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Research Article

Hyperopia as a risk factor for bilateral non-arteritic anterior ischemic optic neuropathy: a comparative retrospective study

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ABSTRACT

Aim: Non-arteritic anterior ischemic optic neuropathy (NAION) is one of the most common causes of sudden, painless vision loss in individuals over the age of 50 and represents the second most frequent optic neuropathy after glaucoma. Our aim was to retrospectively evaluate refractive errors in individuals diagnosed with unilateral and bilateral NAION and to compare these parameters with those of healthy individuals, thereby elucidating the association between hyperopia, and the disease.

Method: This retrospective study included 52 patients diagnosed with NAION at our neuro-ophthalmology department between January and December 2024. Spherical equivalent (SE) values obtained by autorefractometry were classified as emmetropic (−0.50 to +0.50 D), myopic (< −0.50 D), or hyperopic (≥ +0.50 D). Refractive error distributions and mean SE values were compared among three groups: bilateral NAION (12 patients, 24 eyes), unilateral AION (40 patients, 40 eyes), and healthy controls (40 individuals, 40 eyes).

Results: In the control group, refractive error distribution was 32.5% emmetropic, 22.5% myopic, and 45.0% hyperopic, while in the bilateral NAION group, 66.7% were hyperopic, 25.0% emmetropic, and 8.3% myopic; whereas in the unilateral NAION group, 45.0% were hyperopic, 27.5% emmetropic, and 27.5% myopic. Mean SE values were +1.12 ± 1.44 D (range, −1.12 to +4.00) for the bilateral NAION group, +0.18 ± 1.14 D (range, −2.12 to +3.00) for the unilateral NAION group, and +0.19 ± 0.99 D (range, −2.25 to +1.87) for controls. Differences among groups were statistically significant ($p = 0.003$). Post hoc analysis demonstrated significantly greater hyperopia in the bilateral NAION group compared with both the unilateral NAION and control groups. No significant difference was observed between the unilateral NAION and control groups.

Conclusion: Patients with bilateral NAION demonstrated significantly higher levels of hyperopia compared with those with unilateral NAION and healthy controls. These findings suggest that hyperopia may represent a potential risk marker for bilateral NAION. Careful follow-up of hyperopic patients with unilateral NAION may be warranted to enable early detection and management of contralateral-eye involvement.

Keywords: anterior ischemic optic neuropathy, hyperopia, refractive errors, spherical equivalent

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Introduction

Non-arteritic anterior ischemic optic neuropathy (NAION) is one of the most common causes of sudden, painless vision loss in individuals over the age of 50 and represents the second most frequent optic neuropathy after glaucoma (1). NAION is an acute ischemic event that occurs due to impaired perfusion in the laminar and prelaminar regions of the optic nerve (2). Although NAION is most often unilateral at presentation, it may become bilateral over time, typically developing in the early morning hours and potentially leading to permanent vision loss, thereby constituting a significant clinical problem in ophthalmic practice.

In the pathogenesis of NAION, anatomical factors, in addition to systemic vascular comorbidities such as hypertension and diabetes, are known to play an important role (3,4). In particular, a small optic disc and "crowded disc" configuration are thought to predispose individuals to NAION by affecting the perfusion of nerve fibers (5). This structural predisposition is considered a key factor in the susceptibility to ischemic damage at the level of the optic nerve head. The higher prevalence of this structural narrowing in hyperopic eyes has raised interest in the role of refractive errors in the development of NAION (6).

However, the literature presents conflicting evidence. While some studies have identified hyperopia as a risk factor for NAION (7,8), others have reported no significant differences in spherical equivalent (SE) or axial length measurements between patients and controls (9). This controversy suggests that the association between refractive errors and NAION remains incompletely understood, and these contradictory findings underscore the need for a more detailed investigation of the relationship between refractive errors and NAION.

The aim of the present study is to retrospectively evaluate refractive errors in individuals diagnosed with unilateral and bilateral NAION and to compare these parameters with those of healthy individuals, thereby elucidating the association between hyperopia, and the disease. In addition, by specifically focusing on bilateral cases, the study aims to assess whether a distinct refractive profile may reflect a structural predisposition to more extensive optic nerve involvement.

