Egyptian Journal of Ophthalmology (MOC) 2023;3(4):*202-210*

Effect of migraine severity on the retinal nerve fiber layer thickness

Mohamed A. Elshafie,[1-4] Hamdy A. EL-Gazzar,[2] Mayada A. Mohamed,[1] Salma M. Ragab,[3] Mohammed M. Mahmoud,[1] Marwa A. Tabl[2].

[1] Ophthalmology department, Faculty of medicine, Kafr Elsheikh University, Egypt
[2]Ophthalmology department, Faculty of medicine, Benha University, Egypt
[3]Neurology department, Faculty of medicine, Kafr El Sheikh University, Egypt
[4]Ophthalmology department, Faculty of medicine, Delta University, Egypt

Corresponding author: Mohamed Ahmed ELShafie, Ophthalmology department, Faculty of medicine, Kafr Elsheikh University, Egypt. Email: Mohammed_elshafey@med.kfs.edu.eg Tel: 00201069201269

Received: 3-6-2023, Accepted: 7-8-2023, Published online:16-12-2023

EJO(MOC) 2023;3(4):202-210.

Short title: Migraine severity on the retinal nerve fiber layer thickness

Abstract:

Objective: This study's goal is to assess the severity of migraine and effect of drugs on ocular perfusion pressure and RNFL thickness.

Methods: The Ophthalmology office served as the study's setting, Kafr-El Sheikh university hospital, as a cross sectional, prospective and observational study. Each patient or parent gave their permission to conduct the exams. The research comprised of 90 patients aged 15–60 years old, of both sexes.

Results: Average RNFL thickness decreased significantly in the temporo-inferior, temporo-superior, and temporal quadrants as migraine pain intensified. There was statistically significant decrease in nasal-superior (NS) quadrant in patients on acute treatment than patients not on treatment and also than patients on preventive treatment with or without topiramate also, there was statistically significant decrease in T quadrant in patients with preventive treatment with topiramate than those not on treatment and those with acute treatment.

Conclusion: Migraine has a significant impact on the posterior part of the eye. The duration and severity of migraine episodes are thought to contribute to a gradual reduction in ganglion cells and axons, leading to a notable effect on the thickness of the RNFL.

Keywords: Migraine, Retinal Nerve Fiber Layer Thickness, Optical Coherence Tomography.

INTRODUCTION

Migraine is a type of major headache characterized by severe, throbbing pain that can last from a couple of hours to a couple of days at a time. Migraine affects more than a billion individuals (nearly fourteen percent of the global population) and is one of the top sources of disability around the world, based to the Global Burden of Disease Study 2016[1]. According to the 2013 International Classification of Headache Disorders (ICHD-3), there are two primary kinds of migraines: migraines with aura and migraines without aura[2].

Vasodilation was once thought to be the root of migraines, while vasoconstriction was thought to be the source of the accompanying aura. The existing body of information implies that neurovascular dysfunction causes changes in intracranial and extracranial sequence, and that separate neuroanatomical components presumably influence each phase of migraine[3]. As a result of these neurovascular alterations, cerebral and retrobulbar vessels will constrict. Even though it's short-term, chronic sickness can cause less blood to circulate to the optic nerve head (ONH), that can damage the brain and retina/optic nerve in a way that can't be fixed[4]. Variations in ONH microcirculation flow quality can cause ganglion cell death in people with migraines[5].

Migraine severity has been identified as a key outcome in the assessment of therapeutic efficacy in the management of

migraine by a number of clinical and epidemiological research. Patients and doctors alike can use a variety of standardized and validated scales to rate the intensity of their migraines, which is a key indicator of functional impairment. The Migraine Disability Assessment Scale (MIDAS), the Henry Ford Disability Inventory, the Migraine Severity Scale, and the Headache Impact Test are all helpful. Most of these instruments, however, are designed to assess the impairment brought on by migraines and are very susceptible to recollection bias[6].

