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CASE SERIES

Assessment and Grading of Papilledema Using Optical Coherence Tomography

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Abstract

Background: **There is a strong positive significant correlation between grades of papilledema by optical coherence tomography (OCT) and grades of papilledema by the modified Frisen scale.**

Aim: **To identify and correlate the role of coherent optical tomography imaging of the head of the optic nerve with the clinical grading of papilledema using Frisen scale via digital fundus photographs.**

Patients and methods: **This was a randomized study in which 40 patients were selected from the patients attending the outpatient neurology and ophthalmology clinics of Al-Azhar University Hospitals in Cairo between August 2021 and July 2022.**

Results: **The current study showed that the papilledema was distributed according to OCT into 10 (25%) patients with stage 1, 26 (65%) with stage 2, and four (10%) with stage 3. The papilledema was distributed according to modified Frisen scale into 10 (25%) patients with stage 1, 22 (55%) with stage 2, four (10%) with stage 3, and four (10%) with stage 4. There was a highly significant association and correlation between grades of papilledema by OCT and grades of papilledema by the modified Frisen scale ($P < 0.001$).**

Conclusion: **Clinical staging may be supplemented by current OCT measurement. OCT corresponds favorably with clinical staging of optic nerve images for lower-grade anomalies. OCT processing algorithms of thickness of the retinal nerve fiber layer frequently fail with higher grades.**

Keywords: Idiopathic intracranial hypertension, Modified frisen scale, Optical coherence tomography, Papilledema

1. Introduction

The term 'papilledema' describes swelling of the intraocular prelaminar part of the optic disc that rises from increased intracranial tension, transmitted by the cerebrospinal fluid placed within the sheath of retro-bulbar part of optic nerve.[1] The papilledema is mostly bilateral and can occur within hours to weeks. One-sided papilledema is very uncommon. The ballooning of the head of optic nerve is mostly bilateral in intracranial hypertension. Further examination is required when papilledema is discovered during a fundoscopy as failing to address the underlying problem could result in visual loss. Imaging of the brain and/or spine is often used mostly for additional examination.[2] Many imaging techniques have been incorporated to assess the optic disc in patients with papilledema. Using uniocular colored images of the fundus, papilledema can be classified by the Frisen scale by taking into account optical characteristics of the edges of optic nerve head and the discontinuity of blood vessels as they pass through the head of the optic nerve.[3] An edematous optic disc appearance has been recognized since the development of the ophthalmoscope as an acute sign of the disorders of the optic nerve, produced by different pathways such as optic disc drusen,

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demyelination, ischemia, infiltration, and intracranial hypertension. Despite the clear role of ophthalmoscopy in the clinical situations, it is restricted to qualitative assessment.[4]

This study aimed to correlate the role of the coherent optical tomography imaging of the optic nerve head with the clinical grading of papilledema using the Frisen scale via digital fundus photographs.

2. Patients and methods

It is a randomized study in which 40 patients were chosen for the study from the patients attending the outpatient neurology and ophthalmology clinics of Al-Azhar University Hospitals in Cairo between August 2021 and July 2022.

Ethical approval: approval of Departmental and Ethical Committees were obtained from quality education assurance unit, Faculty of Medicine, Al-Azhar University, Egypt.

Inclusion criteria were as follows: patients from either sex aged between 20 and 60 years old, patients with papilledema (due to IIH, idiopathic intra cranial hypertension), and with clear anterior segment media allowing clear fundus photography and optical coherence tomography (OCT) imaging. Exclusion criteria were as follows: any other causes of optic disc swelling such as optic disc drusen, anterior ischemic optic neuropathy, glaucomatous patients, neurodegenerative disorders that affect retinal nerve fiber layer (RNFL) thickness such as Parkinson's disease, multiple sclerosis, high hypermetropic patients, past history of uveitic attacks, and retinal dystrophies.

2.1. Methodology

Complete medical history including previous ocular trauma, medications, or surgeries was taken. Visual acuity assessment was done using Snellen's acuity chart and expressed in decimal notation. Ophthalmological examination included measurement of the intraocular tension using applanation tonometer of the Goldman, slit-lamp examination for evaluation of the anterior segment, fundus evaluation using bio-microscopy with slit lamp and 90 D power lens, coherent optical tomography of the head of the optic nerve, and digital fundus photographs.

2.2. Statistical analysis

The data collected were analyzed by SPSS (statistical package for social science), version 25 (IBM Corp., Armonk, New York, USA) on IBM compatible computer.

Table 1. Patient's demographic data.

