Original Article

Macular star formation in diabetic patients with non-arteritic anterior ischemic optic neuropathy (NA-AION)

CrossMark

Alberto Galvez-Ruiz

Abstract

Background: NA-AION is a condition that exhibits a number of unique characteristics in diabetics compared with the rest of the population. In some diabetic patients with NA-AION, lipid deposits can be observed around the macula forming an incomplete macular star.

Methods: We describe 12 case studies of patients with NA-AION observing the development of lipid deposits around the macula forming an incomplete macular star.

Results: All our patients developed some level of lipid deposits around the macula in the form of a macular hemistar in the course of their illness.

Conclusion: Some authors have suggested that the macular star is formed by transudation from capillaries deep in the optic disk through the intermediary tissue of Kuhnt, which is located between the retina and the anterior portion of the lamina retinalis. However, the development of the macular star is currently understood not as a simple transudation but as a multifactorial process involving the presence of vascular damage around the optic disk, which is considered one of the most important factors leading to its occurrence.

Although some studies mention the presence of a macular star in patients with NA-AION, we believe that this phenomenon may be significantly more common than the current literature suggests.

Keywords: Non-arteritic anterior ischemic optic neuropathy, Lipid deposits, Macular hemistar, Diabetes mellitus, Neuroretinitis, Macular edema

Introduction

One of the risk factors for the development of non-arteritic anterior ischemic optic neuropathy (NA-AION) is the presence of diabetes mellitus (DM).[1–3]

NA-AION does not appear to have a worse prognosis in diabetic patients compared with non-diabetics in terms of visual acuity (VA) and visual field impairment at 6 months after onset.[1]

However, NA-AION does exhibit some peculiar characteristics in diabetic patients:

- involvement or recurrence of NA-AION in the contralateral eye is more common in diabetics.[1]

- clinical detection of incipient NA-AION (i.e., in the asymptomatic phase for the patient) is more common in diabetics.[1]
- in diabetics, optic disk edema takes longer to resolve than in non-diabetics.[1]
- optic disk edema in diabetics with NA-AION is characteristically associated with the presence of prominent telangiectasias and more abundant retinal hemorrhages compared with non-diabetics.[1]

All of these features lead us to the conclusion that NA-AION is a condition that manifests unique characteristics in diabetics relative to the rest of the population.

Neuro-ophthalmology Division, King Khaled Eye Specialist Hospital, Riyadh, Saudi Arabia
e-mail address: algarui@yahoo.com

Production and hosting by Elsevier

In some diabetic patients with NA-AION, lipid deposits can be observed around the macula forming an incomplete macular star. Usually, these exudates appear when the optic disk swelling begins to resolve, and they are not typically present during the period of acute VA loss.[4–6] Although some studies mention the presence of a macular star in patients with NA-AION, we believe that this phenomenon may be more common than has been previously reported in the literature.

We present a series of 12 clinical case studies of patients with NA-AION in whom the presence of an incomplete macular star was detected.

Clinical case studies

We present 12 patients with NA-AION who developed lipid deposits around the macula in the form of a macular hemistar over the course of their illness. Table 1 describes the following clinical characteristics for all patients: age, gender, the presence of unilateral or bilateral NA-AION, the existence of vascular risk factors, such as diabetes mellitus or hypertension, VA in the acute phase and after patient follow-up, color vision, visual field testing results, the onset of macular star formation, the presence of diabetic retinopathy, and cranial and orbital MRI findings.

Mean age of patients in our series was 55 years, with an age range of 43–73 years. 5 patients out of 12 presented with bilateral NA-NAION, calling attention to the fact that in two cases the clinical presentation was simultaneous in both eyes.

It was striking to find cases of bilateral NA-AION in which the macular star was only observed in one eye (patients 2, 11 and 12). If the development of lipid deposits is related to vascular involvement around the optic disk (as will be argued in the discussion), then it would be assumed a priori that the microvascular involvement would be symmetrical in both eyes, with the symmetrical development of macular lipid deposits.

