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Comparative Study Between Specular Microscopy, Pentacam and Anterior Segment Optical Coherence Tomography in Assessment of Central Corneal Thickness

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ABSTRACT

Background: Central corneal thickness (CCT) measurements are important for determining intraocular pressure (IOP), examining corneal endothelium activity, and assessing patients before and after refractive surgery. Contact and non-contact techniques can be used to assess CCT.
Aim of The Work: in individuals with healthy corneas, CCT values taken with three distinct devices: noncontact specular microscope, anterior segment optical coherence tomography (AS-OCT), and pentacam.
Patients and Methods: This is observational prospective cross-sectional study, done at the outpatient clinics of Al-Azhar University hospitals on 100 healthy eyes.
Results: Regarding correlation between CCT measured by pentacam and CCT assessed by AS-OCT and specular microscopy. There was high positive important correlation between CCT assessed by pentacam and CCT assessed by AS-OCT ($r=0.887$, $p<0.001$) & specular microscopy ($r=0.863$, $p<0.001$).
Conclusion: in normal eyes, the mentioned devices have a good correlation. Because there was statistically significant variance, they cannot be utilized interchangeably. Ultrasonic pachymetry is recommended for cases with borderline pentacam pachymetry readings.

Keywords: *Central corneal thickness; Noncontact specular microscope; Ultrasonic pachymetry; Pentacam; Scheimpflug image.*

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INTRODUCTION

Assessment of (CCT) has a great value in different fields of ophthalmology and optometry, especially in diagnosis and treatment of corneal disorders.[1]

CCT is also a key requirement in refractive surgery. It helps in predicting the long-term complications such as postsurgical keratectasia .[2]

The cornea, iris, and anterior chamber are imaged in high-resolution using AS-OCT. It is similar to ultrasound, except instead of sound, it uses light waves to create incredibly high-resolution images of very minute ocular structures. To construct a cross-sectional picture, AS-OCT employs two scanning light beams which reflected again from ocular structures then identified and matched with a reference beam. AS-OCT can be used for evaluation of residual stromal bed after LASIK surgery. [3]

The topographic corneal thickness may be measured using the pentacam. The accuracy of the pentacam and its consistency with other ophthalmic tools in measuring central and peripheral corneal thickness (PCT) have been thoroughly investigated.[4]

We studied the pentacam's inter and intra-session repeatability on CCT and PCT, elevation measurements and the best fit sphere which evaluates posterior corneal topography .[5]

The study's object was to evaluate CCT measurements by three distinct instruments: NCSM, AS-OCT, and pentacam.

PATIENTS AND METHODS

This is cross-sectional prospective observational study, performed on 100 healthy eyes of individuals came to the outpatient clinics, Al-Azhar University hospitals.

Inclusion criteria: Age: 20-50 y old, sex: male and female, spherical equivalent: (-2 to +2 D), healthy cornea and IOP<21mmHg.

Exclusion criteria: Corneal diseases; (dystrophies, degenerations and keratitis), systemic diseases affecting eyes such as diabetes mellitus, past history of ocular trauma or surgeries such as cataract and refractive surgeries and contact lens wearers.

Methodology:

In this study, 100 eyes of 50 cases of both sexes between 20-50 years were evaluated after complete informed consents, in the period from November 2020 to October 2021. The candidates were subjected

to comprehensive history and ocular examination which included: Complete medical history including systemic and ocular history (ocular trauma, surgeries, and medications). Visual acuity assessment (UCVA and BCVA). Ophthalmological examination: pupil examination, slit-lamp biomicroscopy for detection of any corneal abnormalities and assessment of anterior chamber. Fundus examination with Volk non-contact lenses. Assessment of IOP using Goldmann applanation tonometer. Technical assessment of CCT by; NCSM and pentacam: With his or her chin resting on chinrest and forehead resting on forehead strap, the case was sitting with his or her gaze fixed straight ahead on a fixation target. The pentacam's automatic mode was employed. Its automaticity detects the best focus and alignment with the corneal apex then runs a scan. CCT was calculated as the average of three measurements taken from the center 8 mm of the cornea. Anterior segment-OCT: A specialized lens was used to make the OCT device as anterior segment investigating tool. The case was seated with his or her chin on chin rest, forehead against the forehead strap and fixated straight ahead on a fixation target. The 3D mode was chosen. Images were captured when corneal surface had come into clear focus. A true line was drawn manually at the corneal apex from the anterior end of epithelium to the posterior end of endothelium. Thickness was displayed by the device and displayed as CCT.

