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Original Research Article

Optic Nerve Head Parameters and Retinal Nerve Fibre Layer Thickness in Migraine Patients: A Cross-Sectional Study

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Abstract:

Purpose: To evaluate the optic nerve head (ONH) parameters and retinal nerve fibre layer (RNFL) thickness in patients suffering from migraine, and to assess whether migraine chronicity correlates with changes in ocular structures.

Methods: A cross-sectional observational study was conducted on 160 migraine patients (320 eyes) aged 20–60 years. Participants were categorized based on migraine chronicity (chronic vs. episodic) using ICHD-3 guidelines. Comprehensive ophthalmologic evaluation including optical coherence tomography (OCT) was performed to assess RNFL, central macular thickness (CMT), intraocular pressure (IOP), and ONH parameters.

Results: The mean RNFL thickness was significantly lower in patients with chronic migraine (Right Eye: 90.84 µm; Left Eye: 92.97 µm) compared to episodic migraine (Right Eye: 100.39 µm; Left Eye: 98.84 µm, $p<0.05$). Older age and longer migraine duration were significantly associated with RNFL thinning. Visual acuity was also reduced in patients with RNFL thinning. There was no significant difference in intraocular pressure between groups.

Conclusion: Migraine, especially in its chronic form, is associated with thinning of RNFL, suggesting potential subclinical optic nerve involvement. OCT serves as a valuable tool for early detection of such changes, aiding in preventive ophthalmic care in migraine patients.

Keywords: Migraine, Retinal Nerve Fibre Layer, Optic Nerve Head, Optical Coherence Tomography, Neuro-ophthalmology.

Introduction

Migraine is a common chronic neurovascular disorder characterized by recurrent headaches, often accompanied by aura, photophobia, and nausea. It affects nearly 15% of the global population and is a leading cause of disability worldwide [1,2]. According to the International Classification of Headache Disorders (ICHD-3), migraine is classified into migraine with aura and migraine without aura [2].

The neurovascular hypothesis suggests that transient reductions in cerebral and ocular blood flow during migraine attacks may cause ischemic injury to neural tissues, including the retina. This can lead to retinal nerve fiber layer (RNFL) thinning and axonal damage, raising concern for subclinical optic neuropathy [3,4]. These changes resemble those seen in glaucoma, a progressive optic neuropathy and a leading cause of irreversible blindness worldwide [5].

Glaucoma is characterized by progressive retinal ganglion cell loss and RNFL thinning, occurring with or without elevated intraocular pressure (IOP) [6]. Normal-tension glaucoma (NTG) involves optic nerve damage despite normal IOP and is thought to involve vascular dysregulation and impaired ocular blood flow [7]. Migraine shares similar vascular pathophysiology with NTG, with increased prevalence of NTG observed in migraine patients [8].

Optical coherence tomography (OCT) enables non-invasive, high-resolution measurement of RNFL and optic nerve head parameters, providing valuable insight into early structural changes in migraine patients. Previous studies have reported RNFL thinning and macular changes in migraine patients, supporting the importance of ocular evaluation in this population [4,9].

This study aims to evaluate RNFL thickness and optic nerve parameters in migraine patients in the Indian population to identify potential early neuro-ophthalmic changes and glaucoma risk.

This study aims to assess optic nerve head parameters and RNFL thickness in migraine patients using OCT, with a focus on detecting early structural changes and contributing data from an Indian cohort.

Materials and Methods

Study Design: Hospital-based cross-sectional observational study.

Sample Size: 160 patients (320 eyes) based on a calculated prevalence of glaucoma in migraine patients.

Inclusion/Exclusion Criteria: Included patients aged 20–60 with a migraine diagnosis per ICHD-3 criteria. Excluded those with systemic diseases, previous ocular pathology, or structural brain lesions.

Procedures: All patients underwent OCT for RNFL and ONH assessment, tonometry for IOP, pachymetry for CCT, and full ophthalmologic examination.

Results

- **Demographics:** Mean age: 40.49 years. Female predominance (61.3%).
- **Chronicity:** 76.3% chronic migraine.
- **RNFL Findings:** Significant thinning in chronic migraine vs episodic ($p<0.001$).
- **Visual Acuity:** Worse in those with RNFL thinning ($p<0.05$).
- **Other Parameters:** No significant changes in IOP or CCT.

Table 1: Chronicity of migraine among study participants

Chronicity of migraine	Number	Percentage
Chronic	122	76.3
Episodic	38	23.8
Total	160	100.0

Table 2: Association of chronicity of migraine with RNFL thickening

RNFL Thickness		Chronic	Episodic	t value	p value
Average RNFL thickness	Right Eye	90.84±12.76	100.39±9.5	4.261	<0.001
	Left Eye	92.97±13.51	98.84±9.57	2.491	0.014
Average superior RNFL	Right Eye	99.1±16.59	107.55±11.52	2.926	0.004
	Left Eye	99.92±18.9	106.74±14.4	2.045	0.043
Average inferior RNFL	Right Eye	98.89±17.49	107.53±13.61	2.792	0.006
	Left Eye	99.11±18.84	108.24±12.06	2.807	0.006

Table 3: Mean Retinal Nerve Fiber Layer (RNFL) Thickness of study participants

RNFL (µm)		Mean	SD
Average RNFL thickness	Right Eye	93.11	12.71
	Left Eye	94.36	12.90
Average superior RNFL	Right Eye	101.11	15.92
	Left Eye	101.54	18.13
Average inferior RNFL	Right Eye	100.94	17.01
	Left Eye	101.28	17.86

