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Commentary Paper

Non-arteritic Anterior Ischemic Optic Neuropathy MRI Findings Compared With Optic Neuritis: A Narrative Review

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ABSTRACT

Background: Optic neuritis (ON) and non-arteritic anterior ischemic optic neuropathy (NAION) are two common causes of optic neuropathies in adults. The distinction of these two diseases could be challenging, especially in middle-aged patients with no cerebrovascular risk factors.

Objectives: We aimed to review current studies regarding orbital magnetic resonance imaging (MRI) characteristics that may help differentiate equivocal cases.

Materials & Methods: All studies that had compared MRI findings in NAION and ON in PubMed, Scopus, and Google Scholar between 1990 and December 2024 were searched, and their outcomes were subtracted and summarized.

Results: Few studies have compared MRI findings in these two conditions. The presence and location of optic nerve enhancement and the pattern of cerebral white matter lesions seem to be the most determining MRI parameters in these cases.

Conclusion: Intra-orbital enhancement may be in favor of ON. However, if there is any enhancement in NAION, it might be observed in the head of the optic nerve. Further prospective studies are needed to better clarify the details of MRI findings.

Keywords: Non-arteritic anterior ischemic optic neuropathy (NAION), Magnetic resonance imaging (MRI), Orbit, Optic neuritis

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Highlights

- In some cases, differentiation of NAION and ON could be challenging.
- Few studies have compared MRI findings in these two diseases.
- In addition to PCE of the optic nerve, which is more frequent in ON than NAION, the location and characteristics of enhancement may help differentiate between them.
- The enhancement of the optic nerve head (central bright spot sign) could favor NAION diagnosis.
- Positive findings in DWI and PCE MRI may predict ON in one study, but were not confirmed in another study.

Introduction

Non-arteritic anterior ischemic optic neuropathy (NAION) is the second most common optic neuropathy in adults [1]. Optic neuritis (ON) is another common cause of acute optic neuropathy, which often occurs under the age of 50 and could be related to demyelinating disorders. Clinical discrimination of these two optic neuropathies can sometimes be very challenging. The diagnostic dilemma increases when no cerebrovascular risk factors favor NAION, and brain magnetic resonance imaging (MRI) appears normal. Previous studies have shown that the simultaneous presence of white matter hyperintensities in T2 brain MRI with a demyelinating pattern can guide the clinician to diagnose ON. At the same time, NAION is more likely to occur in white matter lesions with the features of microangiopathic and cerebrovascular small vessel disease [2-5].

Early differentiation between the two entities is critical for effective management, prognosis, and future treatment planning. Despite advances in MRI techniques and well-described MRI characteristics of ON, its role in NAION has been less considered. MRI criteria for differentiating one from the other have not been described in the medical literature.

Herein, we aimed to review the current studies considering MRI characteristics that help to differentiate NAION from ON. We searched all studies that used the keywords to compare MRI findings in AION and ON. PubMed, Scopus, and Google Scholar search engines between 1990 and December 2024 were searched, and their outcomes were evaluated, subtracted, summarized, and then categorized.

Current evidence

NAION and ON could present with acute vision loss, but the pathophysiology of vision loss differs in each one. ON is immune-mediated and related to inflammatory and or demyelinating mechanisms. NAION is presumed to be caused by a circulatory insufficiency or an interruption of the blood flow to the optic nerve [1]. MRI characteristics of ON have been well described in the literature, with enhancement and signal tau inversion recovery (STIR). The optic nerve signal abnormalities often involve long segments of the intra-orbital nerve with occasional intracranial extension [6]. In contrast, the MRI characteristics of NAION have been less described. Recently, some studies have compared MRI parameters between ON and NAION patients and suggested that MRI may be useful in distinguishing equivocal cases. Table 1 summarizes these findings.

Rizzo et al. first compared the MRI characteristics of NAION and ON in 2002 [7]. After excluding cases with giant cell arteritis and using a 1.5-Tesla scanner, they reported post-contrast enhancement (PCE) and abnormal STIR signal of optic nerve in 98% and 84% cases of ON, respectively (n=32). In addition, gadolinium enhancement and increased STIR signal were observed when coincidences were in the same region, except for one patient. In 56% of ONs, lesions occupied more than two-thirds of the intra-orbital optic nerve. By contrast, abnormal scans were seen in only 5 (out of 32) cases of NAION, with all 5 cases showing abnormal STIR signal, and only two patients had PCE. The authors concluded that MRI of the optic nerve helps to distinguish visual loss caused by ON from NAION. Consequently, the finding of PCE in 2 (out of 32) of NAIONs was argued by Lee AG [8]. He reported the enhancement of optic nerve in arteritic AION (A-AION) previously [9] and suggested an alternative diagnosis for those two cases of

NAION with optic nerve enhancement. Then, authors replied that their observed enhancement in NAIONs was slight and subtle [10].

