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# Impact of Acute Unilateral Anterior Ischemic Optic Neuropathy on Central Macular Thickness and Foveal Avascular Zone: An Optical Coherence Tomography and Angiography Study

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**Abstract:**

**Introduction:** Non-Arteritic Anterior Ischemic Optic Neuropathy (NAION) is a known ischemic change that causes changes in the optic disc. Fundus fluorescein angiography and field perimetry are useful in the diagnosis of NAION. Optical Coherence Tomography (OCT) and Optical Coherence Tomography Angiography (OCTA), are advanced non-invasive modalities that can be used to evaluate the structural and vascular changes at different retinal layers.

**Aim of the study:** To assess the impact of acute NAION on the central macular thickness and foveal avascular zone via OCT and OCTA during the acute phase (1-3 weeks from onset) before the resolution of disc edema.

**Subjects and Methods:** 30 patients with unilateral acute NAION presenting at the outpatient department at Fayoum University Hospitals were recruited. All cases (diseased and normal eyes) were examined using OCT and OCTA.

**Results:** showed a significantly lower CMT in diseased eyes after the resolution of edema. Reduction in FAZ was statistically non-significant.

**Conclusions:** We can take into consideration the quantitative differences in CMT during follow-up of the progression in NAION cases.

**Keywords:** Optical Coherence Tomography Angiography; Non-Arteritic Anterior Ischemic Optic Neuropathy; Optical Coherence Tomography; Edema.

## 1. Introduction

Anterior type of ischemic optic neuropathy (AION) is a known optic neuropathy characterized by severe, acute, painless visual loss. It is believed to be due to ischemic changes in the anterior segment of the optic disc. AION is subdivided into two types: an arteritic (AAION) and a non-arteritic (NAION) [1]. NAION is considered the most common optic neuropathy (other than glaucoma) above the age of 50 years. It represents up to approximately 85% of all AION cases. Pathogenesis is believed to be a result of hypoperfusion in short posterior ciliary arteries (PCAs) that can be due to systemic or local hypoperfusion [2].

NAION is usually related to arteriosclerosis, hypertension, diabetes mellitus, hyperlipidemia, hyper-homocysteinemia, nocturnal hypotension, sleep apnea and also the structural predisposition in a crowded disc and a small or absent cup. Vessel occlusion is distal to PCAs, affecting para-optic tributaries within the optic disc [1]. Patients are commonly discovered on awakening. On examination, visual acuity is moderately to severely impaired in around 70% of patients. In 30% of cases, visual acuity can be non-affected or only slightly diminished. The majority of cases show inferior altitudinal visual field defects but other pictures like central, para-central, quadrantic or arcuate defects can either be found [2].

OCTA is a trendy, non-invasive investigation which can demonstrate vessels of the retina and optic disc depending on blood flow. It can easily show microvasculature through the detection of blood flow motion contrast with no dye administered [3]. While FFA cannot provide enough demonstration of deep vasculature, OCTA is more efficient in showing macular and radial peri-papillary capillary network [4, 5], which originate from the central retinal artery (superficial plexus in addition to the deep ONH micro-vessels coming out from PCAs (deep plexus) [6].

## 2. Subjects and Methods

### *2.1 Subjects*

This series included thirty persons visiting the Ophthalmology outpatient department in Fayoum University Hospitals, complaining of acute N-AION between April 2021 and April 2022.

#### *Inclusion criteria*

Patients who are ≥40 years old, complaining of unilateral NAION with acute/ abrupt painless diminution of vision and a non-affected other eye.

#### *Exclusion criteria*

Patients diagnosed with AAION or NAION in the non-acute stage or acute N-AION beside another neuropathy affecting the other side were excluded from this study. Subjects that had cataracts or corneal opacities, high intraocular pressure (more than 22 mmHg), and errors >6 diopters were also excluded. Non-cooperative patients were not included.

### *2.2 Study design*

A prospective, observational, comparative study. Normal eyes on the other side were considered the control sample.

### *2.3 Statistical Methods*

This was done via SPSS (version 22; SPSS, Chicago, IL, USA). Data was reported as mean ±standard deviation values. Probability values <0.05 were assumed significant.

## 3. Results

On comparing the demographic characteristics of the patients, the mean age among the study group was (53.1 ±7.5) years old (ranging between 42 and 67 years). 60% were females. Regarding co-morbidities, 23.3% of cases were hypertensive, 16.7% were diabetic, and 13.3% of cases had both HTN and DM (**Table 1**).

**Table 1:** Analysis of demographic characteristics of cases.

| **Variable** | | **Frequency (n=30)** |
|---|---|---|
| Age (years) | Mean ±SD | 53.1 ±7.5 |
| | Range | 42-67 |
| Sex | Male | 12 (40%) |
| | Female | 18 (60%) |
| Co-morbidities | None | 7 (23.3%) |
| | Hypertension (HTN) | 7 (23.3%) |
| | Diabetes mellitus (DM) | 5 (16.7%) |
| | Both HTN & DM | 4 (13.3%) |
| | HTN, anemia, & thyroid | 2 (6.7%) |
| | Behcet's disease / HCV | 2 (6.7%) |
| | HTN – Cardiac disease | 2 (6.7%) |
| | Thyroid disease | 1 (3.3%) |

On analyzing the visual acuity, there was a highly statistically significant difference between diseased and normal eyes with a lower mean VA in the diseased group during all visits. Inside each group, changes in visual acuity over the three follow-up visits were insignificant. On the other side, there was no statistically significant difference as regards intraocular pressure (IOP) (**Table 2**).

