J Pediatr Res 2024;11(3):129-35
DOI: 10.4274/jpr.galenos.2024.67984

Original Article

An Evaluation of Previously Undiagnosed Childhood Primary Headache Cases Through Their EEG and MR Findings

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ABSTRACT

Aim: Headaches are a major cause of presentations to pediatric neurology clinics, the majority being primary. Although diagnosis is mostly based on medical history and physical examination, imaging methods and electroencephalography (EEG) are used for differential diagnosis or identifying accompanying conditions. We evaluated cases of primary headache presenting to a newly established pediatric neurology clinic in July-December 2022 and compared their magnetic resonance imaging (MRI) and EEG findings.

Materials and Methods: Individuals presenting with headaches were first classified as primary or secondary headaches, and patients with primary headaches were included as migraine or tension-type headaches (TTH). Two hundred four patients presented but only fifty migraines and 50 TTH patients, who had EEG and MRI, met the study criteria.

Results: Greater photophobia, phonophobia, and family histories were present in the migraineurs, while attack frequencies were higher and durations shorter in the TTH group (p=0.025, p=0.001, respectively). Pain was generally throbbing in character in the migraine patients and compression in the TTH cases. No pathology was encountered in the MRIs of 90% of the migraine patients and 94% of the TTH group. While no pathology was detected at EEG in most cases, sharp spike-wave activity was determined in 10% of the migraine patients and in 2% of the TTH group.

Conclusion: MRI and EEG are not generally required in the diagnosis of primary headaches once a detailed history and physical examination have been performed. While the majority of brain MRI requests are of no particular diagnostic value, unnecessarily requested EEGs can lead to misdiagnoses. It is crucially important to ensure that patients are closely monitored and that unnecessary requests are avoided.

Keywords: Electroencephalography, migraine, pediatric neurology, primary headache, tension-type headache

Introduction

Headaches, a frequently seen entity in children and adolescents, represent one of the principal causes of presentations to pediatric neurology clinics (1). It is particularly important to establish whether childhood headache is primary or secondary, because these pains can derive from potentially life-threatening central nervous system pathologies, and can also be symptoms of other diseases. Due to the differing etiologies involved, headaches may cause decreased quality of life, absenteeism from school, and restrictions in education (1,2). It generally impacts adversely on children's school and social activities and the work performance of their parents (2).

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Received: 18.04.2024 **Accepted:** 31.07.2024

Headaches are divided into three groups according to The International Classification of Headache Disorders, 3rd edition (beta version) (ICHD-3 beta), primary and secondary headaches, and cranial neuropathy (3). Primary headaches are those not associated with causes such as tumors, meningitis, encephalitis, head trauma, intoxication, or pseudotumor cerebri (4). Diagnosis is based on medical history and a detailed physical examination (5). In addition to blood pressure measurement and fundoscopic examination, the determination of family history and risk factors is highly important for evaluation. Brain imaging and electroencephalography (EEG) must be performed for differential diagnosis when required.

Primary headaches are more common in children, particularly during school-age. Headaches can be associated with several underlying neurological conditions, such as epilepsy. Studies have reported an increased prevalence of epilepsy in children and adolescents with headache, and also greater headaches in patients followed-up due to epilepsy, than in the normal population (5,6). At the same time, headaches may be an epilepsy aura or a postictal symptom of clinical seizures which families are unable to clearly identify. Although EEG findings are not always specific, they can sometimes yield useful information. Ictal changes indicating abnormal electrical activity are observed at EEG during headache attacks, particularly when the headache is associated with seizures, while interictal epileptiform activity may be detected at EEG in some migraine patients.

Magnetic resonance imaging (MRI) of the brain is not normally required when the headache is evaluated as primary. However, MRI is recommended for differential diagnosis in the presence of "red flag" findings following a detailed history directed toward the headache and examination findings. Unnecessary MRIs can sometimes be performed in the absence of detailed evaluations. The purpose of this retrospective study was to evaluate the EEG and MRI findings of previously undiagnosed children presenting with headaches to a newly established pediatric neurology clinic and diagnosed with primary headaches.

