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Klinik Araştırma

Choroidal Thickness and Ocular Hemodynamics in Idiopathic Sudden Sensorineural Hearing Loss

İdiyopatik Ani Sensörinöral İşitme Kaybında Koroid Kalınlığı ve Oküler Hemodinami

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Abstract

Aim: Hypotheses about idiopathic sudden sensorineural hearing loss (ISSNHL) have focused on inflammation and vascular etiopathogenesis. We evaluated the relationship between ISSNHL and choroidal thickness (CT), ocular pulse amplitude (OPA), and intraocular pressure (IOP) to reveal the generality of inflammation and vascular pathology.

Material and Methods: This study was conducted on 34 ISSNHL patients who were admitted within five days and were considered idiopathic with no etiological cause and 34 healthy controls. The ISSNHL group and the control group were assessed in terms of CT, OPA and IOP and ISSNHL groups on both affected (ipsilateral) and non-affected (contralateral) sides. Mild-moderate hearing loss group (n=20) and severe-profound hearing loss group (n=14) were also investigated and ocular parameters were compared.

Results: Choroidal thickness values were increased statistically significantly in the ISSHNL group (p=0.03), but there was no significant difference between groups in terms of OPA and IOP. When the ipsilateral and contralateral sides of ISSHNL patients were compared, no statistical difference was found between the CT, OPA and IOP values (p>0.05). Choroid thickness was found to be higher in severe-profound group rather than the mild-moderate group, but it was not statistically significant.

Conclusion: Increase in CT values of the ISSNHL group supports the relationship between sudden hearing loss and inflammatory processes. The bilateral nature of the findings support that systemic inflammation rather than a local inflammatory response.

Keywords: Choroidal thickness; inflammation; ocular physiology; sensorineural hearing loss

Öz

Amaç: Ani idiyopatik sensörinöral işitme kaybı (AİSNİK) ile ilgili hipotezler, inflamasyon ve vasküler etiyopatogenez üzerine odaklanmıştır. Biz bu çalışmada AİSNİK ile koroid kalınlığı (KK), oküler puls amplitüdü (OPA) ve göz içi basıncı (GİB) arasındaki ilişkiyi değerlendirerek, inflamasyon ve vasküler patolojilerin hastalıktaki rolünü ortaya koymayı amaçladık.

Gereç ve Yöntemler: Ani işitme kaybı şikayetiyle beş gün içinde başvuran ve etiyolojik bir neden bulunmayarak idiyopatik kabul edilen 34 AİSNİK hastası ve 34 sağlıklı gönüllü çalışmaya dahil edildi. AİSNİK grubu ile kontrol grubu ve kendi içinde AİSNİK grubunun etkilenen (ipsilateral) ve etkilenmeyen (kontralateral) tarafları KK, OPA ve GİB açısından karşılaştırıldı. Ayrıca hafif-orta işitme kayıplı grup (n=20) ve ileri-çok ileri işitme kayıplı gruplar (n=14) arasındaki oküler parametreler karşılaştırıldı.

Bulgular: Koroid kalınlığı, AİSNİK grubunda istatistiksel olarak anlamlı düzeyde artmış bulundu (p=0,03). Ancak OPA ve GİB açısından gruplar arasında anlamlı bir fark görülmedi. AİSNİK hastalarının, aynı taraf ve karşı tarafları karşılaştırıldığında KK, OPA ve GİB değerleri arasında istatistiksel olarak fark bulunmadı (p>0.05). Koroid kalınlığı, ileri-çok ileri işitme kaybı izlenen grupta, hafif-orta işitme kaybı izlenen gruba

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göre, artmıştı ancak istatistiksel olarak anlamlı değildi.

Sonuç: AİSNİK grubunun KK değerlerindeki artış, ani işitme kaybı ile inflamatuar süreçler arasındaki ilişkiyi desteklemektedir. Bulguların bilateral olması, lokal bir inflamatuar yanıttan çok sistemik inflamasyonu desteklemektedir.

