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# ORIGINAL ARTICLE

# Role of Optical Coherence Tomography of optic nerve in Diagnosis and Assessment of Degrees of Papilledema

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## ABSTRACT

**Keywords**: Optic nerve head (ONH), cerebrospinal fluid (CSF) and optical coherence tomography.

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Background: Head trauma, brain tumor, brain inflammation, subarachnoid hemorrhage, obstruction of cerebrospinal fluid (CSF) flow, decrease in CSF reabsorption, and idiopathic intracranial hypertension may all cause papilledema. **Objective:** to evaluate the possible role of optical coherence tomography in assessing different degrees of papilledema by measuring the thickness of the retinal nerve fiber layer. **Patients and methods:** Aswan University Hospital's departments of ophthalmology and neurosurgery collaborated on a prospective cohort research (diagnostic study), including 40 patients with (papilledema) in 80 eyes were studied from October 2020 to December 2021. **Result:** The mean Optical coherence tomography-nerve fiber layer (OCT_NFL) for the superior quadrant was 143.9 ± 57.4. Also, the mean OCT_NFL for the inferior quadrant ranged was 164.7 ± 110.6. Meanwhile, the average OCT_NFL for the nasal quadrant was 113.5 ± 478.9. Further, the mean OCT_NFL for the temporal quadrant was 83.9 ± 41.8. Respecting the severity of papilledema, about one-third of the eyes had mild (n = 27), 60% (n = 48) moderate, and 6.3% (n = 5) had severe papilledema. **Conclusion:** the OCT can be used to identify cases of severe papilledema (mild and moderate) with high confidence based on the thickness of the NFL.

## INTRODUCTION:

Edema of the optic disc, also known as optic disc swelling, is characterized by increased axon density and may affect one or both eyes [1]. Ophthalmologists play a critical role in the diagnosis and treatment of optic disc edema, a frequent clinical issue [2].

Papilledema, papillitis, and central retinal vein blockage are pathogenic processes that may lead to optic disc edema. It may also be classified into categories based on whether one side (unilateral) is involved vs the other or whether the two sides (bilateral) have a similar reason [3]. Careful history-taking and a comprehensive examination, focusing on the optic disc, are essential for determining the underlying cause [4].

Head trauma, brain tumor, brain inflammation, subarachnoid hemorrhage, blockage of cerebrospinal fluid (CSF) flow, reduction in CSF reabsorption, and idiopathic intracranial hypertension are all potential causes of papilledema, a specific form of optic-nerve-head (ONH) swelling caused by elevated intracranial pressure [5].

Clinicians often analyze the visual characteristics by directly examining the optic nerve head to determine the degree of papilledema. In the Frisen grading system, the clinician's opinion determines each of the six levels, from 0 (normal) to 5 (severe) [6].

It is important to tell the difference between actual (true) papilledema and false (pseudo) papilledema. Fundus examination and other clinical findings don't always indicate the correct diagnosis [7]. Once a diagnosis of papilledema has been made, whether a decrease in optic nerve edema is due purely to improvement in the nerve's health or if it signals a concurrent loss of axons and viable retinal ganglion cells, resulting in a poor visual outcome [8]. Pseudo papilledema may be distinguished from true papilledema with a fundus fluorescein angiography [9].

The new technique of optical coherence tomography (OCT) may be utilized to assess disc edema by measuring the condition's thickened retinal nerve fiber layer (RNFL) characteristic. It is a common method for diagnosing problems with the eye's optic nerve, retina, and macula without causing any discomfort to the patient. [10]. This study aims to evaluate the possible role of optical coherence tomography in assessing different degrees of papilledema by measuring the thickness of the retinal nerve fiber layer.

## PATIENTS AND METHODS:

This analytical Study (diagnostic study) was conducted on 40 patients with (papilledema) in the departments of Ophthalmology and neurosurgery at Aswan University Hospital from October 2020 to December 2021 and lasted fifteen months.

### Sample size calculation

Using G*Power 3 software for Windows, the sample was found to recruit a minimum number of 32 patients with papilledema to detect an effect size of 0.4 in the accuracy of optic disc OCT in diagnosing different degrees of papilledema, with an error probability of 0.05 and 80% power on a one-tailed test. The sample was raised by 20% to 40 cases for better statistical accuracy and robustness.

**Inclusion criteria:** We included patients with papilledema above the age of fifteen, with transparent media (able to perform OCT), and with a dioptric range of error in vision between(-5: +3).