In 2017, Remond et al. reported focal areas of enhancement in the optic nerve head of all A-AION (15/15) and 7/15 patients with NAION in a prospective survey called "central bright spot sign." This difference was statistically significant, and they concluded that patients without this sign always had a non-arteritic pathophysiology [11]. Recently, in a systematic review of orbital MRI findings in patients with giant cell arteritis and ocular manifestations, the most prevalent regions of enhancement were optic nerve sheath (53%), intraconal fat (25%), and optic nerve/chiasm (14%). MRI has been suggested as an adjunct diagnostic tool [12].

Several studies evaluated diffusion-weighted imaging (DWI) in ischemic optic neuropathies; however, they were non-comparative or had insufficient patients. In 2017, a comparative study conducted by Adesina et al. retrospectively evaluated MRI of NAION and ON patients (n=62 and 27, respectively) [13]. They found positive DWI signal (focal restriction) in 19% of NAIONs and 44% of ONs (P=0.02) and PCE in 39% and 81% of NA-AIONs and ONs, respectively (P<0.001). PCE in NAION patients was more frequent at the optic disc (32%) compared with the intra-orbital segment of the optic nerve (7%), and was bilateral in three patients. The authors suggested that the characteristics of PCE and DWI may help differentiate these two entities. However, they noted that PCE and DWI signals of the optic disc alone did not discriminate between NAION and ON. Positive findings in both DWI and PCE at the intra-orbital segment were predictive of ON over NAION.

Petroulina et al. included both non-arteritic and arteritic AION patients (n=28) and ON (n=22) in a retrospective study [5]. They evaluated MRI findings in different locations of optic nerve and found that PCE of optic nerve was more frequent in ON (77.3% in ON versus 17.9% in AION, P<0.001), while PCE of optic nerve head, bright spot sign, was more frequent in AION than ON (60.7% versus 22.7%, P=0.01). In addition, DWI restriction at different locations (intra-orbital, intraconal, prechiasmal, optic nerve sheath, and perineural fat tissue) was not significantly different between AION and ON. They conducted a model for testing the diagnostic accuracy of parameters to predict the diagnosis and found that DWI added no further useful data. However, the distribution of cerebral T2-hyperintensities, the presence and location of optic nerve enhancement, and the 'central bright spot' sign had good accuracy for the discrimination of AION from ON.

The imaging findings at the optic nerve head in NAION patients in Adesina et al. and Petroulia et al. might be related to the lamina cribrosa (LC) structure. Figure 1