Because they are made of living tissue, biological features like the optic nerve head (ONH) and the retinal nerve fiber layer (RNFL) exhibit considerable variance even within the normal population. The RNFL is widely recognized as a reliable predictor of future visual loss due to glaucoma. Optical Coherence Tomography (OCT) is currently widely utilized for glaucoma testing and monitoring and other ocular neuropathies due to its great capacity to evaluate peri-papillary RNFL thickness. Using OCT, we can tell the difference between a healthy optic disc and RNFL through the quantitative determination of ONH parameters and RNFL thickness.

In addition, OCT is a simple imaging method that does not require any contact between the patient and the technician[7]. The goal of this study is to find out what effect migraine on RNFL thickness and ocular perfusion pressure (OPP) in migraine patients, considering the severity of migraine and the drugs used to treat it.

PATIENTS AND METHODS

The study was performed at the Ophthalmology clinic, Kafr El Sheikh University hospital, as a prospective cross-sectional study. Each patient or parent gave their approval before any examinations were performed.

The study included 90 patients aged 15–60 years old, of both sexes, recruited from Kafr El Sheikh Neurology clinic. A neurology consultant identified each patient with either migraine with aura or migraine without aura (2) based on the International Classification of Headache Disorders, Third Edition criteria.

The exclusion criteria included the following; greater than 3.00 diopters (D) of cylindrical or 4.00 D of spherical refractive error; history of substantial ocular disease including scleritis, glaucoma, uveitis, and ocular HTN; concomitant systemic conditions like DM and hypertension, ocular trauma, retinal pathology, media opacities, history of intra-ocular surgery, other neurological disease e.g. Alzheimer disease, epilepsy and pathological headache and optic nerve anomalies.

Methods:

All participants in this study were subjected to the following procedures:

History: Detailed history from each individual including age, gender, occupation, residence, age of onset, disease duration, migraine characteristic and history of acute and preventive treatment of migraine.

General examination including systolic and diastolic blood pressure.

Full Neurological examination to exclude associated neurological disorder.

Migraine Disability Assessment Scale (MIDAS): The patients were assessed for migraine disability and severity by Migraine Disability Assessment Scale (MIDAS) (8). Patients are asked questions by neurologists about the frequency and duration of their headaches, as well as how often these headaches limit their ability to participate in activities at work, at school, or at home. Once scored, the test gives the patient an idea of how debilitating his/her migraines are based on this scale: Patients who have a mild migraine (MIDAS 6-10) are in Group [1]. Group [2] Patients with moderate migraine (MIDAS 11-20). Group [3]: patients with severe migraine (MIDAS +21). Each group was 30 patients.

Ophthalmic examination: All patients had the following information gathered about them: A patient's best-corrected vision (BCVA), intraocular pressure (IOP) as measured by Goldmann applanation tonometry, and ocular perfusion pressure (2/3 of the mean arterial pressure minus IOP) are all considered. Slit-lamp examination of anterior segment and pupil to exclude any anterior segment pathology or pupil abnormality, fundus examination was performed using a +78 D non-contact lens to examine the optic disc and the fundus for pathology and RNFL thickness is measured by using Heidelberg SD-OCT.

Ethical approval: The Benha University Ethics Committee approved the project in advance (nu. 609).

Statistical Analysis: The information was gathered, checked, and coded before being imported into IBM SPSS version 23. Parametric data were accompanied by mean, standard deviation, and range statistics. The median and interquartile range (IQR) were utilized because the data did not fit a normal distribution. Quantitative and percentage breakdowns of qualitative elements were also presented. In order to compare the groups based on the qualitative data, the Chi-square test was used. Using quantitative data with a parametric distribution, we compared more than two separate groups using the One-Way ANOVA test. The Spearman correlation coefficient was applied to pairs of quantitative components from the same category to establish whether or not they were correlated.

RESULTS

The participants in this study included a total of ninety patients who suffered from migraines. The demographic, general, and ophthalmic data of the patients who were studied are presented in Table 1.