**Exclusion criteria:** patients with other common causes of optic disc edema than papilledema, or with papilledema isn't the only factor that may cause disturbance of vision, patients with other diseases of the optic disc (drusen-myelinated nerve fiber), patients with any disorders of the eye that are linked to glaucoma, and diabetic retinopathy, patients with previous experience with laser treatment or ocular surgery, patients with media obscurities catch the eye, and patients with vascular disorders of the retina were excluded from the study.

## Methods

Patients who have been diagnosed with papilledema or who have symptoms that may point to the presence of papilledema and who visit an outpatient ophthalmology clinic or who are referred from the neurosurgery department undergo a comprehensive general and neuro-ophthalmology examination that includes a brain CT or MRI.

All patients underwent full history information, such as ages, races, genders, underlying ocular diseases, and prior ocular procedures, as part of the baseline information.

We did a complete eye exam, including measurement of the patient's best-corrected visual acuity, refraction assessment, examination of the pupil, color vision assessment, extraocular motility reporting, an examination of the anterior segment of the eye using a slit lamp, tonometry based on the Goldman applanation, dilated fundus examination using a +90 D noncontact lens was done to identify the Frisen grading system, which ranges from 0 (normal) to 5 (severe) [11]. MRI was performed on each and every patient.

**Ophthalmological examination included:**

**Visual field:**

Standard automated perimetry was carried out using the Swedish interactive threshold algorithm (SITA) 24-2 of the Humphrey field analyzer software (Carl Zeiss Meditec), Michigan, America, with the Goldman size III stimulus on a backdrop of 31.5 apostilbs.

Standard white-on-white threshold testing may be completed in two to four minutes using the Octopus 600 in the center visual field. This product is highly recommended because of its extensive test library for central tests such as G, 32, 30-2, 24-2, M, and 10-2, London, as well as its adaptable printouts in Octopus and HFA-format.

**Fundus photographs:**

The fundus fluorescein camera was used in order to get color fundus photography (TOPCON), TRC-NW300 Imagenet,Japanease,

**OCT**

**SD-OCT imaging,** which stands for spectral domain optical coherence tomography

The majority of patients were scanned using an SD-OCT system (RS-300, NIDEK), Japanese. After using an eye drop containing 1% tropicamide to enlarge the pupil, a single operator was responsible for acquiring the picture. A circular scan with a circle diameter of 3.4 mm was centered on the optic disc. An average of three successive OCT images of the RNFL were taken after the participant was instructed to stare at an internal fixation target. The RNFL analysis is carried out with a computerized OCT algorithm (NAVIS –EX VERSION 1.4.1 9). (NEDIK). The average peripapillary RNFLT (360), the average of the four quadrants, and other RNFL characteristics were assessed (superior, nasal, inferior, and temporal).

**Optovue iVue 100 OCT System SD-OCT Imaging, USA.**

Through SD-OCT pictures, quantitative measures, and an evaluation of the optic nerve head (ONH) and retinal nerve fiber layer thickness.

**Statistical analysis:**

Data were checked by the researchers and analyzed using IBM-SPSS 24.0 (IBM-SPSS Inc., Chicago, Illinois, USA). Means, standard deviations, medians, ranges, frequency, and percentages were computed. The NFL was normally distributed, so the one-way analysis of variance (ANOVA) test was carried out to assess the difference between the grades of papilledema regarding the NFL. Subsequently, a post-hoc test was carried out with Bonferroni corrections to make pairwise comparisons between the research groups. When the p-value was less than 0.05, it indicated a statistical significance.

**Ethical considerations:** the study protocol was approved by the research ethics committee of the faculty of Medicine of Aswan University.

**RESULTS:**

A total number of 80 eyes from 40 cases were recruited in the current study. The patient's age ranged between 17 and 57 years, with a median of 33 and a mean of 36.1 ± 9.9 years.

Of the sample, 8 (20%) cases were males, while 32 (80%) were females. Association with other systemic diseases was found free in 26 (65%), Diabetes Mellitus in 3 (7.5%), hypertension in 8 (20%), and both diabetes and hypertension in 3 (7.5%). In comparison, there was no association with other ocular diseases in all (100%) of the studied patients. The treatment modality line was medical treatment in 21 (52.5%) of the patients, while lumber puncture in 11 (27.5%), and shunt was used in 8 (20%) patients. The Ophthalmological examination of the studied sample is demonstrated in Table 1.

