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Relationship between the Pressure-to-Cornea Index and Structural and Functional Measures of Glaucoma

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Abstract

Background

Intraocular pressure (IOP) and central corneal thickness (CCT) are important variables driving the evolution of glaucoma, one of the main causes of permanent blindness. The Pressure-to-Cornea Index (PCI) is a new metric that combines CCT and IOP to give a more thorough evaluation of glaucoma risk. Improved diagnosis and treatment approaches may result from a better understanding of the connection between PCI and structural and functional glaucoma parameters.

Aim

This study aims to evaluate the correlation between the PCI and both structural (retinal nerve fiber layer thickness) and functional (visual field mean deviation) measures of glaucoma.

Methods

In a cross-sectional observational study, 200 participants were enrolled, including 120 glaucoma patients and 80 controls. Comprehensive ophthalmic examinations were conducted, including IOP measurement, CCT assessment, and evaluation of RNFL thickness using optical coherence tomography (OCT). Visual field testing was performed using standard automated perimetry. PCI was calculated as the ratio of IOP to CCT. Statistical analysis was

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conducted using SPSS version 23.0, with correlation and multivariate regression analyses to explore relationships between PCI and glaucoma measures.

Results

The PCI was significantly higher in glaucoma patients (0.041 ± 0.008) compared to controls (0.027 ± 0.005, $p < 0.001$). There was a significant negative correlation between PCI and RNFL thickness ($r = -0.58$, $p < 0.001$) and visual field mean deviation ($r = -0.62$, $p < 0.001$). Multivariate regression analysis identified PCI as an independent predictor of both RNFL thickness and visual field loss, indicating its utility in assessing glaucoma severity.

Conclusion

The PCI is significantly associated with structural and functional measures of glaucoma. Higher PCI values correspond to increased glaucomatous damage, suggesting its potential as a valuable marker for glaucoma diagnosis and progression monitoring.

Recommendations

Incorporating PCI into clinical practice could enhance early detection and management of glaucoma. To confirm the effectiveness of PCI in anticipating the course of glaucoma and directing treatment approaches, more long-term research is advised.

Keywords

Glaucoma, Pressure-to-Cornea Index, Intraocular Pressure, Central Corneal Thickness, Retinal Nerve Fiber Layer

Introduction

Two of the most common signs of glaucoma, one of the primary causes of irreversible blindness worldwide, are rogressive optic neuropathy and visual field loss [1]. One well-established risk factor for glaucoma is increased (IOP); however, its relationship with disease progression is complex and not entirely dependent on absolute IOP values [2]. (CCT) has been recognized as an important modifier in the assessment of IOP, as variations in CCT can lead to over- or underestimation of true IOP, potentially influencing the diagnosis and

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management of glaucoma [3]. Recent studies have suggested that a combined assessment of IOP and CCT may provide a more accurate evaluation of glaucoma risk and progression [4]. The (PCI) is a novel parameter that integrates IOP and CCT, offering a more comprehensive view of the eye's structural characteristics in the context of glaucoma [5]. It has been proposed that PCI can serve as a surrogate marker for ocular rigidity and susceptibility to glaucomatous damage, potentially offering insights into the pathophysiology of the disease [6]. While elevated PCI values have been associated with advanced glaucoma, the exact relationship between PCI and Functioning and structure metrics of glaucoma remains an area of active investigation [7]. Advancements in imaging technologies, such as (OCT), have enabled detailed evaluation of structural changes in the optic nerve head and (RNFL) in glaucoma [8]. Functional assessment using standard automated perimetry (SAP) further complements these structural measurements, providing a comprehensive picture of glaucomatous damage [9]. Understanding the interplay between PCI, structural damage (RNFL thinning), and functional impairment (visual field loss) is crucial for improving glaucoma management and tailoring individualized treatment strategies [10]. This study aims to evaluate the correlation between the PCI and both structural (retinal nerve fiber layer thickness) and functional (visual field mean deviation) measures of glaucoma.

Methodology

Study Design

This is an cross-sectional study.

Study Setting

The study was done at a tertiary eye care center over a duration of one year, providing a comprehensive environment for the recruitment and examination of participants.

Participants

A total of 200 participants were included in the study. These participants were recruited from the outpatient department of the eye care center. The sample included patients diagnosed with glaucoma, as well as a control group of individuals without glaucoma, to provide a comparative analysis of the Pressure-to-Cornea Index across different ocular conditions.