Table (1) shows Demographic, General and Ophthalmic data of the studied patients:

		Mild migraine No. = 30	**Moderate migraine No. = 30**	**Severe migraine No. = 30**
Age (Yrs)	Mean±SD	34.40 ± 11.20	30.63 ± 9.50	32.03 ± 12.45
	Range	14.00 - 50	15 - 46	16 - 60
Sex	Female	25 (83.3%)	24 (80.0%)	20 (66.7%)
	Male	5 (16.7%)	6 (20.0%)	10 (33.3%)
SBP	Mean±SD	117.83 ± 9.26	117.33 ± 9.44	121.57 ± 10.79
	Range	90.00 - 130	100 - 140	100 - 140
DBP	Mean±SD	78.50 ± 7.89	78.00 ± 10.80	77.77 ± 5.22
	Range	60.00 - 90	60 - 90	63 - 85
BCVA	Mean±SD	0.13 ± 0.14	0.08 ± 0.07	0.09 ± 0.09
	Range	0.00 - 0.5	0 - 0.222	0 - 0.262
IOP (mmhg)	Mean±SD	13.43 ± 1.96	12.90 ± 2.34	13.88 ± 1.65
	Range	10.00 - 18.5	9.5 - 18.5	11.5 - 16.5

SBP: systoilic blood pressure. DBP: diastolic blood pressure. BCVA: best corrected visual acuity. IOP: intraocular pressure

Table (2) shows that there was a statistically significant decrease in the average thickness of the RNFL in the tempro-inferior (TI), tempro-superior (TS), and temporal (T) quadrants as the severity of migraine increased, with p-values of 0.001, 0.001, 0.001, and 0.001, respectively, versus no change in the nasal-inferior (NI), nasal-superior (NS), or nasal (N) quadrants, with values of 0.895, 0.791, and 0.065, respectively. Additionally, it demonstrates that there was not found to be a statistically significant association between the severity of migraine and the ocular perfusion pressure of the patients who were analyzed with a p-value of 0.989.

Table (2): Relation between migraine severity and Ophthalmological parameters (RNFL thickness & OPP) of the studied patients:

RNFL Thickness		**Mild migraine No. = 30**	**Moderate migraine No. = 30**	**Severe migraine No. = 30**	**Test value•**	**P-value**
Average	Mean±SD	104.80 ± 7.79	99.00 ± 4.99	92.57 ± 8.88	20.496	0.000*
	Range	92.00 - 119.5	91.5 - 108	79.5 - 108		
TI (um)	Mean±SD	117.22 ± 7.94	108.72 ± 10.53	97.40 ± 13.98	24.079	0.000*
	Range	101.00 - 136.5	87.5 - 135	80 - 138.5		
NI (um)	Mean±SD	117.28 ± 22.82	114.95 ± 18.61	114.52 ± 30.40	0.111	0.895
	Range	78.00 - 183.5	87 - 150.5	69 - 184.5		
TS (um)	Mean±SD	143.92 ± 18.11	135.62 ± 9.36	118.88 ± 15.83	21.965	0.000*
	Range	112.50 - 183	113 - 155.5	91 - 143.5		
NS (um)	Mean±SD	118.33 ± 18.07	116.82 ± 14.39	115.47 ± 15.96	0.235	0.791
	Range	89.50 - 151.5	92.5 - 145.5	92 - 145		
N (um)	Mean±SD	78.02 ± 14.55	73.07 ± 11.51	70.07 ± 13.04	2.821	0.065
	Range	51.50 - 115	46.5 - 89.5	44 - 98.5		
T (um)	Mean±SD	75.23 ± 7.22	69.03 ± 7.60	61.42 ± 7.19	26.681	0.000*
	Range	65.00 - 94	60 - 98	51.5 - 73		
Ocular perfusion pressure		**Mild migraine No. = 30**	**Moderate migraine No. = 30**	**Severe migraine No. = 30**	**Test value**	**P-value**
Mean±SD		47.64 ± 5.49	47.83 ± 6.52	47.69 ± 3.39	0.011	0.989
Range		34.66 - 56.88	35.38 - 61.6	40.72 - 51.94		

Table (3) shows that there was a statistically insignificant relationship between the treatment received by the study patients and the parameters of their RNFL thickness, with the exception of a statistically significant decrease in the NS quadrant in patients on acute treatment compared to patients not on treatment and also compared to patients on preventive treatment with or without topiramate with a p-value of 0.037; there was also a statistically significant decrease in the T quadrant in patients with preventive treatment with topiramate.