Data collection and analysis: IBM SPSS-22 program (Inc, Chicago, IL, USA) has been used to preform statistical analysis. Data have been examined for normal distribution via the Shapiro Walk testing. Qualitative data have been presented as frequency and relative percentage. Chi square testing ($\chi 2$) has been utilized to determine change among 2 or more groups of qualitative variables. Quantitative data have been presented as mean ± SD (Standard deviation). Nondependent sample t-testing has been utilized in comparing among 2 nondependent groups of normal distribution variables (parametric data) &Mann-Whitney testing. P value < 0.05 was judged significant.

RESULTS

This is cross-sectional prospective observational study, performed on 100 healthy eyes of individuals came to the outpatient clinics, Al-Azhar University hospitals.

Parameters		Studied cases (n= 50)	
		N	%
Age (years)	Mean± SD	30.05 ± 9.98	
	Median	30.0	
	Range	20.0- 50.0	
Age groups	20 - 30 years	30	60.0%
	31 - 40 years	15	30.0%
	41 - 50 years	5	10.0%
Sex	Male	27	54.0 %
	Female	23	46.0 %

SD= standard deviation, n: number, %: percentage,

Table 1: Demographic characteristics of studied cases

A total of 100 eyes in 50 cases were involved in this study. As illustrated in table (1): The age of studied cases was 20-50 years with mean ± SD was 30.05 ± 9.98 years and median of 30 years. The commonest age group involved was 20 - 30 years age group with 30 (60.0%) cases followed by 31- 40 years group with 15 (30%) cases. Twenty seven (54 percent) included men, whereas just 23 cases (46% involved women).With male to female ratio of 1.17:1.

	Central corneal thickness (CCT) (n= 100)				
	Mean	± SD	Median	Min.	Max.
AS-OCT	521.55	36.55	523.00	221.00	559.00
Specular microscopy	513.85	24.56	521.50	460.00	594.00
Pentacam	545.99	23.39	546.00	447.00	582.00

Table 2: Mean and range of CCT measured by three different devices

This table shows mean and range of CCT measures by three different instruments. The mean CCT (±SD) for the AS-OCT, specular microscopy and pentacam were 521.55 (±36.55), 513.85 (±24.56), and 545.99 (±23.39) µm, respectively. The minimum and maximum readings of CCT from each machine are also illustrated in Table 2.

CCT(A)	CCT(B)	Mean difference (A-B)	SE	95% Confidence Interval for Difference		p- value
				Lower Bound	Upper Bound	
Pentacam	AS-OCT	24.44	3.307	17.879	31.001	**<0.001**
	Specular microscopy	32.14	1.781	28.606	35.674	**<0.001**

SD= standard deviation, n: number, %: percentage,

Table 3: Difference of mean CCT of Pentacam and other two devices

The mean difference of CCT measured by pentacam and AS-OCT was 24.44 µm with 95% difference was 17.879-31.001; the means were statistically significantly different. The mean difference of CCT measured by pentacam and specular microscopy was 32.14 µm with 95% difference was 28.606-35.674 with statistically significant difference.

CCT(A)	CCT(B)	Mean difference (A-B)	SE	95% Confidence Interval for Difference		p- value
				Lower Bound	Upper Bound	
AS-OCT	Specular microscopy	7.70	3.29	1.15	2.33	0.022

Table 4: Difference of mean CCT of AS-OCT and that of specular microscopy

The mean difference of CCT measured by AS-OCT and specular microscope was 7.70 µm with 95% difference was 1.15- 2.33. The means were significantly different from each other.

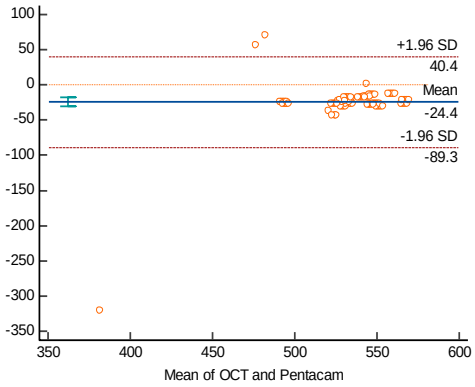

Fig. 1: Bland-Altman plots for AS-OCT and pentacam.

As seen in figure (1), the Bland–Altman plots were utilized to determine if the means of AS-OCT and pentacam readings were in agreement. This resulted in a discrepancy of 24.44 microns between the mean CCT readings given by pentacam and AS-OCT. The standard error of the difference was 3.307. Differences of means of CCT given by pentacam and ant.seg-OCT values that fall within 95 percent confidence range were 40.4 and -89.3.