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Inclusion Criteria

- Individuals with ages 18 and above.
- Identified as having ocular hypertension, normal-tension glaucoma, or primary open-angle glaucoma.
- The readiness to give informed approval.
- The capacity to go through required eye exams.

Exclusion Criteria

- History of ocular surgery or trauma.
- Presence of other ocular diseases that could affect the cornea or intraocular pressure, such as keratoconus or uveitis.
- Use of medications that could influence intraocular pressure or corneal thickness, aside from prescribed anti-glaucoma medications.
- Inability to cooperate with examination procedures.

Bias

Participants were randomly selected from the outpatient department to minimize selection bias, ensuring a broad representation of glaucoma severity and subtypes. Observer bias making sure that all measurements were performed by experienced ophthalmologists using standardized equipment and protocols.

Data Collection

Data collection involved a comprehensive ophthalmic examination for each participant, including:

- Measurement of (IOP) using Goldmann applanation tonometry.
- Assessment of (CCT) using ultrasound pachymetry.
- Evaluation of the optic nerve head and RNFL using optical coherence tomography (OCT).
- Functional assessment of the visual field using standard automated perimetry.

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Demographic information, medical history, and specific details related to glaucoma (e.g., duration, treatment) were also collected using a structured questionnaire.

Procedure

First, participants gave their informed consent after being made aware of the study. Then, in order to evaluate their PCI and identify any functional visual field loss or anatomical alterations in the optic nerve head, they undertook a thorough battery of ocular exams. The ratio of (IOP) to (CCT) was found in order to compute the PCI. For further analysis, every piece of data was methodically documented in a uniform way.

Statistical Analysis

SPSS version 23.0 was used to analyse the data. Participant characteristics were summarised using descriptive statistics. The correlation coefficients between the PCI and glaucoma measurements were evaluated using either Pearson's or Spearman's. Independent predictors of glaucoma severity were discovered by multiple regression analysis, with a p-value < 0.05 indicating statistical significance.

Results

There were 200 participants in all, 120 of whom had glaucoma diagnoses (the study group) and 80 of whom did not (the control group). The participants' mean age was 55.4 ± 12.6 years, with 46% female and 54% male.

Table 1: Baseline Characteristics of Study Participants

Characteristic	**Glaucoma Group (n=120)**	**Control Group (n=80)**	**Total (n=200)**
Mean Age (years)	58.2 ± 11.4	51.8 ± 13.8	55.4 ± 12.6
Gender (M/F)	66/54	42/38	108/92
Mean IOP (mmHg)	22.4 ± 4.8	15.2 ± 2.7	19.5 ± 5.6
Mean CCT (µm)	540.6 ± 35.7	555.4 ± 31.8	547.4 ± 34.2

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Mean Pressure-to-Cornea Index	0.041 ± 0.008	0.027 ± 0.005	0.035 ± 0.010

The primary objective of the study was to assess the correlation between the (PCI) and both structural and functional measures of glaucoma. Structural changes were assessed using the average (RNFL) thickness, while functional impairment was measured using mean deviation (MD) on standard automated perimetry.

Table 2: Correlation between Pressure-to-Cornea Index and Glaucoma Measures

Measure	**Correlation Coefficient (r)**	**p-value**
RNFL Thickness (µm)	-0.58	< 0.001
Visual Field MD (dB)	-0.62	< 0.001

The PCI and RNFL thickness showed a strong negative relation ($r = -0.58$, $p < 0.001$), indicating that thinner RNFL, a marker of advanced glaucoma, was linked to higher PCI values. Likewise, a noteworthy inverse relationship was discovered between PCI and visual field MD ($r = -0.62$, p 0.001), implying that a increased PCI level is associated with more functional impairment as demonstrated by visual field loss.

Comparison between Glaucoma and Control Groups

Comparing the glaucoma group's mean PCI (0.041 ± 0.008) to the control group's (0.027 ± 0.005), There was a notable distinction ($p < 0.001$). This variation emphasises how PCI may be able to differentiate between eyes with glaucoma and those without it.

Table 3: Comparison of PCI between Glaucoma and Control Groups

Group	**Mean PCI ± SD**	**p-value**
Glaucoma	0.041 ± 0.008	< 0.001
Control	0.027 ± 0.005	

Multivariate Regression Analysis

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The study employed a multivariate regression analysis using dependent variables such as visual field MD and RNFL thickness to determine independent predictors of glaucoma severity.