Materials and Methods

This single-center, cross-sectional study was performed at the Hitit University Çorum Erol Olçok Training and Research Hospital, Turkey. This study was approved by the Hitit University Faculty of Medicine Clinical Research and Ethics Committee (decision no.: 2022-105, dated: 14.12.2022). Individuals presenting with headaches as outpatients to the pediatric neurology clinic between July and December 2022 were included in this research. The patients' medical records were examined in detail, and their demographic characteristics such as age and sex, duration and frequency of headache, its character and localization, and any accompanying symptoms such as nausea, and vomiting, photophobia, and phonophobia were evaluated. The cases were first classified as primary or secondary headaches. Those patients with primary headaches were included in the evaluation as migraine or tension-type headache (TTH) according to ICHD-III beta criteria. Those patients with histories of head trauma, aged under six, those with histories of brain surgery by neurosurgery, with neurological diseases such as epilepsy or cerebral palsy, and those previously diagnosed with migraine and TTH and using preventive treatment were not included in this study. The brain MRIs which some patients had undergone as a neuroradiological examination before presenting to the pediatric neurology outpatient clinic, and the brain MRI and EEG findings following presentation to the outpatient clinic for differential diagnosis and to investigate accompanying conditions were evaluated. All scans were performed using Neuron Spectrum 5 (Neurosoft, Ivanovo, Russia) EEG devices with 21 electrodes and a 10-20 system attached to the scalp with paste. The patients' EEG findings were classified as either normal or pathological by the same pediatric neurologist.

Informed consent was waived due to the retrospective nature of this study.

Statistical Analysis

Statistical analyses of the data obtained from patients with primary headaches diagnosed as migraine or TTH were performed on SPSS version 22 software (IBM, Armonk, NY, USA). The chi-square test was employed to compare frequencies between the two groups, the t-test for mean comparisons, and the Mann-Whitney U test was used for non-normally distributed data. Statistical significance was set at $p<0.05$.

Results

Two hundred and four patients presented to our clinic with headaches during the study period. Primary headaches were determined in 153 patients following detailed neurological and systemic examinations, while 51 cases were assessed as secondary headaches. Eighty-one (53%) of the patients with primary headaches were followed up as migraine cases and 61 (40%) as TTH. Unclassifiable primary headache was considered in 11 patients (7%). Fifty-five of the migraine cases were regarded as migraine without

aura and 26 as migraine with aura. EEG was especially planned for migraine patients during aura, while some patients followed-up with TTH also underwent EEG with preliminary diagnoses of epilepsy in terms of comorbidity. These patients' brain MRI images obtained concurrently were also examined. We learned that the great majority of our patients with headaches (54%, n=110) had already undergone brain MRI or brain computed tomography before presenting to the child neurology outpatient clinic.

One hundred patients aged 5-17 years, with a mean age of 149.7±36.5 months, diagnosed with migraine (n=50) and TTH (n=50) were enrolled in this study. The mean age of the migraine group was 147.2±35.3 months and that of the TTH group was 152.2±37.8 months. This difference was not statistically significant (p=0.49). Girls represented 66% (n=33) of the patients with migraine and 62% (n=31) of those diagnosed with TTH. There was no significant gender difference between the groups (p=0.68). A comparison of the duration of symptoms showed that these had generally persisted for three months or 3-6 months in the TTH group, while in the migraine group, they had more frequently been present for more than six months, and sometimes even longer than 24 months. The difference between the groups was statistically significant (p=0.01). These items are presented in Table I and Table II. In the tables, categorical variables are expressed as n (%).

No significant differences were observed in this study between the migraine and TTH groups in terms of the demographic variables of age and sex. However, more family histories were found in the migraineurs (p=0.025). A significant difference was observed between the two groups in terms of attack frequencies and durations (p=0.001). The attack duration in TTH was generally 1-3 hours, while among the migraineurs, the duration usually exceeded three hours. Significant differences were observed between the migraine and TTH groups in terms of photophobia (72% vs. 52%, n=36 vs. n=26, respectively) and phonophobia (70% vs. 28%, n=35 vs. n=14, respectively) (p=0.039 and p=0.001) (Table III).

The patients were also classified on the basis of normal or abnormal EEGs. The descriptive statistics are shown in Table IV, and analysis revealed a significant variation between them (p=0.048). Focal/hemispheric sharp spike waves were observed in four (8%) of the patients followed up due to migraine, and generalized spike and sharp wave activity in one (2%). Focal sharp wave activity was observed in only one of the patients with TTH, and no bilateral sharp wave activity was present in any. Bilateral slow wave activity and background rhythm irregularity were seen in two (4%) of the migraine patients, while focal slowdown at EEG was observed in one in the TTH group.