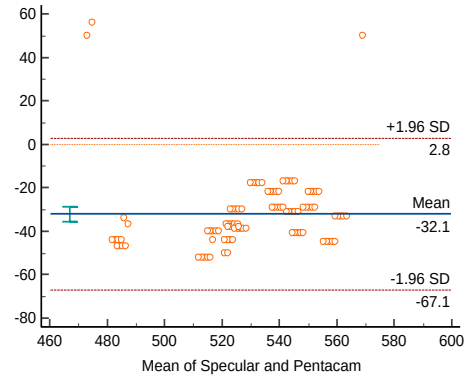

Fig. 2: Bland-Altman plots for specular microscopy and pentacam.

The Bland–Altman plots were also used to assess the agreement among means of specular microscopy and pentacam values as shown in figure (2). The difference of mean CCT readings given by pentacam and specular microscopy was 32.14 µm. Standard error (SE) of difference was 1.781. Differences of means of CCT given by pentacam and specular microscopy values that fall within 95 percent confidence range were 2.8 and -67.1.

DISCUSSION

Among the patients analyzed, there were those of age from 20 to 50 years, having a mean and SD of 30.05(±9.98) years and a median age of 30 years, respectively. It was revealed that a total of 30 cases (60.0 percent) occurred in the 20-to-30-year age group, and that 15 cases (30.0 percent) occurred in the 31-40 year age group. Among the cases investigated, males accounted for 54% of the total, with females accounting for 46%, yielding a ♂ to ♀ ratio of 1.17:1.

Our findings were supported by findings of Li et al. [6], who reported that data from 49 eyes of 49 healthy people were analyzed in total. 24.78 (±4.36) years old was the participants' mean age (with a range of 18–36 years), separated into two groups, with 28 men and 21 women taking part in that study.

Participants were grouped into three age groups in a study done by Kumar et al.[7], those under the age of 20, those between the ages of 21 and 25, and those older than 25 years. The results were published in the journal Psychological Science. Most persons (44.7 percent) were under the age of 20 years, followed by those older than 25 years (29.1 percent), and then those between the ages of 21 and 24 years (26.2 percent). The participants were overwhelmingly female (80.58 percent of the total), the average age was 24.03 years (range from 17 to 34 years).

It was established by the findings of this study that there is a difference in the mean and range of central corneal thickness assessed by three distinct instruments. Based on results from AS-OCT, specular microscopy, and pentacam measurements, we calculated that the mean CCT (standard error of the mean) for each of these three procedures was 521.55 (± 36.55) μm, 513.85 (± 24.56), and 545.99 (± 23.39) μm, respectively.

According to Kumar et al. [7], in their study, the mean CCT (standard deviation) for the Oculus pentacam, the ant.seg.-OCT (Cirrus), the (Tomey) specular microscope, and the Master IOL 700 were 523.75 (±27.75), 517.13 (±28.43), 512.82 (±27.60), and 525.29 (±28.81) μm.

While in the study by Scotto et al. [8], the mean CCT (SD) measured by ant.seg.-OCT and NCSM was 535.8 (±35.5) μm and 547.7 (±38.2) μm, respectively.

O'Donnell et al.[9] stated that the mean (SD) values for CCT performed with pentacam and visante AS-OCT devices were 542.7 (±37.9) microns and 556.7 (±44.4) microns, respectively according to the findings of their research.

Ten researchers observed that the average CCT measured by SL-OCT was 546.36 (±44.17) microns, whereas the average CCT obtained by specular microscopy was 557.61 (±49.92) microns, according to Khaja et al., [10].

According to the findings of Ceylan et al., [11], the mean CCT reading by pentacam was 546.11 (±34.15) μm, whereas the mean CCT reading by ant.seg-OCT was 567.76 (±35.02) μm.

The mean CCT readings obtained by OCT and NCSM were 546.34 μm and 554.34 μm, respectively, in a study carried out by Erdur et al. [12]. This indicated that the two procedures were equal in terms of CCT values.

With regard to correlations between pentacam CCT and AS-OCT and specular microscopy CCT, the current investigation revealed that CCT measured by pentacam and by ant.seg.-OCT ($r= 0.887$, $P<0.001$) & by specular microscopy ($r= 0.863$, $P<0.001$) demonstrated a strong positive and statistically significant association, in sequence. In this study, there was a strong positive correlation between CCT measured by AS-OCT and CCT calculated by specular microscopy ($r=0.474$, $P<0.001$), and this relationship was very significant.

Using pentacam to measure CCT and AS-OCT, the mean difference was 24.44 μm, with the 95 percentile difference ranging from 17.879 to 31.001 μm. In this study, it was discovered that every mean was statistically significantly differ from the other one.

