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YENİYETMƏLƏRDƏ MİOPİYA VƏ MİQREN: DAMAR DƏYİŞİKLİKLƏRİNİN DOPPLEROQRAFİK MEYARLARI

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XÜLASƏ

Miqren yeniyetmələrdə ən geniş yayılmış nevroloji pozğunluqlardan biridir. Miqrenin inkişafına səbəb olan mümkün amillərdən biri də refraksiya pozğunluqları – miopiya, hipermetropiya və astiqmatizm kimi görmə qüsurlarıdır.

Məqsəd – yeniyetmələrdə miqren zamanı refraksiya pozğunluqlarında doppler meyarlarını qiymətləndirmək və göz alması damarlarında qan axınının dəyişiklikləri ilə görmə pozğunluqları arasındakı əlaqəni müəyyənləşdirmək.

Material və metodlar
Tədqiqat üçün 11-17 yaş arasında baş ağrılarından şikayətlənən və refraksiya pozğunluqları diaqnozu ilə 87 pasiyent (174 göz) seçilmişdir. Pasiyentlər 3 qrupa bölünmüşdür: miqrensiz miopiyalı pasiyentlər (n=31), miqreni olan emmetroplar (n=19), miqreni və miopiyası müştərək olan pasiyentlər (n =37). Nəzarət qrupunu 20 sağlam şəxs təşkil etmişdir. Refraksiya pozğunluqlarının dərəcəsindən asılı olaraq miopiyalı pasiyentlər 3 qrupa bölünmüşdür: zəif miopiyalı (–)0,25-dən (–)3,0 D-yaya qədər) 39 pasiyent (44,8%), orta miopiyalı (–)3,25-dən (–)6,0 D-ya qədər) 30 pasiyent (34,5%), yüksək miopiyalı (–)6,0 D-dan yuxarı) 18 pasiyent (20,7%).
Rəngli doppler kartlaşdırılması (RDK) vasitəsilə göz arteriyasında (GA), tor qişanın mərkəzi arteriyasında (TQMA) və arxa qısa siliar arteriyalarda (AQSA) aşağıdakı hemodinamik parametrlər öyrənilmişdir: maksimal sistolik sürət (Vmax), minimal diastolik sürət (Vmin), rezistentlik indeksi (RI). Həmçinin qan axınının asimmetriya dərəcəsi qiymətləndirilmişdir.

Nəticələr
Hər üç arteriyada bütün öyrənilmiş parametrlər üzrə statistik olaraq əhəmiyyətli fərq müəyyən edilmişdir. Miqrenli pasiyentlərdə GA-da Vmax və Vmin-un azalması və RI-nin artması müşahidə olunur ki, bu da miqrenin patogenezində damar komponentinin rolunu göstərə bilər. Daha əhəmiyyətli dəyişikliklər miopiya və miqrenin birlikdə müşahidə olunduğu qrupda qeyd olunmuşdur, xüsusilə də Rİ və Vmin göstəricilərində. Belə dəyişikliklər görmə yüklənməsi və damar disrequlyasiyasının birgə təsiri ilə izah oluna bilər.

Yekun
Tədqiqatımızın nəticələri miqren ağrısının mexanizmində vazomotor pozğunluqların mühüm rol oynadığını təsdiqləyir və doppleroqrafik kriteriyalar yeniyetmələrdə damar pozğunluqlarını obyektivləşdirmək üçün tətbiq oluna bilər.

Açar sözlər: *miopiya, miqren, rəngli doppler kartlaşdırılma, yeniyetmələr*

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MYOPIA AND MIGRAINE IN ADOLESCENTS: DOPPLER CRITERIA OF VASCULAR CHANGES

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SUMMARY

Migraine is among the most prevalent neurological disorders afflicting adolescents. One possible contributing factor to the development of migraines is refractive errors such as myopia, hypermetropia, and astigmatism.