Additionally, there was no statistically significant association between the treatment that was received by the patients and their ocular perfusion pressure with a p-value of 0.17.

Table (3): Relation between migraine treatment and Ophthalmological parameters (RNFL thickness & OPP) of the studied patients:

RNFL Thickness		**Not on ttt**	**Acute ttt**	**Preventive ttt (+) Topiramate**	**Preventive ttt (-) Topiramate**	**Test value•**	**P-value**
		No. = 47	**No. = 11**	**No. = 20**	**No. = 12**		
Average	Mean±SD	100.12 ± 8.70	97.86 ± 8.70	97.80 ± 8.43	96.08 ± 10.57	0.840	0.476
	Range	83 – 119.5	87.5 – 115.5	81 – 108	79.5 – 106		
TI (um)	Mean±SD	108.90 ± 14.74	107.23 ± 10.97	105.68 ± 15.05	107.38 ± 9.48	0.267	0.849
	Range	80 – 136.5	89 – 122.5	84 – 138.5	94.5 – 118		
NI (um)	Mean±SD	116.34 ± 20.86	125.64 ± 38.73	111.05 ± 17.20	110.96 ± 29.60	1.030	0.384
	Range	78 – 163.5	90.5 – 184.5	84 – 137	69 – 141		
TS (um)	Mean±SD	135.78 ± 18.62	125.09 ± 22.90	130.08 ± 16.02	132.79 ± 12.76	1.254	0.295
	Range	94 – 183	91 – 159	101.5 – 150.5	118 – 159		
NS (um)	Mean±SD	118.67 ± 15.09	105.59 ± 12.16	121.30 ± 18.69	112.79 ± 14.30	2.949	0.037*
	Range	89.5 – 151.5	89.5 – 119	91.5 – 145	95 – 128.5		
N (um)	Mean±SD	74.43 ± 13.67	71.86 ± 10.57	76.10 ± 10.45	68.67 ± 18.10	0.895	0.447
	Range	46.5 – 115	62 – 87.5	62 – 98.5	44 – 89.5		
T (um)	Mean±SD	70.21 ± 9.30	70.50 ± 11.77	63.38 ± 7.09	68.96 ± 6.97	2.969	0.036*
	Range	54.5 – 98	56 – 94	51.5 – 73	57 – 82.5		
Ocular perfusion pressure		**Not on ttt**	**Acute ttt**	**Preventive ttt (+) Topiramate**	**Preventive ttt (-) Topiramate**	**Test value**	**P-value**
		No. = 47	**No. = 11**	**No. = 20**	**No. = 12**		
Mean±SD		48.16 ± 4.69	50.03 ± 6.94	46.47 ± 4.89	45.96 ± 5.71	1.691	0.175
Range		34.66 – 56.38	42.2 – 61.6	36.56 – 56.88	35.38 – 51.44		

Table (4) shows that there was statistically significant negative correlation found inbetween disease duration and average RNFL thickness, TI, TS, NS, N and T quadrants while statistically insignificant correlation found between disease duration and ocular perfusion pressure and NI quadrant.

Table (4): Correlation of disease duration with ocular perfusion pressure and RNFL thickness

	Disease duration (year)	
	r	p-value
Ocular perfusion pressure	-0.035	0.742
Average	-0.421**	0.000
TI (um)	-0.428**	0.000
NI (um)	-0.127	0.234
TS (um)	-0.268*	0.011
NS (um)	-0.232*	0.027
N (um)	-0.298**	0.004
T (um)	-0.385**	0.000

DISCUSSION

In terms of its structure, most people agree that the retina is a part of the brain. Changes in the amount of thickness of the retinal nerve fiber layer (RNFL), which is like the gray matter in the brain[10], are only caused by axonal damage. OCT, which stands for "optical coherence tomography," is a benign imaging method that gives high-resolution, cross-sectional pictures of the retinal nerve fiber layer (RNFL), the ganglion cell layer (GCL), and the optic nerve head[11].