Anahtar Sözcükler: İnflamasyon; koroid kalınlığı; oküler fizyoloji; sensörinöral işitme kaybı

Introduction

Sudden sensorineural hearing loss (SSNHL) is characterized by a rapidly progressive hearing loss ranging from seconds to days. Although there is no uniformly accepted description, it is defined as a sensorineural hearing loss of 30 dB or more in a minimum of three successive frequencies developing within 72 h (1). Although some studies suggested a great variety of factors such as infectious diseases (12.8%), otological conditions (4.7%), trauma (4.2%), hematological or vascular causes (2.8%), and neoplastic causes (2.3%), its etiology is still not fully identified and has been accepted to be widely idiopathic (71.0%) (2).

Chronic inflammation can cause microvascular damage, which increases the risk of ischemia (3). Inflammation can cause endothelial dysfunction due to thickening of the vascular wall, which accelerates the development of pro-thrombotic conditions (4). Recently, hypotheses about ISSNHL have centered on chronic inflammation, and in many clinical studies, an association between ISSNHL and inflammatory parameters has been reported (5-8).

The eye is the only organ in which noninvasive capillary blood flow can be monitored. The ophthalmic artery is the only branch of the internal carotid artery outside the cranium and provides the blood supply to the eye (9). The choroid layer is the vascular layer of the eye and the choroidal circulation is a high-flow system. It accounts for 85% of the total blood flow in the eye. The choroidal circulation is under the control of the sympathetic system and is considered non-autoregulated. This lack of autoregulation makes the choroid more sensitive to ocular perfusion pressure (10). Intraocular pressure (IOP) rises every systole and reduces in every diastole. The ocular pulse amplitude (OPA) is the difference between systolic and diastolic IOP, showing the volume of blood pumped into the choroid vessels and indirectly indicates choroid perfusion (11). OPA indicates the resistance of retrobulbar vessels in healthy individuals (12). The availability of ocular blood flow measurements has made it easier to understand the role of ocular hemodynamic changes in the pathophysiology of vascular diseases. In the literature, there are many recent studies examining the association between CT, OPA and IOP values, and systemic diseases, and several recent studies have shown that the choroid layer thickness is increased in inflammatory diseases (13–16).

In our study, we investigated the association of CT, OPA, an IOP values with ISSNHL to reveal whether inflammatory and vascular factors are localized or regional.

Material and Methods

Ethical approval was obtained from the local ethics committee (Ethics no: 2020 /1–1). Fifty two patients, who were admitted to a reference otolaryngology clinicwith sudden hearing loss developing within 3 days were investigated in this study. After getting their medical history and clinical examination, 10 of the 52 patients were excluded from the study due to the presence of ophtalmogic diseases, infectious diseases, autoimmune diseases, metabolic diseases, previous ear and eye surgery, trauma, vascular diseases, drug and substance use. Pure tone audiometry (PTA) test was performed and hearing loss degree of the patients were graded as mild (26–40 dB), moderate (41–60 dB), severe (61–80 dB) and profound (81 dB or greater) according to the World Health Organization (17). Temporal magnetic resonance with gadolinium was performed in all patients who were diagnosed with sudden idiopathic sensorineural hearing loss, where none of the patients showed pathological findings. Forty two patients with no apparent etiological cause were considered ISSNHL. Fourty of the 42 patients approved to participate in the study were referred to the ophthalmology clinic on the same day, before starting ISSNHL treatment. ISSNHL and control group measurements were made by experienced ophthalmologist. For IOP, OPA and CT measurements, while OPA and IOP values were measured using dynamic contour tonometry (DCT), choroidal measurements were made using the spectral-domain optical coherence tomography in choroidal mode (system software version 6.3, SD-OCT; RTVue XR; Optovue, Inc., Fremont, CA, USA).