Purpose – to evaluate Doppler criteria in refractive disorders associated with migraine in adolescents and to investigate the relationship between ocular blood flow changes and visual disturbance.

Material and methods

The study was included 87 patients (174 eyes), aged 11–17 years, with headaches and diagnosed refractive errors, were included. Participants were divided into three groups: patients with myopia without migraine (n=31), patients with migraine without refractive errors (n=19), patients with combined myopia and migraine (n=37). The control group organized 20 healthy volunteers. Patients with myopia were subdivided based on refractive error severity. Low myopia (from (–)0.25 to (–)3.0 D) included 39 patients (44.8%), moderate myopia (from (–)3.25 to (–)6.0 D) included 30 patients (34.5%), and high myopia (more than (–)6.0 D) included 18 patients (20.7%).
The hemodynamic parameters – maximum systolic velocity (Vmax), minimum diastolic velocity (Vmin), and resistance index (RI) – were studied in the ophthalmic artery (OA), central retinal artery (CRA), and posterior short ciliary arteries (PSCA) using color Doppler imaging (CDI). The degree of blood flow asymmetry was also assessed.

Results

Statistically significant differences were found in all studied parameters of the three arteries. In migraine patients, reduced Vmax, Vmin in the OA and increased RI were observed, suggesting a vascular role in migraine pathogenesis. The most pronounced changes appeared in patients with both myopia and migraine, particularly in RI and Vmin. These alterations may result from the combined effects of visual strain and vascular dysregulation.

Conclusion

The results of our research support the idea that vasomotor disturbances play an important role in the mechanisms of migraine pain, and dopplerographic criteria can be used to objectively identify vascular dysfunctions in adolescents.

Key words: *myopia, migraine, color Doppler imaging, adolescents*

Migraine is among the most prevalent neurological disorders afflicting adolescents, exerting a substantial influence on their quality of life, academic performance, and social adaptation [1]. One possible contributing factor to the development of migraines is refractive errors such as myopia, hypermetropia, and astigmatism.

These conditions can cause visual strain, which in turn can trigger headaches. About 36% of parents are unaware of their children's recurrent headaches, which may contribute to delayed medical care [2]. Migraine in children is often not diagnosed by doctors [3], and only 20-30% of children suffering from this condition are diagnosed [4]. Migraine is a primary form of headache [5, 6]; its diagnosis is based on the criteria of the International Classification of Headache Disorders, 3rd revision (ICHD-3) [7], which provides specific diagnostic criteria for migraine in children [8-10].

Differential diagnosis of migraine in children and adolescents is often difficult due to the similarity of clinical manifestations with other forms of cephalalgia. In recent years, increasing attention has been paid to neuroimaging methods and vascular studies, among which Doppler ultrasound plays a special role.

A systematic review by Shayestagül et al. (2017) showed that in most cases of spontaneous migraine attacks, there are no significant changes in the linear blood flow velocity in the middle cerebral artery, except for the early phase of the attack, when a moderate decrease in blood flow may be observed, especially on the side of the pain [11]. At the same time, Olesen (2024) emphasizes in his review the evolution of concepts of cerebral blood flow in migraine: from a simplified model of vasospasm and subsequent vasodilation to complex phase-dependent and neurovascular regulation. This opens up prospects for a more accurate assessment of vascular markers of migraine, including the use of Doppler methods in clinical practice [12].

Refractive errors, especially uncorrected myopia, are increasingly recognized as a significant contributor to migraine development in adolescents due to their association with persistent visual strain. In the progression of myopia, a series of fundus structural changes will occur and changes in the choroid structure are a key factor. Many studies have demonstrated retinal vascular changes in high myopia [13, 14]. Investigating the hemodynamic state of the eye in myopia of varying degrees not only expands our understanding of the underlying pathological mechanisms but also provides important scientific data for developing early intervention and treatment strategies for myopia.

