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Comparison of Central Corneal Thickness Measurements Using Ultrasound Pachymetry and Anterior Segment Optical Coherence Tomography

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Abstract

Background: Central corneal thickness (CCT) is a cornerstone parameter in ophthalmology. It influences glaucoma risk assessment, refractive surgery safety margins, and corneal health evaluation. Traditionally, ultrasound pachymetry (USP) has been regarded as the gold standard, but its reliance on corneal contact and topical anesthesia limits its utilisation. Anterior segment optical coherence tomography (AS-OCT), a non-contact imaging modality, offers a high-resolution alternative. This study aimed to compare CCT measurements obtained by USP and AS-OCT in healthy adults, assessing their agreement and clinical interchangeability.

Methodology: A cross-sectional study was conducted in 70 healthy adults aged 18–60 years. Each participant underwent CCT measurement by AS-OCT followed by USP, with the average three readings each per eye. To minimize the effect of diurnal variation, all measurements were performed between 10 am and 2 pm. Statistical analyses included paired-sample t-tests, Bland–Altman plots, Pearson correlation, and intraclass correlation coefficients (ICC).

Results: USP consistently yielded higher values (mean 550.7 ± 36.2 μm) compared with AS-OCT (mean 528.5 ± 37.4 μm). The mean difference of 22.1 μm was statistically significant ($p < 0.001$), with 95% confidence intervals ranging from 17.4 to 26.9 μm. Despite this systematic bias, a strong positive correlation was observed ($r = 0.856$, $p < 0.001$), and USP demonstrated high reliability (ICC = 0.92). Bland–Altman analysis confirmed systematic differences, with limits of agreement spanning −16.5 to +60.7 μm.

Conclusion: USP and AS-OCT provide strongly correlated but systematically different CCT measurements. USP consistently yields higher values, therefore, the two methods should not be used interchangeably. For accurate longitudinal monitoring, clinicians should employ the same device consistently. AS-OCT offers a practical non-contact alternative, but interpretation requires device-specific normative data. Recognizing these discrepancies is essential for precise glaucoma care, refractive surgery planning, and corneal disease management.

Key Words: AS-OCT; USP; Ultrasound pachymetry; Cornea; Central corneal thickness

Introduction

The cornea, together with its overlying tear film, provides a smooth anterior refractive surface essential for clear vision and serves as a protective barrier against infections and environmental insults.[1] In adults, the mean horizontal corneal diameter measures approximately 11.5–12 mm, while the vertical diameter is 10.5–11 mm.[2] The anterior corneal surface contributes about +43.0 to +43.5 diopters of refractive power.[3] Structurally, the cornea is elliptical, relatively steep centrally, and flatter toward the periphery, forming a highly efficient optical system.

Central corneal thickness (CCT) is a key parameter in ophthalmology. The central region (within 4 mm of the optical axis) is thinner than the mid-periphery, and variations in thickness reflect endothelial pump function and corneal physiology.[4,5] CCT can fluctuate with blinking, contact lens wear, and sleep.[6]

Clinically, CCT measurement plays an important role in the evaluation and management of conditions such as keratoconus, corneal dystrophies, contact lens use, and in patients undergoing refractive or keratoplasty procedures.[7-9]

Although CCT is not diagnostic of glaucoma nor used to differentiate its subtypes, it is an important adjunct in glaucoma care. Knowledge of CCT assists in interpreting intraocular pressure (IOP) readings obtained by applanation tonometry, as thinner corneas may lead to underestimation and thicker corneas to overestimation of true IOP values.[10] Thus, CCT contributes to individualized risk assessment, treatment planning, and long-term management in glaucoma patients.[11] Furthermore, CCT is critical in refractive surgery, where a minimum residual stromal bed of 300 μm is required to reduce the risk of postoperative keratoectasia.[12] It is also considered in cataract surgery planning, particularly in intraocular lens (IOL) power calculations.[13]

Several devices are available for measuring CCT, based on optical and ultrasound technologies. Ultrasound pachymetry (USP) remains the gold standard due to its widespread use and reliability, but it requires corneal contact, topical anesthesia, and carries risks of infection or epithelial damage.[14,15] Inaccuracies may also arise from probe misalignment or poor fixation.[16] To overcome these limitations, non-contact modalities such as Pentacam Corneal Topography, Anterior Segment Optical Coherence Tomography (AS-OCT), and Tonopachymetry have been developed.[17-19]