	Patient group ($N = 40$) [n (%)]
Sex	
Female	34 (85)
Male	6 (15)
Age (years)	
Median (minimum–maximum)	31 (20–56)
Mean ± SD	36.08 ± 12.47
Eye laterality	
OD	20 (50)
OS	20 (50)

The study included eyes of 40 patients, distributed as 34 (85%) females and six (15%) males. Their median age was 31 years and ranged from 20 to 56 years with mean ± SD of 36.08 ± 12.47 years. In 20 (50%) patients, the right eye was examined, whereas in the other 20 (50%), the left eye was examined.

Table 2. Thickness of the layer of the nerve fibers of the retina and best-corrected visual acuity of patients.

	Mean	SD	Median	Minimum	Maximum
RNFL thickness	112.04	19.79	108.50	84.00	152.00
BCVA	0.78	0.16	0.80	0.50	1.00

This table shows that the RNFL thickness median was 108.5 and ranged from 84 to 152 with mean ± SD 112.04 ± 19.79, while the BCVA median was 0.80 and ranged from 0.50 to 1.00 with mean ± SD of 0.78 ± 0.16.
BCVA, best-corrected visual acuity; RNFL, retinal nerve fiber layer.

Table 3. Papilledema grading by optical coherence tomography.

Papilledema grade OCT	Frequency	Percent
Stage 1	10	25
Stage 2	26	65
Stage 3	4	10
Total	40	100.0

The table shows that the papilledema was distributed according to optical coherence tomography into 10 (25%) patients with stage 1, 26 (65%) with stage 2, and four (10%) with stage 3.
OCT, optical coherence tomography.

Table 4. Papilledema grading by the modified Frisen scale.

Papilledema grade MFS	Frequency	Percent
Stage 1	10	25
Stage 2	22	55
Stage 3	4	10
Stage 4	4	10
Total	40	100.0

The table shows that the papilledema was distributed according to modified Frisen scale into 10 (25%) patients with stage 1, 22 (55%) patients with stage 2, four (10%) patients with stage 3, and four (10%) patients with stage 4.

3. Results

There was a strong positive significant correlation between grades of papilledemaby optical coherence

Table 5. Association between grades of papilledema by optical coherence tomography and grades of papilledema by modified Frisen scale.

	Papilledema grade OCT				χ^2	*P*
	Stage 1	Stage 2	Stage 3	Total		
Papilledema grade MFS						
Stage 1						
n (%)	10 (25)	0	0	10 (25)		
Stage 2						
n (%)	0	22 (55)	0	22 (55)		
Stage 3						
n (%)	0	4 (10)	0	4 (10)	37.556	>0.001
Stage 4						
n (%)	0	0	4 (10)	4 (10)		
Total						
n (%)	10 (25)	26 (65)	4 (10)	40 (100.0)		

This table shows that there was a marked association between grades of papilledema by optical coherence tomography and grades of papilledema by modified Frisen scale ($P < 0.001$).
OCT, optical coherence tomography.

tomography and grades of papilledema by modified Frisen scale (Tables 1–8).

4. Discussion

Optic disc swelling occurs due to intracranial hypertension and can cause optic atrophy and loss of vision if kept without treatment. Sharp increase of intracranial tension may be caused by disorders such as trauma of the head, thrombosis of venous sinuses of the brain, or massive stroke. However, the commonest chronic etiologies are intracranial masses or idiopathic increased intracranial tension. The prevalence of idiopathic increased intracranial tension is estimated as one to three per 100 000 per year, and it often occurs in young, obese females. Papilledema, a healthy neurological state other than disorders of the cranial nerves, a healthy cerebral parenchyma on magnetic resonance imaging, a healthy composition of cerebrospinal fluid, and an opening fluid pressure more than 25 cmH_2O for confirmed IIH and more than 20 mmHg for suspected IIH are its diagnostic criteria.[1] It might be challenging to distinguish papilledema from pseudopapilledema or healthy optic discs in a clinical situations. The degree and characteristics of papilledema reflect potential intracranial tension conditions and stages of the underlying disorder.Consequently, methods that are noninvasive, accurate, and visualize the optic nerve objectively are required. Papilledema had previously been categorized into different stages by a grading system put out by Frisen scale. However, this scale is restricted by significant interrater and intrarater variability. By implementing OCT, the disadvantages of such subjective and discontinuous approaches can be eliminated. Although mainly integrated for macular disorders, its spectrum has developed to include degenerative disorders of the optic nerve and the visual pathway, including glaucoma, optic neuritis, and multiple sclerosis. The peripapillary RNFL has been the primary target for assessment of papilledema because optic disc swelling is more challenging to detect by coherent optical tomography. However, a volumetric

Table 6. Comparison of different stages of papilledema by optical coherence tomography regarding age, thickness of the layer of nerve fibers of the retina, and best-corrected visual acuity of patients.

