The newer generation of ultrasonic pachymeters work by way of Corneal Waveform (CWF).

Pentacam is the Gold Standard in Anterior Segment Tomography. Equipped with an automatically rotating Scheimpflug camera, the Pentacam performs a complete measurement of the anterior eye segment in less than 2 seconds during which 50 images with 500 true elevation points can be recorded. These data then provide the basis for a three-dimensional model of the complete anterior eye segment. Automatic representation of corneal thickness in the centre of the pupil, corneal thickness in the apex, the thinnest point of the cornea, corneal volume, anterior chamber angle and volume are documented [17].

Although ultrasound-based systems offer the advantages of relative ease of use, they experience relatively high errors in measure-ments, possibly as a result of difficulties in centration and alignment. The need for topical anesthesia and contact of the probe with the cornea has led to the search for non-invasive alternative solutions without the risk of epithelial lesions and transmission of infection.

The present study was conducted to compare the CCT readings of Ultrasonic Pachymeter and Pentacam.

2. METHODOLOGY

50 myopic persons of Indian Sikh origin were selected randomly and they were explained about the nature of the study and a written consent was obtained. All patients were subjected to complete ophthalmic examination including uncorrected visual acuity, refraction, detailed slit lamp examination, measurement of intraocular pressure and dilated fundus examination. Then the patients were subjected to CCT measurement with two methods Pentacam HR and Ultrasonic Pachymetry.

All myopic patients of Indian Sikh origin irrespective of their myopic status who have not undergone any ophthalmic surgical procedure before were included in the study. The presence

of any of the following disqualified the patient from inclusion in the study:

- History of previous eye surgeries.
- History of trauma.
- Contact lens wear.
- Corneal pathologies that might influence corneal thickness or structure (like infection, encroached pterygium, dystrophy, ectasia etc.).
- Glaucoma, diabetes mellitus, or other acute or chronic diseases possibly affecting the corneal thickness.
- Inability to fixate on the target.

All measurements were performed in the undilated eyes after 2 hours of awakening on the same day to avoid any diurnal variation of CCT. CCT was determined with two different modalities - with Pentacam HR and with Ultrasonic Pachymetry. Ultrasonic pachymetry measurements were scheduled after Pentacam measurements to avoid influence on the Pentacam readings as a result of corneal flattening. The same ophthalmic technician took all the measurements.

In Pentacam HR (Oculus, Wetzlar, Germany) the patient were seated with his or her chin on a chin rest and forehead against the forehead strap and asked to fixate straight ahead on a fixation target for the duration of the scan (2 seconds). The Rotating Scheimpflug imaging was performed automatically to reduce the operator dependent variations and measurements were taken when the image was focussed and the corneal vertex correctly aligned. Three CCT measurements were taken for each eye from the thinnest cornea and the minimum was taken in to account.

CCT was measured using a handheld Ultrasonic Pachymeter (Pachette 2, DGH Technology Inc, US) calibrated by the manufacturer. The cornea was anesthetized with topical anesthetic eye drops 0.5% proparacaine and recordings were taken after 90 seconds of instillation to avoid any variation of CCT due to topical anesthetic. The patient was sitted and asked to fixate a target right in front. The Pachymeter probe was brought in light contact with the cornea centrally and perpendicularly and three readings were taken. CCT were recorded as the minimum of three individual readings.

Data of each patient were entered in the proforma. Measured values of the two devices were compared with each other and the result was analysed statistically.

2.1 Statistical Analysis

All the data were tested for normality before analysis.

- Statistical analysis was performed using SPSS for windows version 20 and Microsoft office excel.
- Continuous variables are represented as mean (SD).
- The difference of CCT measurement between Pentacam and Ultrasonic Pachymetry were compared using unpaired t-test and P value was calculated. P value of <0.05 was considered statistically significant.
- The 95% level of agreement was calculated using the Bland Altman plot. The difference between the two was plotted against the mean.
- The Pearson coefficient was calculated to show any correlation.

3. RESULTS AND DISCUSSION

100 eyes of 50 myopic patients of Indian Sikh origin were studied. Out of the 50 patients 37 were males and 13 were females (Table 1). The age of subjects ranged from 16 to to 45 years with mean 31.2 (SD 6.22) years (Table 2). The mean refractive error was found to be 3.32 (SD1.66 D).

In the present study the CCT reading has been taken 2 hours after awakening due to diurnal variation of CCT. An increase in CCT during night has been found which generally reaches the value of previous night after 2 hours of awakening [18]. All the CCT measurements were taken with the patient in sitting position. It has been found that CCT is influenced by body positioning. It decreases linearly in first 30 minutes of supine positioning [19].

The CCT has been found to increase initially and then returns to normal after 80 seconds of instillation of 0.5% topical proparacaine. There occurs a secondary rise in CCT after 5 minutes of instillation [20]. CCT measurement was taken after 90 seconds of topical instillation of proparacaine eye drop in the current study.

