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Research Article

Variation Observed in Central Corneal Thickness Measurement Using Non-Contact Methods in Refractive Errors: A Comparative Study

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Abstract

Objective: To compare Central Corneal Thickness (CCT) measurements using Specular Microscopy, Tonopachymetry and Anterior Segment Optical Coherence Tomography (AS-OCT) and assess inter-device agreement. The study also evaluates central corneal thickness distribution across refractive error types-myopia and hypermetropia.

Methods: This cross-sectional study included 398 eyes from 201 patients aged 15-45 years with myopia or hypermetropia attending a tertiary care ophthalmology outpatient department over 6 months. CCT was measured using Cirrus HD-OCT 500, Topcon CT-1P Tonopachymeter and Topcon SP-1P Specular Microscope.

Results: Mean CCT values were 515.33;0.0 μm (Specular), 515.63 ± 30.89 μm (Tonopachymeter) and 520.94 ± 31.18 μm (AS-OCT). AS-OCT readings were consistently higher (~5-6 μm; $p<0.001$). The strongest correlation was between Specular Microscopy and Tonopachymetry ($r=0.984$). No statistically significant CCT differences were found between myopic and hypermetropic eyes.

Conclusion: AS-OCT consistently records slightly higher CCT values (~5-6 μm) compared to other modalities, likely due to its high optical resolution and inclusion of the tear film. All three methods demonstrated very strong correlations across refractive error subgroups, indicating clinical interchangeability, though method-specific biases must be considered when making surgical or diagnostic decisions.

Keywords: Central Corneal Thickness; Anterior Segment Optical Coherence Tomography (AS-OCT); Tonopachymetry; Specular Microscopy; Refractive Error

Introduction

Central Corneal Thickness (CCT) is an important and sensitive indicator of corneal health. It is integral to managing various eye conditions and clinically important in the diagnosis and monitoring of corneal physiology, corneal diseases (such as Fuch's endothelial dystrophy, Endothelitis, pellucid marginal degeneration), corneal ectatic conditions, contact lens research and preoperative evaluation in refractive surgery [1,2]. Interpretation of Intraocular Pressure (IOP) measured by applanation tonometry in clinical applications such as glaucoma management is influenced by central corneal thickness and Corneal thickness is also an independent risk factor for the development of glaucoma. The success of refractive surgeries depends on accurate pachymetry measurement and risk of development of post op corneal ectasia [3-5]. The emergence of refractive surgery and the identification of corneal thickness as an important clinical variable highlights the growing significance of pachymetry, not only for corneal and refractive surgeons but also in routine ophthalmic practice.

Ultrasound pachymetry is regarded as the gold standard procedure for measuring corneal thickness. This method involves direct contact with the cornea and utilizes the Doppler Effect to ascertain thickness. Due to its contact nature, there is a risk of epithelial defects, corneal indentation and potential inaccuracies caused by the user. Until recently, ultrasound pachymetry was the most widely used clinical technique for measuring central corneal thickness. However, it also carries risks such as the potential transmission of infections due to direct corneal contact and interobserver variability. To overcome limitations, various non-contact methods have been developed, offering rapid, reliable and objective central corneal thickness measurements, such as specular microscopy, optical coherence tomography, Scheimpflug imaging, Pentacam, Tonopachymeter. The relationship between Central Corneal Thickness and refractive errors is complex and influenced by various factors, including age, gender and ethnicity and there is limited information on the distribution of central corneal thickness in specific populations with refractive errors. In our study we aimed to compare central corneal thickness measurement using Specular microscopy, Tonopachymetry and AS-OCT and degree of systematic difference and the level of agreement between these three modalities. We also aimed to find distribution of central corneal thickness in refractive errors such as myopia and hypermetropia.

Materials And Methods

The present study was conducted as a facility based cross-sectional study on patients with Refractive error (Myopia and Hypermetropia) attending the Ophthalmology Out Patient Department (OPD) for Refractive correction at tertiary care centre, Jamnagar during the study period of 6 months i.e. from 1st February 2025 to 31st July 2025. All outdoor patients with Refractive error such as Myopia and Hypermetropia in the age group of 15-45years were included whereas patients with Normal Visual Acuity, Corneal Pathology (such as oedema, scarring, corneal dystrophy, Dry Eye and High Astigmatism or Keratoconus), Cataract or Pseudophakia, previous history of refractive surgery, wearing contact lens, Glaucoma, uveitis, retinal pathology, ocular trauma or past surgical history and patients with systemic Illness such as Diabetes, hypertension, connective tissue disease, psychiatric disease and uncooperative patients were excluded from the study.