**Table 1: Ophthalmological examination of the studied sample**

| **Variable** | **n = 40** |
|---|---|
| **Laterality of papilledema**<br>• Unilateral<br>• Bilateral | <br>7 (17.5%)<br>33 (32.5%) |
| **BCVA**<br>• Mean ± SD<br>• Median (Range) | <br>0.72 ± 0.2<br>0.7 (0.2 – 1.0) |
| **IOP**<br>• Mean ± SD<br>• Median (Range) | <br>15.44 ± 2.2<br>15 (9 – 22) |
| **Colour Vision**<br>• Normal<br>• Affected | <br>77 (96.25%)<br>3( 3.75%) |
| **Pupil**<br>• Normal<br>• Relative afferent pupil defect | <br>35 (87.50%)<br>5 (12.50%) |
| **Ocular Motility**<br>• Normal<br>• Affected (limited in abduction (six nerve palsy) | <br>72 (90%)<br>8(10%) |
| **Papilledema Grade** | |

| | |
|---|---|
| • Mild(1,2)<br>• Moderate(3,4)<br>• Severe(5) | 27 (33.7%)<br>48 (60%)<br>5 (6.3%) |
| **Visual field**<br>• Enlarged Blind Spot<br>• Lower Hemi field Defect<br>• Inferior Defect<br>• Nasal Scotoma<br>• Altitudinal Defect<br>• Nerve Dysfunction<br>• Normal<br>• Total defect | <br>29 (36.25%)<br>3 (3.75%)<br>3 (3.75%)<br>4 (5%)<br>1 (1.25%)<br>5 (6.25%)<br>32 (40%)<br>3 (3.75%) |

The average values of NFL for the different quadrants are illustrated in Table 2.

**Table 2: Average Values of nerve fiber layer (NFL) in different quadrants:**

| OCT NFL | | n = 40 |
|---|---|---|
| **Superior** | • Mean ± SD | 143.92 ± 57.4 |
| | • Median (Range) | 136 (55 - 340) |
| **Inferior** | • Mean ± SD | 164.73 ± 110.6 |
| | • Median (Range) | 137 (28 - 417) |
| **Nasal** | • Mean ± SD | 113.54 ± 78.9 |
| | • Median (Range) | 89 (39 - 430) |
| **Temporal** | • Mean ± SD | 83.91 ± 41.8 |
| | • Median (Range) | 73 (34 - 258) |

The difference between papilledema grades regarding the nerve fiber layer in each quadrant is displayed in Table 3.

**Table 3: Comparison between different Papilledema Grades regarding the nerve fiber layer (NFL) measures in each region:**

| (Mean ± SD) | Mild (a) (n = 27) | Moderate (b) (n = 48) | Severe (c) (n = 5) | P-value* |
|---|---|---|---|---|
| **Superior** | 141.63 ± 37.5 | 151.88 ± 62.9 | 65.71 ± 9.5 | **= 0.041** |
| **P-value*****| **a vs b = 0.624** | **b vs c= 0.034** | **a vs c = 0.047** | |
| **Inferior** | 130.57 ± 32.1 | 190.09 ± 39.3 | 61.71 ± 9.2 | **= 0.045** |
| **P-value*****| **a vs b = 0.087** | **b vs c = 0.021** | **a vs c = 0.049** | |
| **Nasal** | 82.52 ± 20.7 | 134.66 ± 19.1 | 42.02 ± 2.6 | **= 0.019** |
| **P-value*****| **a vs b = 0.061** | **b vs c = 0.009** | **a vs c = 0.044** | |
| **Temporal** | 72.50 ± 7.4 | 92.24 ± 5.1 | 52.33 ± 2.8 | = 0.112 |
| **P-value*****| **a vs b = 0.109** | **b vs c = 0.066** | **a vs c = 0.207** | |
| | | | | |