For measuring CT, a subfoveal vertical line from the outer side of retina pigment epithelium to the choroidal-scleral junction and two extra lines at the temporal and nasal sides at 500 mm intervals were drawn. The average of these 3 measures was accepted as CT (Figure 1). Only the patients whose IOP and OPA measurements were in the highest quality Q1 classification in terms of quality values were included. So, among 40 patients, 6 patients were excluded from the ISSNHL study group. The healthy control group

constituted 34 subjects without any systemic disease, whose IOP, OPA, and CT values were obtained in the ophthalmology clinic.

In the ISSNHL group, ophthalmological measurements of the affected side (ipsilateral) and those on the non-affected (contralateral) eye were compared. Since there was no significant difference between the ipsilateral and contralateral eyes in ISSNHL and control groups, the average CT, OPA and IOP measurements of both groups were used. Average CT, OPA and Intraocular pressure measurements in ISSNHL and control groups were compared. Additionally, mild-moderate hearing loss group (n=20) and severe-profound hearing loss group (n=14) were also compared.

Statistical analysis

When investigating the normal distribution of variables, due to the number of units Shapiro Wilk's was used.

While examining the differences between the groups, Student t-tests were used if the variables displayed a normal distribution. Mann Whitney U-test was utilized if the variables did not have a normal distribution. While examining the relationships between the groups of nominal variables, the Chi-Square test was applied. As the significance level, 0.05 was used. There is a significant relationship when $p<0.05$, and there is no significant relationship if $p>0.05$.

Figure 1. Choroidal thickness measurements of an healthy individual (A) and a patient with ISSNHL (B) measured by spectral OCT device. A subfoveal perpendicular line from outer edge of retina pigment epithelium to the choroid-sclera junction and two additional lines at nasal and temporal sides at 500 mm intervals were drawn. The mean value of these 3 measures was accepted as the choroidal thickness.

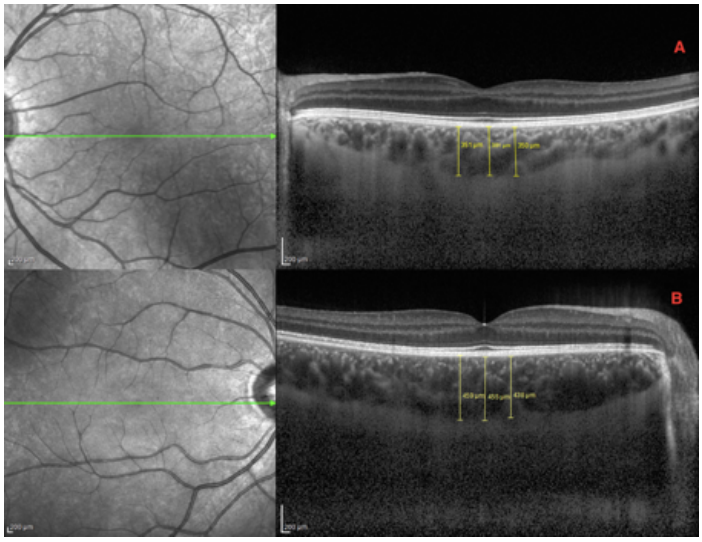

Table 1. Distribution of sex and age

	Patient (n,%)	Control (n,%)	P value
Sex			0,628*
Female	16 (47,1)	18 (52,9)	
Male	18 (52,9)	16 (47,1)	
Age, mean±SD (year)	38,76±12,82	41,37±5,53	0.219**

SD: Standart Deviation, *Chi Square Test, **Independent T Test

Table 2. Comparison of IOP, OPA, CT among patients with ISSNHL (ipsilateraally and controlaterally)

	Ipsilateral group, Mean±SD (n:34)	Controlateral group, Mean±SD (n:34)	P value
IOP	15.27±2,63	15,40±2,37	0.681*
OPA	2,39±0,94	2,21±0,595	0,411*
CT	320,97±107,57	321,88±192,22	0,972**

IOP: Intraocular Pressure, OPA: Ocular Pulse Amplitude, CT: Choroidal Thickness, ISSNHL: Idiopathic sudden sensorineural hearing loss, SD: Standart Deviation, *Mann Whitney U Test, **Independent T Test