In this study, we found that there was statistically insignificant link between the severity of migraines and the level of ocular perfusion pressure in the people who were studied, and our p-value for this hypothesis was 0.989. In a study that came to a similar conclusion, Salman et al.[12] discovered that the level of ocular perfusion pressure did not significantly differ between patients with severe and mild migraines ($p>0.05$). In addition, Martinez et al.[5] discovered that there was not a significant difference ($p>0.05$) among patients in the migraine group who had higher MIDAS scores and those who had lower MIDAS scores when it came to ocular perfusion pressure.

The findings of this research demonstrated that the average width of the RNFL decreased in a way that was statistically significant, TI, TS, and T quadrants as the severity of migraine increased, with p-values of less than 0.001, less than 0.001, less than 0.001, and less than 0.001; correspondingly.

It was discovered that RNFL thicknesses in the temporal and inferior regions were negatively correlated with MIDAS ratings ($p=0.045$, $p=0.026$, and $p=0.023$, correspondingly), as discovered by Ulusoy et al.[15] in their study. This offered further evidence in support of the conclusions that we had acquired. In addition, Patients who had greater MIDAS ratings saw a reduction in RNFL thickness, as reported by Martinez et al.[5]. This was one of the findings that supported their hypothesis. The MIDAS score was applied in that particular study in order to assess the intensity of pain that individuals who suffered from migraines were enduring. The researchers found that there was a correlation that ran in the other direction between the thickness of the RNFL and the scores on the MIDAS.

According to our study, there was a statistically significant decrease in the number of patients who showed abnormalities in the NS quadrant. There was a statistically significant decrease in the T quadrant in patients who had previously received treatment with topiramate as compared to patients who had not previously received treatment with topiramate, patients who were not receiving treatment, and patients who were receiving acute treatment (p-value = 0.037).

Ewering et al.[16] examined the thickness of the RNFL in individuals who had chronic-type clustering headaches with that of healthy controls and people with episodic-type cluster headaches and discovered that the chronic-type cluster headache patients had considerably thinner RNFLs. Their findings, which revealed a considerable decline in the RNFL thickness, provided support for our data, which indicated the same thing. In addition to this, it was found that the thickness of the temporal RNFL decreased among those who received treatment with therapy as opposed to healthy controls and those who did not receive treatment with therapy. This was the case in all of the patients who participated in the study. In that one trial, researchers observed that treatment had the same impact on the RNFL as the systemic effects of cluster headaches. This was found out in the research.

Patients with migraine who had a history of prolonged medication or oxygen usage displayed considerable thinning of the outer temporal region, as discovered by Tecellioglu et al.[17]. This finding was statistically significant (p 0.005). Individuals who have a history of utilizing oxygen or narcotics were found to have this condition.

As a result of this study, we were able to demonstrate that there is a statistically significant inverse link between the length of the disease and the average RNFL thickness, as well as the TI, TS, NS, and N and T quadrants.

In a study that came to a similar conclusion, Feng et al.[18] discovered that the length of time a person had suffered from migraines was related with significant changes in RNFL. Ewering et al.[16] found that patients with chronic-type cluster headaches had thinner RNFLs than either healthy controls or patients with episodic-type headaches. This was the result of a decrease in the mean thickness of Ewering et al. Their findings, which revealed a considerable decline in the RNFL thickness, provided support for our data, which indicated the same thing. In addition to this, it was found that the thickness of the temporal RNFL decreased among those who received treatment with treatment as opposed to normal controls and those who did not receive treatment with therapy. This was the case in all of the patients who participated in the study. In that one study, it was found out that the thinning of the RNFL was induced not only by the systemic effect of cluster headaches but also by the effect of treatment. This was found out in the research.

Tecellioglu et al.[17] discovered that patients with migraine who had a history of chronic drug or oxygen usage more than 15 years, exhibited significant thinning of the outer temporal region (p 0.005).

The RNFL in patients whose migraine history spanned more than 15 years. In addition, Gunes et al.[19] discovered that there was a substantial link between the duration of a headache and the thickness of the superior RNFL ($r = -0.21$, $p = 0.02$), as well as a significant association between the frequency of attacks and the thickness of the temporal RNFL ($r = -0.19$, $p = 0.03$). According to the findings of Abdellatif et al.[20], duration had a strong inverse correlation with the superior (p=0.032) and inferior (p0.001) quadrants of the RNFL, as well as the superior (p=0.006) and inferior.