All of the patients were diabetic, except patient 10, who was only hypertensive. In all patients, the macular star was incomplete (hemistar). 6 patients in our study had NPDR (non-proliferative diabetic retinopathy) and 6 other patients had no DR (diabetic retinopathy). Regarding the presence of vascular risk factors, 7 patients out of 12 had hypertension.

The initial mean VA of our patients was 20/300 (considering only the affected eye). The VA improved significantly in 4 patients after several months of development, remaining without significant changes in the rest of patients. The average follow-up time for our series was 7.4 months with a range of 4–12 months. Regarding the color vision measured with the Ishihara test, there was a great variability in the eyes with NA-NAION with a range from 0/15 to 15/15 and an average of 2/15.

It was also observed a large variability in the visual field defects in the affected eyes: 2 patients had superior altitudinal defect; 5 patients, inferior altitudinal defect; 2 patients, central scotoma; 4 patients with inferior-nasal defect and two patients with residual islet.

The time required for the formation of the macular star in the series presented varied between 1 week and 8 weeks. In this regard, one important limitation of our study should be mentioned: we considered the time of the macular star's appearance to be the first visit at which it is detected. How-

ever, it is possible that lipid deposits may have already been present prior to the visit. In fact, there were cases in which the macular star was already disappearing when it was first observed (patients 2, 5, 6 and 8).

Fig. 1 shows the fundi in patients 1–12.

Only one patient experienced neurosensory elevation or ophthalmoscopically observed detachment due to the accumulation of subfoveal fluid (patient 12). These findings were confirmed by performing optical coherence tomography (OCT) (Fig. 2).

Discussion

In this paper, we presented a clinical series of 12 patients with NA-AION in whom lipid deposits were detected around the macula during the clinical course of their disease (usually coinciding with the resolution of the optic disk edema) forming an incomplete macular star or a hemistar.

To start with this discussion we will comment the frequency of the possible etiologies that may be responsible for the pattern of optic disk edema with macular star, Chang et al.[7] published a report of a series of 173 eyes presenting with optic neuropathy of different etiologies. Only 23 had macular lipid exudates accompanying optic disk edema. Of these 23 eyes, 15 had neuroretinitis, 6 had NA-AION, and 2 were secondary to papilledema. Particularly for the NA-AION group, these authors found a clear correlation between macular star appearance and the age of patients as well as the existence of diabetes mellitus (DM) and arterial hypertension. It is also noteworthy that there was no worsening of VA secondary to the presence of lipid exudation in this study. This result suggests that decreased VA is due to the presence of optic nerve involvement but not to lipid exudates.

In our series, it was difficult to establish a relationship between the macular star and the deteriorating VA, mainly because VA varies greatly in NA-AION, and in many cases, VA is not recovered. The most common visual field defect in patients with NA-AION is an absolute inferonasal defect followed by a relative inferior altitudinal defect.[8] We suggest that if parafoveal lipid deposits cause visual field changes, these would have to consist of a central defect. In this regard, of the cases presented, 9 eyes (patients 1, 2 left eye, 3 right eye, 4, 5, 7, 8, 11 and 12) had visual field defects typical of NA-AION, and only 4 eyes (patient 2 right eye, 3 left eye, 6 and 10) had absolute central defects. Thus, we can conclude that only 4 eyes in our series (30.7%) could hypothetically have visual field defects attributable to the presence of lipid deposits.

Between the different etiologies mentioned before, the association of optic disk edema and lipid deposits in the form of a macular star occurs mainly in a condition called neuroretinitis. This condition may be idiopathic or secondary to syphilis, cat-scratch disease (CSD), Lyme disease and toxoplasmosis (although there is a long list of infectious agents listed as potential pathogenetic agents in different studies).[9–11]

In neuroretinitis, the primary process involves optic nerve inflammation causing a secondary lipid exudate in the macula (although there are cases of genuine retinitis, especially in CSD).[9,12] Lipid deposits are often not evident initially but develop approximately 9–12 days after the appearance of the optic disk edema.[9,12]

Table 1. This table describes the following clinical characteristics for patients 1–12: age, gender, the presence of unilateral or bilateral NA-AION, the existence of vascular risk factors, such as diabetes mellitus or hypertension, visual acuity in the acute phase and after patient follow-up, color vision, visual field testing defects, the onset of macular star formation, the presence of diabetic retinopathy, and cranial and orbital MRI findings.