Table 3. Comparison of IOP, OPA, CT results between patients with ISSNHL and controls

	IPatient group, Mean±SD (n:34)	Control group, Mean±SD (n:34)	P value*
IOP	15.27±2,63	14,32±02,17	0.212
OPA	2,39±0,94	2,11±0,52	0,307
CT	320,97±107,57	246,29±31,22	0,03

IOP: Intraocular Pressure, OPA: Ocular Pulse Amplitude, CT: Choroidal Thickness, ISSNHL: Idiopathic sudden sensorineural hearing loss, SD: Standart Deviation, *Mann Whitney U Test

Results

There was no significant difference between ISSNHL group and the control group in terms of gender and age (Table 1). All patients had unilateral sudden sensorineural hearing loss and unaffected ear hearing levels were normal.

In the ISSNHL group, IOP, OPA, and CT values were not statistically significant between the ipsilateral sides and contralateral sides (p>0.05) (Table 2).Therefore, the average values of both eye measurements were taken for other comparisons.

The choroidal thickness measurements in the ISSNHL group were found to be significantly higher than the control group (p=0.03). The OPA and IOP values in the ISSNHL group were also higher than the control group, but the difference was not statistically significant (p>0.05) (Table 3).

Of the 34 patients, 9 had mild hearing loss, 11 had moderate, 13 had severe and one had profound hearing loss. Due to the small number of patients, the mild and moderate hearing loss group was considered one group (n=20) and the patients with severe and profound hearing loss as another group (n=14). When these two groups were compared, CT was higher in the severe-profound group, but it was not statistically significant (309.90±90.93 and 341.21±115.33 (p=0.383), respectively).

Discussion

Many etiological causes have been suggested for ISSNHL, but most of them have not been unequivocally confirmed. Although its etiology is still unclear, inflammation has been reported to be one of the major accountable factors associated with ISSNHL (18). Inflammation can occur either directly due to infection or secondarily to vascular insufficiency (19). There are also studies supporting vascular etiology, which is one of the main hypotheses due to the similarity of ISSNHL to vascular ischemic diseases such as being unilateral and having a sudden onset in addition to its increased prevalence in people with underlying vascular diseases (20, 21). Perhaps ISSNHL can be more accurately defined as a clinical syndrome without a single identifiable cause that is valid for all cases. Every finding related to the etiology will improve the understanding of the disease.

The choroidal circulation has been described as “end-arterial” system without anastomoses (22). Like the eye, the human inner ear is supplied with labyrinthine end artery (23). This anatomical and functional similarity of the choroid and inner ear and ability to measure the capillary blood flow of the eye with noninvasive and objective methods made us think that the pathological eye values and the evaluation of whether these values are significant on the affected ear side may shed light on the etiology of ISSNHL.

We found a statistically significant increase in choroid thickness in both eyes of ISSNHL patients, but we did not find any significant difference between the CT, IOP and OPA levels of the affected side and that of the opposite side in ISSNHL patients. We interpreted these results as the presence of systemic inflammation rather than a localized inflammation in the etiology of the ISSNHL. Although it was not statistically significant, choroidal thickness was found to be higher in the severe-profound group than in the mild-moderate group. The increase in inflammation correlated with the hearing loss severity, thus supporting the relationship between them.

To date, many studies have been conducted to elucidate the etiology or physiopathology of ISSNHL. Many laboratory parameters that are indicators of inflammation have also been recently investigated in sudden hearing loss patients. Öcal et al. showed that the C-reactive protein (CRP)/albumin ratios were higher in ISSNHL patients comparing to the healthy controls (6). Yoon et al. investigated the role of mononuclear cells and inflammatory cytokines in sudden sensorineural hearing loss and suggested that tumor necrosis factor-α levels and monocyte population may play a role in its etiology (24). Various inflammation indicators such as white blood cell (WBC) and WBC subtype counts, IL-6, inflammation

CRP-to-albumin ratio, platelet-to-lymphocyte ratio and neutrophil-to-lymphocyte ratio have also been found to be significantly associated with ISSHL (5).