Circulatory disorders in the vascular bed of the organ of vision are given considerable attention, as their presence and severity are associated with the genesis of many pathological conditions of the eye [15, 16]. In many ways, such high interest among clinicians is due to the fact that non-invasive determination of blood circulation in the vessels of the eye and orbit in various conditions with primary or secondary involvement of the organ of vision in the pathological process is becoming increasingly widespread in everyday practice.

Given the widespread introduction of Doppler imaging in ophthalmology, as well as the need to apply this technique in various fields of ophthalmology, CDI is currently considered the preferred method among various methods of hemodynamic examination.

The advantage of this method lies in its accessibility, the reliability of the results obtained, and the virtual absence of contraindications [15 - 18]. As a non-invasive method for assessing blood flow in the vessels of the eyeball, CDI can play an important role in the diagnosis of vascular and functional disorders associated with migraine in adolescents.

Purpose – to evaluate Doppler criteria in refractive disorders associated with migraine in adolescents and to investigate the relationship between ocular blood flow changes and visual disturbance.

Material and methods

This study was conducted at the National Ophthalmology Centre named after Academician Zarifa Aliyeva. A total of 87 patients (174 eyes), aged 11 to 17 years, presenting with headaches and diagnosed refractive errors were enrolled in the study. Adolescents diagnosed with migraine according to ICHD-3 (International Classification of Headache Disorders, 3rd edition) [7], verified by a neurologist. Exclusion criteria: other types of headache or cephalalgia, coexisting ophthalmopathies: glaucoma, inflammatory eye diseases, systemic conditions affecting hemodynamics (anemia, autonomic dysfunctions, cardiovascular diseases, etc.).

Patients were assigned to 3 groups: patients with myopia without migraine (n = 31), patients with migraine without refractive errors (n = 19), patients with combined myopia and migraine (n = 37), and healthy volunteers (control group, n = 25). Additionally, patients with myopia were subdivided based on refractive error severity. Low myopia (from (–)0.25 to (–)3.0 D) included 39 patients (44,8%), moderate myopia (from (–)3.25 to (–)6.0 D) included 30 patients (34.5%), and high myopia (more than (–)6.0 D) included 18 patients (20.7%).

This classification allows us to assess the effect of the degree of myopia on hemodynamic parameters. The distribution of patients by clinical groups and degree of myopia is presented in **Table 1**.

Hemodynamic parameters were assessed using CDI of the eyeball and retrobulbar vessels. The study was conducted on the Toshiba "Nemio XG SSA-580A" ultrasound diagnostic system with a linear probe operating at 8 MHz. Patients in this study did not undergo any special preparation. To visualize blood flow in the OA, CRA, and short posterior ciliary arteries (SPCA), energy mapping mode was used, followed by CDI mode.

The optic nerve serves as a reference point for identifying vascular branches in the retrobulbar space; vessels are determined based on their presumed anatomical course and color code. Doppler spectrum analysis was used to identify pulsatile arterial blood flow with characteristic systolic and diastolic peaks. When assessing Doppler flow characteristics, attention was paid to the shape of the pulse wave. In the OA, CRA and SPCA, the following hemodynamic parameters were analyzed: peak systolic velocity (Vmax), end diastolic velocity (Vmin), RI, as well the degree of blood flow asymmetry was evaluated.

The examinations were performed at standard times of day to minimize diurnal variation. During the measurements, patients were in a constant sitting position, all evaluations were performed by a single experienced operator. Three consecutive spectral measurements were performed for each eye, and the mean was calculated from the results. Both eyes were evaluated, and the

Table 1. *Distribution of patients by clinical groups and degree of myopia*

Group	*Number of patients (n)*	*% of total sample*	*Degree of myopia (n / % of group)*
Group M *(Myopia without migraine)*	31	35.6%	Low myopia — 21 (53.8%) Moderate myopia — 11 (28.2%) High myopia — 7 (17.9%)
Group H *(Myopia without migraine)*	19	21.8%	—
Group MH *(myopia + migraine)*	37	42.5%	Low myopia — 16 (43.2%) Moderate myopia — 10 (27.0%) High myopia — 11 (29.8%)