Table 4: Multivariate Regression Analysis for Predictors of RNFL Thickness

Variable	β Coefficient	Standard Error	p-value
Age	-0.12	0.05	0.03
Intraocular Pressure	-0.18	0.04	< 0.001
Central Corneal Thickness	0.07	0.03	0.12
Pressure-to-Cornea Index	-0.45	0.09	< 0.001

Table 5: Multivariate Regression Analysis for Predictors of Visual Field MD

Variable	β Coefficient	Standard Error	p-value
Age	-0.15	0.06	0.02
Intraocular Pressure	-0.22	0.05	< 0.001
Central Corneal Thickness	0.05	0.04	0.20
Pressure-to-Cornea Index	-0.48	0.10	< 0.001

The multivariate regression analysis demonstrated that the Pressure-to-Cornea Index was an independent predictor of both RNFL thickness ($\beta = -0.45$, $p < 0.001$) and visual field MD ($\beta = -0.48$, $p < 0.001$). This suggests that even after adjusting for other factors like age and intraocular pressure, PCI remains a reliable indication of both structural and functional impairment in glaucoma.

Findings

- The PCI was significantly higher in patients with glaucoma compared to controls.
- A higher PCI was significantly correlated with thinner RNFL and greater visual field loss.
- PCI was found to be an independent predictor of glaucoma severity, suggesting its potential utility in glaucoma diagnosis and monitoring.

Discussion

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Eighty people functioned as controls in this study, while 120 people had been diagnosed with glaucoma. The PCI values of the glaucoma and control groups were found to differ significantly, with the glaucoma group exhibiting a significantly higher mean PCI (0.041 ± 0.008) in comparison to the control group (0.027 ± 0.005, $p < 0.001$). This finding suggests that the PCI may be a useful marker for distinguishing between glaucomatous and non-glaucomatous eyes.

The study also demonstrated significant negative correlations between PCI and key indicators of glaucoma severity, namely (RNFL) thickness and visual field (MD). Higher PCI values were associated with thinner RNFL ($r = -0.58$, $p < 0.001$) and worse visual field performance ($r = -0.62$, $p < 0.001$). These correlations indicate that as the PCI increases, both structural damage to the optic nerve and functional impairment in vision become more pronounced, highlighting the utility of PCI as a marker of glaucoma progression.

Further analysis using multivariate regression demonstrated that PCI is an independent predictor of both RNFL thickness and visual field MD, even after adjusting for other variables such as age, intraocular pressure, and central corneal thickness. The β coefficient for PCI was -0.45 for RNFL thickness and -0.48 for visual field MD, both with p-values < 0.001. This suggests that PCI is a robust indicator of disease severity and can help predict the extent of structural and functional damage in glaucoma patients.

A cross-sectional study by Shah et al. (2020) looked at the relationship between glaucoma measurements in 100 eyes and PCI. The study discovered a statistically significant difference (p=0.000) in PCI values between the various patient groups. PCI and the cup-to-disc ratio (C/D) showed a positive association (p=0.000), however PCI and (MD) showed a negative correlation (p=0.000). Furthermore, a p-value of 0.106 indicated a positive connection between PCI and pattern standard deviation (PSD). According to the study's findings, PCI may be a helpful technique for assessing the severity of glaucoma and a single risk factor [11].

Park et al.'s (2018) study focused on the relationship between corneal biomechanical properties and structural biomarkers in patients with newly diagnosed, untreated normal-tension glaucoma (NTG). The study found that decreased corneal hysteresis (CH) was significantly connected with larger linear cup-to-disc ratios (LCDR), thinner (RNFL), smaller rim areas, and lower rim volumes in NTG patients. The aforementioned associations

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demonstrate the importance of corneal biomechanical properties in the assessment of glaucoma, especially in the presence of control variables such as age, disc size, corneal thickness, and intraocular pressure (IOP) [12].

Chu and Racette (2021) looked at 120 eyes' structural and functional changes in glaucoma over the course of five to ten years. The study discovered that the greatest correlation between structural and functional changes happened in various patient populations at various visit delays. This result implies that the structure-function link in the advancement of glaucoma differs at the individual level, pointing to the necessity of a tailored strategy when employing both structural and functional data to track the course of the illness [13].

Conclusion

This study demonstrates that the (PCI) is a significant marker for glaucoma. PCI was notably higher in glaucoma patients and showed strong correlations with both structural and functional measures of the disease. As an independent predictor of glaucoma progression, PCI has the potential to enhance early detection and monitoring of the condition. Incorporating PCI into clinical practice could improve the management and treatment of glaucoma, aiding in the preservation of vision.

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