

Comparison of Central Corneal Thickness Measurements Using Contact and Non-contact Pachymetry Devices in Glaucoma Patients

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ABSTRACT:

Objective: To explore the relationship between contact and non-contact pachymetry methods in measuring central corneal thickness among patients diagnosed with primary open-angle glaucoma.

Methodology: After ethical approval, written permission was obtained from all eligible participants after providing full details about the procedure, risks, and benefits of the study for this cross-sectional study. Central corneal thickness was calculated by contact method using Nidek Al scan biometer ultrasound measurement & by non-contact methods using Nidek Al scan biometer optical measurement, TOMEY TMS 5 slit corneal topographer, and REXXAN SPM-700 specular microscope. All collected data was digitized for use in the research analysis.

Results: The mean $\pm$ standard deviation of age was 57.90 ± 12.19 years. In the distribution of gender, 44.0% were male and 56.0% were female. A statistically significant correlation was observed between contact and non-contact pachymetry measurements of central corneal thickness, with Pearson's correlation coefficient calculated at $r = 0.773$ ($P < 0.05$).

Conclusion: A positive significant linear correlation was noted between contact and non-contact pachymetry devices in the measurement of central corneal thickness.

Key words: Contact Pachymetry, Corneal Thickness, Open Angle Glaucoma, non-contact Pachymetry

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Introduction:

Glaucoma, an irreversible chronic optic neuropathy is linked with distinctive alterations at the optic nerve head and correspondent visual field damage with IOP being the most important factor.¹ Global prevalence² shows that by 2040, the population affected by glaucoma is projected to reach 111.8 million, with a significantly higher impact on individuals living in Asia and Africa. Primary open-angle glaucoma (POAG) is the cardinal form of glaucoma and the second major contributor to vision impairment across the globe.³ Several risk factors have been associated with primary open-angle glaucoma (POAG), including increased intraocular pressure (IOP), advancing age, African American or Hispanic ethnicity, and a family history of the disease.⁴ Lately, Central corneal thickness (CCT) is a notable contributing constituent for glaucoma that can substantially

affect intraocular pressure (IOP) readings obtained through conventional methods.⁵ CCT is a critical parameter in the evaluation and management of glaucoma, primarily due to its influence on intraocular pressure (IOP) measurements obtained through applanation tonometry. IOP is the only modifiable risk factor in glaucoma, and its accurate assessment is essential for diagnosis, monitoring, and treatment decisions. However, IOP readings can be significantly affected by variations in corneal thickness. Thinner corneas can cause intraocular pressure (IOP) readings to be underestimated, whereas thicker corneas may lead to an overestimation of the actual IOP. This may lead to either missed or delayed diagnosis in patients with thin corneas, or unnecessary treatment in those with thicker corneas. Therefore, a correction factor should be applied to the measured IOP when central corneal thickness differs from the average.⁶ If the CCT deviates from the average of 520 μ m, and additional 0.7mm is required for each 10 μ m. A perfect measurement ought to be precise, consistent, simple and swift to carry out.⁷ Hence, CCT not only aids in interpreting IOP values more accurately but also serves as determinant for the development and exacerbation of glaucomatous optic neuropathy. Incorporating CCT measurements into routine glaucoma assessment is essential to ensure precise clinical judgment and individualized patient care.

Research has likewise detailed the association of thin CCT with POAG and normal-tension glaucoma (NTG), as well as the link between Ocular Hypertension (OHT) and thick corneas.⁸ Over time, various methods have been developed to measure central corneal thickness (CCT), such as ultrasound pachymetry, ultrasound biomicroscopy, slit-scanning corneal topography, confocal microscopy, optical biometry, the Scheimpflug system, specular microscopy, spectral-domain optical coherence tomography (OCT), and very high-frequency ultrasound scanning (VHFUS).⁹ These measurement methods can be categorized as con-