After obtaining ethical clearance from Institute's ethical committee, all the patients satisfying selection criteria were included and detailed clinical and ocular history was obtained. Further, all the patients were subjected to detailed Ocular and general physical examination. Examination of anterior segment was done on torch light and confirmed with Slit lamp Examination and Fundus examination was done with direct ophthalmoscope. Autorefraction was done followed by subjective refraction and retinoscopy for objective measurement of refractive error as a part of routine opd procedure to improve accuracy. Central corneal thickness was measured using Non-contact methods Cirrus HD OCT 500 using Corneal Lens, TOPCON CT 1P Tono pachymeter and TOPCON SP1P specular microscope.

Statistical Analysis

Data was compiled using MsExcel and analysed using IBM SPSS software version 20. Descriptive Statistics was used in the form of Mean ± Standard Deviation to summarize continuous variables and percentages and proportions to describe categorical data. Inferential Statistics in the form of chi square test (for categorical variables), paired t test (mean CCT values measured by different methods), independent T test (difference in mean CCT between individuals of varying refractive error) were used. Pearson's Correlation Coefficient (r) was used to measure the strength and direction of the linear relationship between CCT measurements obtained by three different methods in overall population and stratified by refractive errors. P-values of less than 0.05 was considered statistically significant.

Results

This study was conducted on a total of 398 eyes of 201 patients. The mean age of patients was 26.01 ± 8.87 years. The largest proportion of our study population (42.8%) belonged to the 21-30 years age group. The male: female ratio was 0.97:1. Myopia was detected in 61.3% eyes whereas hypermetropia was observed in 38.7% eyes (Table 1). Specular Microscopy measured a mean CCT of 515.33 ± 30.0 μm, with values ranging from 422 to 596 μm. Tonopachymeter recorded a slightly higher mean CCT of 515.63 ± 30.89 μm, with a range of 431 to 594 μm. AS-OCT showed the highest mean CCT among the three methods at 520.94 ± 31.18 μm, with a range of 428 to 619 μm (Fig. 1). The mean difference in CCT between specular Microscopy and Tonopachymeter was -0.294 ± 5.55 μm and the observed difference was statistically insignificant ($p>0.05$). On the other hand, mean difference in CCT between the readings of tonopachymeter and AS-OCT was -5.319 ± 6.44 μm and between specula microscopy and AS-OCT was -5.613 ± 7.203 μm, which was statistically significant ($p<0.05$) (Table 2).

Although the myopic group consistently exhibited marginally higher CCT values, the differences were not statistically significant, suggesting that refractive error type does not substantially influence corneal thickness in this cohort (Table 3). In myopic eyes, the paired t-test analysis showed a small, statistically non-significant mean difference of -0.68 μm between specular microscopy and tonopachymetry (p=0.07). In hypermetropic eyes, the difference between specular microscopy and tonopachymetry was minimal (0.32 μm) and statistically non-significant (p=0.42). However, both comparisons involving AS-OCT showed statistically significant differences: -5.90 μm between tonopachymetry and AS-OCT and -5.58 μm between specular microscopy and AS-OCT (both p=0.001).

In our study, we observed a strongest correlation between specular microscopy and tonopachymeter (r=0.984; p<0.05). Also, the correlation between tonopachymeter and AS-OCT as well as Specular microscopy and AS OCT (r=0.979 and 0.973 respectively; p<0.05). In eyes with myopia, the correlation of Central Corneal Thickness (CCT) measurements between the three methods was very strong and statistically significant. The correlation between specular microscopy and AS-OCT was 0.977, between tonopachymeter and AS-OCT was 0.980 and between specular microscopy and tonopachymeter was 0.983, with all comparisons showing a p-value of 0.001, indicating excellent agreement among the methods. In eyes with hypermetropia, correlation between specular microscopy and AS-OCT was 0.967, between tonopachymeter and AS-OCT was 0.972 and between specular microscopy and tonopachymeter was 0.989, with all comparisons having a p-value of 0.001, indicating a high degree of agreement across the methods (Table 4,Fig. 2). The mean speculated tear film thickness was found to be 5.319 μm when derived from the difference between AS OCT and tonopachymeter, between AS OCT and specular microscopy, the mean speculated tear film thickness was slightly higher at 5.613 μm (Fig. 3).