These findings support the hypothesis that migraine's transient cerebral vasospasm and extended duration represent perfusion fluctuations and extended vasoconstriction, causing damage to the eye's primary vascular structure—the choroid—and, to a lesser extent, the RNFL and GCL, from the chronic oligemic-hypoxic insult[21]. Although it is unknown whether the intensity of a migraine episode influences the intensity of vascular spasm, the fact that significant choroidal thinning occurs during an attack leads us to conclude that spasm alone is the true causal cause.

The scope of this investigation is limited. This study has some limitations due to its single-center design and its modest sample size across age and gender. These results also need to be replicated in a wider patient population, across multiple sex and age groups. Few studies have examined how varying treatment modalities affect RNFL thickness.

CONCLUSION

In conclusion, migraine has a significant impact on the structures behind the eyes. Our study of the etiopathologic relationship between intraocular pressure, RNFL thicknesses, ocular perfusion pressure parameters, and acute migraine attacks leads us to believe that RNFL thicknesses are significantly influenced by the severity and duration of migraine attacks. This is probably caused by the progressive loss of ganglion cells and axons.

ACKNOWLEDGEMENT: None

Data Availability: The authors declare that all data supporting the findings of this study are available within the article and its supplementary information file.

Competing interests: The authors declare no competing interests.

Corresponding author

Correspondence to: Mohamed A. ELShafie

Email: Mohammed_elshafey@med.kfs.edu.eg

Affiliations

Mohamed A. ELShafie. Ophthalmology department, Faculty of medicine, Kafr Elsheikh University, Egypt

Ethics declarations: All procedures performed in the study followed the 1964 Helsinki declaration and its later amendments, University Ethics Committee approved the project.

Conflict of interest

Mohamed A. Elshafie, Hamdy A. EL-Gazzar, Mayada A. Mohamed, Salma M. Ragab, Mohammed M. Mahmoud, Marwa A. Tabl. All authors have no conflicts of interest that are directly relevant to the content of this review.

Funding: No sources of funding were used to conduct this review.

Reviewer disclosures: No relevant financial or other relationships to disclose.

Declaration of interest: No financial affiliations or financial involvement with any organization or entity with a financial competing with the subject matter or materials discussed in the review.