Table 2. *Doppler parameters of blood flow in the arteries of the eye (mean values ± standard deviation)*

Artery / Parameter	*M (n=31)*	*H (n=19)*	*MH (n=37)*	*Control(n=25)*
OA				
Vmax (cm/s)	26.2 ± 2.7	23.4 ± 2.3	21.6 ± 2.1	31.5 ± 2.6
Vmin (cm/s)	8.0 ± 0.8	6.9 ± 0.6	6.1 ± 0.7	8.6 ± 0.7
RI	0.74 ± 0.02	0.76 ± 0.03	0.77 ± 0.03	0.72 ± 0.02
CRA				
Vmax (cm/s)	9.4 ± 0.7	8.6 ± 0.9	7.8 ± 0.8	11.7 ± 0.8
Vmin (cm/s)	2.8 ± 0.2	2.3 ± 0.2	2.1 ± 0.3	3.1 ± 0.3
RI	0.75 ± 0.03	0.78 ± 0.03	0.79 ± 0.04	0.73 ± 0.02
SPCA				
Vmax (cm/s)	11.8 ± 0.9	10.1 ± 0.8	9.6 ± 0.9	14.5 ± 0.7
Vmin (cm/s)	3.2 ± 0.2	2.6 ± 0.3	2.4 ± 0.3	3.6 ± 0.3
RI	0.75 ± 0.02	0.77 ± 0.03	0.78 ± 0.03	0.72 ± 0.02

unit of analysis was the individual patient.

The control group for defining reference values for hemodynamic parameters consisted of 25 healthy volunteers aged 11-24 years.

Statistical data processing was performed using IBM SPSS Statistics 26.0 software. The Shapiro–Wilk test was used to verify the correctness or accuracy of the distribution of continuous variables. To compare the mean values of linear blood flow velocity and RI between groups, Student's t-test was used for normally distributed data. Comparison of more than two groups by Doppler parameters was performed using ANOVA followed by Tukey's honest significance test.

The frequency of migraine occurrence in different groups was analyzed using Pearson's χ^2 test. Pearson's correlation coefficient (r) was used to assess the relationship between the degree of myopia and the frequency of migraine attacks. Differences were considered statistically significant at a significance level of p< 0,05.

Results

Patients with a combination of myopia (M group) and migraine (MH group) showed the most pronounced decrease in Vmax and Vmin in the OA and SPCA compared to other groups. In the group of patients with migraine without refractive errors (H group), a decrease in blood flow velocity parameters was also observed compared to the control group, but to a lesser extent than in the MH group.

In patients with isolated myopia, hemodynamic parameters were closer to normal, especially in cases of low myopia. The level of blood flow asymmetry in paired ophthalmic arteries was higher in groups with migraine symptoms, which may also indicate vascular tone disorders and regional blood flow regulation imbalance.

When comparing hemodynamic parameters between clinical groups, significant differences were found. They also had a higher RI, indicating increased vascular resistance. Doppler parameters of blood flow in the arteries of the eye are presented in **Table 2.**