Our patients' brain MRIs were evaluated. The MRI results were compared between the migraine and TTH groups. Arachnoid cyst was detected in 4% of the migraine patients, non-specific white matter anomaly in 2%, septal deviation in 2%, and adenoid vegetation in 2%. Non-specific white matter anomaly was detected in 2% of the patients followed up due to TTH and septal deviation in 2%. No significant differences were determined between the two groups in terms of their MRI images. These data are shown in Table IV and Table V.

Table I. Demographic characteristics of the children with migraine and tension-type headache

Demographic characteristics	**Migraine n (%)**	**Tension-type headache n (%)**	**p value**
Female	33 (66)	31 (62)	0.068
Male	17 (34)	19 (38)	
Age groups (years)			
6-8	5 (10)	4 (8)	
9-10	11 (22)	10 (20)	
11-14	20 (40)	16 (32)	
15-18	14 (28)	20 (40)	
Family history of headache	26 (52)	15 (30)	0.025*
Accompanying disease	9 (18)	9 (18)	
Using medication	3 (6)	2 (4)	

*p<0.05

Table II. Headache characteristics of children with migraine and tension-type headaches			
	Migraine n (%)	**Tension-type headache n (%)**	**p value**
Localization			
Frontal	18 (36)	23 (46)	0.09
Temporal	26 (52)	17 (34)	
Occipital	-	4 (8)	
Vertex	6 (12)	6 (12)	
Duration since onset			
3-6 month	5 (10)	14 (28)	0.001*
7-12 months	13 (26)	10 (20)	
13-24 months	13 (26)	5 (10)	
Longer than 24 months	16 (32)	7 (14)	
Frequency			
Every day	5 (10)	21 (42)	0.001*
Less than three times a week	35 (70)	22 (44)	
Less than four times a month	10 (20)	7 (14)	
Attack duration			
1-3 hours	15 (30)	44 (88)	0.001*
4-6 hours	24 (48)	6 (12)	
7-12 hours	7 (14)	-	
13-24 hours	3 (6)	-	
Longer than 24 hours	1 (2)	-	
Character of pain			
Throbbing	46 (92)	23 (46)	0.001*
Compression	3 (6)	22 (44)	
Stabbing	1 (2)	5 (10)	
*p<0.05			

Table III. Symptoms accompanying headaches			
	Migraine n (%)	**Tension-type headache n (%)**	**p value**
Nausea	41 (84)	31 (62)	0.026*
Vomiting	11 (22)	7 (14)	0.298
Photophobia	36 (72)	26 (52)	0.039*
Phonophobia	35 (70)	14 (28)	0.001*
Waking at night	8 (16)	6 (12)	0.564
*p<0.05			

Table IV. EEG findings in headaches			
	Migraine n (%)	**TTH n (%)**	**p value**
Normal	42 (84)	48 (96)	0.048*
Abnormal			
Bilateral/generalized spike/sharp wave activity	1 (2)		
Focal/hemispheric spike/sharp wave activity	4 (8)	1 (2)	
Bilateral slow wave activity or background rhythm irregularity	2 (4)		
Focal slowdown	1 (2)	1 (2)	
*p<0.05, EEG: Electroencephalography			

Table V. MRI findings in headaches			
	Migraine n (%)	**Tension-type headache n (%)**	**p value**
Normal	45 (90)	47 (94)	0.059
Abnormal			
Arachnoid cysts	2 (4)	1 (2)	
Non-specific white matter abnormalities	1 (2)	1 (2)	
Septal deviation	1 (2)	1 (2)	
Adenoid vegetation	1 (2)		
*p<0.05, MRI: Magnetic resonance imaging			

Table VI. Causes of secondary headache in our study	
	Number n (%)
Upper respiratory tract infections (sinusitis, otitis)	33/51 (64.7)
Discopathy (accompanied by neck pain)	4/51 (7.8)
Hypertension	2/51 (3.95)
Dental decay	3/51 (5.9)
Trauma	2/51 (3.95)
Refractive errors (astigmatism)	4/51 (7.8)
Benign intracranial hypertension	3/51 (5.9)

Discussion

Headaches are pains resulting from infectious, physical causes, or chemical causes which affect the pain-sensitive structures inside and outside the head. In order for headaches to be defined as primary, no underlying pathological finding must be identified. Primary headaches are an important public health problem which adversely affect the individuals concerned, their families, and even the entire community, in the majority of cases. The prevalence of primary headaches in adults is approximately 42%. The figure among the pediatric population is unclear, although a significant increase has been determined in recent years (7). Approximately 60% of children and adolescents experience headaches at least once in their lives. Headaches before the age of four years is very rare, although their prevalence rises thereafter (2,8).