**Table 2:** Comparison of IOP and VA between groups and inside each group.

| **Variable** | | **Diseased (n =30)** | **Fellow (n =30)** | ***P* -value** |
|---|---|---|---|---|
| **IOP** | | 14.63 ±2.3 | 14.6 ±0.7 | 0.9 |
| **VA** | 1st visit | 0.178 ±0.24 | 0.465 ±0.29 | <0.001* |
| | 2nd visit | 0.18 ±0.24 | 0.465 ±0.291 | <0.001* |
| | 3rd visit | 0.173 ±0.229 | 0.465 ±0.291 | <0.001* |

** Significant at p <0.05.*

CMT in OCTs of diseased eyes was significantly lower in the second and third visits. While in the first visit, CMT was insignificantly lower in diseased eyes. Inside the diseased group, we found a statistically significant drop in CMT during the second visit. During the third visit, no significant change was seen. The control group (normal eyes) had no significant change in all visits (**Table 3, Figure 1**).

**Table 3**: Comparison of OCT (CMT) changes in different study groups.

| Variable | | Diseased (n =30) | Fellow (n =30) | *P* -value |
|---|---|---|---|---|
| **CMT** | 1st visit | 261.43 ±44.49 | 253.73 ±42.02 | 0.5 |
| | 2nd visit | 237.37 ±23.25 | 251.13 ±27.53 | 0.04* |
| | 3rd visit | 235.47 ±23.45 | 250.6 ±27.18 | 0.02* |
| ***P* -value** | | 0.008*[a]<br>0.1[b] | 0.6[a]<br>0.08[b] | |

** Significant at p <0.05, a: change between 1st and 2nd visit, b: change between 2nd and 3rd visit*

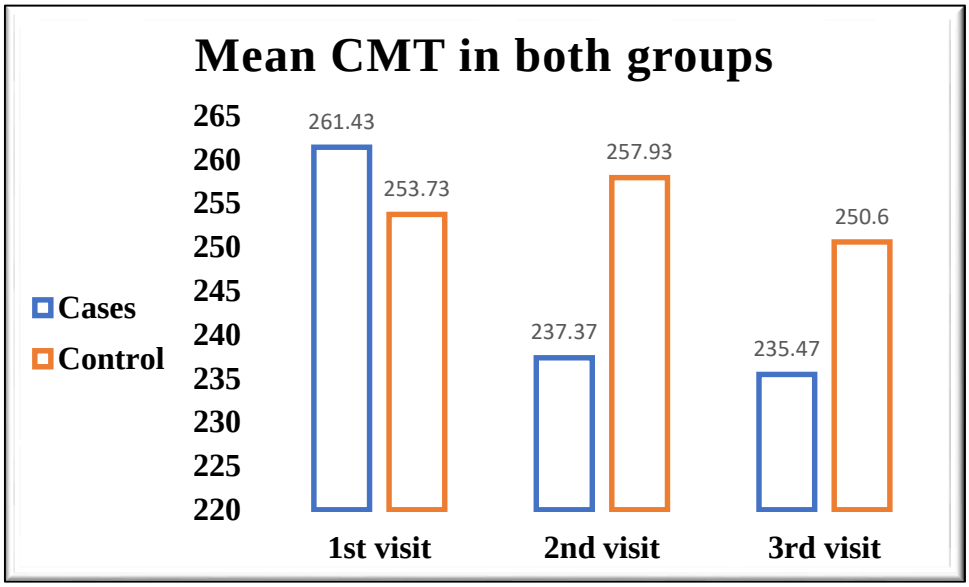


**Figure 1: Comparison of CMT between study groups.**

On Examining FAZ during all visits, a non-significant difference between case and control groups in all visits was observed. Changes in FAZ between consequent visits in both diseased and normal eyes were also non-significant (**Figure 2, Tables 4, 5)**.