Baseline Variables		**Frequency**	**Percentage (%)**
Age (years) (n=201)	≤20	63	31.3
	21 to 30	86	42.8
	31 to 40	36	17.9
	>40	16	8.0
Gender (n=201)	Male	99	49.3
	Female	102	50.7
Refractive error (n=398)	Myopia	244	61.3
	Hypermetropia	154	38.7

Table 1: Distribution according to baseline variables.

CCT (μm)	**Specular Microscopy vs. Tonopachymeter**	**Tonopachymeter vs. AS OCT**	**Specular Microscopy vs. AS OCT**
Mean difference	-0.294	-5.319	-5.613
SD	5.55	6.44	7.203
95% CI	-0.84 to 0.253	-5.953 to -4.685	-6.32 to -4.90
P value*	0.29	**0.001**	**0.001**

Table 2: Comparison of Central Corneal Thickness (CCT) between three measurement methods.

CCT (μm)	**Refractive Error**				**P value***
	Myopia (n=244)		**Hypermetropia (n=154)**		
	Mean	**SD**	**Mean**	**SD**	
Specular microscopy	517.08	29.602	512.56	30.512	0.143
Tonopachymeter	517.76	30.133	512.24	31.873	0.082
AS OCT	522.71	30.976	518.14	31.390	0.155
*Independent t test					

Table 3: Comparison of Central Corneal Thickness (CCT) between patients with myopia and hypermetropia across the three measurement method.

CCT by Various Methods	Total		Myopia		Hypermetropia	
	Correlation	P value	Correlation	P value	Correlation	P value
Specular microscopy with AS OCT	0.973	0.0001	0.977	0.001	0.967	0.001
Tonopachymeter with AS OCT	0.979	0.0001	0.980	0.001	0.972	0.001
Specular microscopy with tonopachymeter	0.984	0.0001	0.983	0.001	0.989	0.001

Table 4: Correlation of CCT measurements between various methods.

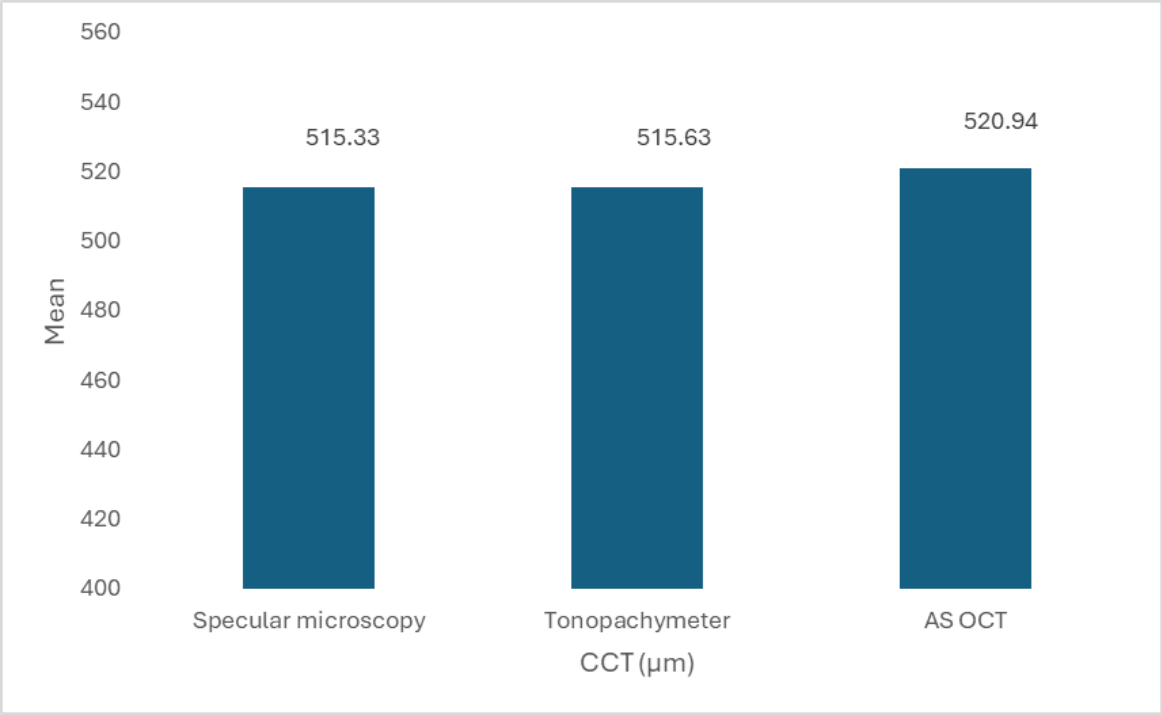

Figure 1: Mean central corneal thickness by various methods in study population.

