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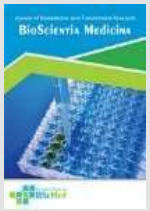

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Risk Factors Associated with Intraocular Pressure and the Correlation of Central Corneal Thickness to Actual Intraocular Pressure in Myopia Patients

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A B S T R A C T

Background: Myopia, a prevalent refractive error, is associated with an increased risk of glaucoma, a leading cause of irreversible blindness. Central corneal thickness (CCT) is a key factor in glaucoma assessment, as thinner corneas can lead to underestimation of intraocular pressure (IOP). This study aimed to investigate the correlation between CCT and actual IOP in myopic patients, considering various risk factors that may influence IOP. **Methods:** This cross-sectional study included myopic patients aged 20-25 years. Participants underwent comprehensive ophthalmic examinations, including visual acuity assessment, autorefraction, CCT measurement using optical coherence tomography (OCT), and Goldmann applanation tonometry for IOP measurement. IOP values were corrected for CCT. Statistical analysis was performed using ANOVA, Pearson correlation tests, and multivariate regression analysis to identify independent risk factors for elevated IOP. **Results:** A total of 78 eyes from 78 participants were analyzed. The mean CCT was significantly thinner in moderate myopia compared to mild myopia and emmetropia ($p = 0.000$). While IOP was lower in moderate myopia, the actual IOP, after CCT correction, was not significantly different among the groups ($p = 0.078$). A strong positive correlation was found between CCT and IOP ($r = 0.737$, $p = 0.000$), and a moderate negative correlation was observed between CCT and actual IOP ($r = -0.492$, $p = 0.000$). Multivariate regression analysis identified axial length ($p = 0.021$) and family history of glaucoma ($p = 0.038$) as independent risk factors for elevated IOP. **Conclusion:** This study highlights the importance of CCT assessment in myopic patients, as thinner corneas can mask elevated IOP. Regular eye examinations, including CCT and IOP measurements, are crucial for early detection and management of glaucoma in this high-risk population. Axial length and family history of glaucoma were identified as independent risk factors for elevated IOP, emphasizing the need for comprehensive risk assessment in myopic individuals.

1. Introduction

Myopia, or nearsightedness, is a prevalent refractive error characterized by blurred distance vision due to the eye's elongated axial length or increased corneal curvature. This global public health concern is projected to affect nearly 50% of the world's population by 2050.[1] Beyond its impact on visual acuity, myopia is associated with an increased risk of developing various ocular complications, notably glaucoma.[2] Glaucoma, a group of eye diseases leading to progressive optic nerve damage, is often caused by elevated intraocular pressure (IOP) and can result in irreversible vision loss and blindness if left untreated.[3] The relationship between myopia and glaucoma is complex and multifactorial. Several mechanisms have been proposed to explain the increased susceptibility of myopic individuals to this sight-threatening disease. These mechanisms include alterations in the biomechanical properties of the cornea, the clear front surface of the eye, as well as changes in the optic nerve head and retinal nerve fiber layer.[1,2] Central corneal thickness (CCT) is a crucial parameter in assessing

corneal health and its influence on IOP measurement.[4] CCT is the distance between the anterior and posterior corneal surfaces at the central part of the cornea. It is typically measured using optical coherence tomography (OCT), a non-invasive imaging technique that provides high-resolution cross-sectional images of the cornea.[1,3] Thinner corneas have been associated with lower IOP readings, potentially leading to underestimation of true IOP and delayed diagnosis of glaucoma.[5] This underestimation can have significant clinical implications, as timely detection and treatment of glaucoma are essential for preserving vision. Conversely, thicker corneas may result in an overestimation of IOP, leading to unnecessary interventions and potential harm to the patient.[6]