Mean Pachymetry reading with Ultrasound Pachymeter was 557.9 micrometers (SD 9.727) and with Pentacam was 562.3 micrometers (SD 9.91) (Table 3). The mean difference of CCT measured with Pentacam and Ultrasound

Pachymeter was found to be statistically significant as *P* value < 0.05. Pearson correlation coefficient showed good correlation between the instruments (r= 0.974). Bland Altman analysis confirmed these results. The mean difference was was -4.44 micrometers (95% LOA -0.108 to -8.77 micrometers) (Fig. 1).

In Fig. 2 there is a scatter plot showing CCT readings in Pentacam and Ultrasound Pachymeter.

Many tools have been used in assessing central corneal thickness (CCT) including Ultrasonic Pachymetry, [6] contact and noncontact Specular microscopy, [21,22] Optical coherence tomography (OCT), [23] Ultrasound biomicroscopy, Slit-scanning corneal topography (Orbscan), [7,24] Confocal microscopy and the Pentacam scheimpflug system [15,25-28].

Contact Ultrasonic Pachymetry is the most routinely used method for the measurement of CCT. There exists some degree of variability in intraoperator and interoperator reproducibility while recording measurements [29-31]. Findl O, et al. and Solomon OD demonstrated that the variability in measurements in Ultrasound Pachymetry may be attributed to the following facts [32,33].

1. Placement of the probe on the corneal center is subjective and the perpendicularity of the probe with respect to the cornea is often difficult to ascertain. Operator-dependent errors due to off-center placement of probe may cause thicker CCT measurements.
2. Indentation of cornea may lead to slightly thinner CCT readings.
3. Use of handheld probe can produce applanation force that can displace the 7 to 30 µm thick tear film.
4. The location where the ultrasonic probe is applied may vary in repeated measurements.

So non-contact methods especially the Pentacam HR is a very good alternative. Pentacam is a Scheimpflug based system for imaging the cornea and anterior segment of the eye. In Pentacam, there is a precise control of centralization. Pentacam demonstrated stable central and peripheral corneal thickness measurements. There is another camera in the Pentacam system that repeatedly monitors minute eye movements during the rotational imaging process [29]. Furthermore, it may be uncomfortable for the patient and the risk of epithelial damage and cross-infection exists in ultrasonic pachymeter technique as it requires corneal contact [34]. That is why there is a growing interest of using the non-contact methods especially the Pentacam [29].

The findings of the present study indicated high correlations between CCT measurements of Pentacam and Ultrasonic Pachymeter with a Pearson correlation coefficient of 0.974. Several studies have investigated and confirmed the high correlation in CCT measurements made with contact (Ultrasound Pachymeter) and noncontact methods [35-38]. O'Donnell et al compared CCT measurements with Ultrasound Pachymeter and the Pentacam in normal corneas and reported high correlations between these two devices [25]. Barkana et al found very little difference between Ultrasound and Pentacam readings of the CCT, and stated that Pentacam is a valuable diagnostic tool [29].

Results of the study by Amano et al also verified these findings [39]. In the study, they showed the CCT readings with Pentacam was comparable to that of Ultrasound Pachymeter. The measurements by the two instruments had significant linear correlation with one another with good repeatability. In the study, they found a mean CCT of 545 (SD 31.3) µm with the Ultrasonic Pachymeter and 538 (SD 31.3) µm with the Pentacam in Japanese people. However, the CCT readings with Pentacam were lower than those with ultrasonic pachymeter which is not in agreement with our study. This could be the effect of sample size examined in the study. In our study we found a tendency of overestimation of CCT by Pentacam, however the amount of overestimation was of little significance (4.44 micrometer). Al mazine HS et al. also demonstrated that the CCT measurements by the Pentacam and Ultrasound Pachymetry are highly correlated [40]. They found the mean CCT as 544.1 (SD 35.4) micrometer with Ultrasonic Pachymetry and 552.4 (SD 37.0) micrometer with Oculus Pentacam in Saudi Arabia adults. Compared with Ultrasonic Pachymeter, Pentacam overestimated the CCT by a mean of 8.2 micrometer in their study. In the present study the amount of overestimation of CCT by Pentacam over Ultrasonic Pachymeter is 4.44 micrometer which is of little significance.

The studies conducted by of Bedei A. et al and Huang et al demonstrated about repeatability of

measurements of CCT in Pentacam [41,42]. Gunvant P et al. showed the measurement of CCT using ultrasound pachymeter were repeatable and had excellent interobserver reliability. Measurement variation amounted to less than 0.2% assuming a mean CCT of 538 micrometer [43].

The mean CCT in our study was similar to that of 540.4 (SD 33.6) µm in Indians by Chua J et al and within the limits for mean CCT reported by other studies, ie, 520–579 µm [1]. The corneas of African Americans have been reported to be thinner and those of Caucasians and Mongoloids as thicker [44-50].