	Age/gender	NA-AION	DM	HBP	VA/Initial	VA/Final	Color vision	VF	Onset of Macular star formation (weeks)	Presence of diabetic retinopathy	MRI
1	72 years Male	Bilateral (sequential) RE 7/2011 LE 9/2011	+	−	1/200 1/200	1/200 1/200 Follow-up: 6 months	0/15 0/15	BE: inferior altitudinal defect	RE: 8 weeks LE: not present	No	Signs of chronic ischemia
2	73 years Male	Bilateral (simultaneous)	+	−	2/200 20/30	20/25 20/25 Follow-up: 1 year	1/15 15/15	RE: central scotoma LE: superior altitudinal central scotoma	RE: 3 weeks LE: not present	Yes (non-proliferative)	Normal
3	53 years Male	Bilateral (sequential) RE: 3/2011 LE: 3/1012	+	+	20/30 Hand movements	20/25 Counting fingers Follow-up: 1 year	1/15 0/15	RE: inferior nasal defect LE: residual temporal island	RE: ? (previous NA-AION episode) LE: 4 weeks	Yes (non-proliferative)	Signs of chronic ischemia
4	43 years Male	Unilateral RE: Old CRVO LE.	+	−	20/400 5-6/200	20/400 5-6/200 Follow-up: 6 months	0/15 0/15	RE: relative superior altitudinal defect LE: cecocentral defect	RE: 1 week	No	Normal
5	60 years Female	Unilateral LE	+	-	20/25 CF	20/25 CD Follow-up: 7 months	13/15 0/15	RE: normal LE: superior altitudinal defect	LE: 3 weeks	Yes (non-proliferative)	–
6	56 years Male	Unilateral LE	+	+	20/20 20/200	20/20 20/25 Follow-up: 1 year	15/15 0/15	RE: normal LE: cecocentral scotoma	LE: 4 weeks	No	Normal
7	52 years Female	Unilateral RE	+	+	20/300 20/60	20/100 20/25 Follow-up: 4 months	1/15 15/15	RE: normal LE: nasal and superior nasal scotoma	RE: 4–5 weeks	Yes (non-proliferative)	–
8	55 years Male	Unilateral RE	+	+	20/50 20/40	20/40 20/40 5 months	8/15 15/15	RE: inferior nasal absolute scotoma LE: normal	RE: 3 weeks	Yes (non-proliferative)	Ischemic lesions
9	54 years Male	Unilateral RE	+	+	20/200 20/20	20/80 20/20 Follow-up: 5 months	0/15 15/15	RE: central residual island (reliable?) LE: normal	RE: 4 weeks	No	–
10	52 years Male	Unilateral RE	−	+	2/200 20/20	2/200 20/20 Follow-up: 6 weeks	0/15 15/15	RE: central and superior altitudinal scotoma LE: normal	RE: 4 weeks	No	Ischemic brain changes
11	46 years Male	Bilateral RE 4/2011 LE 1/2013	+	+	1/200 20/20	20/400 1/200 Follow-up: 8 months	0/15 0/15	RE: inferior nasal defect LE: superior altitudinal defect. Concentric reduction	RE: 4 weeks LE: no development	Yes (non-proliferative)	–
12	44 years Male	Simultaneous bilateral RE/LE (RE probable diabetic papillopathy)	+	−	20/20 20/300	20/20 20/40 4-6 weeks	15/15 6/15	RE: normal LE: inferior altitudinal defect	RE: no development LE: 1 week	No	MRI: Normal OCT: neurosensory elevation LE