Papilledema grade OCT	Groups			ANOVA test	
	Stage 1 ($N = 6$) (mean ± SD)	Stage 2 ($N = 18$) (mean ± SD)	Stage 3 ($N = 2$) (mean ± SD)	*F*	*P* value
Age	27.33 ± 7.39	36.78 ± 11.77	56.00 ± 0.00	5.523	0.011
RNFL thickness	89.50 ± 4.93	115.50 ± 14.80	148.50 ± 4.95	17.597	>0.001
BCVA	0.90 ± 0.11	0.78 ± 0.14	0.50 ± 0.00	7.137	0.004

The age and RNFL thickness in cases with papilledema were significantly increased and BCVA was significantly decreased as the stages of papilledema graded by OCT increased.
ANOVA, analysis of variance; BCVA, best-corrected visual acuity; OCT, optical coherence tomography; RNFL, retinal nerve fiber layer.

Table 7. Comparison of grades of papilledema by modified Frisen scale regarding age, thickness of layer of nerve fibers of the retina, and best-corrected visual acuity of patients.

Papilledema grade MF	Stages				ANOVA test	
	Stage 1 ($N = 6$) (mean ± SD)	Stage 2 ($N = 14$) (mean ± SD)	Stage 3 ($N = 2$) (mean ± SD)	Stage 4 ($N = 4$) (mean ± SD)	*F*	*P* value
Age	27.33 ± 7.39	32.79 ± 10.16	51.50 ± 2.12	53.00 ± 3.46	9.881	>0.001
RNFL thickness	89.50 ± 4.93	111.86 ± 12.62	120.5 ± 21.92	142.25 ± 9.64	17.007	>0.001
BCVA	0.90 ± 0.11	0.81 ± 0.13	0.70 ± 0.14	0.55 ± 0.06	7.800	0.001

The age and RNFL thickness in cases with papilledema were significantly increased and BCVA was significantly decreased as the stages of papilledema graded by MFS increased.
ANOVA, analysis of variance; BCVA, best-corrected visual acuity; RNFL, retinal nerve fiber layer.

Table 8. Correlation between grades of papilledema by optical coherence tomography and grades of papilledema by modified Frisen scale.

Studied parameters	Papilledema grade OCT	
	r	*P* value
Papilledema grade MFS	0.871	>0.001

There was a strong positive significant correlation between grades of papilledema by optical coherence tomography and grades of papilledema by modified Frisen scale ($r = 0.871$, $P \leq 0.001$).
OCT, optical coherence tomography.

evaluation may more accurately reflect morphologic alterations in the optic disc.[5] Coherent optical tomography is useful in assessment of different ophthalmic diseases such as glaucoma, diabetic retinopathy, cystoid macular edema, central serous retinopathy, and macular hole. Few studies denote the use of coherent optical tomography imaging in measuring the layer of nerve fibers of retina or total thickening of the retina in patient with papilledema.[6] The main goal of this work was to assess and compare the capabilities of coherent optical tomography and clinical evaluation in the diagnosis and grading of papilledema. This randomized study included 40 patients from the patients attending the outpatient neurology and ophthalmology clinics of Al-Azhar University hospitals in Cairo. Digital images of the head of the optic nerve of the right or left eye were chosen for comparison with coherent optical tomography imaging of the optic nerve head to correlate OCT results with clinical grading of papilledema using the modified Frisen scale. The duration of the study ranged from 6 to 12 months.