***ANOVA test was used to compare the mean among groups**

****Post-hoc test with Tukey's Correction was used for Pairwise comparisons**

**Case presentation**

**Cases:**

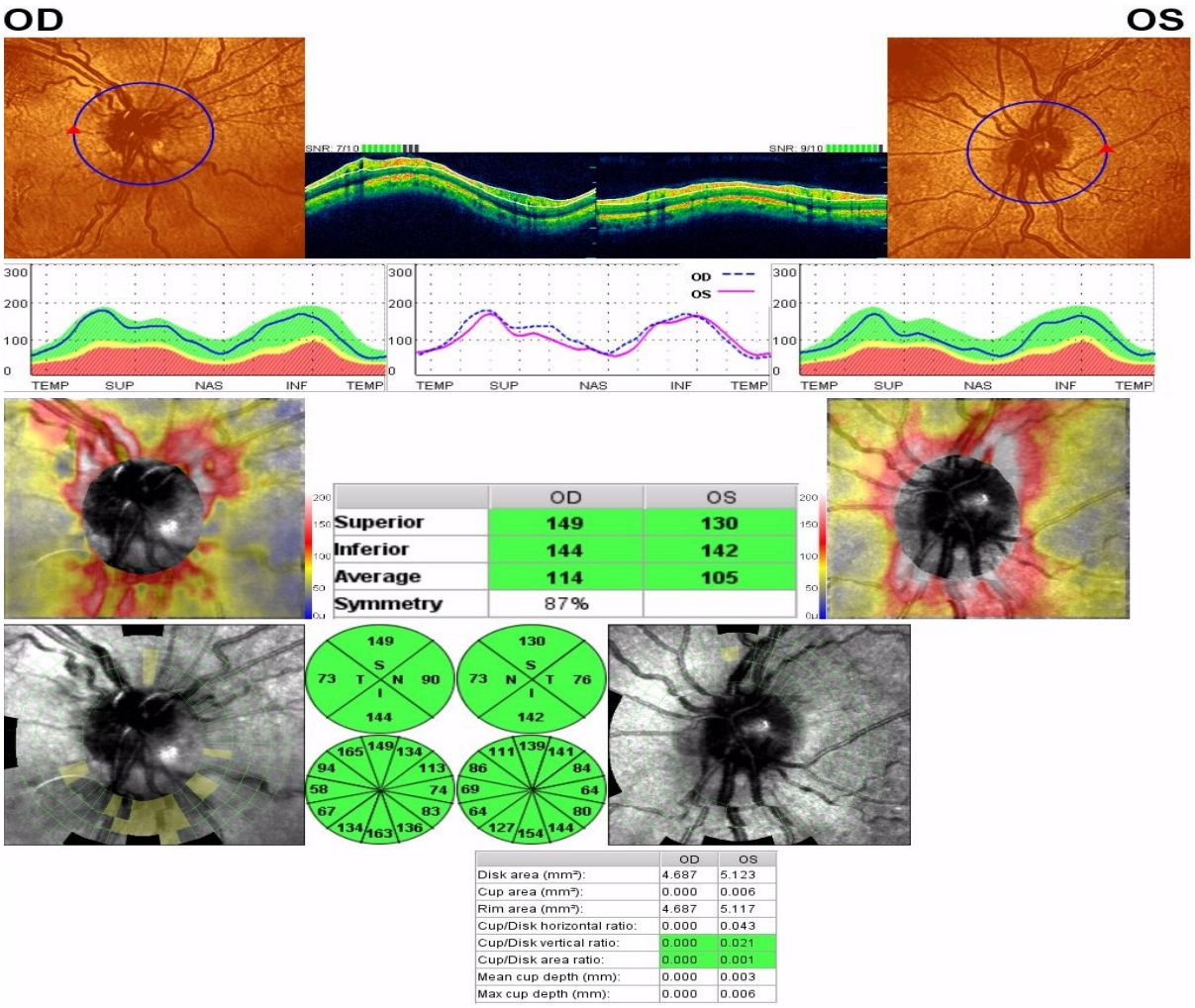


**Figure (1): Case 1**

Female, pt, 28y,

IOP: RT 13 LT12

V/A: RT 0.8 LT 0.8 BCVF: 0.9 0.9

Fundus examination :grade 1st papilledema (mild papilledema)

V/F: Within normal visual field.