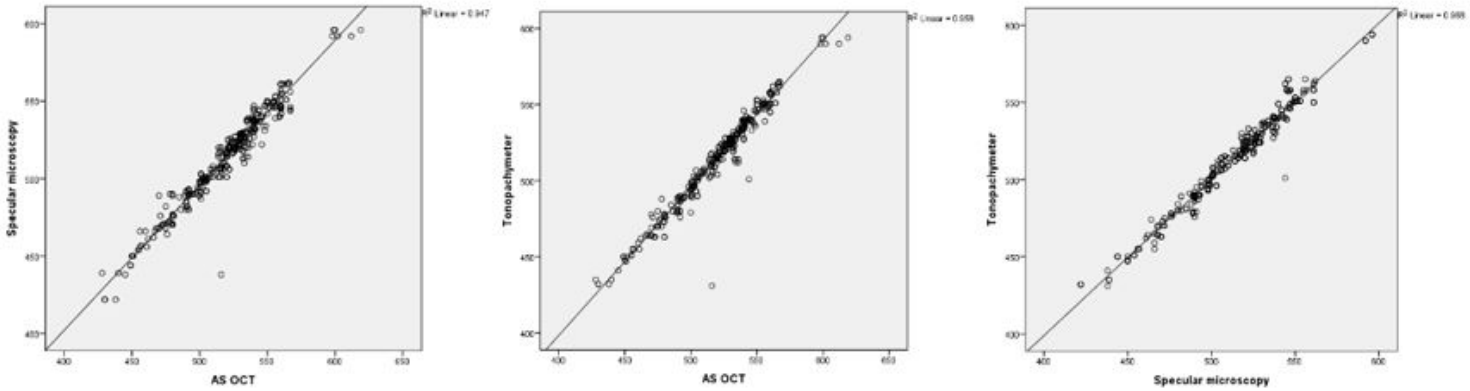

Figure 2: Correlation of CCT measurements between the methods.