The main results of this study were as follows: the study included 40 patients distributed as 34 (85%) females and six (15%) males. Their median age was 31 years and ranged from 20 to 56 years with mean ± SD of 36.08 ± 12.47 years. In 20 (50%) patients, the right eye was examined, whereas in the other 20 (50%), the left eye was examined. Our results were supported by a study of Dreesbach et al.,[7] as they reported that the age of patients with intracranial hypertension was 30 ± 11 years (mean ± SD) and of the controls was 30 ± 10 years ($P = 0.34$). Overall, 95% of them were females ($P = 0.93$). The present study showed that the median RNFL thickness was 108.5 and ranged from 84 to 152 with mean ± SD of 112.04 ± 19.79, whereas the median best-corrected visual acuity was 0.80 and ranged from 0.50 to 1.00 with mean ± SD of 0.78 ± 0.16. Our results were supported by a study of Khalil and Labib[8] as they reported that although the initial average thickness of the nerve fiber layer of the retina was collectively much higher than that of healthy individuals, it was greater than average databases in 40% of cases, near average in 32% of cases, and less than normal in 28% of the cases. The current study showed that papilledema was distributed according to OCT into 10 (25%) patients with stage 1, 26 (65%) with stage 2, and four (10%) with stage 3. The papilledema was distributed according to modified Frisen scale into 10 (25%) patients with stage 1, 22 (55%) with stage 2, four (10%) with stage 3, and four (10%) with stage 4. There was a highly significant association between grades of papilledema by OCT and grades of papilledema by modified Frisen scale ($P < 0.001$). There was a strong positive marked association between grades of papilledema by OCT and grades of papilledema by modified Frisen scale ($r = 0.871$, $P < 0.001$). Our findings were supported by a study by Scott et al.[9] who found that, following the majority rule, of 36 individuals with papilledema, seven (19%) had grade 0, seven (19%) had grade 1, 10 (28%) had grade 2, four (11%) had grade 3, and eight (22%) had grade 4 − disc edema. However, in the study of Mohamed et al.,[10] seven (21%) had stage 1, 10 (30%) had stage 2, four (12%) had stage 3, and nine (27%) had stage 4. They noticed a significant association between the MFS and OCT results. The Spearman rank was 0.727 ($P = 0.0005$) when modified frisen scale (MFS) grade from images was compared with OCT RNFL thickness. The Spearman rank correlation between total thickness of the retina obtained by coherent optical tomography and MFS grade determined with photographs was 0.789 ($P = 0.0005$). Our results were supported by a study of Nguyen et al.,[11] as they reported that in comparison with the control and mild papilloedema (PO) groups, the mean thickness of the nerve fiber layer of the retina was considerably higher in the moderate–severe papilledema group ($P = 0.001$) than in either group. However, there was no large disparity between the mild PO group and the control group in the average RNFL thickness values ($P < 0.017$). The two-way analysis of variance showed an effect of group and of quadrant on the thickness of nerve fiber layer of the retina [$F(6, 129) = 20$, $P < 0.001$]. There was no dissimilarity in RNFL thicknesses between the mild papilledema group and the control group in each quadrant (temporal, $P = 1$, superior, $P = 1$, nasal, $P = 1$, and inferior, $P = 0.9$), despite the fact that mean thickness of the nerve fiber layer of the retina was much higher in the moderate–severe papilledema group than the mild papilledema group in all quadrants ($P = 0.001$) and in the control group ($P = 0.001$). Khalil and Labib demonstrated that in patients with increased intracranial tension, the initial thickness of nerve fiber layer of the retina was markedly

greater, whereas ganglion cell complex was markedly less than controls ($P = 0.045$ and 0.004, respectively). Intra cranial pressure (ICP) measurements and papilledema stage were shown to be strongly associated ($r = 0.494$, $P = 0.000$(. In the definitive data, the ganglion cell complex and nerve fiber layer of the retina values significantly decreased ($P = 0.000$ and 0.002, respectively) and the mean deviation significantly improved ($P = 0.003$). According to the study by Scott and colleagues, a significant association between the MFS and OCT findings was found. Spearman rank was 0.85 ($P = 0.001$) when MFS grade from photography was compared with OCT RNFL thickness (using the majority rule). Total thickness of the retina measured by coherent optical tomography and MFS degree from images had a Spearman rank of 0.87 ($P = 0.001$) when compared. Spearman rank was 0.79 ($P = 0.001$) and 0.83 ($P = 0.001$) for the latter during cross-check staging by one of us (Lee Frisen). Furthermore, the study by Mohamed and colleagues revealed significant correlations between coherent optical tomography measures of the thickness of the nerve fiber layer of the retina and total thickness of the retina and the MFS stage from pictures. They observed a significant association between the MFS and OCT results when grading papilledema. The Spearman rank was 0.727 ($P = 0.0005$) when MFS grade from photos was compared with OCT RNFL thickness. The Spearman rank correlation between coherent optical tomography measures of the total thickness of the retina and modified Frisen scale stage determined from pictures was 0.789 ($P = 0.0005$). Our study denotes that coherent optical tomography and modified Frisen scale are integral procedures that can be used for monitoring patients with papilledema. Coherent optical tomography measurements can be helpful in grading papilledema; for lower grades, OCT compares favorably with clinical staging using MFS, but for marked degrees, coherent optical tomography coding techniques of thickness of the layer of nerve fiber of the retina usually fail.

5. Conclusion

Clinical staging may be supplemented by current OCT measurement. OCT corresponds favorably with clinical grading of optic disc images for lower-grade disorders. Coherent optical tomography coding techniques of thickness of the layer of nerve fiber of the retina usually fail with higher grades.

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Consent statement

The nature of the study was clearly explained to each patient. An informed written consent was obtained.

Conflict of interest

There are no conflicts of interest.

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