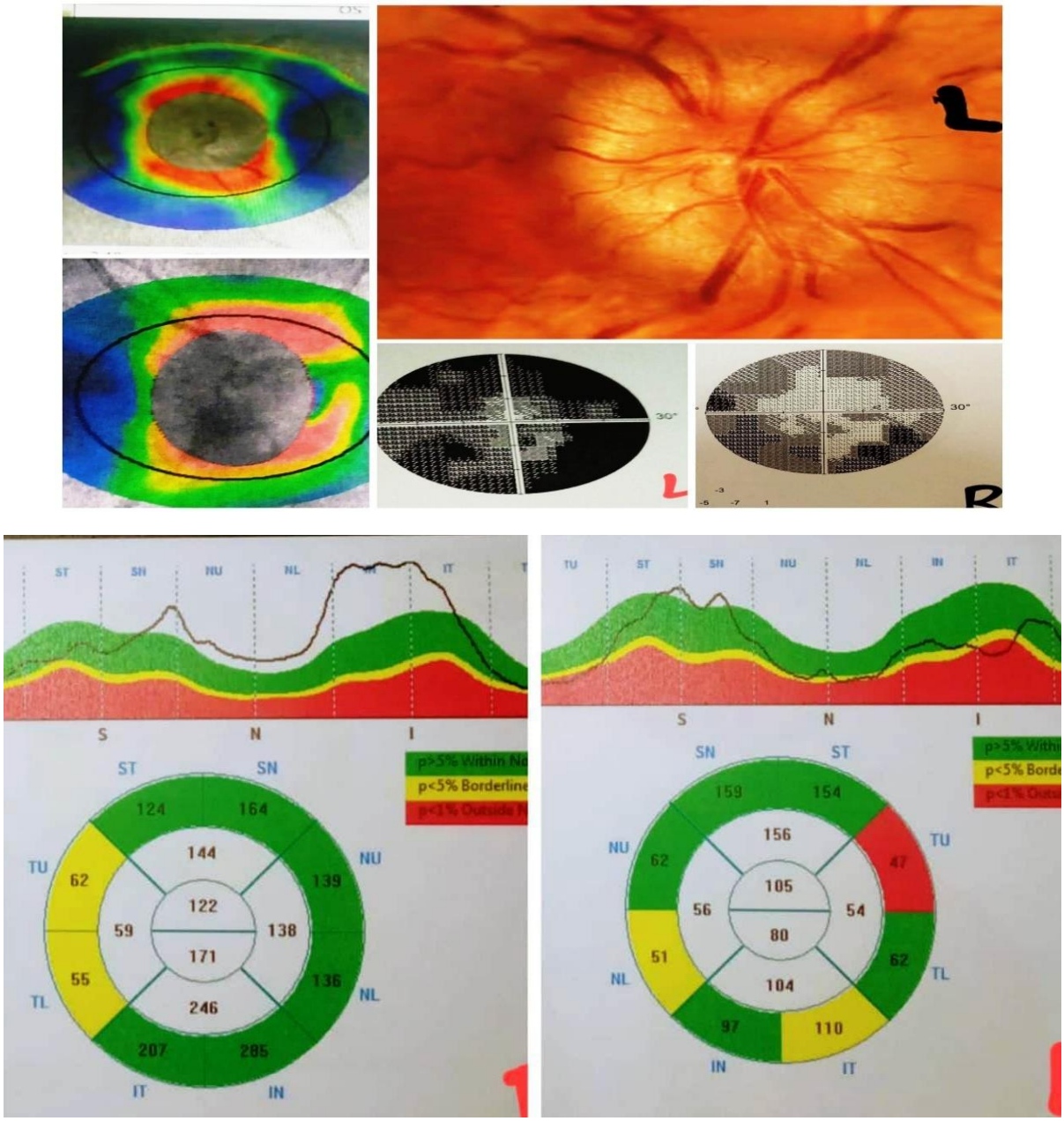


**Figure (2,a): Case 2**

Female pt, 48 y, IOP :Rt 14 Lt 12

V/A: Rt 0.2 Lt 0.1 BCVA:0.4 0.2

Pupil RRR

Fundus examination: bilateral 2nd to 3rd (moderate) papilledema.