Another study, done by Kanellopoulus et al. [13] on 50 normal corneas, discovered that the coefficient of determination (R2) between pentacam and AS-OCT was 0.895. However, despite the fact that they claim that the two devices are intimately connected, they determined that the total AS-OCT values are thinner than those produced with the pentacam.

According to the findings of Krysik et al. [14], the mean CCT assessed by pentacam device is much greater than the mean CCT evaluated by the CASIA SS-1000 AS-OCT system.

According to Ashour et al. [15] in their study on CCT in normal corneas, they found high agreement between US pachymetry and pentacam, US pachymetry and ant.seg.-OCT, and pentacam and ant.seg.-OCT with mean differences of 1.3±9.4, 0.4±10.4 &1.7±10.7μm (insignificant statistically) among the three pairs. The coefficient of determination is 1 between the three pairs, and a value of Cronbach's alpha > 0.9 between the three pairs.

The results of a study carried out by Azzam et al. [16] to obtain CCT measurements by different tools revealed that the mean thickness (CCT) readings taken by pentacam (532.88 ±34.15 μm) were much thicker than those taken by NCSM (531.92±33.64 μm) by 0.96 μm, with 0.824 as a P value (non-significant), indicating that any one of these instruments can be used as alternative to the others for the assessment of CCT.

According to the findings of Erdur et al. [12], there was a good connection between instruments: NCSM with SD-OCT ($p < 0.01$ for CCT, $r = 0.975$). The mean discrepancies (lower/upper limits of agreement) for CCT values between SD-OCT and NSM were -8.1 x 7.7 μm (7/-23.2).

We discovered that the Bland–Altman plots may also be used to analyze the agreement among the mean(s) of pentacam and ant.seg.-OCT readings, as demonstrated by our findings. This resulted in a discrepancy of 24.44 microns between the mean CCT values obtained by pentacam and AS-OCT. The standard error of the difference was 3.307. CCT mean differences determined from pentacam and AS-OCT readings that fall within the 95 percent confidence interval are 40.4 and -89.3. Also utilized to assess the degree of agreement among the means of pentacam and specular microscopy results was the Bland–Altman plot (Bland–Altman plot). This resulted in a 32.14 micron disparity between the mean CCT readings given by pentacam and specular microscopy. The standard error of the difference (SE) was 1.781.

We found that 2.8 and -67.1 were the differences between the means of CCT acquired from pentacam and the values obtained from specular microscopy that fall within the 95 percent confidence interval.

While in the study of Li et al. [6], the Bland-Altman analysis of central corneal thickness measurements by pentacam and CASIA2 AS-OCT reveals 9.64 μm as a mean difference, 13.10 μm as a COR, and 2.42 percent as a relative COR with P=0.639, In addition, there were no statistically significantly different values in assessments of PCT among pentacam and AS-OCT. P values for PCT were (P=0.717 for superior CT, P=0.314 for inferior CT, P=0.425 for nasal CT, P=0.410 for temporal CT) between both devices.

According to Ceylan [11] and colleagues, a good degree of agreement was found in the Bland-Altman analysis comparing data collected with either the pentacam or the Stratus OCT instruments. The equipment used to test corneal thickness had a significant impact on the results. Corneal thicknesses computed using pentacam were found to be lower than those obtained with Stratus OCT. Stratus OCT was used to acquire these results. Both of the technologies used for assessment of CCT were simple to use, non-invasive, and highly effective. On the other hand, those equipments were not interchangeable. However, the significant limits of manual measurements and being not the best choice for CCT measurement, Stratus OCT can be used in the absence of alternative measuring instruments that were specifically developed for the purpose.

Analogous study by Kumar et al. [7] discovered that Bland–Altman plots were also utilized to investigate the agreement among the mean of pentacam device and the mean of ant.seg.-OCT values. As measured by pentacam device and ant.seg.-OCT, the difference in mean CCT values was 2.6 microns. The difference was measured with a standard deviation (SD) of 5.65. CCT mean differences given by IOL Master 700 and pentacam values that fall within a 95 percent confidence range are -9.08 and 14.28, respectively, according to the results. Due to the fact that values collected from these devices are dispersed over the plot, correlation between them is impossible. The Bland–Altman figure depicts the degree of agreement among the pentacam and the specular microscopy methods. The values were displayed. The difference between the mean CCT value taken by the pentacam and the specular microscopy methods was 10.92 microns. 13.45 was the SD (standard deviation) of that difference. The differences between the averages of CCT acquired using specular microscopy and the values obtained from pentacam that fall within the 95 percent confidence range are –13.08 and 37.45, respectively. Because the data collected via these devices were dispersed throughout the plot, it was impossible to link the values gained through them.