Methods

This study was conducted using a retrospective case–control design to evaluate refractive parameters in individuals diagnosed with NAION. Data were obtained from the archival records of the Neuro-Ophthalmology Clinic at Beyoğlu Eye Training and Research Hospital. The study was approved by the Ethics Committee of the University of Health Sciences. The study adhered to the principles of the Declaration of Helsinki. Due to the retrospective nature of the study, the requirement for informed consent was waived by the local ethics committee.

A total of 92 participants were included and divided into three groups: bilateral NAION (12 patients, 24 eyes), unilateral NAION (40 patients, 40 eyes), and healthy individuals matched for age and sex as controls (40 individuals, 40 eyes). Inclusion criteria were age 18 years or older and a clinically confirmed diagnosis of NAION. Exclusion criteria comprised arteritic AION, optic neuritis, glaucoma and other optic neuropathies, high refractive errors exceeding ±6.00 D, retinal diseases, previous ocular surgery, and systemic or neurological disorders that could cause visual loss.

Refractive measurements for all participants were obtained using an autorefractometer (KR-800 Auto Kerato-Refractometer, TOPCON, Japan). The spherical equivalent (SE) was calculated by adding half of the cylindrical value to the spherical value (SE = S + C/2), and astigmatism (AST) values were also recorded. Based on SE values, refractive errors were

classified as myopia (SE ≤ −0.50 D), emmetropia (−0.50 D < SE < +0.50 D), and hyperopia (SE ≥ +0.50 D).

Statistical analyses were performed using SPSS software version 22.0 (IBM Corp., Armonk, NY, USA). The Shapiro–Wilk test was used to assess the distribution of data. For normally distributed variables, ANOVA and post hoc Tukey HSD tests were applied, whereas the Kruskal–Wallis and Mann–Whitney U tests were used for non-normally distributed data. Fisher's exact test was employed to compare categorical variables. A p-value of less than 0.05 was considered statistically significant.

Because bilateral NAION is clinically rare, the number of patients in this group was limited. Therefore, data from both eyes of the 12 patients in the bilateral group were analyzed separately (n = 24 eyes). This approach was chosen to increase the amount of data and to allow for the evaluation of refractive characteristics in both eyes of bilateral cases. However, it should be noted that measurements from both eyes of the same individual are not entirely statistically independent, and results should be interpreted with this consideration in mind. Accordingly, this analysis should be regarded as exploratory due to the potential for inter-eye correlation.

Results

Comparison of Age of Patients

The mean age of the control group was 53.76 ± 7.11 years, while the mean ages of the unilateral and bilateral NAION groups were 56.35 ± 9.33 years and 60.08 ± 7.06 years, respectively. No statistically significant difference in age was found among the unilateral NAION, bilateral NAION, and control groups, although the difference approached significance (p = 0.052). According to independent samples t-test results, there was no statistically significant difference in age between the NAION groups (p = 0.151). This finding suggests that refractive parameters could be evaluated with minimal potential confounding by age-related variation.

Refractive Parameters and Distributions According to NAION Groups

The mean spherical equivalent (SE) and astigmatism (AST) values were compared, and refractive classifications were evaluated among the three groups. Participants were divided into unilateral NAION (n = 40), bilateral NAION (n = 12), and healthy control (n = 40) groups (Table 1). The mean SE in the bilateral NAION group was 1.12 ± 1.43 D, which was significantly

Table 1. Refractive Parameters and Distributions According to NAION Groups

Parameter	Bilateral NAION	Unilateral NAION	Control	p value
Number of Eyes (n)	24	40	40	
Mean SE (±SD)	1.12 ± 1.44[a,b]	0.18 ± 1.14	0.19 ± 0.99	0.003
Range [Min-Max]	-1.12 – 4.00	-2.12 – 3.00	-2.25 – 1.87	
Hyperopia (%)	66.7%[c,d]	45.0%	45.0%	0.032
Emmetropia (%)	25.0%	27.5%	32.5%	0.326
Myopia (%)	8.3%	27.5%	22.5%	0.412
Mean AST (±SD)	-0.77 ± 0.47[c]	-0.70 ± 0.45	-0.39 ± 0.42	0.041
Range [Min-Max]	-1.87 – -0.25	-2.00 – 0.00	-1.25 – 0.00	