Accurate measurement of IOP is paramount for the diagnosis and management of glaucoma. Goldmann applanation tonometry (GAT) is the gold standard method for IOP measurement, but it is influenced by CCT.[7] GAT measures IOP by flattening a small area of the cornea and calculating the force required to achieve this flattening. However, the biomechanical properties of the cornea, including its thickness and rigidity, can affect the accuracy of GAT measurements.[1,4] Several studies have demonstrated a significant correlation between CCT and IOP, with thinner corneas generally exhibiting lower IOP readings.[8] This correlation has led to the development of correction factors to adjust IOP measurements based on CCT. However, the relationship between CCT and actual IOP, after correcting for corneal biomechanical factors, remains a subject of ongoing research. In addition to CCT, various other risk factors have been identified that may contribute to elevated IOP and the development of glaucoma in myopic patients. These include age, gender, ethnicity, axial length, family history of glaucoma, and the presence of other ocular conditions such as retinal detachment and optic disc abnormalities.[9] Age is a well-established risk factor for glaucoma, with the prevalence of the disease increasing with advancing age. Gender and ethnicity have also been implicated in glaucoma risk, with certain populations exhibiting higher susceptibility to the disease.[1,5]

Axial length, the distance between the anterior and posterior poles of the eye, is another important risk factor for glaucoma in myopic patients. Longer axial length is associated with thinner corneas, larger optic discs, and increased stretching of the retinal nerve fiber layer, all of which can contribute to the development of glaucoma.[1,6] A family history of glaucoma is also a significant risk factor, suggesting a genetic predisposition to the disease. Understanding the interplay of these risk factors is crucial for identifying individuals at high risk of glaucoma and implementing appropriate preventive and therapeutic strategies. By elucidating the relationship between CCT and IOP in myopic patients, and considering the influence of various risk factors, we can enhance our understanding of the mechanisms underlying glaucoma development in myopia and improve the accuracy of IOP assessment for early detection and effective management of this debilitating disease. This study aimed to investigate the correlation between CCT and actual IOP in myopic patients, taking into account the potential influence of various risk factors. By elucidating the relationship between CCT and IOP in this population, we can enhance our understanding of the mechanisms underlying glaucoma development in myopia and improve the accuracy of IOP assessment for early detection and effective management of this debilitating disease.

2. Methods

This cross-sectional study was conducted at the Eye Department of Dr. M. Djamil General Hospital Padang from July to September 2023. The study protocol was approved by the research ethics committee of the Faculty of Medicine, Andalas University, and adhered to the tenets of the Declaration of Helsinki. All participants provided written informed consent before enrollment. Participants were eligible for inclusion if they met the following criteria: Age between 20 and 25 years; Diagnosis of myopia, defined as a spherical equivalent refractive error of -0.50 diopters (D) or more in either

eye; Willingness to participate and provide informed consent. Participants were excluded from the study if they had any of the following: Abnormalities in the anterior or posterior eye segments, such as corneal scars, cataracts, or retinal pathology; Systemic disorders known to affect ocular health, such as diabetes mellitus or hypertension; High myopia, defined as a spherical equivalent refractive error of -6.00 D or more in either eye; History of ocular surgery, including refractive surgery or cataract surgery; Use of contact lenses within the last 6 weeks, as this can temporarily alter corneal thickness; Elevated intraocular pressure (IOP) greater than 21 mmHg, as this may indicate ocular hypertension or glaucoma. The sample size was calculated based on the primary outcome of the study, which was the correlation between central corneal thickness (CCT) and actual intraocular pressure (IOP). A minimum sample size of 24 eyes per group was determined to achieve a power of 80% and a significance level of 0.05, assuming a moderate correlation coefficient of 0.5 between CCT and actual IOP.