Meta-analyses have shown that USP often yields slightly higher CCT values compared to optical methods, though findings across studies remain inconsistent, with some reporting no difference or even thicker values by OCT.[20-24] More recently, dedicated AS-OCT systems have provided high-resolution cross-sectional imaging of the cornea, enabling both central and regional pachymetry as well as detailed anterior segment analysis.[25,26] Evidence suggests systematic differences between USP and AS-OCT measurements, warranting further investigation.[11]

The aim of this study is to prospectively compare CCT measurements obtained by AS-OCT with conventional USP in healthy adults at Albayda Medical Center, and to evaluate the degree of systematic difference and level of agreement between the two techniques.

Patients and Methods

Study Design and Participants

This cross-sectional observational study was conducted in the Department of Ophthalmology at Albayda Medical Center. A non-probability consecutive sampling technique was employed.[6] Eligible participants included healthy adults of both genders, aged 18–60 years. Exclusion criteria were the presence of ocular diseases such as glaucoma, keratoconus, or high myopia, history of ocular surgery, contact lens use, or systemic illnesses.[7]

Clinical Examination

All participants underwent a comprehensive ophthalmic evaluation, including detailed medical and ocular history, visual acuity assessment, subjective and objective refraction, slit-lamp biomicroscopy, and dilated fundus examination.[20]

Measurement of Central Corneal Thickness (CCT)

CCT was measured first using anterior segment optical coherence tomography (AS-OCT; CASIA2).[21,22]

Subsequently, CCT was measured using ultrasound pachymetry (USP), the conventional gold standard.[23] After counseling, topical anesthesia was instilled in both eyes. Following a 30-second interval, participants were instructed to fixate on a distant target while the probe was gently placed at the central cornea. Three consecutive readings were obtained per eye, and the mean value was recorded. The probe was sterilized after each use to minimize infection risk.[24] To reduce diurnal variation, all measurements were performed between 10:00 am and 2:00 pm, at least three hours after waking up.[25,26]

Statistical Analysis

Data were analyzed using appropriate statistical software. Mean CCT values obtained by AS-OCT and USP were compared using paired-sample t-tests. Agreement between the two methods was assessed using Bland–Altman plots, which evaluated systematic bias and 95% limits of agreement.[8] Pearson correlation coefficients were calculated to determine the strength of association, and intraclass correlation coefficients (ICC) were used to assess reliability.[18,19] A p-value ≤ 0.05 was considered statistically significant.

Results

Descriptive Statistics

The descriptive statistics are summarized in Table 1. The mean CCT measured by ultrasound pachymetry (USP) was 550.7 ± 36.2 μm, which was consistently higher than the mean obtained by anterior segment optical coherence tomography (AS-OCT) at 528.5 ± 37.4 μm. The mean difference (X–Y) between the two methods was 22.1 ± 19.8 μm, indicating a systematic bias favoring higher USP values. The standard deviations of both methods were comparable, suggesting similar variability in measurement.

Table 1: Descriptive Statistics of CCT Measurements by USP and AS-OCT

Descriptive Statistics	Mean	Std. Deviation
USP (X)	550.69	36.18
AS OCT (Y)	528.54	37.39
X - Y	22.15	19.80

Paired-Samples T-Test

The paired-samples t-test (Table 2) confirmed that the difference in mean CCT between USP and AS-OCT was statistically significant (mean difference = 22.1 μm, 95% CI: 17.4–26.9 μm, p < 0.001). This finding demonstrates that the two methods cannot be used interchangeably, as USP consistently yields higher values.

Table 2: Paired-samples t-test comparing USP and AS-OCT measurements.

		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t-test	Df	Significance (2-tailed)
					Lower	Upper			
Pair 1	USP (X) - AS OCT (Y)	22.148	19.805	2.367	17.425	26.870	9.356	69	.0001

Correlation Analysis

Pearson correlation analysis (Table 3) revealed a strong positive correlation between USP and AS-OCT measurements (r = 0.856, $p < 0.001$). This indicates that although USP values are systematically higher, both methods vary in a consistent manner, with higher readings in one method corresponding to higher readings in the other.[18,19]

Table 3: Pearson correlation between USP and AS-OCT measurements.