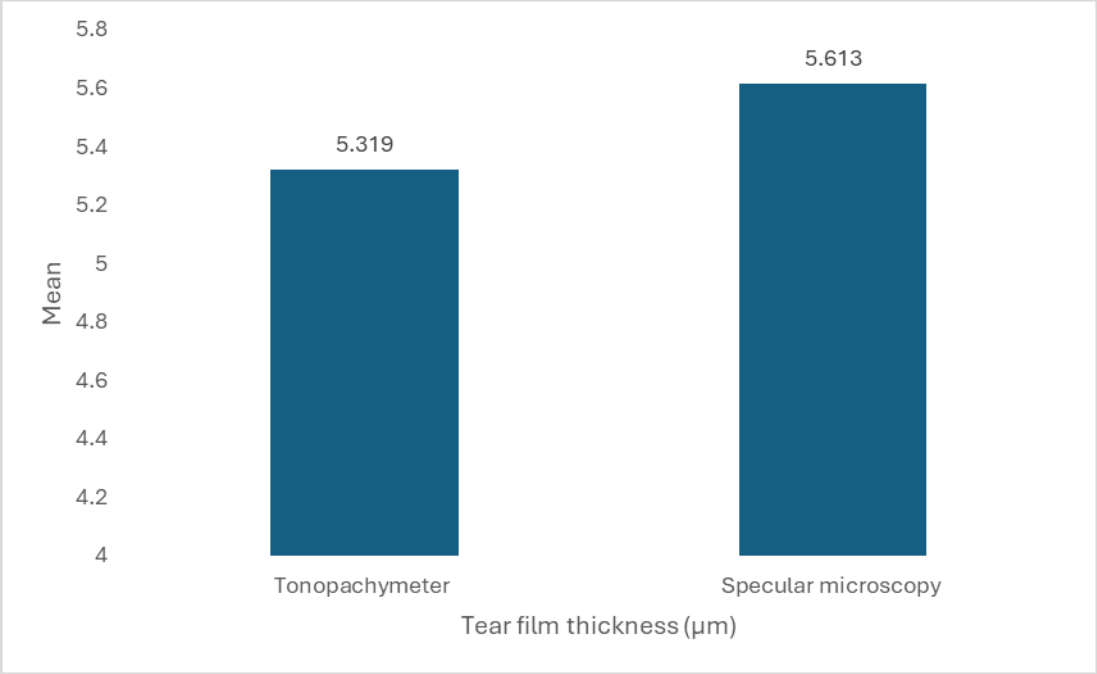

Figure 3: Speculated tear film thickness by AS OCT as measured from difference in CCT from other two methods.

Discussion

Accurate measurement of Central Corneal Thickness (CCT) is crucial in modern ophthalmic practice. CCT not only plays a key role in diagnosing and managing glaucoma but also serves as an essential parameter in preoperative evaluation for refractive surgery and corneal diseases [1,2]. Several modalities are available to measure CCT, including Anterior Segment Optical Coherence Tomography (AS OCT), Tonopachymetry and Specular Microscopy. Each method operates on different principles-optical interferometry, specular reflection and endothelial imaging respectively leading to variability in measurements. The choice of CCT measurement technique can significantly influence clinical decisions [10]. Dedicated Noncontact AS-OCT devices are non-invasive and non-contact procedures, which relies on the principle of interferometry to detect minute differences in tissue depth. They provide high resolution cross-sectional imaging of the cornea with both central and regional pachymetry. The OCT device captures a corneal sectional image, which is then analysed by software. In this case, the central corneal thickness value is calculated from tear film to corneal endothelium. Noncontact Tonopachymetry is a technique that combines the functions of tonometer and optical pachymeter. The pachymetry function measures CCT at the apex of the cornea by determining the distance between optical reflections from the anterior and posterior surfaces of the cornea. Non-contact specular microscopy measures CCT according to the principle of reflection of light from the anterior and posterior surfaces of the cornea, (tear film, corneal epithelium and aqueous humour) causes a light reflection due to a different refractive index. It obtains CCT values by considering the space between the tear film and the corneal endothelium [11,12].

In parallel, understanding the distribution of refractive errors, particularly myopia and hypermetropia, is increasingly important considering global trends. Myopia has reached epidemic proportions in several parts of the world, especially among younger populations, while hypermetropia remains more prevalent in older individuals. According to the VISION 2020 Global Initiative and studies by Holden et al., the prevalence of myopia has surged in younger populations due to increase near work and reduced outdoor activity. The data presented in this study reveal no significant difference in central corneal thickness between myopic and hypermetropic groups. Although myopic eyes tend to have slightly thicker corneas on average, this finding contrasts with previous studies, such as those by Chang, et al., which suggested that myopic eyes often exhibit thinner corneas due to axial elongation. However, the relationship between refractive errors and corneal thickness has been shown to vary across populations and methodologies. Several studies have similarly found no significant correlation between refractive error and central corneal thickness.

The observed mean CCT values in this study are consistent with globally reported averages. Doughty, et al., reported a mean CCT of 535 ± 31 µm in a meta-analysis of 47 studies. Aghaian, et al., documented mean CCT of 555.6, 550.4, 550.6 and 548.1

micron in Chinese, Caucasian, Filipino and Hispanic population [195]. While our results appear slightly lower than these published averages, they remain within the expected physiological range of 500-560 μm. Differences in population ethnicity, age structure and environmental influences such as altitude and UV exposure may account for slight regional variation in CCT.

