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The Role of Intraocular Pressure in Peripapillary RNFL Thickness Changes in Healthy Myopic Eyes

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Abstract

The peripapillary retinal nerve fiber layer (RNFL) is a vital structure in the eye, responsible for transmitting visual information from the retina to the brain. In myopic eyes, which have an elongated axial length, the RNFL is particularly vulnerable to structural changes. Intraocular pressure (IOP) has long been recognized as a crucial factor influencing optic nerve health. This article explores the relationship between IOP and peripapillary RNFL thickness changes in healthy myopic eyes, shedding light on the clinical implications and potential avenues for future research.

Keywords: Myopia; Intraocular pressure; Peripapillary RNFL; Myopic eyes

Introduction

Myopia, or nearsightedness, is a prevalent refractive error characterized by an elongated eyeball. Myopic eyes are at an increased risk of various ocular pathologies, including glaucoma and myopic maculopathy. The peripapillary RNFL, a bundle of nerve fibers originating from retinal ganglion cells, is prone to thinning and structural alterations in myopic eyes. Elevated intraocular pressure has long been associated with glaucoma, but its impact on the peripapillary RNFL thickness in healthy myopic eyes warrants further investigation [1].

Myopia is one of the most common ocular diseases worldwide. The prevalence of myopia is estimated at approximately 20% to 30% among children in Singapore, and this figure is expected to increase in the future. Generally, high myopia is defined as occurring when the spherical equivalent reaches at least 6 dioptres (D) and the axial length elongates above 26 mm. The anatomic features of myopia that involve changes in the optic nerve, such as a large optic disc and optic tilt, also increase the risk of primary open angle glaucoma. Although measuring the visual field is the gold standard for the diagnosis of glaucoma, structural changes such as thinning of the RNFL, which consists mainly of ganglion cells, precede functional defects. Structural change is observed six years prior to any detectable visual field defects in up to 60% of eyes [2]. Additionally, the RNFL plays a role in the pathological mechanism of myopia. Therefore, it can be used as a tool to distinguish glaucoma from myopia, diagnose early glaucoma, and better understand the progression of myopia.

Age

When people receive OCT examination, examiners should record their age first. It not only helps us discern the target patient from those who have the same names but also compares them to the corresponding age-matched normal database to exclude age confounders. A cross-sectional observational study of 82 Taiwanese adults over 65 years old found that the global RNFL thickness was reduced by 4.97 μm every ten years. Among different age groups, a 10-year gap could cause the average RNFL thickness to decrease from 1.5 to 2.5 μm. This difference between the above studies may be attributed to the latter subjects being younger [3]. Histological data have also revealed nearly 4000–5000 optic nerve fibres lost per year. However, this decline along with the increase in age did not occur equally around the optic disc. The decrease in superior and inferior sectors was more obvious in the position where the main retinal blood vessels resided, while the nasal and temporal halves did not show this relevance, suggesting a redistribution of axons with age. The mechanism by which these two areas are preferentially affected is unclear. Some investigators have attributed it to the more rapid atrophy of larger-diameter nerve fibres; these two quadrants are where large-diameter fibres are most abundant [4].

Anatomy of peripapillary RNFL in myopic eyes

Myopic eyes undergo biomechanical changes due to elongation of the axial length, resulting in mechanical stretching and thinning of the peripapillary RNFL. This structural alteration can impact the optic nerve's health and visual function [5]. Understanding the complex interactions between intraocular pressure and RNFL thickness is essential for evaluating the risk of glaucoma and other optic nerve-related diseases in myopic individuals.

Intraocular pressure and RNFL thickness in healthy myopic eyes

Several studies have attempted to elucidate the relationship between IOP and peripapillary RNFL thickness in healthy myopic eyes. Some research suggests that higher IOP is associated with thinner RNFL in myopic individuals, while others find no significant correlation. These divergent findings may be attributed to variations in study methodologies, sample sizes, and patient demographics.