Arslan et al. reported that the prevalence of SSNHL was increased among migraine patients and they interpreted that vasospasm may be involved in the etiology of both diseases (20). However, Dervisogullari et al. examined OPA and CT in a migraine attack, they observed that the CT decreased during attack due to vasospasm, but there was no significant difference in OPA (25). Several studies have also shown that the choroid thickness decreases after caffeine intake and local anesthetic applications (26,27). In our study, we observed that the CT of ISSNHL patients was increased compared to healthy controls. It suggests that inflammation rather than vasospasm is important in its etiology.

Choroidal thickness increases in exacerbations in autoimmune and autoinflammatory diseases. Sometimes choroid thickness can also increase before exacerbations through subclinical (28). Caliskan et al. found that choroid thickness increases during the active period in Graves' disease, and there was no difference between patients and the control group during the inactive period (13). Turkcu et al. found an increase in the CT in patients with psoriasis compared to those in the healthy control group and suggested that this increase is due to increased TNF-α level (14). Choroid thickness was increased in Behcet's disease and inflammatory bowel disease patients as well (15,16). Our results are also compatible with these studies further supporting the association of inflammation with choroid thickening.

According to our literature research, there is no previous study on the association between choroid thickness, OPA and IOP levels, and ISSNHL. Although the relationship between choroid thickness and inflammation has been demonstrated in many studies, there was no publication investigating the relationship between ISSNHL and choroidal thickness, which makes this study the first study on this subject.

Conclusion

However, it was not statistically significant, we found that choroidal thickness was increased in the severe-profound group compared to the mild-moderate group. In studies with a larger number of patients, the relationship between choroidal thickness and the severity of hearing loss can be better examined. Also, studies that compare the recovery status of patients and the change in choroidal thickness will contribute to the literature.

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References

1.Stachler RJ, Chandrasekhar SS, Archer SM, Rosenfeld RM, Schwartz SR, Barrs DM et al. Clinical practice guideline: sudden hearing loss. Otolaryngol Head Neck Surg. 2012;146:S1-35.

2.Chau JK, Lin JR, Atashband S, Irvine RA, Westerberg BD. Systematic review of the evidence for the etiology of adult sudden sensorineural hearing loss. Laryngoscope. 2010;120:1011-21.

3.Dziedzic T. Systemic inflammation as a therapeutic target in acute ischemic stroke. Expert Rev Neurother. 2015;15:523-31.

4.Quaranta N, De Ceglie V, D'Elia A. Endothelial dysfunction in idiopathic sudden sensorineural hearing loss: A Review. Audiol Res. 2016;6:151.

5.Mosnier I, Stepanian A, Baron G, Bodenez C, Robier A, Meyer B et al. Cardiovascular and thromboembolic risk factors in idiopathic sudden sensorineural hearing loss: a case-control study. Audiol Neurootol. 2011;16:55-66.

6.Ocal R, Akın Ocal FC, Gulluev M, Alataş N. Is the C-reactive protein/albumin ratio a prognostic and predictive factor in sudden hearing loss? Braz J Otorhinolaryngol. 2020;86:180-4.

7.Seo YJ, Jeong JH, Choi JY, Moon IS. Neutrophil-to-lymphocyte ratio and platelet-to-lymphocyte ratio:novel markers for diagnosis and prognosis in patients with idiopathic sudden sensorineural hearing loss. Dis Markers. 2014; 2014:702807.

8.Masuda M, Kanzaki S, Minami S, Kikuchi J, Kanzaki J, Sato H et al. Correlations of inflammatory biomarkers with the onset and prognosis of idiopathic sudden sensorineural hearing loss. Otol Neurotol. 2012;33:1142-50.

9.Bill A, Sperber GO. Control of retinal and choroidal blood flow. Eye (Lond). 1990;4:319-25.

10.Ehrlich R, Harris A, Wentz SM, Moore NA, Siesky B A. Anatomy and regulation of the optic nerve blood flow. 2017, https://doi.org/10.1016/ B978-0-12-809324-5.01301-8.