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tact (ultrasound) or non- contact (optical) based on their operational definitions. The gold standard technique for assessing CCT is ultrasound pachymetry (USP) due to its reliability and portability. This approach has multiple constraints, such as cornea-probe interaction, corneal indentation, a potential compression effect and the requirement for topical anesthesia. Moreover, the probe should be positioned at a right angle to the corneal surface to get precise measurement. Nonetheless, specular microscopy is a non-invasive technique for measuring CCT. There is also an inherent risk of epithelial erosions, infections, and discomfort for the patient. The noncontact optical methods rely less on the operator and have the benefit of revealing the thinnest sections of the cornea.¹⁰ Most studies evaluating CCT have primarily focused on healthy eyes, particularly within the Pakistani population. For instance, Qamar-ul-Islam SM et al.¹¹ in a study comparing contact and non-contact modalities for measuring CCT, concluded that there was a statistically significant linear correlation among all measurement techniques ($p < 0.01$), with excellent intra-operator repeatability across devices. However, research specifically exploring the correlation between contact and non-contact pachymetry in glaucoma patients remains limited. The implications of such studies in glaucomatous eyes have, so far, been relatively underexplored and inconclusive. The findings of this study may help determine which pachymetry technique, contact or non-contact, is more precise, efficient, and patient-friendly in the assessment of CCT in individuals with glaucoma. Non-contact methods offer the advantage of being quick, non-invasive, and more comfortable for patients, reducing the risk of infection and measurement errors related to corneal indentation or probe misalignment.¹² On the other hand, contact pachymetry, while traditionally considered more accurate, requires topical anesthesia and physical contact with the cornea, which may not be suitable for all patients. Identifying the most appropriate technique can lead to faster, safer, and more reliable CCT measurements, thereby facilitating earlier diagnosis and more effective treatment planning for glaucoma patients, ultimately improving clinical outcomes and patient experience.

Objective:

To explore the relationship between contact and non-contact pachymetry methods in measuring central corneal thickness among patients diagnosed with primary open-angle glaucoma.

Methodology:

This cross sectional study was executed at Department of Ophthalmology and Visual Health Sciences, Dow Medical College, Dr. Ruth KM Pfau Civil Hospital Karachi and SMBB Trauma Centre, Karachi during July 2025 till August 2025 (2months). IRB approval was sought from the institute's ethical committee (IRB-4071/DUHS approval/2025/253). Sample size was calculated by using PASS 15. Previous studies reflected that the correlation of CCT measurement by using contact and no-contact pachymetry in patient with glaucoma was 0.88.¹³ Hence using Confidence Level 99% and margin of error 5% the required sample size for this study was calculated to be 12. However, we enrolled 50 patients with glaucoma in our study since the turn out of glaucoma patients in our OPD is higher. Data was collected using non-probability consecutive sampling technique via a pilot tested questionnaire. All patients after getting a briefing of study were given time to give decision to participate. Written consent was taken from willing participants. Those who met the inclusion and exclusion

criteria were registered. Risk of contact methods were explained to each participant. A total 50 patients with already diagnosed POAG were included in this study. Complete history of patients was taken along with ocular examination. Any allergy to eye drops in past was asked in specific. Visual acuity was assessed via trained senior optometrist. After instilling local anesthetic drops and staining with fluorescein intraocular pressure was measured by applanation tonometer under cobalt blue filter for accuracy. After a slit bio-microscopy for anterior segment assessment Gonioscopy was done by skilled consultant. Gonioscopy was again done under topic anesthesia and using methyl for contact. Later pupil was dilated using tropicamide 1% and using 90 Diopter lens indirect funduscopy was done. Next patient were taken to investigation room where Central Corneal Thickness was assessed using different techniques. Central corneal thickness can be calculated by contact method using Nidek Al scan biometer ultrasound measurement & by non-contact methods using Nidek Al scan biometer optical measurement; TOMEY TMS 5 slit corneal topographer, and REXXAN SPM-700 specular microscope.

CCT measurements were initially obtained using non-contact methods to minimize the risk of physical distortion or pressure-related artifacts commonly associated with contact techniques. To ensure reliability and reduce measurement variability, each device was used to take three consecutive readings, all performed by the same examiner, thereby minimizing intra-observer variability. A standardized interval of five minutes was maintained between the use of different instruments to avoid potential influence from prior measurements.

For each measurement session, images were captured and evaluated individually using the respective device. The specular microscope provided CCT values within a range of 400 to 750 μm by analyzing the reflective interfaces of the anterior and posterior corneal surfaces. The AL-Scan optical biometer utilizes the Scheimpflug imaging technique, which dispenses high-resolution cross-sectional images for accurate assessment of corneal thickness. The Tomey TMS-5 corneal topographer combines both Scheimpflug imaging and Placido disc principles, offering detailed anterior segment analysis. It captures 25 to 31 concentric rings, with each ring recording approximately 256 data points, and completes each measurement in roughly one second.

Prior to each reading, patients were instructed to blink to ensure an evenly distributed tear film and then maintain steady fixation on the device's internal target once proper head alignment was achieved. This protocol was designed to optimize measurement accuracy and standardize the procedure across all instruments used in the study

A central corneal zone measuring 3.0 mm in diameter was used for thickness assessment. CCT was measured using both contact and non-contact pachymetry devices. Ultrasound pachymetry was performed by calculating the time delay between ultrasound echoes reflected from the anterior and posterior corneal surfaces. Prior to ultrasound measurements, topical anesthesia (0.5% proparacaine) was administered to ensure patient comfort. The probe tip was gently placed perpendicular to the central cornea, just above the pupil, avoiding excessive pressure that could affect accuracy.