Correlations		
		OCT(Y)
USP(X)	Pearson Correlation	.856**
	Sig. (2-tailed)	.0001
	N	70
**Correlation is significant at the 0.01 level (2-tailed)		

Distribution Analysis

Histograms of USP and AS-OCT measurements (Figures 1 and 2) demonstrated approximately normal distributions, with bell-shaped curves centered around their respective means. This supports the assumption of normality required for parametric statistical testing.

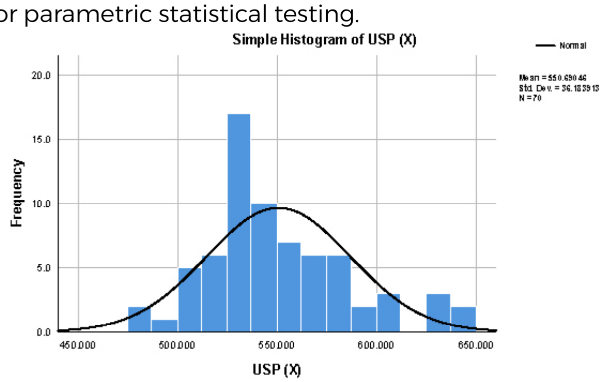

Figure 1: Frequency distribution of USP measurements.

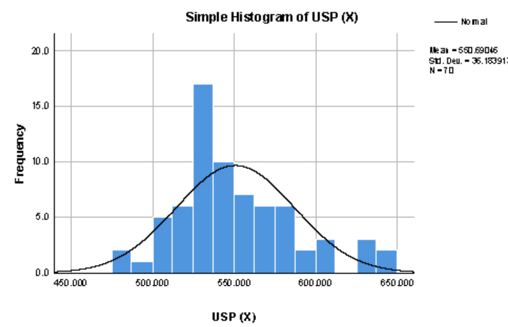

Figure 2: Frequency distribution of AS-OCT measurements.

Scatter Plot Analysis

The scatter plot (Figure 3) illustrates the relationship between USP and AS-OCT measurements. The data points are distributed along an upward linear trend, confirming the strong positive correlation observed in the Pearson analysis.[18]

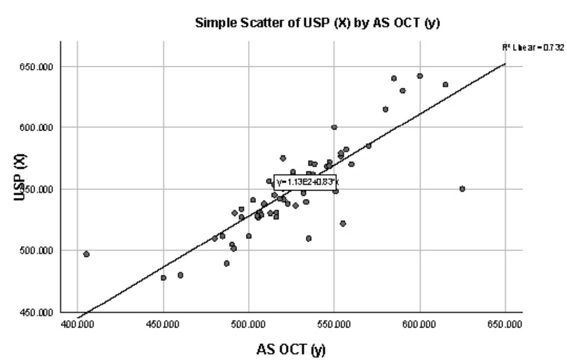

Figure 3: Scatter plot showing correlation between USP and AS-OCT measurements.

Discussion

Ultrasound pachymetry (USP) has long been considered the gold standard for central corneal thickness (CCT) measurement.[23] However, optical modalities such as anterior segment optical coherence tomography (AS-OCT) have gained wide clinical use due to their non-contact nature and high-resolution imaging capabilities.[21,22] Previous studies have consistently reported that although USP and optical pachymetry are strongly correlated, they cannot be used interchangeably.[11,19]

In the present study, the mean CCT measured by USP was 550.7 ± 36.2 μm, compared with 528.5 ± 37.4 μm by AS-OCT, yielding a mean difference of 22.1 μm. This difference was statistically significant ($p < 0.001$), confirming that USP consistently provides higher values than AS-OCT. Similar findings have been reported in other studies, where AS-OCT measurements were lower than USP in normal eyes.[20,21] Conversely, some reports found no significant differences, or even higher values with AS-OCT, suggesting that discrepancies may be device-specific and influenced by factors such as corneal curvature, tear film stability, and alignment variability during acquisition.[22-24]