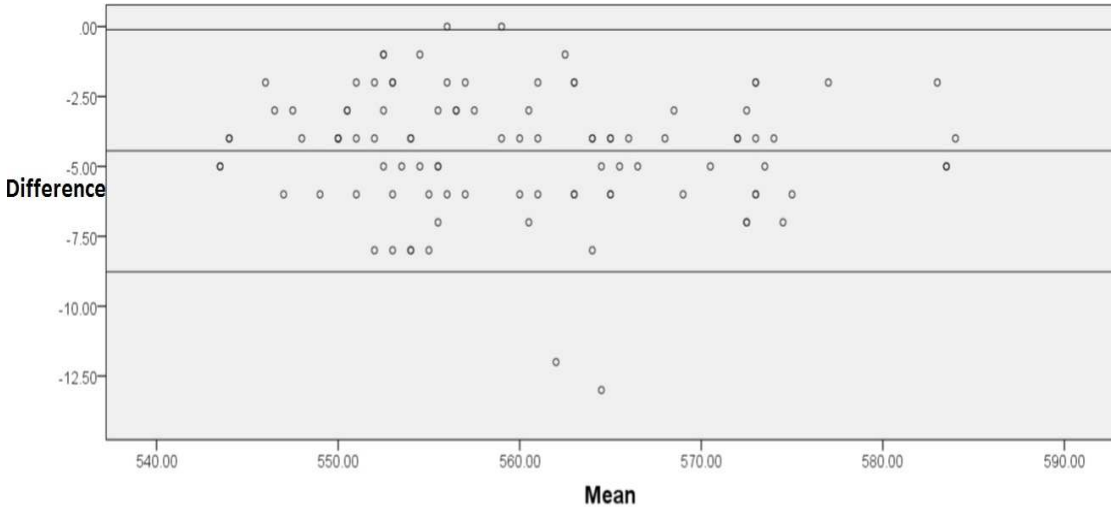

Fig. 1. Bland Altman plot demonstrating CCT measurements obtained using pentacam and ultrasound pachymetry against mean values for both the devices. The 95% limits of agreement are represented as upper and lower lines (-0.108 and -8.77 micrometers)

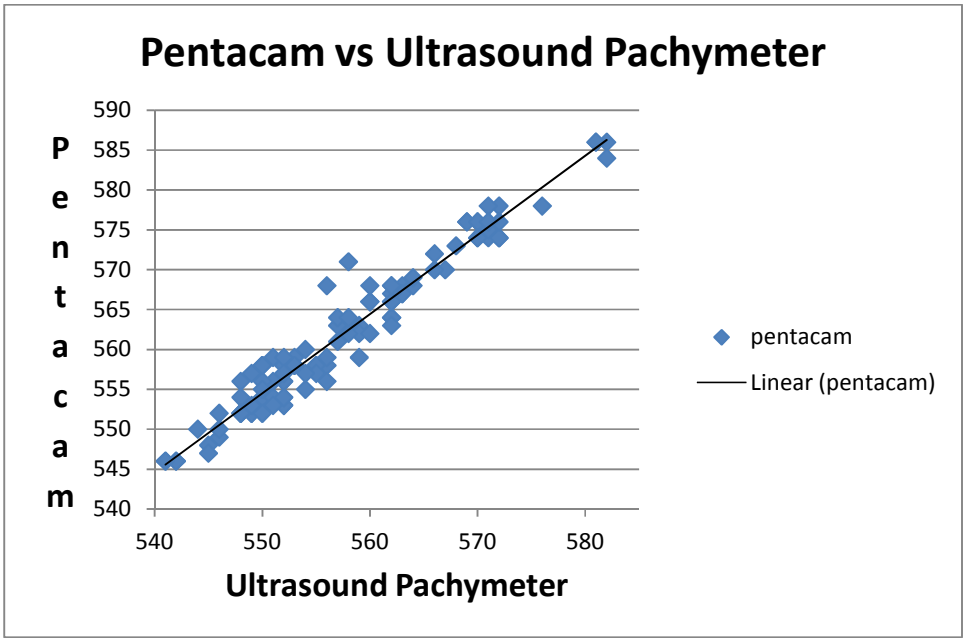

Fig. 2. The CCT readings (in micrometer) in ultrasound pachymeter and pentacam have been shown in a scatter plot

Table 1. Showing sex distribution

Sex	No. of people
Males	37
Females	13
Total	50

Table 2. Showing age wise distribution

Age group	No. of people
10-19	1
20-29	22
30-39	26
40-49	1
Total	50

Table 3. Total mean CCT reading in myopic patients with ultrasound pachymetry and pentacam

CCT (in µm)	Ultrasound pachymeter	Pentacam
Mean (in µm)	557.9	562.3
Standard daviation (SD in µm)	9.727	9.91
Maximum (in µm)	582	586
Minimum (in µm)	541	546

P value= 0.0016 (Highly significant)
The mean and SD of CCT value (in micrometer) has been compared in Ultrasound Pachymeter and Pentacam

4. CONCLUSION

In conclusion, CCT measurements obtained with either the non contact Pentacam or contact Ultrasonic Pachymeter are close to each other with tendency of obtaining slightly higher readings with Pentacam.

CONSENT

All the patients have given their written consent to be included in the study and its publication.

ETHICAL CLEARANCE

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/14843