Doppler measurements of blood flow in the ocular arteries revealed the most pronounced changes in the group with both myopia and migraine. In the OA, Vmax was 21.6 ± 2.1 cm/s in the MH group, compared to 26.2 ± 2.7 cm/s in the myopia-only group, 23.4 ± 2.3 cm/s in the migraine-only (H) group, and 31,5 ± 2.6 cm/s in controls. Vmin in the OA was 6.1 ± 0.7 cm/s (MH), 8.0 ± 0.8 cm/s (M), 6.9 ± 0.6 cm/s (H), and 8,6 ± 0.7 cm/s (control). The RI was elevated in the MH group at 0,77 ± 0.03 versus 0.74 ± 0.02 in M, 0.76 ± 0.03 in H, and 0.72 ± 0.02 in controls. In the CRA, Vmax was 7.8 ± 0.8 cm/s in MH, 9.4 ± 0.7 cm/s in M, 8.6 ± 0.9 cm/s in H, and 11.7 ± 0.8 cm/s in controls. Vmin was 2.1 ± 0.3 cm/s (MH) versus 2.8 ± 0.2 cm/s (M), 2.3 ± 0.2 cm/s (H), and 3.1 ± 0.3 cm/s (control). The RI was 0.79 ± 0.04 in MH, 0.75 ± 0.03 in M, 0.78 ± 0.03 in H, and 0.73 ± 0.02 in controls. For the SPCA, Vmax was 9.6 ± 0.9 cm/s in MH, 11.8 ± 0.9 cm/s in M, 10.1 ± 0.8 cm/s in H, and 14.5 ± 0.7 cm/s in controls. Vmin values were 2.4 ± 0.3 cm/s (MH), 3.2 ± 0.2 cm/s (M), 2.6 ± 0.3 cm/s (H), and 3.6 ± 0.3 cm/s (control). RI was elevated in MH at 0.78 ± 0.03, compared with 0.75 ± 0.02 in M, 0.77 ± 0.03 in H, and 0.72 ± 0.02 in controls.

These results demonstrate that adolescents with combined myopia and migraine exhibit decreased blood flow velocities (Vmax and Vmin) and increased RI in all examined ocular arteries, indicating impaired ocular perfusion and possible vascular dysregulation. These findings indicate elevated vascular resistance and impaired microcirculation within the OA, which may contribute to ocular and neurovascular complications in patients with higher degrees of myopia. The χ^2 analysis revealed a statistically significant association between the presence of migraine and clinical group membership ($\chi^2 = 112.6$; df = 2; $p < 0.0001$).

The most pronounced association was observed in the group of patients with a combination of myopia and migraine, where migraine attacks were recorded in all examined patients (100%), while in the group with myopia only, migraine was not detected in any patient. This confirms the significance of the MH group as a separate clinical category with a pronounced vascular-neurological component. To identify the relationship between the degree of myopia (in diopters) and the frequency of migraine attacks per month, Pearson's correlation analysis was performed in groups of patients with myopia and a combination of myopia and migraine.

The results of the analysis demonstrated a moderate positive correlation between the degree of myopia and the frequency of migraine attacks: $r = 0.58$; $p < 0.01$, which indicates a statistically significant relationship between these parameters. The data may indicate a possible contribution of common vascular or neurological mechanisms to the pathogenesis of both conditions. **Table 3** shows the results of differences in all arteries.

The **Table 3** shows F-values and corresponding p-values for comparisons of Vmax, Vmin, and RI in each artery. All parameters demonstrated statistically significant differences between groups, with p-values ranging from <0.0001 to <0.001. OA: Vmax F = 9.84, $p < 0.0001$; Vmin F = 11.2, $p < 0.0001$; RI F = 13.7, $p < 0.0001$. MH group had lower Vmax and Vmin and higher RI than M and C groups. CRA: Vmax F = 8.65, $p < 0.0001$; Vmin F = 10.3, $p < 0.0001$; RI F = 12.1, $p < 0.0001$. MH group showed reduced Vmax and Vmin and increased RI relative to M and C; H group also had some RI increase. SPCA: Vmax F = 7.94, $p < 0.001$; Vmin F = 9.76, $p < 0.001$; RI F = 14.2, $p < 0.0001$. MH group had lower Vmax and higher RI; H group

Table 3. *Summary of significant differences across all arteries*

Parameter / Artery	*OA — Vmax*	*OA — Vmin*	*OA — RI*	*CRA — Vmax*	*CRA — Vmin*	*CRA — RI*	*SPCA — Vmax*	*SPCA — Vmin*	*SPCA — RI*
F-value	9.84	11.2	13.7	8.65	10.3	12.1	7.94	9.76	14.2
p-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.001	<0.001	<0.0001
Tukey's HSD	MH<M, MH<C	MH<C, H<C	MH<M, MH<C, H<C	MH<M, MH<C	MH<C, H<C	MH<M, MH<C, H<C	MH<C	H<C	MH<M, H<C