Despite the systematic bias, our results demonstrated a strong positive correlation ($r = 0.856$, $p < 0.001$) between USP and AS-OCT, indicating that both modalities provide consistent relative measurements. This agrees with previous studies showing high reproducibility and correlation between the two techniques.[11,18] Clinically, this implies that while absolute values differ, either device may be used for longitudinal monitoring, provided the same instrument is consistently employed during follow-up.[19]

USP remains reliable but is operator-dependent, requiring topical anesthesia and direct corneal contact, which introduces risks of epithelial damage and infection.[24] Variability between examiners has also been reported. In contrast, AS-OCT offers a practical, non-contact alternative, though device-specific normative data are essential for accurate interpretation.[21,22]

Beyond glaucoma care, CCT measurement plays a critical role in refractive surgery planning, where a minimum residual stromal bed of 300 µm is required to reduce the risk of postoperative keratoectasia.[12] It also contributes to intraocular lens (IOL) power calculations in cataract surgery and to the evaluation of corneal endothelial function.[13]

Limitations

This study was conducted in a single center with a relatively small sample size, which may limit generalizability. Only one AS-OCT device was used, and results may vary across different OCT platforms. Furthermore, measurements were restricted to healthy adults, and findings may not apply to patients with corneal pathology.

Conclusion

USP and AS-OCT provide strongly correlated but systematically different CCT measurements. USP consistently yields higher values, and the two methods cannot be used interchangeably in clinical follow-up.[11,19]

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Ethics

Ethical approval was granted by the IRB of Albayda Medical Centre. An informed consent was obtained from all participants.

Conflicts of Interest

The authors declare no conflicts of interest associated with this manuscript.

Author Contributions

Both authors jointly participated in the interpretation of results of the manuscript and approved the final version for submission.