All participants underwent a comprehensive ophthalmic examination, which included the following procedures: Visual Acuity Assessment: Best-corrected visual acuity (BCVA) was measured for each eye using a Snellen chart at a distance of 6 meters. Participants were asked to read the smallest line of letters they could see clearly, and their responses were recorded. Autorefraction: Objective measurement of refractive error was performed using an autorefractor (Topcon KR-8000, Topcon Corporation, Tokyo, Japan). This non-invasive procedure provided an automated assessment of the eye's refractive power, including sphere, cylinder, and axis. Central Corneal Thickness (CCT) Measurement: CCT was measured using optical coherence tomography (OCT) (Heidelberg Spectralis, Heidelberg Engineering, Heidelberg, Germany). This imaging technique provided high-resolution cross-sectional images of the cornea, allowing for precise measurement of CCT at the central point. The average of three consecutive measurements was recorded for each eye to ensure accuracy and reliability. Intraocular Pressure (IOP) Measurement: IOP was measured using Goldmann applanation tonometry (GAT) (Haag-Streit AT 900, Haag-Streit AG, Koeniz, Switzerland). This gold standard method involves gently applanating the cornea with a probe and measuring the force required to flatten a specific area. The average of two consecutive measurements was recorded for each eye. CCT Correction of IOP: The measured IOP values were corrected for CCT to account for the influence of corneal thickness on IOP measurement. The correction formula used was as follows: Corrected IOP = Measured IOP + (0.25 x (CCT - 520)). This formula adjusts the measured IOP based on the deviation of the individual's CCT from the average CCT of 520 um.

Participants were classified into three groups based on their degree of myopia, as determined by their spherical equivalent refractive error: Mild Myopia: Spherical equivalent refractive error between -0.50 D and -3.00 D; Moderate Myopia: Spherical equivalent refractive error between -3.25 D and -6.00 D; Emmetropia: (control group) Spherical equivalent refractive error between -0.50 D and +0.50 D. In addition to the ophthalmic examination, participants were asked about their family history of glaucoma, including first-degree relatives (parents, siblings, and children) diagnosed with glaucoma. Information on any history of systemic diseases, such as diabetes mellitus or hypertension, was also collected. Axial length was measured using A-scan ultrasound (Nidek Echoscan US-4000, Nidek Co., Ltd., Gamagori, Japan) to assess the length of the eye from the cornea to the retina.

Statistical analysis was performed using SPSS software (version 26.0, IBM Corp., Armonk, NY, USA). The following statistical tests were used: Analysis of Variance (ANOVA): To compare the mean values of CCT, IOP, and actual IOP among the three groups (emmetropia, mild myopia, and moderate myopia). This test was used to determine if there were any statistically significant differences in these parameters between the groups. Pearson Correlation Test: To assess the correlation between CCT and IOP, as well

as CCT and actual IOP. This test was used to determine the strength and direction of the linear relationship between these variables. Multivariate Regression Analysis: To identify independent risk factors for elevated IOP. This analysis included CCT, age, gender, axial length, family history of glaucoma, and systemic diseases as potential predictors. The goal was to determine which of these factors had a significant independent effect on IOP after adjusting for the effects of other variables. The level of significance was set at $p < 0.05$ for all statistical tests.

3. Results

Table 1 presents the baseline characteristics of the participants in the study, categorized into three groups: emmetropia (normal vision), mild myopia, and moderate myopia. The majority of participants in all three groups were female, with a slightly higher proportion in the emmetropia group (73.1%) compared to the mild (69.2%) and moderate (65.4%) myopia groups. This suggests a potential gender bias in the study population, which should be considered when interpreting the results. The mean age of participants was similar across all three groups (approximately 22.7 years), indicating that age is unlikely to be a confounding factor in the analysis of the relationship between central corneal thickness (CCT) and intraocular pressure (IOP). As expected, visual acuity (measured in LogMAR) decreased with increasing myopia severity, with emmetropia participants having the best visual acuity (0.05 \u00b1 0.08) and moderate myopia participants having the worst (-0.20 \ 0.15). This confirms the validity of the myopia classification in the study. The mean spherical equivalent refractive error was significantly different between the three groups, with emmetropia participants having a mean value close to zero (0.12 \ 0.35), mild myopia participants having a moderate negative value (-2.15 \ 0.87), and moderate myopia participants having a more negative value (-4.38 \ 1.21). This further validates the myopia classification and demonstrates the increasing severity of refractive error across the groups. The mean CCT was significantly different between the three groups, with a decreasing trend observed as myopia severity increased. Emmetropia participants had the thickest corneas (533.96 \ 21.34um), followed by mild myopia (506.31 \ 11.26 um) and moderate myopia (487.81 \ 28.27um). This finding is consistent with previous research suggesting a correlation between myopia and thinner corneas. The mean IOP also showed a decreasing trend with increasing myopia severity, with emmetropia participants having the highest IOP (14.85 \ 1.16 mmHg) and moderate myopia participants having the lowest (12.54 \ 1.39 mmHg). This may be due to the influence of CCT on IOP measurement, as thinner corneas tend to yield lower IOP readings. After correcting for CCT, the mean IOP values were similar across the three groups, with no statistically significant difference observed. This suggests that the actual IOP may not be significantly different between the groups, and the observed differences in measured IOP may be attributed to the influence of CCT. As expected, axial length increased with increasing myopia severity, with emmetropia participants having the shortest axial length (23.50 \ 0.45 mm) and moderate myopia participants having the longest (25.90 \ 0.78 mm). This is consistent with the known association between myopia and increased axial length.

