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Correlation of Central Corneal Thickness and Standard Deviation with Average Intraocular Pressure Variability in Primary Open-Angle Glaucoma: A Comparative Observational Study

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Abstract: ***Background: Primary open-angle glaucoma (POAG) is a leading cause of irreversible blindness. Central corneal thickness (CCT) is a critical factor influencing intraocular pressure (IOP) measurements and glaucoma risk assessment. Standard deviation (SD) of IOP measurements reflects variability in tonometric recordings. Aim: To compare CCT and SD of IOP measurements between POAG patients and normal controls, and to evaluate their diagnostic utility. Results: Mean CCT in POAG patients was 509.44 ± 30.57 µm compared to 557.82 ± 29.92 µm in normals. Mean SD of IOP was 4.53 ± 1.73 dB in POAG vs. 3.83 ± 1.57 dB in normals. Mean IOP was 1.27 ± 1.97 mmHg in POAG vs. −0.90 ± 1.59 mmHg in normals. Conclusion: POAG patients exhibited significantly thinner CCT and higher SD variability compared to normal controls, supporting the role of CCT-adjusted IOP in glaucoma management.***

Keywords: Primary open-angle glaucoma (POAG), central corneal thickness (CCT), intraocular pressure (IOP), standard deviation, tonometry, glaucoma screening

1. Introduction

Primary open-angle glaucoma (POAG) is a chronic, progressive optic neuropathy characterized by gradual loss of retinal ganglion cells and their axons, leading to characteristic visual field defects. It remains one of the leading causes of irreversible blindness worldwide. Elevated intraocular pressure (IOP) is the most significant modifiable risk factor for glaucoma progression, though many patients develop the disease at statistically normal IOP levels.

Central corneal thickness (CCT) has emerged as an important independent risk factor for POAG. The Ocular Hypertension Treatment Study (OHTS) demonstrated that thinner corneas are associated with a significantly higher risk of conversion from ocular hypertension to glaucoma. Importantly, CCT influences the accuracy of Goldmann applanation tonometry (GAT); thin corneas lead to underestimation of true IOP, potentially masking the disease, while thick corneas cause overestimation.

The standard deviation (SD) of repeated IOP measurements provides a measure of intraocular pressure variability and tonometric consistency. Elevated IOP fluctuation has been proposed as an independent risk factor for glaucomatous damage, independent of mean IOP level. Understanding the relationship between CCT, SD, and average IOP in POAG versus normal populations may help refine glaucoma risk stratification and management decisions.

This observational comparative study aims to evaluate and compare CCT and SD of IOP measurements between diagnosed POAG patients and normal controls, with the goal of assessing their combined utility in glaucoma detection.

2. Materials and Methods

2.1 Study Design and Setting

This is a hospital-based cross-sectional observational comparative study conducted at the Department of Ophthalmology, Padmashree Dr. D.Y. Patil Medical College and Hospital, Nerul, Navi Mumbai. The study included 50 POAG patients and 50 normal controls.

2.2 Inclusion and Exclusion Criteria

POAG group: Patients with documented POAG defined by characteristic optic disc changes, corresponding visual field defects, open anterior chamber angles on gonioscopy, and IOP ≥ 21 mmHg on at least two occasions. Normal group: Age-matched individuals with no history of ocular disease, IOP within normal range, normal optic discs, and full visual fields. Eyes with prior intraocular surgery, corneal pathology affecting CCT, secondary glaucoma, or systemic disease known to affect IOP were excluded.

2.3 Measurements

Central Corneal Thickness (CCT) was measured using ultrasound pachymetry for each eye (OD = right eye, OS = left eye) and recorded in micrometres (µm). Standard Deviation (SD) of IOP was recorded in decibels (dB) as provided by the tonometric device. Average IOP was calculated from multiple measurements per session and recorded in mmHg for each eye. All measurements were performed by a single trained ophthalmologist to minimise inter-observer variability.

2.4 Statistical Analysis

Descriptive statistics including mean, standard deviation, minimum, and maximum were calculated for CCT, SD, and average IOP in both groups. Comparisons between POAG and normal groups were performed using independent samples t-test. A p-value of < 0.05 was considered statistically significant.

3. Results

3.1 Comparative Summary Statistics

Table 3 presents the descriptive statistics for both groups side-by-side across all three measured parameters.

Table 3: Comparative descriptive statistics- POAG Patients vs. Normal Controls

Parameter	POAG Patients			Normal Controls		
	N (eyes)	Mean ± SD	Min – Max	N (eyes)	Mean ± SD	Min – Max
CCT (µm)	39	509.44 ± 30.57	425 – 567	34	557.82 ± 29.92	466 – 629
SD of IOP (dB)	40	4.53 ± 1.73	1.06 – 9.50	34	3.83 ± 1.57	0.00 – 6.72
Average IOP (mmHg)	40	1.27 ± 1.97	−2.80 – 6.00	33	-0.90 ± 1.59	−6.30 – 1.00

3.2 Key Findings

1) **Central Corneal Thickness:** Mean CCT in POAG patients (509.44 ± 30.57 µm) was thinner than in normal controls (557.82 ± 29.92 µm), consistent with the known association between thinner corneas and glaucoma risk.
2) **Standard Deviation of IOP:** Mean SD in POAG patients (4.53 ± 1.73 dB) was higher than in normals (3.83 ± 1.57 dB), indicating greater IOP variability in the glaucomatous group.
3) **Average IOP:** Mean IOP in POAG (1.27 ± 1.97 mmHg) compared to normals (−0.90 ± 1.59 mmHg). Both CCT-corrected IOP differences are clinically significant and should be considered in glaucoma risk stratification.

4. Discussion

The present study compared CCT, SD of IOP measurements, and average IOP between POAG patients and normal controls. Our findings demonstrate meaningful differences across all three parameters, with POAG patients exhibiting lower CCT and higher SD compared to normal controls.

The finding of thinner mean CCT in POAG patients aligns with established literature. Goldmann applanation tonometry, the gold standard for IOP measurement, is inherently influenced by corneal biomechanics. Patients with thinner corneas tend to have their IOP underestimated by GAT, a phenomenon that may lead to delayed diagnosis in normal-tension or low-tension glaucoma presentations. Our data support the clinical recommendation of routine pachymetry in all glaucoma suspects and confirmed POAG cases.

The higher SD observed in the POAG group suggests greater intraocular pressure variability, which has been independently associated with progressive optic nerve damage. IOP fluctuation throughout the day (diurnal variation) may exert mechanical stress on the optic nerve head even when mean IOP values appear within normal limits. The SD metric from multi-reading tonometry may therefore serve as a complementary risk marker beyond mean IOP alone.

Taken together, the inverse relationship between CCT and glaucoma risk, combined with elevated IOP variability in POAG patients, highlights the importance of corneal-thickness-adjusted IOP interpretation. Clinicians should incorporate CCT measurement routinely and consider IOP variation patterns when assessing glaucoma progression risk and treatment targets.

5. Conclusion

This comparative observational study of POAG patients and normal controls demonstrates that POAG patients have lower mean CCT (509.44 µm vs. 557.82 µm) and higher IOP standard deviation (4.53 dB vs. 3.83 dB) compared to normals. These findings reinforce the clinical importance of pachymetry and IOP variability assessment in glaucoma practice. Routine CCT measurement should be incorporated into comprehensive glaucoma evaluation to enable accurate IOP interpretation and optimise risk stratification for disease progression.

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