AS-OCT consistently measured CCT values ~5-6 μm higher than both specular microscopy and tonopachymetry which is in line with Gokcinar, et al., Literature suggests that AS-OCT measurements are often 5-10 μm higher, likely due to inclusion of the tear film and better visualization of stromal boundaries [17-22]. These systematic differences might be related to measurement methodology, technology precision or operator variance. AS-OCT uses optical interferometry, measuring from the air-tear film interface to the posterior corneal boundary, potentially capturing more accurately the actual anatomical boundaries due to high resolution, as it includes tear film thickness too, thus slightly thicker measurements. OCT systems take nearly 26,000 A-scans per second with 5 μm axial resolution. This high-speed scanning makes ocular movements negligible during measurements, giving a minimal corneal variation. Regular calibration checks and adherence to strict imaging protocols can mitigate systematic biases. The study confirms excellent agreement between specular microscopy and tonopachymetry and a consistent positive bias in AS-OCT readings. This minor but systematic difference underscores the need for method-specific normative data and highlights the importance of using a single, consistent modality in serial measurements, particularly in refractive surgery, where corneal thickness determines eligibility and safety and Glaucoma management, where CCT is used to adjust Intraocular Pressure (IOP) readings. The correlation analysis underscores very high agreement among all instruments despite systematic differences, confirming each method's reliability for clinical use. The highest correlation was found between Specular microscopy and Tonopachymeter (R=0.984). The consistently high correlations between the three CCT measurement techniques (Specular microscopy, Tono pachymeter and AS OCT) across refractive error groups highlight the robust agreement and reliability among these modalities. Despite earlier observed systematic differences especially the higher values obtained by AS OCT these strong correlations suggest that all three instruments can reliably measure corneal thickness and are suitable for clinical applications. The findings suggest clinicians can reliably choose among these methods based on patient comfort, availability, clinical context or procedural considerations, albeit acknowledging systematic differences in absolute measurements.

Clinically, while inter-instrument agreement in relative measurements is excellent, slight method-specific differences must be accounted for when making clinical decisions-particularly in scenarios where precise corneal thickness values critically influence surgical or therapeutic choices, such as glaucoma management, refractive surgery or keratoconus screening. Such differences emphasize the importance of device-specific baselines and consistent measurement techniques in clinical follow-up and surgical evaluation.

By comparing AS-OCT with the other two modalities, the speculated tear film thickness was estimated to be around 5.3-5.6 μm, supporting the idea that AS-OCT captures an additional anterior Tear optical layer absent in other methods. Our study had certain limitations. First, small sample size and cross-sectional nature of the study limit the ability to assess longitudinal changes in CCT that would be more informative for understanding how it changes with age or refractive error evolution. Myopia is more commonly observed in younger individuals, while hypermetropia tends to be prevalent in older adults (>45 years). Central Corneal Thickness (CCT) decreases with age, it is theoretically expected that myopic patients would have thinner corneas and hypermetropic patients thicker ones. However, our study demonstrated a contrasting pattern, likely influenced by age-related confounding, which was not assessed in our study. The study population may lack ethnic diversity and since CCT varies significantly across ethnic groups (e.g., thinner corneas in African descent, thicker in East Asians), the results may not be generalizable to all populations.

Conclusion

AS-OCT consistently records slightly higher CCT values (~5-6 μm) compared to other modalities, likely due to its high optical resolution and inclusion of the tear film, whose estimated thickness ranges from 5.3 to 5.6 μm when inferred from AS-OCT measurements. AS-OCT, Specular Microscopy and Tonopachymetry show excellent agreement, with the highest inter-instrument correlation, supporting their reliability in clinical settings. No significant difference in CCT was observed between myopic and hypermetropic groups in our cohort, suggesting that refractive error type alone may not dictate corneal thickness. Some limitation are, studyIt hashad a modest, cross-sectional sample with limited ethnic diversity and unequal refractive-error distribution, restricting longitudinal interpretation and generalizability across populations. The detectable difference in CCT between AS-OCT and other modalities suggests tear film thickness can be calculated and can be helpful in Dry Eye Disease. All

three methods demonstrated very strong correlations across refractive error subgroups, suggesting clinical interchangeability, though method-specific biases must be considered when making surgical or diagnostic decisions. All three methods are non-contact and quick methods, which generally leads to good patient comfort, but Tonopachymetry and Specular Microscopy tend to be slightly faster, while AS-OCT offers more detailed imaging at the expense of a bit longer scan time.

Conflict of Interest

The author declares no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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Author's Contributions

All authors have contributed equally to this work and have reviewed and approved the final manuscript for publication.

Consent For Publication

Not applicable.

Ethical Statement

Not Applicable.