11.Williamson TH, Harris A. Ocular blood flow

measurement. Br J Ophthalmol. 1994;78:939-45.
12.Stalmans I, Harris A, Fieuws S, Zeyen T, Vanbellinghen V, McCranor L et al. Color Doppler imaging and ocular pulse amplitude in glaucomatous and healthy eyes. Eur J Ophthalmol. 2009;19:580-7.
13.Calıskan S, Acar M, Gurdal C. Choroidal thickness in patients with Graves' ophthalmopathy. Curr Eye Res. 2017;42:484-90.
14.Turkcu FM, Sahin A, Yuksel H, Akkurt M, Ucmak D, Cınar Y et al. Evaluation of choroidal thickness in psoriasis using optical coherence tomography. Int Ophthalmol. 2016;36:851-4.
15.Karadag AS, Bilgin B, Soylu MB. Comparison of optical coherence tomographic findings between Behcet disease patients with and without ocular involvement and healthy subjects. Arq Bras Oftalmol. 2017;80:69-73.
16.Onal IK, Yuksel E, Bayrakceken K, Demir MM, Karaca EE, Ibis M et al. Measurement and clinical implications of choroidal thickness in patients with inflammatory bowel disease. Arq Bras Oftalmol. 2015;78:278-82.
17.Report of the informal working group on prevention of deafness and hearing impairment programme planning, Geneva, 18-21 June 1991. Geneva: World Health Organization; 1991. Available from: http://www.who.int/iris/handle/10665/58839.
18.Hiramatsu M, Teranishi M, Uchida Y, Nishio N, Suzuki H, Kato K et al. Polymorphisms in genes involved in inflammatory pathways in patients with sudden sensorineural hearing loss. J Neurogenet. 2012;26:387-96.
19.Crane RA, Camilon M, Nguyen S, Meyer TA. Steroids for treatment of sudden sensorineural hearing loss: a meta-analysis of randomized controlled trials. Laryngoscope. 2015;125:209-17.
20.Arslan Y, Arslan İB, Aydin H, Yagiz Ö, Tokucoglu F, Cukurova İ. The etiological relationship between mgraine and sudden hearing loss. Otol Neurotol. 2017;38:1411-4.
21.Hsu HT, Chen JY, Weng SF, Huang KH, Lin YS. Increased risk of erectile dysfunction in patients with sudden sensorineural hearing loss: a nationwide, population-based cohort study. Otol Neurotol. 2013; 34:862-7.
22.Alm A. Ocular circulation. In: Hart W, ed. Adler's Physiology of the Eye: Clinical Application. St. Louis, MO: Mosby-Year Book, Inc. 1992: 199–227.
23.Mei X, Atturo F, Wadin K, Larsson S, Agrawal S, Ladak HM et al. Human inner ear blood supply revisited: the Uppsala collection of temporal bone-an international resource of education and collaboration. Ups J Med Sci. 2018;123:131-42.
24.Yoon TH, Paparella MM, Schachern PA, Alleva M. Histopathology of sudden hearing loss. Laryngoscope. 1990;100:707-15.
25.Dervisogullari MS, Totan Y, Gencler OS. Choroid thickness and ocular pulse amplitude in migraine during attack. Eye (Lond). 2015;29:371-5.
26.Dervisogulları MS, Totan Y, Yuce A, Kulak AE. Acute effects of caffeine on choroidal thickness and ocular pulse amplitude. Cutan Ocul Toxicol. 2016; 35:281-86.
27.Dogan S, Simsek A, Bayraktar C, Yazici H, Sarikaya Y, Karatas M et al. Ocular blood flow alterations during inferior turbinate radiofrequency reduction under local anesthesia. Am J Rhinol Allergy. 2016;30:185-8.
28.Steiner M, Esteban-Ortega MDM, Muñoz-Fernández S. Choroidal and retinal thickness in systemic autoimmune and inflammatory diseases: A review. Surv Ophthalmol. 2019;64:757-69.