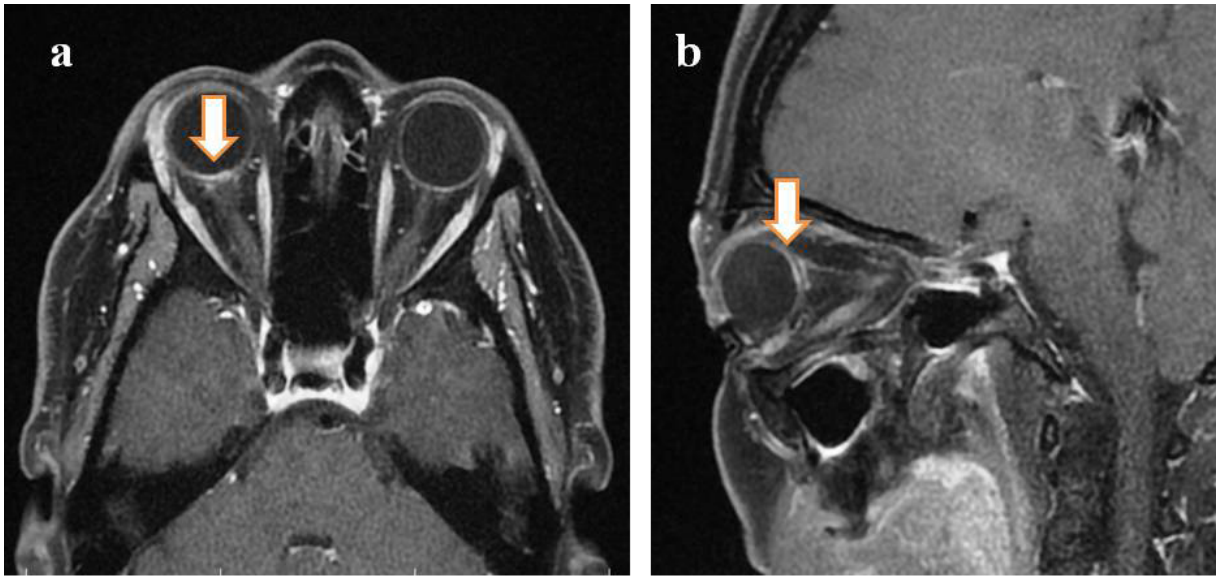

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Figure 1. Three-Tesla post-contrast T1 fat-suppressed orbital MRI in axial (a) and sagittal (b) Views in a patient with non-arteritic ischemic optic neuropathy

Note: White arrows indicate the bright spot sign and lamina cribrosa enhancement in a and b, respectively.

Table 1. MRI characteristics to differentiate non-arteritic ischemic optic neuropathy from optic neuritis

Ref.	NAION*					ON				
	Mean Age of Patients (y)	PCE	STIR Increased Signal	DWI Restriction	White Matter Abnormalities**	Mean Age of Patients (y)	PCE	STIR Increased Signal	DWI Restriction	White Matter Abnormalities
Rizzo et al. 2002 [7]	33 (16-59)	2/32	5/32	-------	20/32	62 (38-78)	30/31	27/32	------	21/32
Adesina et al. 2017 [13]	53.6±9.4	24/62 (39%)	------	12/62	-------	37.5±12	22/27 (81%)	------	12/27	------
Petroulia et al. 2023 [5]	62.47±9.99	5/28 (17.9%)	-------	0/28 (0.0%)	Microangiopathic 11/28 (39.3%) Demyelinating 2/28 (7.1%)	41.34±14.05	17/22 (77.3%)	-------	2/22 (9.1%)	Microangiopathic 0/22 (0.0%) Demyelinating 10/22 (45.5%)

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Abbreviations: NAION: Non-arteritic anterior ischemic optic neuropathy; ON: Optic neuritis; DWI: Diffusion-weighted imaging; PCE: Post-contrast enhancement; STIR: Signal tau inversion recovery.

*Petroulia et al. included both NAION and arteritic AION. DWI restriction in the intracranial region was depicted,**Rizzo et al. did not specify the pattern of white matter abnormality.

shows a high-resolution (3-Tesla) orbital MRI of one of our patients diagnosed with NAION. The observed enhancement in the optic nerve head could be attributable to LC. Lamina cribrosa is a mesh-like structure at the optic nerve head that allows retinal ganglion cell axons to pass through the sclera. LC enhancement in NAION could result from edema following the ischemic insult. In the brain, ion (Na^+, Cl^-) channels are damaged quickly after ischemia, and there is an intracellular cytotoxic edema. Then, extracellular ionic and vasogenic edema (extravasation of plasma protein) occurs [14]. As the optic nerve is a part of the central nervous system, a similar mechanism may be involved in the pathophysiology of NAION, which could explain the extravasation of contrast and subsequent enhancement of ischemic edematous LC. This finding contrasts with enhancing patterns of optic neuritis, in which the optic nerve short or long segment or chiasma enhancement was often seen [6].

Conclusion

When the clinical diagnosis of NAION and ON is doubtful in patients with acute vision loss, MRI findings may aid in proper diagnosis. The presence and location of optic nerve enhancement seem to be the most important factors. Intra-orbital enhancement may be in favor of ON. However, if there is any enhancement in AION, it will be observed in the head of the optic nerve. However, further prospective studies are necessary to confirm the insufficient existing evidence. LC enhancement in high-resolution orbital MRI needs further surveys. Future studies of NAIONs could expand the insights into the underlying pathophysiology and treatment options regarding high-resolution MRI.

Study limitations

As the diagnosis of NAION is mainly clinical, data regarding MRI findings in AION are scant. The comparative studies of MRIs in AION and ON were retrospective. Some included brain MRI, which may not be sufficient for detailed orbital evaluation, and some patients had received steroid pulse before their MRI studies. Finally, arteritic and non-arteritic AIONs, which may have different MRI findings, are not separated in one study.

Ethical Considerations

Compliance with ethical guidelines

We presented a balanced overview of existing research to avoid bias and selective reporting. To avoid misleading conclusions, we ensured all referenced studies, including their limitations, are correctly cited.

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Conflict of interest

The author declared no conflict of interest.

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