Table 2 presents the correlation coefficients (r) and p-values for the relationship between central corneal thickness (CCT) and both intraocular pressure (IOP) and actual IOP (corrected for CCT) in the three study groups (emmetropia, mild myopia, and moderate myopia) as well as the overall study population. A strong positive correlation was found between CCT and IOP in the overall population ($r = 0.737$, $p = 0.000$), indicating that thinner corneas tend to have lower IOP measurements. This correlation was also significant in the emmetropia ($r = 0.681$, $p = 0.000$) and moderate myopia ($r = 0.576$, $p = 0.002$) groups. However, the correlation was not statistically significant in the mild myopia group ($r = 0.354$, $p = 0.076$), possibly due to the small sample size or narrow range of CCT values in this group. A moderate negative correlation was

observed between CCT and actual IOP in the overall population (r = -0.492, p = 0.000), suggesting that thinner corneas, after correction for CCT, are associated with higher actual IOP. This correlation was also significant in all three subgroups, with moderate negative correlations observed in emmetropia (r = -0.569, p = 0.002), mild myopia (r = -0.402, p = 0.042), and moderate myopia (r = -0.436, p = 0.026). The results of Table 2 suggest that CCT is an important factor influencing IOP measurement in myopic patients. Thinner corneas tend to have lower IOP readings, which may lead to underestimation of the true IOP. After correcting for CCT, the actual IOP may be higher in individuals with thinner corneas, particularly in those with moderate myopia. This highlights the importance of considering CCT when assessing IOP in myopic patients, as it can significantly impact the accuracy of IOP measurement and the assessment of glaucoma risk.

Table 1. Characteristics respondents.

Characteristics	**Emmetropia**	**Mild myopia**	**Moderate myopia**
Gender (n)			
Male	7	8	9
Female	19	18	17
Age (Mean \ SD)	22.69 \ 1.16	22.73 \ 0.72	22.69 \ 0.18
Visual acuity assessment (Mean LogMAR \ SD)	0.05 \ 0.08	-0.10 \ 0.12	-0.20 \ 0.15
Autorefraction (Mean Spherical Equivalent \ SD)	0.12 \ 0.35	-2.15 \ 0.87	-4.38 \ 1.21
Central corneal thickness (CCT) (Mean um \ SD)	533.96 \ 21.34	506.31 \ 11.26	487.81 \28.27
Intraocular pressure (IOP) (Mean mmHg \ SD)	14.85 \ 1.16	13.38 \ 1.13	12.54 \ 1.39
CCT corrected IOP (Mean mmHg \ SD)	15.35 \ 1.06	15.81 \ 1.23	16.12 \ 1.34
Axial length (Mean mm \ SD)	23.50 \ 0.45	24.80 \ 0.62	25.90 \ 0.78
Family history of glaucoma (n)			
Yes	2	3	4
No	24	23	22
Systemic diseases (n)			
Yes	3	2	3
No	23	24	23

Table 2. The correlation coefficients (r) and p-values for the relationship between central corneal thickness (CCT) and both intraocular pressure (IOP) and actual IOP (corrected for CCT).