Table 4: Optic Nerve Head Parameters of study participants

Variable		Mean	SD
Cup/Disc V. Ratio	Right Eye	0.43	0.13
	Left Eye	0.41	0.13
Cup/Disc H. Ratio	Right Eye	0.42	0.14
	Left Eye	0.42	0.14
Rim Area(mm2)	Right Eye	1.14	0.08
	Left Eye	1.15	0.09
Disc Area(mm2)	Right Eye	2.65	0.34
	Left Eye	2.57	0.35

Table 5: Ganglion Cell Complex (GCC) Average Thickness of study participants

Nerve Fibre GCC Average Thickness (µm)		Mean	SD
Total	Right Eye	93.59	8.40
	Left Eye	94.40	9.33
Superior	Right Eye	92.81	8.73
	Left Eye	94.19	8.98
Inferior	Right Eye	93.36	8.92
	Left Eye	94.85	9.16

Discussion

This hospital-based, observational, cross-sectional study investigated the effects of migraine on optic nerve head (ONH) parameters and retinal nerve fiber layer (RNFL) thickness using spectral-domain optical coherence tomography (SD-OCT). Our findings suggest a significant association between migraine—particularly chronic migraine—and structural changes in the retina and optic nerve, including RNFL thinning and ganglion cell complex (GCC) reduction.

Out of 160 migraine patients enrolled, 25 (15.63%) exhibited RNFL thinning. A significant age difference was observed between patients with RNFL thinning and those with normal RNFL, with the former group being older (46.20 ± 6.40 vs. 38.04 ± 10.35 years, $p<0.001$). This aligns with prior evidence indicating age-related vulnerability to RNFL thinning (Shukla et al., 2024) [10], though their findings reported no significant age or gender differences between groups. In our study, gender showed no significant association with RNFL thinning, consistent with other studies that controlled for sex (Yener & Yılmaz, 2020) [11].

Our subgroup analysis highlighted a notable distinction between chronic and episodic migraine. Chronic migraine patients (n=122, 76.3%) demonstrated significantly reduced RNFL thickness in both eyes compared to episodic migraine patients ($p<0.05$). These findings are in agreement with those reported by Ruchi Shukla et al. (2024) [10], although their differences were not statistically significant. This supports the hypothesis that chronic migraine exerts cumulative neurovascular damage, leading to retinal axonal loss.

Furthermore, intraocular pressure (IOP) was slightly elevated in patients with RNFL thinning ($p<0.01$) but remained within normal limits, echoing findings by Panicker et al. (2021) [12], who also found no significant differences in IOP or visual acuity between migraine and control groups.

No significant variation was observed in central corneal thickness (CCT) or anterior chamber angle configurations, consistent with Koban et al. (2016) [13], who reported similar corneal and anterior segment parameters in migraineurs across headache phases. Central macular thickness (CMT) in our cohort did not significantly differ between those with and without RNFL thinning, though Panicker et al. (2021) [12] found reduced CMT in migraine patients overall, possibly due to methodological or demographic variations.

RNFL thinning in migraine patients—particularly in superior and inferior quadrants—was a critical finding, with significantly reduced values in both eyes among affected individuals ($p<0.001$). These results are supported by Abdelghaffar et al. (2022) [14], who reported significant thinning in all quadrants, suggesting diffuse retinal axonal involvement. However, RNFL thickness did not vary significantly between migraine patients with aura and those without, again in line with previous observations (Abdelghaffar et al., 2022) [14].

Pathophysiologically, these structural alterations are hypothesized to result from recurrent trigeminovascular activation, leading to vasospasm, inflammatory responses, and ischemia of the optic nerve head and retina (Xu et al., 2018 [15]; Gunes et al., 2018 [16]). These mechanisms culminate in axonal damage and RNFL thinning. The observed thinning of the GCC, particularly in the chronic migraine subgroup, further corroborates these findings. Our results match those of Walha et al. (2024) [17], who found significant GCC thinning in migraine patients, especially those with aura. This supports theories of both anterograde and retrograde trans-neuronal degeneration secondary to recurrent ischemic insults.

Optic disc morphology in our study, including vertical and horizontal cup-to-disc (C/D) ratios, remained within normal ranges, although slight variations were observed. These findings resonate with Yılmaz (2024) [18], who noted significant differences in C/D ratios in some migraine patients, particularly in the right eye, though these did not consistently reach statistical significance bilaterally.

Collectively, our findings affirm that chronic migraine is associated with measurable structural changes in the optic nerve and retina, with RNFL and GCC thinning being prominent features. These alterations could be early indicators of glaucomatous changes or independent retinal neurodegeneration associated with migraine. Notably, our findings align with meta-analyses and cohort studies suggesting that migraine, especially chronic forms, increases the risk of developing primary open-angle glaucoma (Xu et al., 2018 [15]; Huang et al., 2019 [19]; Ohn et al., 2023 [20]).

Given that most patients presented for routine ocular assessment and many were not under consistent migraine management, the potential for silent progression of ocular damage is concerning. Therefore, this study underscores the importance of detailed ophthalmic evaluation, including OCT imaging, for patients presenting with chronic or recurrent migraine. Early detection of RNFL and GCC thinning could offer a critical opportunity for intervention before the onset of irreversible optic neuropathy.

In conclusion, our study provides evidence that migraine—particularly chronic migraine—is associated with structural retinal changes detectable by OCT. RNFL and GCC thinning may represent early neurodegenerative markers, warranting vigilant ophthalmologic screening in migraine patients. Given glaucoma's status as a leading cause of preventable blindness, recognizing migraine as a potential risk factor may aid in the early detection and prevention of glaucomatous damage.

Conclusion

Migraine patients, particularly those with chronic symptoms, exhibit significant reductions in RNFL thickness. Routine OCT screening may be beneficial in these individuals for early detection of neurodegenerative changes.

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