Two hundred four patients presented to the pediatric neurology clinic due to headaches during the short, six-month study period. A large part, approximately 75% of these cases, were evaluated as primary headaches. Our patients were asked 'red flag' questions when taking about their histories. Secondary headache should initially be considered when the patient is young (particularly younger than six years), when there are systemic symptoms such as fever, when the pain alters the character of an already existing headache, when there is a history of trauma or neoplasm, when the pain rouses the patient from their sleep, when there is a worsening of pain during coughing, sneezing, exercising, or the Valsalva maneuver or when waking in the morning and in the presence of abnormal neurological findings (9).

Some children with primary headaches may experience paroxysmal altered states of consciousness, or episodic symptoms and abnormal movements reminiscent of epileptic seizures. In many cases, EEG can help establish whether these attacks are caused by underlying epilepsy or else represent symptoms of a primary headache disorder.

Headache can be seen before, after, or during epileptic seizures (10). However, the relationship between headache and epilepsy has not been adequately investigated. Headache and epileptic seizures are known to share several pathophysiological mechanisms. Ion channel disorders and neurotransmitters in particular are thought to be responsible for these mechanisms. Cortical spreading depression and neuronal hyperexcitability are thought to be responsible for the relationship between migraine and epilepsy in society, especially in children. However, no genetic or environmental risk factor has to date been identified between the two diseases.

The prevalence of epilepsy in the community is 0.5-1.5% but ranges between 1% and 17% in patients with migraine. The prevalence of migraine in the community is 5-18% but ranges between 8% and 24% in patients with epilepsy. A possible relationship has been suggested between these two diseases due to the increased prevalence of both primary headache and epilepsy in the normal population. Indeed, this comorbidity condition has been reported to be more common in some types of epilepsy.

Routine interictal EEG is not recommended for patients with headache. However, EEG can be performed for differential diagnosis in cases of a history of suspected epilepsy. Ictal EEG is thought to be potentially beneficial in some forms of migraine (basilar or hemiplegic).

Evaluation of our patients' EEGs revealed no pathology in 84% (n=42) of those with migraine and 96% of those with TTH. Epileptiform discharge was observed in 10% (n=5) of those patients with migraine and focal slowing in 6% (n=3). While no specific EEG abnormality is expected in migraine, studies have reported that focal slowing may be seen during aura, but the findings are usually normal (10,11). These abnormalities may appear on a transient basis during the ictal phase of the migraine aura, and specific EEG changes may not always be seen during aura. This is thought to be associated with cortical spreading depression and the complex physiopathology of migraine.

According to the current literature, routine imaging is not recommended for children presenting with recurrent headaches if neurological examinations are normal (12). The probability of a space-occupying lesions in the brain in these patients is reported to be low, especially if the children's complaints persist for longer than one month, in the absence of a history of seizure or abnormal gait findings, and if migraine is also present in a member of the family (12). Unfortunately, however, in the majority of cases, MRI or brain tomography are performed for the purpose of lowering parental anxiety and in order not to overlook a potential intracranial pathology. As reported in the present study, brain MRI or computed tomography were assessed by pediatricians in order to ensure that severe conditions such as brain tumors were not overlooked or due to parental anxiety. Repeat evaluations of the MRI results revealed abnormalities such as arachnoid cyst, septal deviation, adenoid vegetation, and non-specific white matter lesions. These are known to be incidental findings and do not generally require any specific medical treatment.

Evaluation of secondary headaches revealed upper respiratory tract infection findings in 33 of the 51 patients, discopathy accompanied by neck pain in four, elevated blood pressure in two, headache associated with dental decay in three, and headache secondary to recent trauma in two. The patients were asked whether they had presented to an ophthalmologist in the previous six months. Refractive error (astigmatism) was detected in four patients and benign intracranial hypertension findings in three. The causes of secondary headaches in our study are shown in Table VI.