References

1. Doughty MJ, Zaman ML. Human corneal thickness and its impact on intraocular pressure measures: a review and meta-analysis approach. Surv Ophthalmol. 2000;44(4):367-408. doi:10.1016/S0039-6257(00)00110-7.
2. Rufer F, Schroder A, Erb C. White-to-white corneal diameter: normal values in healthy humans obtained with the Orbscan II topography system. Cornea. 2005;24(3):259-61. doi:10.1097/01.ico.0000148312.01805.53.
3. Garg A. Instant clinical diagnosis in ophthalmology: anterior segment diseases. New Delhi: Jaypee Brothers Medical Publishers; 2010.
4. Ismaili M, Kaçaniku G, Spahiu K, Hoxha G, Nakeva-Janevska N, Dimovska-Jordanova V. Determination of central corneal thickness in patients with refractive anomalies and emmetropy. Open J Ophthalmol. 2019;9(2):35-46. doi:10.4236/ojoph.2019.92005.
5. Can E, Eser-Ozturk H, Duran M, Cetinkaya T, Arıturk N. Comparison of central corneal thickness measurements using different imaging devices and ultrasound pachymetry. Indian J Ophthalmol. 2019;67(4):496-9.
6. Binnawi KH, Elzubeir H, Osman E, Abdu M. Central corneal thickness measurement using ultrasonic pachymeter, optical coherence tomography, and TMS-5 topographer. Oman J Ophthalmol. 2019;12(1):15-9. doi:10.4103/ojo.OJO_96_2018.
7. Krachmer JH, Mannis MJ, Holland EJ. Cornea. 3rd ed. St. Louis: Mosby Elsevier; 2011.
8. Pillunat KR, Waibel S, Spoerl E, Herber R, Pillunat LE. Comparison of central corneal thickness measurements using optical and ultrasound pachymetry in glaucoma patients and elderly and young controls. J Glaucoma. 2019;28(6):540-5. doi:10.1097/IJG.0000000000001231.
9. Condon PI, O'Keefe M, Binder PS. Long-term results of laser in situ keratomileusis for high myopia: risk for ectasia. J Cataract Refract Surg. 2007;33(4):583-90. doi:10.1016/j.jcrs.2006.12.015.
10. Brittingham S, Tappeiner C, Frueh BE. Corneal cross-linking in keratoconus using the standard and rapid treatment protocol: differences in demarcation line and 12-month outcomes. Invest Ophthalmol Vis Sci. 2014;55(12):8371-6. doi:10.1167/iovs.14-15444.
11. Alonso RS, Fontes BM, Ventura MP, Ambrósio R Jr. Repeatability of central corneal thickness measurement with Pentacam HR system. Rev Bras Oftalmol. 2012;71:14-7. doi:10.1590/S0034-72802012000100003.
12. Valdez-García JE, Hernandez-Camarena JC, Loya-García D, Lopez-Montemayor P, Ortiz-Morales G, Merayo-Lloves J. Safety and efficacy of myopic LASIK performed on thin corneas. Open Ophthalmol J. 2020;14(1):33-8. doi:10.2174/1874364102014010033.
13. Wang M, Kugler LJ. Atlas and clinical reference guide for corneal topography. Thorofare (NJ): SLACK Incorporated; 2014.
14. Üçer MB, Bozkurt E. Comparison of central corneal thickness measurements with three different optical devices. Ophthalmol Eye Dis. 2021;13:251584142199563.
15. Peyman M, Tai LY, Khaw KW, Ng CM, Win MM, Subrayan V. Accutome PachPen handheld ultrasonic pachymeter: intraobserver repeatability and interobserver reproducibility by personnel of different training grades. Int Ophthalmol. 2014;34(6):1193-9. doi:10.1007/s10792-014-9989-6.
16. Jiang JY, Ong K. Variability of central corneal thickness measurements: comparing Zeiss IOL Master and Tomey corneal specular microscope. Asia Pac J Ophthalmol. 2019;8(4):275-9. doi:10.1097/APO.0000000000000258.
17. Kumar KK, Prakash AA, Neeraja TG, Adappa KT, Prabha TSC, Gangasagara SB. Comparison of central corneal thickness measurements obtained by Pentacam, IOLMaster 700, Cirrus AS-OCT and Tomey specular microscopy in normal eyes. Indian J Ophthalmol. 2021;69(7):1713-7. doi:10.4103/ijo.ijo_3364_20.
18. González-Pérez J, Queiruga Piñeiro J, Sánchez García Á, González Méijome JM. Comparison of central corneal thickness measured by ultrasound pachymetry, corneal topography, tono-pachymetry and AS-OCT. Curr Eye Res. 2018;43(7):866-72. doi:10.1080/02713683.2018.1461910.
19. Wirbelauer C, Scholz C, Hoerauf H, et al. Noncontact corneal pachymetry with slit lamp-adapted optical coherence tomography. Am J Ophthalmol. 2002;133(4):444-50. doi:10.1016/S0002-9394(01)01425-8.
20. Wong AC, Wong CC, Yuen NS, Hui SP. Correlational study of central corneal thickness measurements in Hong Kong Chinese using OCT, Orbscan and USP. Eye (Lond). 2002;16(6):715-21.
21. Bechmann M, Thiel MJ, Roesen B, et al. Central corneal thickness determined with optical coherence tomography in various types of glaucoma. Br J Ophthalmol. 2000;84(11):1233-7.
22. Fishman GR, Pons ME, Seedor JA, et al. Assessment of central corneal thickness using optical coherence tomography. J Cataract Refract Surg. 2005;31(4):707-11. doi:10.1016/j.jcrs.2004.09.021.
23. Leung DY, Lam DK, Yeung BY, Lam DS. Comparison between central corneal thickness measurements by ultrasound pachymetry and optical coherence tomography. Clin Exp Ophthalmol. 2006;34(8):751-4. doi:10.1111/j.1442-9071.2006.01343.x.
24. Zhao PS, Wong TY, Wong WL, et al. Comparison of central corneal thickness measurements by Visante AS-OCT with ultrasound pachymetry. Am J Ophthalmol. 2007;143(6):1047-9. doi:10.1016/j.ajo.2007.01.050.
25. Rao HL, Pahuja S, Murthy SI, Senthil S. Central corneal thickness measurement. Ophthalmology. 2011;118(5):1010.
26. Bullimore MA, Slade S, Yoo P, Otani T. An evaluation of the IOLMaster 700. Eye Contact Lens. 2019;45(2):117-23.