REFERENCES

1. Stovner LJ, Nichols E, Steiner TJ, Abd-Allah F, Abdelalim A, Al-Raddadi RM, Ansha MG, Barac A, Bensenor IM, Doan LP, Edessa D, Endres M, Foreman KJ, Gankpe FG, Gopalkrishna G, Goulart AC, Gupta R, Hankey GJ, Hay SI, Murray CJL. Global, regional, and national burden of migraine and tension-type headache. The Lancet Neurology, 2018;17(11):954–976.
2. Headache Classification Committee of the International Headache Society (IHS) The International Classification of Headache Disorders, 3rd edition. Cephalalgia, 2018;38(1):1–211.
3. Ashina S, Bendtsen, L, Ashina, M. Pathophysiology of migraine and tension-type headache. Techniques in Regional Anesthesia and Pain Management, 2012;16(1):14–18.
4. Friberg L, Olesen J, Lassen NA, Olsen TS, Karle A. Cerebral oxygen extraction, oxygen consumption, and regional cerebral blood flow during the aura phase of migraine. Stroke, 1994;25(5):974–979.
5. Martinez A, Proupim N, Sanchez M. Retinal nerve fibre layer thickness measurements using optical coherence tomography in migraine patients. British Journal of Ophthalmology, 2008;92(8):1069–1075.
6. Kosinski M, Bayliss MS, Bjorner JB, Ware Jr, JE, Garber WH, Batenhorst A, Cady R, Dahlöf CGH, Dowson A, Tepper S. A six-item short-form survey for measuring headache impact. Quality of Life Research, 2003;12(8):963–974.
7. Cruz-Herranz A, Balk LJ, Oberwahrenbrock T, Saidha S, Martinez-Lapiscina EH, Lagreze WA, Schuman JS, Villoslada P, Calabresi P, Balcer L, Petzold A, Green AJ, Paul F, Brandt AU, Albrecht P. The APOSTEL recommendations for reporting quantitative optical coherence tomography studies. Neurology, 2016;86(24):2303–2309.
8. Zandifar A, Asgari F, Haghdoost F, Masjedi SS, Manouchehri N, Banihashemi M, Ghorbani A, Najafi MR, Saadatnia M, Lipton RB. Reliability and validity of the migraine disability assessment scale among migraine and tension type headache in Iranian patients. BioMed Research International, 2014;978064.
9. Ao R, Wang R, Yang M, Wei S, Shi X, Yu S. Altered Retinal Nerve Fiber Layer Thickness and Choroid Thickness in Patients with Migraine. European Neurology, 2018;80(3–4):130–137.
10. Labib DM, Hegazy M, Esmat SM, Ali EAH, Talaat F. Retinal nerve fiber layer and ganglion cell layer changes using optical coherence tomography in patients with chronic migraine: a case-control study. The Egyptian Journal of Neurology, Psychiatry and Neurosurgery, 2020;56(1):86.
11. Chiang MC, Dumitrascu OM, Chhabra N, Chiang CC. Migraine with Visual aura and the Risk of Stroke- a Narrative Review. Journal of Stroke and Cerebrovascular Diseases. 2021;30(11):106067.
12. Salman AG, Hamid MAA, Mansour DE. Correlation of visual field defects and optical coherence tomography finding in migraine patients. Saudi Journal of Ophthalmology. 2015;29(1):76–80.
13. Lin X, Yi Z, Zhang X, Liu Q, Zhang H, Cai R, Chen C, Zhang H, Zhao P, Pan P. Retinal nerve fiber layer changes in migraine: a systematic review and meta-analysis. Neurological Sciences, 2021;42(3):871–881.
14. Bulboacă AE, Stănescu IC, Bolboacă SD, Bulboacă AC, Bodizs GI, Nicula CA. Retinal Nerve Fiber Layer Thickness and Oxidative Stress Parameters in Migraine Patients without Aura: A Pilot Study. Antioxidants, 2020;9(6):494.
15. Ulusoy D, Ulusoy E, Duru Z. Evaluation of retinal nerve fibre layer and ganglion cell complex thickness with optical coherence tomography in migraine patients. Annals of Medical Research, 2019;04:170.
16. Ewering C, Haşal N, Alten F, Clemens CR, Eter N, Oberwahrenbrock T, Kadas EM, Zimmermann H, Brandt AU, Osada, N, Paul F, Marziniak M. Temporal retinal

nerve fibre layer thinning in cluster headache patients detected by optical coherence tomography. Cephalalgia, 2015;35(11):946–958.

17. Tecellioglu, Mehmet, Cem Cankaya. "Evaluation of macular and retinal nerve fiber layer thicknesses in episodic-type cluster headache patients by optical coherence tomography." (2019).

18. Feng YF, Guo H, Huang JH, Yu JG, Yuan F. Retinal Nerve Fiber Layer Thickness Changes in Migraine: A Meta-Analysis of Case–Control Studies. Current Eye Research, 2016;41(6):814–822.

19. Gunes A, Demirci S, Tok L, Tok O, Demirci S, Kutluhan, S. Is Retinal Nerve Fiber Layer Thickness Change Related to Headache Lateralization in Migraine? Korean Journal of Ophthalmology, 2016;30(2):134.

20. Abdellatif MK, Fouad MM. Effect of duration and severity of migraine on retinal nerve fiber layer, ganglion cell layer, and choroidal thickness. European Journal of Ophthalmology, 2018;28(6):714–721.

21. Raut S, Singh U, Sarmah D, Datta A, Baidya F, Shah B, Bohra M, Jagtap P, Sarkar A, Kalia K, Borah A, Dave KR, Yavagal DR., Bhattacharya P. Migraine and Ischemic Stroke: Deciphering the Bidirectional Pathway. ACS Chemical Neuroscience, 2020;11(11):1525–1538.