V/F: Rt lower nasal scotoma

Lt nasal hemifield

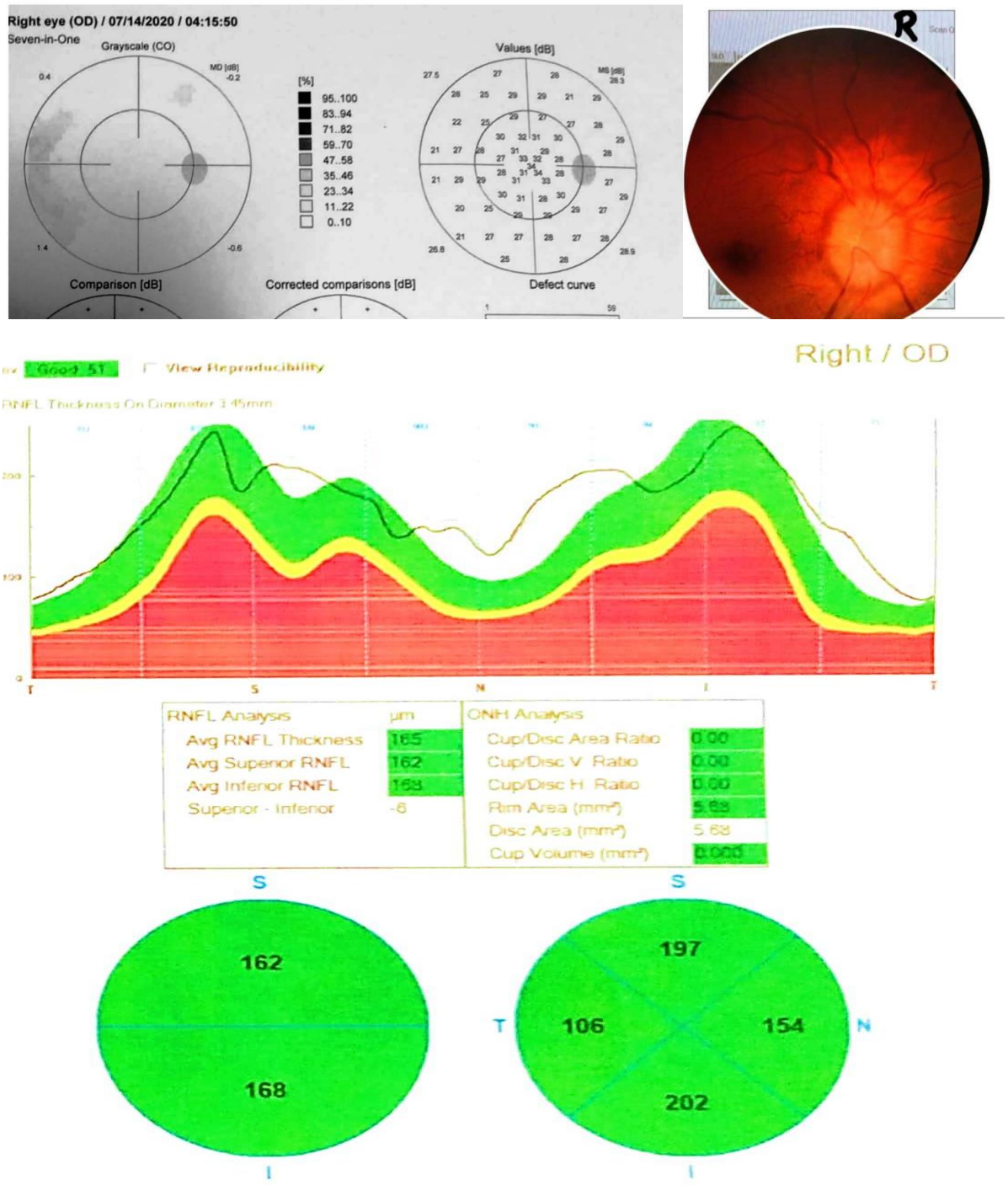


**Figure (2,b): Case 2**

**DISCUSSION:**

Papilledema is an ophthalmologic condition characterized by swelling of the optic disc due to elevated intracranial pressure [12]. Clinical presentations of papilledema include vision loss, headaches, and pulsatile tinnitus [13].

The Etiology of papilledema is quite heterogeneous; the primary cause of papilledema is increased intracranial pressure, which is often associated with conditions like idiopathic intracranial hypertension (IIH) [14].

Papilledema can also be secondary to other conditions, such as intracranial masses, craniosynostosis, or spinal ependymoma [15-17]. Moreover, papilledema can be the result of various space-occupying lesions, venous sinus thrombosis, or hemorrhage [18,19]. Complications of papilledema can have significant consequences, leading to optic atrophy and vision loss if left untreated. Complications related to the treatment of papilledema can also arise. For instance, intracranial venous sinus stenting for IIH may lead to complications such as stent stenosis, pseudoaneurysm, and hemorrhages [20].