SE = Spherical Equivalent, AST = Astigmatism. All continuous variables are presented as mean ± standard deviation and range. Values are presented as mean ± standard deviation and range for continuous variables, and as percentages for categorical variables. Comparisons were performed using one-way ANOVA or Kruskal–Wallis test for continuous variables and Fisher's exact test for categorical variables, as appropriate.
a $p < 0.01$ vs control group; b $p < 0.01$ vs unilateral NAION group; c $p < 0.05$ vs control group; d $p < 0.05$ vs unilateral NAION group.

higher than that of both the unilateral NAION group (0.51 ± 1.14 D) and the control group (0.23 ± 1.03 D) (p = 0.003) (Figure 1). Post hoc analyses revealed that this difference was statistically significant between the bilateral and control groups (p = 0.007) and between the bilateral and unilateral groups (p = 0.006). No significant difference was found between the unilateral and control groups in terms of SE (p = 0.999).

According to refractive classification, the prevalence of hyperopia was 66.7% in the bilateral NAION group, 45% in the unilateral NAION group, and 45% in the control group (Table 1). A statistically significant difference in the prevalence of hyperopia was observed between the bilateral group and both the control and unilateral groups (Fisher's exact test: bilateral vs control, p = 0.032; bilateral vs unilateral, p = 0.026). There was no significant difference between the unilateral and control groups.

When astigmatism values were examined, the mean AST was −0.77 ± 0.47 D in the bilateral group and −0.39 ± 0.42 D in the control group (Table 1), and this difference was statistically significant (p = 0.045). The unilateral group (−0.70 ± 0.45) showed similar AST values to the bilateral group, and a significant difference was found compared to the control group (p = 0.049).

Comparison of SE Values Between NAION and Contralateral Eyes

The mean SE values of affected and contralateral eyes in unilateral NAION were 0.182 ± 1.135 D and 0.197 ± 1.251 D, respectively (Figure 2). SE values in NAION eyes showed a normal distribution (p = 0.933), whereas contralateral eyes did not (p = 0.019); however, a paired t-test was used due to the adequate sample size. No significant difference was found between affected and contralateral eyes (p = 0.910), indicating that refractive status may have a limited association with unilateral NAION, at least in terms of spherical equivalent.

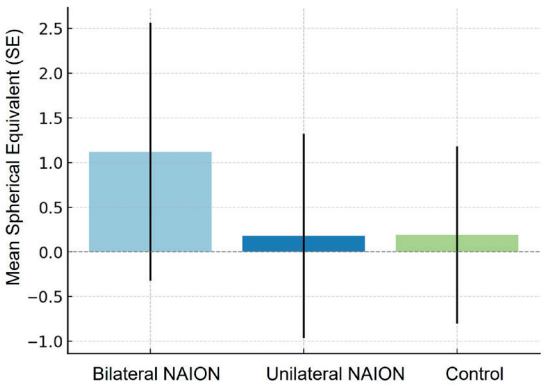

Figure 1. Comparison of mean spherical equivalent (SE, diopters) among bilateral NAION, unilateral NAION, and control groups. Data are presented as mean ± standard deviation (SD). The mean SE was significantly higher in the bilateral NAION group compared with both the unilateral NAION and control groups (p = 0.003).

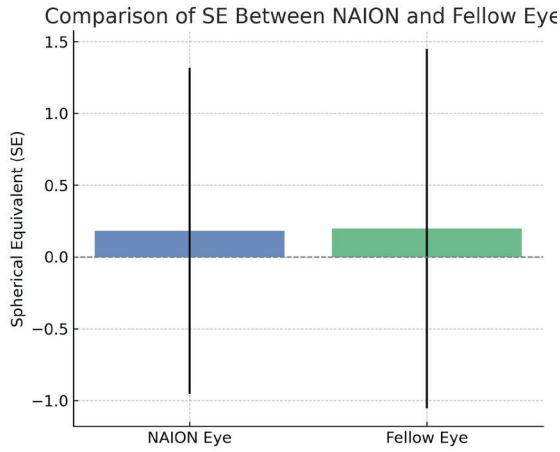

Figure 2. Comparison of spherical equivalent (SE, diopters) between affected NAION eyes and fellow eyes in unilateral NAION patients. Data are presented as mean ± standard deviation (SD). No statistically significant difference was observed between the two eyes (p = 0.910).