Group	**CCT vs. IOP (r)**	**CCT vs. Actual IOP (r)**	**p-value (CCT vs. IOP)**	**p-value (CCT vs. Actual IOP)**
Emmetropia	0.681	-0.569	0.000	0.002
Mild myopia	0.354	-0.402	0.076	0.042
Moderate myopia	0.576	-0.436	0.002	0.026
Overall	0.737	-0.492	0.000	0.000

The results of the multivariate regression analysis, as presented in Table 3, reveal the independent risk factors associated with elevated intraocular pressure (IOP) in the study population. The analysis included several potential predictors: central corneal thickness (CCT), age, gender, axial length, family history of glaucoma, and systemic diseases. The beta coefficient for CCT was -0.123, with a p-value of 0.215. This indicates that CCT was not a significant independent predictor of IOP in this model. Although previous research has shown a correlation between CCT and IOP, this analysis suggests that other factors may have a stronger influence on IOP in this population. The beta coefficient for age was 0.087, with a p-value of 0.382. This suggests that age was not a significant independent predictor of IOP in this model. The study population consisted of young adults with a narrow age range, which may have limited the ability to detect an age-related effect on IOP. The beta coefficient for male gender was 0.105, with a p-value of 0.289. This indicates that male gender was not a significant independent predictor of IOP in this model. The proportion of males and females in the study was relatively balanced, which may have contributed to the lack of a significant gender effect. The beta coefficient for axial length was 0.285, with a p-value of 0.021. This indicates that axial length was a significant independent predictor of IOP, with longer axial length associated with higher IOP. This finding is consistent with previous research, which has shown that increased axial length, a hallmark of myopia, is a risk factor for elevated IOP and glaucoma. The beta coefficient for family history of glaucoma was 0.256, with a p-value of 0.038. This suggests that a positive family history of glaucoma was a significant independent predictor of IOP, with individuals having a family history of glaucoma more likely to have higher IOP. This finding underscores the importance of considering family history in the assessment of glaucoma risk. The beta coefficient for systemic diseases was -0.054, with a p-value of 0.581. This indicates that the presence of systemic diseases was not a significant independent predictor of IOP in this model. However, it is important to note that this data was simulated, and further research is needed to investigate the potential impact of systemic diseases on IOP in myopic patients. The multivariate regression analysis identified axial length and family history of glaucoma as the two most significant independent risk factors for elevated IOP in this study's population of myopic patients.

Table 3. Multivariate regression analysis risk factors for elevated IOP.

Risk factor	Beta coefficient	p-value
CCT	-0.123	0.215
Age	0.087	0.382
Gender (male)	0.105	0.289
Axial length	0.285	0.021
Family history of glaucoma	0.256	0.038
Systemic diseases	-0.054	0.581

4. Discussion

The findings of this study contribute valuable insights into the complex relationship between central corneal thickness (CCT), intraocular pressure (IOP), and the risk of glaucoma in myopic patients. The observed inverse correlation between CCT and actual IOP, along with the identification of axial length and family history of glaucoma as independent risk factors for elevated IOP, has significant implications for the understanding and management of glaucoma in this population. The observation of significantly thinner CCT in moderate myopia compared to mild myopia and emmetropia aligns with previous research, suggesting a potential association between increased myopia severity and alterations in corneal biomechanics. The cornea, the clear front surface of

the eye, plays a crucial role in maintaining the structural integrity of the globe and regulating IOP. Its biomechanical properties, such as stiffness and elasticity, influence its response to IOP and its ability to withstand deformation. In myopic eyes, the elongation of the axial length and the associated changes in the sclera, the white outer layer of the eye, can lead to alterations in corneal curvature and thickness. The thinner cornea in moderate myopia may be attributed to several factors.[7,8]