CONCLUSION

All the above three devices have a good correlation with each other in eyes having normal characteristics. We can-not use the above mentioned devices interchangeably because there were statistically significant variations. Ant.seg.-OCT and non-contact specular microscope (NCSM) revealed thinner values than pentacam. We recommend ultrasound pachymetry in individuals having borderline CCT readings by pentacam.

REFERENCES

1. Patwardhan AA, Khan M, Mollan SP, Haigh P. The importance of central corneal thickness measurements and decision making in general ophthalmology clinics: a masked observational study. *BMC Ophthalmol*. 2008; 8:1.

2. Malecaze F, Coullet J, Calvas P, Fournié P, Arné JL. & Brodaty C. Corneal ectasia after photorefractive keratectomy for low myopia. *Ophthalmology*. 2006; 113(5): 742–6.

3. Radhakrishnana S. Anterior Segment Optical Coherence Tomography, 2014.

4. Lam AK, Chen D. Pentacam pachymetry: comparison with non-contact specular microscopy on the central cornea and inter-session repeatability on the peripheral cornea. *Clin Exp Optom*. 2007; 90: 108– 14.

5. Chen D, Lam AK. Intrasession and intersession repeatability of the Pentacam system on posterior corneal assessment in the normal human eye. *J Cataract Refract Surg*. 2007; 33: 448–54.

6. Li X, Zhou Y, Young CA, Chen A, Jin G, Zheng D. Comparison of a new anterior segment optical coherence tomography and Oculus Pentacam for measurement of anterior chamber depth and corneal thickness. *Annals of Translational Medicine*. 2020; 8(14): 857.

7. Kumar K, Prakash AA, Neeraja TG, Adappa KT, TS CP, Gangasagara SB. To compare central corneal thickness measurements obtained by Pentacam with those obtained by IOL Master 700, Cirrus anterior segment optical coherence tomography and Tomey specular microscopy in normal healthy eyes. *Indian Journal of Ophthalmology*. 2021; 69(7): 1713-7.

8. Scotto R, Bagnis A, Papadia M, Cutolo CA, Risso D, Traverso CE. Comparison of central corneal thickness measurements using ultrasonic pachymetry, anterior segment OCT and noncontact specular microscopy. *Journal of glaucoma*. 2017; 26(10): 860-5.

9. O'Donnell C, Hartwig A, Radhakrishnan H. Comparison of central corneal thickness and anterior chamber depth measured using LenStar LS900, Pentacam, and Visante AS-OCT. *Cornea*. 2012; 31(9): 983-8.

10. Khaja, W. A., Grover, S., Kelmenson, A. T., Ferguson, L. R., Sambhav, K., & Chalam, K. V. Comparison of central corneal thickness: ultrasound pachymetry versus slit-lamp optical coherence tomography, specular microscopy, and Orbscan. *Clinical Ophthalmology (Auckland, NZ).* 2015; 9: 1065.

11. Ceylan OM, Turk A, Erdurman C, Mumcuoglu T, Erdem U, Gokce G, et al. Comparison of oculus

pentacam and stratus optical coherence tomography for measurement of central corneal thickness. *Cornea*. 2011; 30(6): 670–4.

12. Erdur SK, Demirci G, Dikkaya F, Kocabora MS, Ozsutcu M. Comparison of central corneal thickness with ultrasound pachymetry, noncontact specular microscopy and spectral domain optical coherence tomography. *Semin Ophthalmol*. 2018; 33(6): 782–7.

13. Kanellopoulos AJ, Asimellis G. Comparison of high-resolution Scheimpflug and high-frequency ultrasound biomicroscopy to anterior-segment OCT corneal thickness measurements. *Clin Ophthalmol*. 2013; 7: 2239–47.

14. Krysik K, Dobrowolski D, Stanienda-Sokol K. Scheimpflug Camera and Swept-Source Optical Coherence Tomography in Pachymetry Evaluation of Diabetic Patients. *J Ophthalmol*. 2019; 4532657.

15. Ashour DM, Ismail AT, Roshdy M, Tagoury E, Abd Elwahab K. Assessment of Corneal Thickness in Healthy and Diseased Corneas by Different Imaging Techniques. *The Egyptian Journal of Hospital Medicine*. 2018; 72(5): 4576–81.

16. Azzam RI., Kasem MA., Khattab A. & El-Fallal HM. Measurement of central corneal thickness by different techniques. *J of the Egyptian Ophthalmological Society*. 2017; 110(4): 114–7.