Abbreviations: NA-AION: non-arteritic anterior ischemic optic neuropathy; DM: Diabetes Mellitus; HBP: High blood pressure; VA: visual acuity; VF: visual field; MRI: Magnetic resonance imaging; RE: right eye; LE: left eye; BE: both eyes; CRVO: Central retinal artery occlusion; OCT: optical coherence tomography.
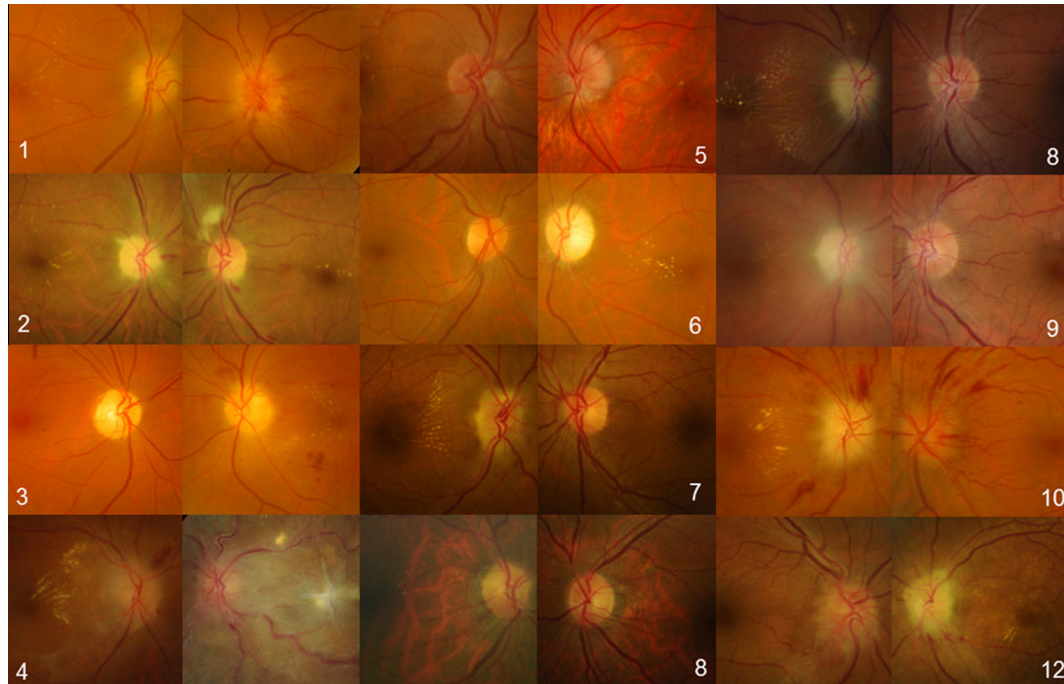
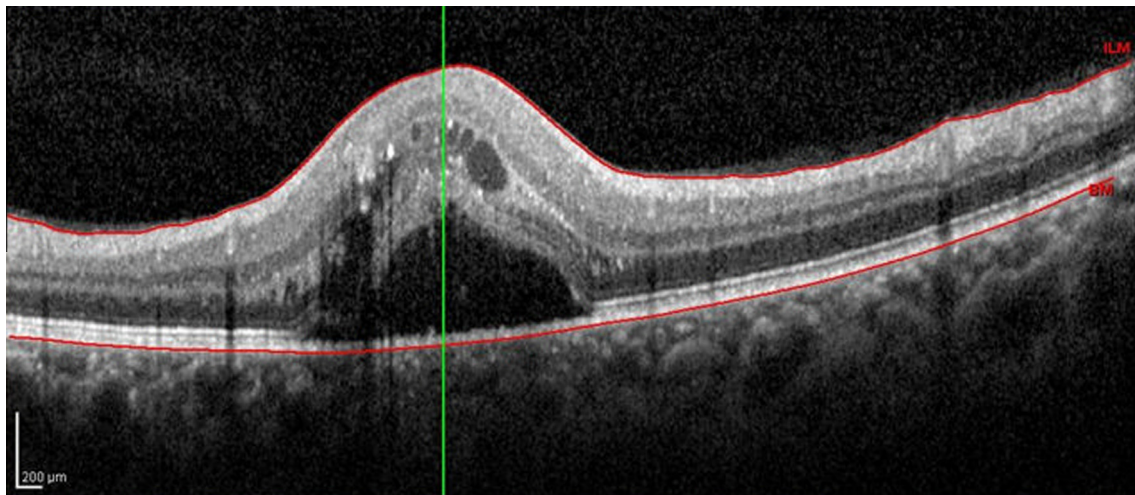**Figure 1.** Fundus appearance in patients 1–12.