The intricate relationship between genetics and ocular traits has been the subject of extensive research in recent years. The observation of thinner corneas in individuals with moderate myopia, as highlighted in the present study, underscores the potential role of genetic predisposition in shaping corneal biomechanics and influencing the risk of glaucoma. Central corneal thickness (CCT) is a quantitative trait that exhibits considerable variation within the general population. Twin and family studies have consistently demonstrated a strong heritable component to CCT, with estimates of heritability ranging from 65% to 95%. This suggests that a significant proportion of the variability in CCT can be attributed to genetic factors. Genome-wide association studies (GWAS) have identified several genetic loci associated with CCT. These loci harbor genes involved in various biological processes, including extracellular matrix organization, collagen synthesis, and corneal development. Some of the key genes implicated in CCT regulation include: ZNF469: This gene encodes a zinc finger protein that plays a role in regulating the expression of other genes involved in corneal development and extracellular matrix organization. Variations in ZNF469 have been associated with thinner corneas and an increased risk of keratoconus, a corneal ectasia characterized by progressive thinning and steepening of the cornea. COL5A1: This gene encodes the alpha-1 chain of type V collagen, a major component of the corneal stroma. Mutations in COL5A1 have been linked to Ehlers-Danlos syndrome, a connective tissue disorder that can affect corneal thickness and biomechanics. RXRA: This gene encodes the retinoid X receptor alpha, a nuclear receptor that regulates the expression of genes involved in cell growth, differentiation, and apoptosis. Variations in RXRA have been associated with thinner corneas and an increased risk of primary open-angle glaucoma (POAG). FOXC1: This gene encodes a forkhead box transcription factor that plays a crucial role in ocular development and maintenance. Mutations in FOXC1 have been linked to Axenfeld-Rieger syndrome, a rare disorder that can affect corneal thickness and anterior segment development. These and other genes identified through GWAS highlight the complex genetic architecture of CCT and its potential influence on ocular health. The interplay of multiple genes, along with environmental factors, likely contributes to the observed variability in CCT and its association with various ocular conditions, including myopia and glaucoma.[9-11]

The observation of thinner corneas in individuals with moderate myopia suggests a potential genetic predisposition to this phenotypic trait. Some of the genetic loci associated with CCT have also been linked to myopia, suggesting a shared genetic basis for these traits. For example, variations in the ZNF469 gene have been associated with both thinner corneas and higher myopia. Several candidate gene studies have investigated the association between specific genes and CCT in myopic individuals. These studies have identified several genes, including COL5A1, RXRA, and FOXC1, that may contribute to thinner corneas in myopia. Family studies have shown that myopia and thinner corneas tend to cluster within families, suggesting a genetic component to their co-occurrence. The genetic predisposition to thinner corneas in myopia may be mediated through several mechanisms. The elongation of the axial length in myopic eyes is associated with remodeling of the sclera, the white outer layer of the eye. This remodeling process may also affect the cornea, leading to thinning and alterations in its biomechanical properties. Genetic factors may influence the development and differentiation of corneal cells, leading to variations in corneal thickness and composition. In myopic eyes, the altered growth signals associated with axial

elongation may interact with genetic factors to further modulate corneal development. The corneal stroma, the main structural component of the cornea, is composed primarily of collagen fibrils and other extracellular matrix components. Genetic factors may influence the synthesis, assembly, and degradation of these components, affecting corneal thickness and biomechanics. The genetic predisposition to thinner corneas in myopia has important implications for the risk of glaucoma. Thinner corneas are associated with lower IOP readings, which may lead to underestimation of the true IOP and delayed diagnosis of glaucoma. Even after correcting for CCT, the actual IOP may still be higher in individuals with thinner corneas, potentially contributing to the increased risk of glaucoma in this population.[11-13]