Discussion

Hyperopia is typically associated with shorter axial length and smaller overall globe size. This anatomical configuration can result in a narrower scleral canal and a crowded optic disc, creating structural compression at the

level of the optic nerve head and potentially predisposing to perfusion disturbances. As the spherical equivalent shifts toward hyperopia, this configuration may become more susceptible to ischemic events. Although axial length and optic nerve head morphology were not directly measured in our study, these features are generally known to be more prevalent in hyperopic eyes (5,7). Therefore, hyperopia in the present study should be regarded as a surrogate marker of structural predisposition rather than a direct causal factor. This structural predisposition may be more apparent in bilateral NAION cases.

Our findings demonstrate significantly higher SE values and a greater prevalence of hyperopia in the bilateral NAION group compared with the unilateral NAION and control groups. This suggests that hyperopic individuals with structurally small optic discs may have an increased susceptibility to ischemia (6,10). Katz and Spencer reported that the optic nerve head in hyperopic individuals is typically smaller and more crowded, representing a potential risk factor for NAION (7). In contrast, Falavarjani et al. found no direct association between refraction or axial length parameters and NAION development (8). By specifically focusing on bilateral cases, our study highlights that hyperopia is more prominent in this subgroup. However, this association should be interpreted with caution given the retrospective design and the absence of direct structural measurements.

The findings regarding astigmatism are also noteworthy. The bilateral NAION group exhibited higher AST values than the control group, suggesting that not only SE but also corneal shape-related structural factors may have a role in optic nerve perfusion (11,12). However, since a well-established pathophysiological link between astigmatism and NAION does not yet exist, this finding should be considered exploratory. The similarity of refractive parameters between the unilateral NAION and control groups is also striking. This may indicate that vascular risk factors such as hypertension, diabetes, or obstructive sleep apnea play a more dominant role than structural predisposition in unilateral cases (2,13-15). In this context, considering refractive values—particularly in bilateral NAION cases—may aid in early detection, risk assessment, and clinical follow-up. Nevertheless, prospective studies are required to confirm any potential clinical utility.

This study has several limitations. The number of patients in the bilateral NAION group was relatively small, primarily because bilateral NAION is a rare clinical entity, with an incidence reported to be approximately 15–20% in the literature (16-19). The limited number of cases at the study center also affected sample size. Additionally, because both eyes were affected in bilateral NAION patients, data from each eye were analyzed separately. While this approach better reflects clinical reality, it should be interpreted with the understanding that data from both eyes of the same patient are not statistically independent. This consideration is particularly relevant in analyses assuming independence. Future studies with larger sample sizes and multilevel statistical models will be better equipped to address this limitation.

The retrospective design also limits the ability to establish causality. Furthermore, axial length measurements, optic nerve head morphology, and OCT imaging data were not available, preventing direct evaluation of the relationship between hyperopia and structural parameters. Prospective studies with larger cohorts and integrated advanced imaging modalities are needed to expand current knowledge in this area.

Conclusion

This study demonstrated that patients with bilateral non-arteritic anterior ischemic optic neuropathy (NAION) have significantly higher spherical equivalent values and a greater prevalence of hyperopia compared

with unilateral NAION patients and healthy controls. In addition, astigmatism values were significantly higher in bilateral cases. These findings suggest that structural predisposition may play an important role in the development of bilateral NAION. Although anatomical parameters such as axial length and optic disc morphology were not directly measured, features commonly seen in hyperopic eyes—such as smaller globe size and crowded optic discs—may contribute to increased susceptibility to ischemia.

Importantly, hyperopia may represent a potential risk marker for bilateral NAION, indicating that patients with unilateral NAION and hyperopia could benefit from closer clinical follow-up for possible fellow-eye involvement. Identifying such patients may allow clinicians to implement timely preventive measures and individualized follow-up strategies. Considering refractive values, particularly in bilateral NAION cases, may therefore be useful for early detection, risk stratification, and clinical monitoring. Future prospective studies with larger sample sizes and advanced imaging modalities are warranted to further clarify this relationship and to explore preventive strategies for fellow-eye involvement in hyperopic individuals.

Ethical approval

This study was approved by the University of Health Sciences Hamidiye Scientific Research Ethics Committee (date: 27.03.2025, number: 7/14; meeting number: 2025/7)..

Author contribution

The authors confirm contribution to the paper as follows: Study conception and design: ST, MT; data collection: ST, İU, MT; analysis and interpretation of results: ST, İU, MT; draft manuscript preparation: ST, İU. All authors reviewed the results and approved the final version of the manuscript.

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Conflict of interest

The authors declare that there is no conflict of interest.

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