References

1. Vedana G, Villarreal G Jr, Jun AS. Fuchs endothelial corneal dystrophy: current perspectives. Clin Ophthalmol. 2016;10:321-30.
2. Gruenauer-Kloevekorn C, Fischer U, Kloevekorn-Norgall K, Duncker GI. Pellucid marginal corneal degeneration: evaluation of the corneal surface and contact lens fitting. Br J Ophthalmol. 2006;90(3):318-23.
3. Belovay GW, Goldberg I. The thick and thin of the central corneal thickness in glaucoma. Eye. 2018;32:915.
4. Argento C, Cosentino MJ, Tytiun A, Rapetti G, Zarate J. Corneal ectasia after laser *in-situ* keratomileusis. J Cataract Refract Surg. 2001;27:1440-8.
5. Randleman JB, Russell B, Ward MA, Thompson KP, Stulting RD. Risk factors and prognosis for corneal ectasia after LASIK. Ophthalmology. 2003;110:267-75.
6. Foster CS, Azar DT, Dohlman CH. Smolin and Thoft's the cornea: Scientific foundations and clinical practice. Philadelphia: Lippincott Williams and Wilkins; 2005.
7. Beutelspacher SC, Serbecic N, Scheuerle AF. Assessment of central corneal thickness using OCT, ultrasound, optical low coherence reflectometry and Scheimpflug pachymetry. Eur J Ophthalmol. 2011;21(2):132-7.
8. Patel SV, Hodge DO, Treichel EJ, Spiegel MR, Baratz KH. Predicting the prognosis of Fuchs endothelial corneal dystrophy by using Scheimpflug tomography. Ophthalmology. 2020;127(3):315-23.
9. Navyasree C, Satapathy J. Correlation of central corneal thickness with refractive error, corneal curvature and axial length: an observational study. TNOA J Ophthalmic Sci Res. 2024;62(1):75-9.
10. Özyol E, Özyol P. Comparison of central corneal thickness with four noncontact devices: an agreement analysis of swept-source technology. Indian J Ophthalmol. 2017;65(6):461-5.
11. Mayali H, Altinisik M, Diri I, Ilker S, Kurt E, Kayikcioglu O. Comparison of central corneal thickness measurements by contact and non-contact pachymetry devices. J Curr Glaucoma Pract. 2021;15(1):28-33.
12. Kim JS, Rho CR, Cho YW, Shin J. Comparison of corneal thickness measurements using ultrasound pachymetry, noncontact tonopachy, Pentacam HR and Fourier-domain OCT. Medicine (Baltimore). 2021;100(16):e25638.
13. Morgan IG, French AN, Ashby RS, Guo X, Ding X, He M, et al. The epidemics of myopia: Aetiology and prevention. Prog Retin Eye Res. 2018;62:134-49.
14. VISION 2020. The international agency for the prevention of blindness. [Last accessed on: November 9, 2025] https://www.iapb.org/about/history/vision-2020/
15. Chang SW, Tsai IL, Hu FR, Lin LL, Shih YF. The cornea in young myopic adults. Br J Ophthalmol. 2001;85(8):916-20.

16. Gab-Alla AA. Reference values of the central corneal thickness with different refractive errors for the adult Egyptian population. Clin Ophthalmol. 2020;14:3465-74.
17. Pedersen L, Hjortdal J, Ehlers N. Central corneal thickness in high myopia. Acta Ophthalmol Scand. 2005;83(5):539-42.
18. Doughty MJ, Zaman ML. Human corneal thickness and its impact on intraocular pressure measures: a review and meta-analysis approach. Surv Ophthalmol. 2000;44(5):367-408.
19. Aghaian E, Choe JE, Lin S, Stamper RL. Central corneal thickness of Caucasians, Chinese, Hispanics, Filipinos, African Americans and Japanese in a glaucoma clinic. Ophthalmology. 2004;111(12):2211-9.
20. Gokcinar NB, Yumusak E, Ornek N, Yorubulut S, Onaran Z. Agreement and repeatability of central corneal thickness measurements by four different optical devices and an ultrasound pachymeter. Int Ophthalmol. 2019;39(7):1589-98.
21. Reinstein DZ, Yap TE, Archer TJ, Gobbe M, Silverman RH. Comparison of corneal epithelial thickness measurement between Fourier-domain OCT and very high-frequency digital ultrasound. J Refract Surg. 2015;31(7):438-45.
22. Le Q, Chen Y, Yang Y, Xu J. Measurement of corneal and limbal epithelial thickness by anterior segment optical coherence tomography and *in-vivo* confocal microscopy. BMC Ophthalmol. 2016;16:163.
23. Zhao PS, Wong TY, Wong WL, Saw SM, Aung T. Comparison of central corneal thickness measurements by Visante anterior segment optical coherence tomography with ultrasound pachymetry. Am J Ophthalmol. 2007;143(6):1047-9.

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