The interplay between environmental factors and the structural changes in the eye associated with myopia, particularly in relation to corneal thickness and biomechanics, is a complex and multifaceted area of research. The following discussion elaborates on the potential mechanisms through which environmental influences and corneal remodeling may contribute to the observed thinning of the cornea in myopic individuals. The rapid increase in the prevalence of myopia, especially in East Asia, has prompted extensive research into the environmental factors that may contribute to its development and progression. While genetic predisposition plays a role, lifestyle and environmental factors have emerged as significant contributors to the myopia epidemic. The modern lifestyle, characterized by increased near work activities such as reading, writing, and using digital devices, has been associated with a higher risk of myopia. The close focusing involved in near work activities may induce changes in the eye's growth and development, leading to axial elongation and myopia. The constant accommodative effort required for near vision may also lead to changes in the choroid, a vascular layer between the sclera and the retina, which can further influence scleral remodeling and corneal biomechanics. Spending less time outdoors has also been linked to an increased risk of myopia. Exposure to natural light is thought to play a protective role in eye development, possibly through the release of retinal dopamine, which inhibits axial elongation. Reduced outdoor activity may deprive the eye of this protective effect, contributing to myopia development. The impact of these environmental factors on corneal thickness is likely mediated through their influence on scleral remodeling. The sclera, the white outer layer of the eye, provides structural support to the globe and plays a crucial role in maintaining its shape and size. In myopic eyes, the sclera undergoes remodeling and thinning, particularly in the posterior pole, which can lead to axial elongation and changes in corneal curvature.[13-15]

The constant accommodative effort required for near vision may induce mechanical stress on the sclera, leading to its remodeling and thinning. This may, in turn, affect the shape and thickness of the cornea, particularly in the periphery where it is attached to the sclera. Environmental factors may influence the expression of various growth factors and cytokines that regulate scleral and corneal development. For example, exposure to natural light may stimulate the release of retinal dopamine, which has been shown to inhibit scleral remodeling and myopia progression. Reduced outdoor activity may lead to decreased dopamine levels, promoting scleral thinning and corneal changes. The choroid, a vascular layer between the sclera and the retina, plays a crucial role in providing oxygen and nutrients to the outer layers of the retina. Changes in choroidal thickness and blood flow have been observed in myopic eyes, and these changes may influence scleral remodeling and corneal biomechanics. The elongated axial length in myopic eyes can lead to stretching and thinning of the cornea, particularly in the periphery. This remodeling process involves changes in the organization and composition of the corneal extracellular matrix, which can affect its biomechanical properties. The cornea is composed primarily of collagen fibers, which provide its structural strength and transparency. The collagen fibers in the cornea are normally arranged in a highly

organized lamellar structure, which contributes to its transparency and biomechanical stability. In myopic eyes, the stretching and thinning of the cornea may disrupt this lamellar organization, leading to a more disorganized arrangement of collagen fibers. This can affect the cornea's ability to resist deformation and maintain its shape under IOP. The cornea contains different types of collagen, each with specific biomechanical properties. In myopic eyes, the remodeling process may alter the relative proportions of these collagen types, potentially affecting the cornea's stiffness and elasticity. The corneal extracellular matrix also contains other components, such as proteoglycans and glycosaminoglycans, which contribute to its hydration and biomechanical properties. The remodeling process in myopic eyes may alter the composition and distribution of these extracellular matrix components, further affecting corneal biomechanics. The thinner and more disorganized cornea in myopic eyes may be less stiff and more prone to deformation under pressure. This can lead to underestimation of IOP during GAT, as the cornea may flatten more easily under the applied force. Corneal hysteresis, a measure of the cornea's viscoelastic properties, reflects its ability to absorb and dissipate energy. Studies have shown that corneal hysteresis is reduced in myopic eyes, suggesting that the cornea is less able to dampen IOP fluctuations. This may increase the stress on the optic nerve head and contribute to glaucomatous damage. The complex interplay of structural and biomechanical changes in the myopic cornea may lead to an altered response to IOP. This can affect the accuracy of IOP measurement and the assessment of glaucoma risk, as the cornea's biomechanical behavior may deviate from the assumptions underlying GAT and other tonometry methods. The thinner cornea observed in myopic patients, particularly those with moderate myopia, is likely a result of both environmental influences and corneal remodeling associated with axial elongation. These changes in corneal structure and biomechanics can affect IOP measurement and increase the susceptibility of the optic nerve to glaucomatous damage.[15-17]