Other relevant variables including patient age, gender, IOP, CCT measured by specular microscopy, and CCT from ultrasound pachymetry were recorded systematically

in a standardized template. All accumulated data was input and interpreted using SPSS version 23. Categorical variables such as gender were presented as frequencies and percentages. Quantitative parameters including age, IOP, and CCT were summarized as mean $\pm$ SD (standard deviation) or median with interquartile range (IQR), depending on data normality assessed by the Shapiro-Wilk test. Pearson's correlation coefficient (r) was used to gauge the inter-relationship between contact (ultrasound pachymetry) and non-contact CCT measurement methods, which included the NIDEK AL-Scan optical biometer, Tomey TMS-5 corneal topographer, and Rexam SPM-700 specular microscope. Potential confounding variables such as age, gender, and IOP were managed through stratification. Post-stratification analysis was conducted using Pearson's correlation, considering a p-value $\leq$ 0.05 as statistically significant. Scatter plots were created to visually depict the correlations between contact and non-contact pachymetry measurements.

Results:

In this study, 50 patients were recognized to have primary open-angle glaucoma and hence were enrolled to evaluate the correlation between contact and non-contact pachymetry devices in measuring central corneal thickness (CCT). Among the participants, 22 patients (44%) were male and 28 (56%) were female, resulting in a gender ratio of approximately 11:14. The normality of continuous quantitative variables was evaluated using the Shapiro-Wilk test. The average age of the study population was 57.90 years with a standard deviation of 12.19 years, while the mean intraocular pressure (IOP) was 24.96mmHg with a standard deviation of 2.19 mmHg. The p-values for CCT measurements were 0.129 for contact pachymetry and 0.057 for non-contact pachymetry, as summarized in Table 1. These p-values suggest that the data for CCT measurements from both methods approached but did not reach statistical significance in terms of deviation from normality.

Table No1: Mean of Quantitative Variables.

Variables	Mean $\pm$ SD	p-value
Age (years)	57.90 $\pm$ 12.19	0.309
IOP	24.96 $\pm$ 2.19mmHg	0.217
CCT (on contact)	552.36 $\pm$ 47.24 μ m	0.129
CCT (non-contact)	524.16 $\pm$ 57.28 μ m	0.057

The correlation between contact and non-contact pachymetry devices for measuring central corneal thickness (CCT) was analyzed using Pearson's correlation coefficient, yielding $r = 0.773$, which indicates a strong positive relationship. This correlation was found to be statistically meaningful with a p-value < 0.05 , as presented in Table 2.

Table No 2: Correlation between contact and non-contact using Shapiro-Wilk test

Correlation	Mean $\pm$ SD (μ m)	r	p-value
CCT on contact	552.36 $\pm$ 47.24	0.773	0.0001
CCT on non-contact	524.16 $\pm$ 57.28		

Participants were stratified according to age, gender, and

intraocular pressure (IOP) to assess potential variations in central corneal thickness (CCT) measurements obtained using both contact and non-contact pachymetry methods. The statistical analysis assessing these variations is summarized in Table 3.

Table No 3: Correlation between contact and non-contact using Shapiro-Wilk test for age groups.

AGE GROUPS				
Age in years	Correlation	Mean ±SD (μm)	r	p-value
40-60	CCT on contact	551.03 ±47.30	0.78	0.0001
	CCT on non-contact	524.80 ±56.69		
>60	CCT on contact	554.35 ±48.31	0.76	0.0001
	CCT on non-contact	523.20 ±59.62		
GENDER				
Gender	Correlation	Mean ± SD (μm)	r	p-value
Male	CCT on contact	546.86 ±47.42	0.81	0.0001
	CCT on non-contact	515.45 ±60.83		
Female	CCT on contact	556.68 ±47.51	0.73	0.0001
	CCT on non-contact	531.00 ±54.46		
IOP				
IOP (mmHg)	Correlation	Mean ± SD (μm)	r	p-Value
21-25	CCT on contact	552.07± 49.93	0.74	0.0001
	CCT on non-contact	520.68 ±56.45		
>25	CCT on contact	552.73 ±44.74	0.82	0.0001
	CCT on non-contact	528.59 ±59.35		

Discussion:

In the present study, the average age of the participants was 57.90 years with a standard deviation of 12.19 years, which closely aligns with findings reported Tsung-Ho Ou et al.¹⁴, who documented a similar mean age of 56.29 years and a standard deviation of 13.1 years in their glaucoma cohort. Regarding gender distribution, our study showed a male-to-female ratio of 11:14. This result is comparable to that reported by Toptan et al.¹⁵ in a Nigerian study conducted amongst health individuals a roughly similar ratio of 13:12 was documented. In our study, the mean central corneal thickness (CCT) measured using non-contact pachymetry was 524.16 μ m, with a standard deviation of 57.28 μ m. These results are consistent with the findings reported by Çevik SG et al.¹⁶ who evaluated 148 eyes using non-contact specular microscopy (NCSM) and reported

a mean CCT of 510.8 μm with a standard deviation of 42 μm .

Our results demonstrated a statistically significant difference in central corneal thickness (CCT) measurements between contact and non-contact pachymetry techniques across both younger and older age groups. This contrasts with the findings of study by Pillunat KR et al.¹⁷ where a conclusion that ultrasound pachymetry tends to yield higher values than optical methods in younger subjects was drawn. Similarly no significant difference was noted in older patients in comparative study.

In this study, a strong and statistically significant positive correlation was observed between contact and non-contact pachymetry measurements ($r = 0.773$, $p = 0.0001$). This level of correlation is comparable to that reported by Babbar S et al.¹³, who found a correlation of 0.88 between ultrasound pachymetry and specular microscopy for CCT measurement in glaucoma patients. Similarly, Mayali et al.¹⁸ reported a correlation of 0.89 between contact and non-contact methods, further validating the agreement between these techniques.

Non-contact specular microscopy (NCSM) is widely used for assessing the corneal endothelium and continues to serve as a reliable method for measuring central corneal thickness (CCT). This technique utilizes light reflected from the anterior and posterior surfaces of the cornea at a precise angle, enabling clear visualization of the endothelium along with accurate corneal thickness measurements. However, accurate readings with NCSM depend on obtaining sharp and well-defined reflections, which may be affected by surface irregularities or suboptimal alignment.

Recently, anterior segment optical coherence tomography (AS-OCT) has emerged as an effective non-contact technique for detailed corneal imaging. AS-OCT provides high-resolution cross-sectional images, allowing precise measurement of both central and regional corneal thickness, as well as clear visualization of the iridocorneal angle and other anterior segment structures. For instance, a study by Wong AC et al.¹⁹ in China demonstrated the use of retinal OCT devices adapted for anterior segment imaging to measure central corneal thickness. Bechmann M et al.²⁰ also noted that AS-OCT measurements tend to show a systematic reduction in CCT values compared to ultrasound pachymetry, a difference attributed to the optical principles underlying OCT. However, findings have not been entirely consistent across the literature. For instance, Fishman GR et al.²¹ found no significant difference between OCT and ultrasound measurements, while Leung DY et al.²² reported thicker values with OCT. Zhao PS et al.²³ further supported the presence of systematic differences in a study using a dedicated AS-OCT system.

Traditionally, optical pachymetry has been regarded as the benchmark technique for measuring corneal thickness. However, in recent decades, ultrasonic pachymetry has become more widely adopted due to its ease of use, portability, and relatively lower cost. A meta-analysis by Doughty MJ et al.²⁴ concluded that ultrasonic pachymetry tends to yield slightly higher CCT values compared to optical methods. Currently, ultrasound pachymetry remains the most commonly used technique in clinical settings²⁵, wherein the measurement involves direct contact of a probe with the anterior corneal surface.²⁶ Despite its widespread use, this method has several limitations, including potential measurement errors due to probe misalignment, corneal indentation, and insufficient tear film redistribution during contact.

Our study is limited by its single-center design and inclusion of only primary open-angle glaucoma patients. Other subtypes of glaucoma, such as angle-closure or secondary glaucoma were not included, although these conditions may also influence corneal structure and IOP readings. Additionally, other corneal variables such as curvature, biomechanical properties, and endothelial cell count were not assessed, which could potentially influence pachymetry measurements.

Conclusion:

In summary, when assessing central corneal thickness (CCT) in patients with primary open-angle glaucoma, a strong positive linear association was discovered between contact and non-contact pachymetry techniques. This implies that in clinical practice, non-contact approaches could be dependable substitutes for contact-based procedures. However, it is advised that carefully planned prospective multicenter studies with bigger sample sizes be carried out, including more clinical characteristics, particularly within the Pakistani community, in order to increase the validity of these findings and enhance their generalizability.

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"Author's Contribution"	
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Zaheer Sultan	Research data collection
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Osama Bin	Proof reading
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