Ethnicity

RNFL variations among different ethnic groups have attracted attention from many investigators. Different ethnicities have different RNFL thicknesses; for example, a study determined that people of European descent were likely to have thinner RNFL than people of other ethnicities [5]. Similarly, other studies found that normal Caucasian subjects had thinner RNFLs than normal subjects of Hispanic or Asian

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heritage. When African Americans were measured, their average RNFL thickness was 101.1 mm, which was thicker than the 98.1 mm reported in Caucasian subjects. A Singaporean study reported thinner RNFLs in the local population than in Chinese people.

Ocular biomechanics and IOP

The biomechanics of the eye play a pivotal role in determining its susceptibility to IOP-related changes. In myopic eyes, the elongated axial length alters the biomechanical properties [6], affecting the distribution of IOP-induced stress on the peripapillary RNFL. Understanding these biomechanical changes is crucial in comprehending the complex relationship between IOP and RNFL thickness in myopic eyes.

Characteristics of the optic disc

As the convergence of the retinal nerve fibre layer constitutes a part of the optic disc, its thickness may be associated with the disc area. As shown in a previous histomorphometric study, the larger optic disc accommodated more retinal nerve fibre axons [7]. Clinical research also concluded that the optic disc area had a positive relationship with AL, as long eyes with more retinal surfaces could contain more RNFL than normal eyes. In children, a large cup/disc ratio with a large disc area is usually recognized as a normal sign. However, 13% of them developed glaucoma for just 3 years. RNFL thickness in myopic children with larger cup disc ratios did not change significantly [8]. RNFL losses usually occurred after the age of 50 years, as claimed by Parikh et al. the relationship between RNFL thickness and large disc size might be attributed to overestimation caused by the shorter distance from the scanning circle to the disc margin, as RNFL thickness becomes thinner with increasing distance from the disc margin.

Clinical implications

The findings from research investigating IOP and peripapillary RNFL thickness in healthy myopic eyes have important clinical implications. Monitoring IOP levels and RNFL thickness in myopic individuals could aid in the early detection and management of glaucoma and other optic nerve-related diseases. Additionally, it may help identify individuals at higher risk for these conditions [9].

OCT segmentation

Artefacts Accurate delineation of the retinal layers can guarantee the correct RNFL measurements. It has been reported that at least one segmentation error occurred in 19.9% to 46.3% of scans. Such segmentation artefacts are especially likely to occur in high myopia. This relatively high estimation of the possibility of segmentation errors might be attributed to thinner RNFL thickness caused by elongation of the eye. Therefore, this segmentation error caused by thinner RNFL thickness might result in more errors in both high myopia and glaucomatous eyes since glaucoma is associated with decreased regional RNFL thickness [10]. In addition, when posterior staphyloma exits myopia, retinal layer delineation will be more difficult due to the challenge of identifying the boundary of the eye. In this case, manual correction was especially important. The diagnostic capability of the RNFL thickness in glaucoma measured by OCT significantly improved after manual correction of segmentation errors. Additionally, when OCT scans are with larger diameters, a segmentation error has more opportunities to occur in larger areas. Scans with larger diameters can measure farther from the optic disc rim. As we mentioned above, the RNFL became thinner with increasing distance to the optic disc. A thinner RNFL is associated with more segmentation errors. Based on this, to increase the diagnostic capability of OCT, some segmentation correction software and a more accurate automated segmentation algorithm are needed [11].

Future directions

As research on this topic continues, several areas warrant further exploration. Longitudinal studies tracking changes in IOP and RNFL thickness over time in myopic individuals could provide valuable insights into the progression of optic nerve changes [12]. Additionally, investigating the impact of IOP-lowering interventions, such as ocular hypotensive medications or surgical procedures, on RNFL thickness in myopic eyes could have significant clinical implications.

Conclusion

The relationship between intraocular pressure and peripapillary RNFL thickness in healthy myopic eyes is a complex and evolving field of study. Understanding the impact of IOP on the structural integrity of the RNFL in myopic individuals is crucial for assessing the risk of glaucoma and other optic nerve-related disorders. Further research in this area will undoubtedly contribute to improved clinical management and better visual outcomes for myopic patients.

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