Note: *The F values and corresponding p-levels of significance are presented for differences between groups in terms of CDI parameters (Vmax and Vmin, RI in OA, CRA and SPCA). According to Tukey's analysis, the most pronounced changes were observed in the MH group.*

Table 4. *Results of ANOVA and Tukey's honest significance test analysis for the Vmax parameter in the OA*

Comparable groups	*Average Vmax (cm/s) ± SD*	*Statistical criterion*	*p-value*	*Significance*
MH	26.4 ± 4.8			
M	31.9 ± 5.1	MH < M	< 0.01	Yes
H	29.2 ± 4.9	H < Control	< 0.05	Yes
Control	35.7 ± 5.3	MH < Control	< 0.001	Yes
ANOVA		F = 9.84	< 0.0001	Yes

had lower Vmin. The MH group consistently exhibited the most pronounced vascular changes, indicating elevated resistance and impaired microcirculation compared to other groups.

The analysis showed statistically significant differences in all parameters studied in all three arteries. The changes were most pronounced in the group with a combination of myopia and migraine MH, especially in terms of the RI and Vmin. This may indicate a violation of vascular tone and a decrease in perfusion in the OA in this category of patients.

The differences identified between the groups also confirm the importance of a comprehensive approach to the study of vascular disorders in the diagnosis and treatment of patients with myopia and migraine. To assess the differences between the groups, an analysis of variance (ANOVA) was performed for each parameter, and the most pronounced differences were recorded in the OA for the Vmax parameter: $F = 9.84$; $p < 0.0001$ **(Table 4)**.

Tukey's honest significance test analysis revealed statistically significant differences between the study groups, highlighting meaningful alterations in ocular hemodynamics. Comparable patterns of significance were observed across all arteries examined, with the most pronounced changes in the RI and Vmin. In the OA, the MH group demonstrated a decrease in Vmax to 21.6 ± 2.1 cm/s and Vmin to 6.1 ± 0.7 cm/s, compared with the myopia-only group (M) with Vmax 26.2 ± 2.7 cm/s and Vmin 8.0 ± 0.8 cm/s, and the control group with Vmax 31.5 ± 2.6 cm/s and Vmin 8.6 ± 0.7 cm/s. The RI was highest in the MH group (0.77 ± 0.03) relative to M (0.74 ± 0.02) and controls (0.72 ± 0.02). Similar trends were observed in the CRA and SPCA, with Vmax, Vmin, and RI values showing statistically significant differences ($p < 0.001$ to $p < 0.0001$) across groups.

These findings suggest that vascular factors play a substantial role in the pathogenesis of both myopia and migraine, particularly when these conditions coexist. The pronounced hemodynamic alterations in the combined myopia and migraine group likely reflect the cumulative impact of visual strain, impaired autoregulatory vascular mechanisms, and neurovascular instability. Reduced perfusion capacity, as evidenced by lower Vmin and elevated RI, may serve as an independent risk factor for migraine attacks, indicating that vascular dysregulation contributes not only to ocular complications but also to neurological manifestations. Patients with migraine exhibited a consistent decrease in linear blood flow velocity in the OA accompanied by an increase in RI, supporting the hypothesis of a vascular component in migraine pathophysiology. These results reinforce the notion that vasomotor dysfunction, including impaired autoregulation and regional hypoperfusion, plays a critical role in the mechanisms underlying migraine pain.

Consequently, Doppler criteria obtained via CDI provide an objective and clinically relevant means to identify vascular disturbances in adolescents, offering valuable insights for early detection, differential diagnosis, and individualized management strategies.