Papilledema is typically graded using the Frisén scale, which provides a standardized method for assessing the severity of optic disc swelling due to increased intracranial pressure. The Frisén scale ranges from 0 to 5, representing a spectrum of papilledema severity. Grade 0 indicates a normal optic disc, while grade 5 signifies severe papilledema [21]. The grading is based on specific features observed during fundus examination or imaging, such as the extent of disc elevation, presence of peripapillary halo, and obscuration of blood vessels [22].

Diagnostic modalities for papilledema are essential for accurate identification and management. Multiple imaging techniques have been explored for their efficacy in detecting papilledema as well as its etiology. Magnetic resonance imaging (MRI) and magnetic resonance venography (MRV) are the most reliable diagnostic tools for conditions like cerebral venous thrombosis. They are particularly recommended during pregnancy [23]. Optical coherence tomography (OCT) is a noninvasive imaging modality with high resolution that can effectively differentiate between papilledema and pseudopapilledema by measuring the thickening of the peripapillary retinal nerve fiber layer [24].

OCT has shown good diagnostic accuracy in children and has emerged as a valuable predictive tool in diagnosing IIH, providing insights beyond traditional criteria [25,26]. Clinicians employ various diagnostic modalities, including fundus photography, OCT, and ophthalmoscopic examination, to assess and grade papilledema accurately. OCT provides detailed structural measurements such as peripapillary RNFL thickness, optic nerve head volumetric analysis, and macular anatomy, making it valuable in diagnosing and monitoring papilledema [27]

A total number of 80 eyes from 40 cases were recruited in the current study to evaluate the possible role of OCT in assessing different degrees of papilledema by measuring the thickness of the retinal nerve fiber layer. We analyzed retinal nerve fiber layer (NFL) thickness across different grades of papilledema in various optic nerve quadrants. The superior, inferior, and nasal quadrants all showed significantly reduced mean NFL thickness in severe papilledema grades compared to mild and moderate grades, with no notable difference between mild and moderate grades in these quadrants. The superior quadrant had mean NFL thicknesses of 65.7 ± 9.5 in

severe grades, 141.6 ± 37.9 in mild (p = 0.047), and 151.9 ± 9.5 in moderate (p = 0.034). The inferior quadrant showed mean thicknesses of 61.7 ± 9.2 in severe, 130.6 ± 32.6 in mild (p = 0.049), and 190.1 ± 39.3 in moderate (p = 0.021). The nasal quadrant exhibited mean thicknesses of 42.2 ± 2.6 in severe, 82.5 ± 20.7 in mild (p = 0.044), and 134.7 ± 19.1 in moderate (p = 0.009). However, a non-significant positive correlation was observed between papilledema severity up to moderate cases, shifting to a negative correlation in severe cases. This is likely due to severe papilledema leading to optic atrophy, resulting in reduced NFL thickness. On the other hand, the temporal quadrant did not show significant differences in mean NFL thickness across the three grades of papilledema. [28].

Our findings are partially consistent with the study by Allam et al. (2022), who investigated the relationship between NFL thickness and papilledema severity in patients with idiopathic intracranial hypertension. Allam et al. observed a significant positive correlation between NFL thickness and papilledema severity. However, a key difference lies in the definition of severe papilledema: Allam et al. classified it as Grade 3-4 on the Frisén scale, whereas we classified it as Grade 5. As a result, what we entitle as moderate papilledema matches with their mild and moderate categories, and our moderate group corresponds to their severe group. Allam et al. reported mean NFL thicknesses of 98.30 ± 24.97 for mild, 162.69 ± 36.96 for moderate, and 247.40 ± 37.69 for severe papilledema, indicating an increase in NFL thickness with greater severity. They also found a significant correlation between papilledema severity and NFL thickness all across the optic nerve, including the temporal quadrant [29]. Similarly, Vijay et al. (2020) demonstrated that OCT measures correlate with papilledema severity using the Frisén grading system [30]. Furthermore, Kwapong et al. (2023) found that during acute intracranial hypertension, NFL thickening correlates with intracranial pressure elevation and papilledema severity [31].

## CONCLUSION:

In conclusion, OCT can be used to identify cases of severe papilledema (mild and moderate) with high confidence based on the thickness of the NFL. However, it can't statistically differentiate between mild and moderate grades of the Frisén scale, but there was a clinically significant difference between mild and moderate when it was used alone or in correlation with OCT findings.

## RECOMMENDATION:

Further research with a bigger sample size is required to validate the possibility that the total retinal thickness measured by OCT may reveal a proportionately greater change per degree of disc edema than the RNFL thickness measured by OCT.

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