In patients presenting to our clinic due to primary headache, no evident pathology was encountered in the MRIs of 90% of the migraine patients and 94% of those with TTH in this study. The existing literature concludes that routine imaging is not indicated when the neurological examinations of children presenting to the clinic with headaches are normal (12). The likelihood of a space-occupying lesion in the brain is reported to be low, particularly if the children's complaints persist for longer than one month, without any history of seizure or abnormal gait findings, or if a migraineur is present in the family (11). Unfortunately, in the majority of cases, MRI or tomography of the brain is performed in order to reduce parental anxieties rather than to exclude an intracranial pathology.

Study Limitations

One particular strength of this research is that it involved previously undiagnosed patients. The principal limitations are the fact that it was conducted in a newly established center, with a relatively small number of patients, and with a shorter follow-up period than in other studies. Despite these limitations, however, our data are promising due to their similarity to those of other studies.

Conclusion

Headaches represent one of the most frequent reasons for admission to pediatric neurology clinics. MRI and EEG are not generally required in the diagnosis of primary headaches

once a detailed history and physical examination have been performed. While the majority of brain MRI requests are of no particular diagnostic value, unnecessarily requested EEGs can lead to misdiagnoses. It is therefore crucially important to ensure that patients are closely monitored and that unnecessary requests are avoided. In order to enhance our current understanding of this subject, we recommend that normal and abnormal EEGs be compared with larger patient numbers and with longer follow-up times, such as five to ten years.

Ethics

Ethics Committee Approval: This study was approved by the Hitit University Faculty of Medicine Clinical Research and Ethics Committee (decision no.: 2022-105, dated: 14.12.2022).

Informed Consent: Informed consent was waived due to the retrospective nature of this study.

Authorship Contributions

Surgical and Medical Practices: S.Ö., Concept: S.Ö., Design: S.Ö., Data Collection and/or Processing: S.Ö., E.K., Analysis and/or Interpretation: S.Ö., E.K., Literature Search: S.Ö., E.K., Writing: S.Ö., E.K.

Conflict of Interest: The authors declare that there is no conflict of interest regarding the publication of this article.

Financial Disclosure: The authors received no financial support for the research, authorship, and/or publication of this article.

References

1. Gofshteyn JS, Stephenson DJ. Diagnosis and Management of Childhood Headache. Curr Probl Pediatr Adolesc Health Care. 2016; 46:36-51.
2. Nieswand V, Richter M, Gossrau G. Epidemiology of Headache in Children and Adolescents-Another Type of Pandemia. Curr Pain Headache Rep. 2020; 24:62.
3. Headache Classification Committee of the International Headache Society (IHS) The International Classification of Headache Disorders, 3rd edition. Cephalalgia. 2018; 38:1-211.
4. Kabbouche MA, Kacperski J, O'Brien HL PS, Powers SW, Hershey AD. Headache in Children and Adolescents. In: Swaiman KF A, S, Ferriero DM, Schor NF E, editors. Swaiman's Pediatric Neurology Neurology. Sixth. Elsevier Saunders, UK/USA; 2018. p. 647-55.
5. Rho YI, Kim SH, Kang HC, Lee YJ, Kim YO, Kim SK. EEG Characteristics and Diagnostic Implications in Childhood Headache: A Multi-Center Study. Front Neurol. 2020; 11:569486.
6. Kim S. Pediatric headache: a narrative review. J Yeungnam Med Sci. 2022; 39:278-84.
7. Baglioni V, Orecchio S, Esposito D, Faedda N, Natalucci G, Guidetti V. Tension-Type Headache in Children and Adolescents. Life. 2023; 13:825.
8. Antonaci F, Voiticovschi-Iosob C, Di Stefano AL, Galli F, Ozge A, Balottin U. The evolution of headache from childhood to adulthood: a review of the literature. J Headache Pain. 2014; 15:15.
9. Park EG, Yoo IH. The diagnostic values of red flags in pediatric patients with headache. Brain Dev. 2022; 44:512-9.
10. Bauer PR, Tolner EA, Keezer MR, Ferrari MD, Sander JW. Headache in people with epilepsy. Nat Rev Neurol. 2021; 17:529-44.
11. Canpolat M, Topcu A, Kardas F, et al. An assessment of the relation between vitamin D levels and electroencephalogram (EEG) changes in migraine patients. Bratisl Lek Listy. 2022; 123:92-9.
12. Martens D, Oster I, Gottschling S, et al. Cerebral MRI and EEG studies in the initial management of pediatric headaches. Swiss Med Wkly. 2012; 142:w13625.