Figure 2. Optical coherence tomography (OCT) showing neurosensory detachment due to subfoveal fluid accumulation in patient 12.

As mentioned in the results, in our study, the time to the formation of the macular star in the series presented varied between 1 week and 8 weeks. In this regard, one important limitation of our study should be mentioned: the time of onset of the macular star was considered to be the first visit at which it was detected. Therefore, it is possible that lipid deposits were present prior to the visit. In fact, there were cases in which the macular star was already disappearing when it is first observed (patients 2, 5, 6 and 8). In such cases, it was obvious that the onset occurred prior to the visit. Therefore, although our results appear to suggest that the macular hemistars in our series appeared later compared with the findings of Brazis et al. and Purvin et al. for patients with neuroretinitis [9,12], these results must be interpreted with caution.

Regardless of the exact timing of the macular hemistar formation, it is clear that its formation occurs only after the onset of optic disk edema. Therefore, its presence can be easily overlooked if a second fundus examination is not performed after the acute phase of NA-AION. The low frequency at which cases involving the formation of a macular star are reported in the scientific literature may be due not only to the fact that this condition is most likely not very common but also that it can be overlooked if a second fundus examination is not performed within the first weeks of its development.

In some patients, it is necessary to make a differential diagnosis between a macular star secondary to neuroretinitis (NR) and to NA-AION. This differential diagnosis is based mainly on the age of onset (younger patients in cases of

NR) and the presence of vascular risk factors. In addition, the occurrence of macular stars secondary to NA-AION is characterized by permanent visual field defects and a lack of VA recovery; these outcomes are in contrast to neuroretinitis, after which most patients have an excellent recovery. It is also worth mentioning that the macular star is not usually complete in patients with NA-AION, unlike in the cases of neuroretinitis.[12]

Perhaps this clinical series shows that if a diabetic patient presents with sudden VA loss, optic disk edema and incomplete macular star formation, it is most likely a case of NA-AION. In these cases, it would most likely be unnecessary to request laboratory tests to rule out infectious agents associated with neuroretinitis.

With regard to the etiopathogenesis it is hypothesized that macular stars form from the transudation of deep capillaries in the optic disk.[7,8] Such transudation occurs through the intermediary tissue of Kuhnt, located between the retina and the anterior portion of the lamina retinalis. Some authors have reported that this tissue functions as a blood-optic nerve barrier.[7,13,14] With the breakdown of this barrier, fluid transudation from the optic nerve would reach the macula, specifically the outer plexiform layer. As a result of the radial configuration of this layer, the star pattern[12] tends to occur. In some cases, fluid transudation can cause neurosensory detachment.[12] However, other factors have also been proposed that could favor macular star formation, including altering the barrier function of the border tissue of Elschnig, a lack of self-regulation of the short ciliary arteries, a high level of serum cholesterol, and the presence of retinal microangiopathy.[7,13]

Thus, although the development of a macular star can be understood not as simple transudation but rather as a multifactorial process, there is a consensus that one of the most important factors leading to its occurrence is the presence of vascular compromise around the optic disk. This process would partially explain why macular star occurs more frequently in diabetic patients with NA-AION.[7]

Regarding the limitations of this study, as we said before, it should be mentioned: the time of onset of the macular star was considered to be the first visit at which it was detected. Therefore, it is possible that lipid deposits were present prior to the visit.