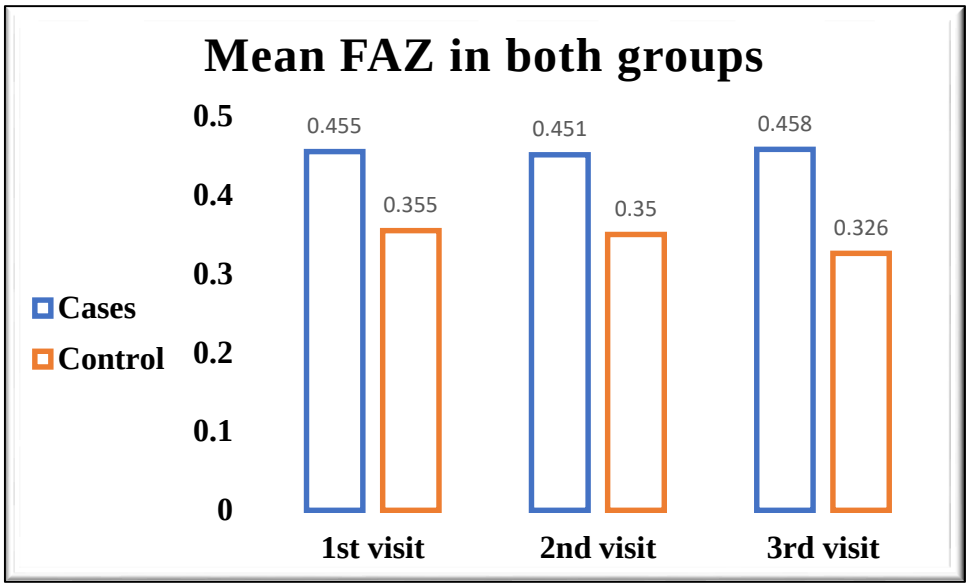


**Figure 2:** Comparison of mean FAZ in different study groups.

**Table 4:** Comparison of FAZ during follow-up in different study groups.

| Variable | | Diseased (n =30) | Fellow (n =30) | *P* -value |
|---|---|---|---|---|
| **FAZ** | 1st visit | 0.455 ±0.465 | 0.355 ±0.15 | 0.3 |
| | 2nd visit | 0.451 ±0.411 | 0.35 ±0.131 | 0.2 |
| | 3rd visit | 0.458 ±0.406 | 0.326 ±0.122 | 0.09 |

** Significant at p <0.05.*

**Table 5:** Comparison of FAZ follow-up inside each study group.

| Variable | | Diseased (n =30) | Fellow (n =30) |
|---|---|---|---|
| **FAZ** | 1st visit | 0.455 ±0.465 | 0.355 ±0.15 |
| | 2nd visit | 0.451 ±0.411 | 0.35 ±0.131 |
| | 3rd visit | 0.458 ±0.406 | 0.326 ±0.122 |
| ***P* -value** | | 0.7[a]<br>0.6[b] | 0.8[a]<br>0.1[b] |

** Significant at p <0.05, a: change between 1st and 2nd visit, b: change between 2nd and 3rd visit*

## 4. Discussion

NAION is known to be the most common acute optic neuropathy in patients above fifty years old [1].

On analyzing the demographic characteristics of our patients, the mean and range of age were not much different from most studies in the literature, but the female predominance found in this series was uncommon in other series. A systematic review and meta-analysis published in 2022 by *Khalili* et al. reported that only five out of the 26 studies included in the review had female predominance [6]. Although most publications have demonstrated no sex predisposition, one large case-control series found males to be more vulnerable to developing NAION [7].

Regarding co-morbidities, 23.3% of our patients had hypertension, 16.7% had diabetes mellitus, and both hypertension and diabetes mellitus were found in 13.3% of patients.

We found a statistically considerable drop of visual acuity (VA) in diseased eyes in all patients during all visits. The drop in visual acuity over time in diseased eyes was also significant. In contrast, we found non-considerable differences in intraocular pressure (I.O.P). This was found consistent with most studies in the literature [6, 7].

Apart from the first visit, analysis of CMT showed a significantly lower mean in diseased eyes. There was also a significant decrease in most OCTs of diseased eyes during follow-up. Fernández-Buenaga et al. (2009) did a cross-section study on 24 patients with unilateral NAION (eleven females, thirteen males; mean age was 64 ± 9 years) [7]. All subjects had a full examination. Normal and diseased eyes were scanned with Stratus OCT. Diseased eyes had considerably lower average CMT (195 ±26 μm) than non-affected eyes (209 ±23 μm) with a probability value of 0.023.

Our results found that differences in FAZ between case and control groups during all visits were non-significant with p-values >0.05. Changes inside each group between consequent visits were also non-significant.

Depending on our results, we can take into consideration the quantitative differences in CMT during follow-up of the progression in NAION cases. OCT and OCTA are fast and noninvasive investigations that can easily detect

structural defects and quantitative changes in vascularity, respectively. It can give data about vessels of the retina, choroid and optic disc via one scan.

## 5. Conclusion

We have used OCT for quantitative analysis and comparison of central macular thickness in affected and fellow eyes. Changes were recorded from the onset till 12 weeks in the case and control groups. The results showed significant thinning of CMT in diseased eyes after the resolution of edema. FAZ analysis showed no significant differences between diseased and normal eyes during all visits. Changes inside each group were also non-significant. Changes found in fellow normal eyes were not significant all over the follow-up period.

**Ethical committee approval:** This research has been granted the prerequisite acceptance from the Research Ethical Committee in the Faculty of Medicine, Fayoum University, Egypt. Participants were educated about the objectives, examination, investigations, confidentiality and their privilege to decline participation. Every patient has given an informed consent.

**Competing interests:** There are no conflicts of interest for the authors.

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