Discussion

The data obtained confirm the presence of pronounced hemodynamic changes in adolescents with a combination of myopia and migraine, especially in the form of a decrease in linear blood flow velocity (Vmax and Vmin) and an increase in the RI, which indicates vascular dysregulation. These results are consistent with the review by Olesen (2024), which emphasizes the complex phase-dependent regulation of blood flow in migraine, going beyond the classical model of vasospasm [12].

The presence of a moderate positive correlation between the degree of myopia and the frequency of migraine attacks ($r = 0.58$; $p < 0.01$) may indicate common pathophysiological mechanisms involving both the visual and cerebral vascular pools. A similar interaction of neurovascular factors is described in the works of Golovacheva et al. (2018), which focus on neurovascular disorders in patients with migraine [5].

It is important to note that even adolescents with migraine without refractive disorders show signs of hypoperfusion, which is consistent with the results of a systematic review by Shayestagül et al. (2017), which revealed a decrease in blood flow at the onset of an attack [11]. A marked increase in RI in the SPCA and CRA also reflects the likely involvement of retrobulbar hemodynamics in the formation of pain syndrome.

The observed asymmetry of blood flow in paired ophthalmic arteries in patients with migraine may indicate a disturbance in the autonomic regulation of vascular tone, which requires further study. Given the high diagnostic value and accessibility of CDI it is advisable to consider it as a promising tool in the screening of adolescents with cephalic syndrome of unknown etiology [15, 16]. Studies have shown that during migraine attacks, changes in vascular tone may not be confined to the brain but also affect extracranial vessels, including the ophthalmic and central retinal arteries. This raises the question of whether ophthalmic Doppler changes could serve as early indicators of systemic vascular vulnerability in young migraineurs. Our findings are consistent with previous international studies that reported changes in retrobulbar blood flow in patients with migraine.

For example, a study using CDI in migraine patients without aura demonstrated significantly increased RI and in the CRA and SPCA, even during interictal periods — indicating persistent autonomic vascular dysfunction [19]. In the work of Yu S. (2023), changes in retrobulbar blood flow in patients with pathological myopia were analyzed using CDI. Similarly, in pathological myopia, reduced peak systolic and end-diastolic velocities and elevated RI have been observed, likely reflecting decreased microvascular perfusion due to axial elongation and vascular remodeling. The author also studied the relationship between changes in blood flow and the characteristic changes that occur with myopia [20].

The studies we reviewed examined changes in the ocular vessels in myopia and migraine. However, the available literature does not contain any publications that simultaneously examine ocular vessels in both myopia and migraine, as we examined in our study.

The coexistence of migraine and myopia, as demonstrated in our study, may amplify vascular dysregulation by combining mechanisms of hypoperfusion and neurovascular instability. We also conducted a correlation analysis of hemodynamic changes and refractive errors among the studied patients with myopia and a combination of myopia and migraine.

Conclusion

Using the CDI as a non-invasive and reliable tool, it is possible to assess vascular changes in adolescents with migraine, refractive errors, and especially in patients with both diseases. Its application allows clinicians to detect early hemodynamic disturbances in the OA, CRA, SPCA providing objective evidence of vascular dysregulation that may underlie both ocular and neurological symptoms.

The use of CDI can improve differential diagnosis by distinguishing migraine-associated vascular changes from isolated refractive abnormalities, thereby reducing the risk of overdiagnosis and unnecessary interventions. Furthermore, identifying vascular impairments may inform personalized management strategies, including visual ergonomics, pharmacologic modulation of vascular tone, and targeted follow-up. Despite these promising findings, further research is warranted to refine Doppler diagnostic criteria, investigate longitudinal changes in ocular perfusion, and clarify the mechanistic link between visual and neurovascular alterations. Ultimately, Doppler assessment of ocular blood flow represents a valuable, practical approach for verifying the vascular component of pathogenesis in adolescents presenting with combined ophthalmological and neurological symptoms, offering a pathway toward more precise, individualized care.

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