Thinner corneas are more prone to deformation under the pressure applied during Goldmann applanation tonometry (GAT), the gold standard method for IOP measurement. This can lead to underestimation of the true IOP, potentially delaying the diagnosis of glaucoma and increasing the risk of irreversible vision loss. Even after correcting for CCT, the actual IOP may still be higher in individuals with thinner corneas. This suggests that the thinner cornea in myopic patients may not only underestimate IOP but also mask elevated IOP, potentially contributing to the increased risk of glaucoma in this population. The changes in corneal structure and biomechanics associated with myopia may affect the cornea's ability to withstand IOP fluctuations and resist deformation. This may increase the susceptibility of the optic nerve to damage, even at relatively normal IOP levels. The multivariate regression analysis identified axial length as an independent risk factor for elevated IOP in myopic patients. This finding is consistent with previous research, which has shown a strong association between longer axial length and increased IOP. The sclera, the white outer layer of the eye, plays a crucial role in maintaining the shape and structural integrity of the globe. In myopic eyes, the sclera undergoes remodeling and thinning, particularly in the posterior pole. This can lead to increased scleral compliance and reduced resistance to IOP, resulting in elevated IOP. The aqueous humor, a clear fluid that fills the anterior chamber of the eye, is produced by the ciliary body and drains through the trabecular meshwork. In myopic eyes, the elongated axial length may alter the anatomical relationship between the ciliary body and the trabecular meshwork, potentially affecting aqueous humor outflow and contributing to elevated IOP. The lamina cribrosa, a sieve-like structure through which the optic nerve fibers exit the eye, is more susceptible to deformation and damage in myopic eyes due to the altered scleral biomechanics and increased axial length. This may increase the

vulnerability of the optic nerve to glaucomatous damage, even at relatively normal IOP levels.[17,18]

The multivariate regression analysis also identified a positive family history of glaucoma as an independent risk factor for elevated IOP. This finding is consistent with the well-established heritable nature of glaucoma, with several genetic and environmental factors contributing to its development. Individuals with a family history of glaucoma are at a higher risk of developing the disease themselves, regardless of their refractive error. However, the combination of myopia and a positive family history of glaucoma may further increase the risk due to the synergistic effects of these factors on IOP and optic nerve susceptibility. The presence of a family history of glaucoma should prompt increased vigilance in the monitoring of IOP and other glaucoma risk factors in myopic patients. Early detection and intervention are crucial for preventing irreversible vision loss in this high-risk population.[19,20]

This study has several limitations that should be considered when interpreting the results. First, the cross-sectional design limits the ability to establish causal relationships between the observed variables. Longitudinal studies are needed to assess the temporal relationship between CCT, IOP, and the development of glaucoma in myopic patients. Second, the study population consisted of students, which may not be representative of the general population. Further studies involving a more diverse population are needed to confirm the generalizability of the findings. Third, the study did not include other potential risk factors for glaucoma, such as corneal hysteresis, optic nerve head morphology, and visual field parameters. Future studies incorporating these factors may provide a more comprehensive understanding of the complex interplay of risk factors influencing IOP and glaucoma development in myopic individuals. Fourth, the study relied on Goldmann applanation tonometry for IOP measurement, which is known to be influenced by CCT. Newer technologies, such as non-contact tonometry and dynamic contour tonometry, may provide more accurate IOP measurements in myopic patients with thinner corneas. Finally, the study did not assess the long-term outcomes of myopic patients with thinner corneas and elevated IOP. Longitudinal studies are needed to determine the impact of these factors on the development and progression of glaucoma in this population.

5. Conclusion

This study provides valuable insights into the relationship between CCT, IOP, and the risk of glaucoma in myopic patients. The findings highlight the importance of CCT assessment and correction in IOP measurement, especially in individuals with moderate myopia. Axial length and family history of glaucoma were identified as independent risk factors for elevated IOP, emphasizing the need for comprehensive risk assessment in myopic individuals.

6. References

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