Also, in only one of our patients was neurosensory elevation or detachment due to subfoveal fluid accumulation observed on OCT (patient 12). We recognize that OCT was not performed systematically on the remaining patients, and this was another limitation of the present study. However, no signs of subfoveal neurosensory detachment were observed ophthalmoscopically in the other patients.

In conclusion, in this study, we presented 12 patients with NA-AION (11 of whom were diabetic) in whom lipid deposits accumulated around the macula during the course of their disease, forming a macular hemistar. These findings reinforce the idea that NA-AION exhibits a number of unique characteristics in diabetics compared with the rest of the population. Moreover, although studies that mention the presence of a macular star in NA-AION have been published, we believe that this phenomenon may be more common than the current literature suggests.

Conflict of interest

The authors declared that there is no conflict of interest.

References

1. Hayreh SS, Zimmerman MB. Nonarteritic anterior ischemic optic neuropathy: clinical characteristics in diabetic patients versus nondiabetic patients. *Ophthalmology* 2008 Oct;**115**(10):1818–25.
2. Chen T, Song D, Shan G, Wang K, Wang Y, Ma J, et al. The association between diabetes mellitus and nonarteritic anterior ischemic optic neuropathy: a systematic review and meta-analysis. *PLoS One* 2013 Sep 30;**8**(9):e76653.
3. Lee MS, Grossman D, Arnold AC, Sloan FA. Incidence of nonarteritic anterior ischemic optic neuropathy: increased risk among diabetic patients. *Ophthalmology* 2011 May;**118**(5):959–63.
4. Hayreh SS. Ischemic optic neuropathy. *Prog Retin Eye Res* 2009 Jan;**28**(1):34–62.
5. Hayreh SS. Role of retinal hypoxia in diabetic macular edema: a new concept. *Graefes Arch Clin Exp Ophthalmol* 2008 Mar;**246**(3): 353–61.
6. Tomsak RL, Zakov ZN. Nonarteritic anterior ischemic optic neuropathy with macular edema: visual improvement and fluorescein angiographic characteristics. *J Neuroophthalmol* 1998 Sep;**18**(3):166–8.
7. Wang AG, Liu JH, Lin CL, Yen MY. Macular Star in optic neuropathy. *Ann Ophthalmol* 1995;**27**(2):107–12, SICI: 0003–4886(1995) 27:2.
8. Hayreh SS, Zimmerman B. Visual field abnormalities in nonarteritic anterior ischemic optic neuropathy: their pattern and prevalence at initial examination. *Arch Ophthalmol* 2005 Nov;**123**(11):1554–62.
9. Brazis PW, Lee AG. Optic disk edema with a macular star. *Mayo Clin Proc* 1996 Dec;**71**(12):1162–6.
10. Biancardi AL, Curi AL. Cat-scratch disease. *Ocul Immunol Inflamm* 2014 Apr;**22**(2):148–54.
11. Chi SL, Stinnett S, Eggenberger E, Foroozan R, Golnik K, Lee MS, et al. Clinical characteristics in 53 patients with cat scratch optic neuropathy. *Ophthalmology* 2012 Jan;**119**(1):183–7.
12. Purvin V, Sundaram S, Kawasaki A. Neuroretinitis: review of the literature and new observations. *J Neuroophthalmol* 2011 Mar;**31**(1):58–68.
13. Tso MO, Shih CY, McLean IW. Is there a blood-brain barrier at the optic nerve head? *Arch Ophthalmol* 1975 Sep;**93**(9):815–25.
14. Kitamei H, Suzuki Y, Takahashi M, Katsuta S, Kato H, Yokoi M, et al. Retinal angiography and optical coherence tomography disclose focal optic disc vascular leakage and lipid-rich fluid accumulation within the retina in a patient with leber idiopathic stellate neuroretinitis. *J Neuroophthalmol* 2009 Sep;**29**(3):203–7.