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EFFECTS OF CHANGES IN DYNAMIC CHARACTERISTICS OF THE MIDDLE EAR ON TRANSIENT-EVOKED OTOACOUSTIC EMISSIONS

UTICAJ IZMENJENIH DINAMIČKIH KARAKTERISTIKA SREDNJEG UVA NA TRANZITORNE OTOAKUSTIČKE EMISIJE

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Summary - Transient-evoked otoacoustic emissions are transmitted through the middle ear. The purpose of this study was to investigate the effects of dynamic properties of the transmission system on the measurability of transient otoacoustic emissions. The authors analyzed the presence of transient otoacoustic emissions in 48 children with serous otitis media regarding the tympanogram, presence and type of effusion and pure tone average findings. The results obtained in this research show the predominant absence of transient otoacoustic emissions in patients with type B tympanogram (69.1%) especially if the effusion is mucoid (77.5%) with the hearing loss of 15 decibel hearing level. This research shows that disorders in dynamic characteristics of the middle ear in patients with serous otitis obstruct the transmission of acoustic energy and affect the measurability of transient otoacoustic emissions, especially if the effusion is mucoid and hearing loss of 15 decibel hearing level.

Key words: Otoacoustic Emissions, Spontaneous; Cochlea + pathology; Otitis Media with Effusion; Diagnosis; Acoustic Impedance Tests; Child; Child, Preschool; Auditory Threshold

Introduction

Transient-evoked otoacoustic emissions (TEOAEs) provide an objective, simple, quick and non-invasive test of cochlear function. Their clinical application is extensive in healthy persons as well as in patients with hearing impairment. Nowadays, the routine use of TEOAEs is present in newborn hearing screening and in ototoxicity monitoring [1,2]. In this way, we are able to detect a drop of hearing threshold in newborns up to 30 decibel hearing level (dB HL) as well as ototoxic cochlear lesion in children and adults.

Altered tympanometric findings or the presence of effusion in the middle ear may affect the measurability or cause the absence of TEOAEs [2,3].

Surveys have identified the effects of dynamic characteristics of the middle ear on TEOAEs [2].

The research carried out by Koivunena and his colleagues has shown that there is a significant reduction of amplitude or a complete absence of measurable TEOAEs in type B tympanograms [4].

In their work, Davilis, Kores and their colleagues have studied the possibility of applying TEOAEs in detecting middle ear pathology. They have concluded that TEOAE response is absent in patients with type B tympanogram in 43% to 72.3% of the cases, depending on the hearing threshold [5].

According to some authors, even the smallest amount of effusion in the middle ear in patients with serous otitis media confirmed by myringotomy leads to immesurability of TEOAE [6,7]. In their work, Amedee and his colleagues show that TEOAE is measurable even in the presence of effusion in the middle ear, provided it is not a high-viscosity effusion. According to research conducted by Zhao and his colleagues, the dynamic characteristics of the middle ear, determined by the mobility of the transmission system, are the factors controlling the TEOAE status [8]. In his work, Koivunen shows that the TEOAE response depends not only on the quantity, but also on the quality of the effusion. Mucous effusion reduces measurable emissions to a greater extent than non-mucous one, but substantial reduction of TEOAEs is manifest in both cases [9,10]. This research shows that the transmission of acoustic energy through the middle ear is altered in patients with serous otitis media.

In observing the relation between TEOAEs and hearing threshold, it is known that there is an absence of measurable emissions in patients with sensorineural hearing impairment greater than 30 dB HL. In their work, Zhao, Wada and others show that TEOAEs are measurable in patients with preserved sensorineural function and irregular middle ear dynamic characteristics and in cases with the hearing threshold of 40 dB HL. A higher incidence of measurable TEOAEs has been found in patients with serous otitis media when compared to patients with chronic otitis media with the same hearing threshold [8].

Transient-evoked otoacoustic emissions are a valuable and useful test for observing middle ear...
The patients were 4 to 12 years old. Most patients were older than 4 and younger than 12 (Graph 1).

According to the tympanometry results, 81 patients were type B, and 15 patients were type A or C. TEOAEs were measurable in 73.3% of the patients with type A and C tympanogram and in 30.8% of the patients with type B, the difference being statistically very significant ($\chi^2 = 9.740; \text{df} = 1; p = 0.002$) (Table 1).

The analysis of measurability of TEOAEs in correlation with the presence and viscosity of effusion in the middle ear showed that 61.76% of the screened ears without effusion had detected TEOAEs. Where mucous effusion was present, TEOAEs were detected in 22.5%, and non-mucous in 27.3% (Table 2, Graph 2).

This difference is statistically very significant ($\chi^2 = 13.363; \text{df} = 2; p = 0.001$).

When we traced the correlation between TEOAE and the viscosity of the effusion, we found that their presence was less frequently detected in patients with mucous effusion, but with no significant statistical difference ($\chi^2 = 0.176; \text{df} = 1; p = 0.675$).

By observing the presence of TEOAEs in correlation with the hearing threshold, we found measurable TEOAEs in 75% of the patients with the hearing threshold of 15 dB HL under, 38.3% of those with the threshold of 16 to 30 dB HL, and 24.3% of those with the threshold greater than 30 dB HL. This

### Table 1. TEOAEs in correlation with tympanogram

<table>
<thead>
<tr>
<th>TEOAE</th>
<th>A and C</th>
<th>% Frequency</th>
<th>B</th>
<th>% Frequency</th>
<th>Total</th>
<th>% Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes/Da</td>
<td>11</td>
<td>73.33%</td>
<td>25</td>
<td>30.86%</td>
<td>36</td>
<td>37.50%</td>
</tr>
<tr>
<td>No/Ne</td>
<td>4</td>
<td>26.67%</td>
<td>56</td>
<td>69.14%</td>
<td>60</td>
<td>62.50%</td>
</tr>
<tr>
<td>Total/Upunpo</td>
<td>15</td>
<td>100%</td>
<td>81</td>
<td>100%</td>
<td>96</td>
<td>100%</td>
</tr>
</tbody>
</table>

### Graph 2. TEOAE in correlation with the presence and type of effusion

**Grafikon 2. TEAOE u odnosu na prisustvo i tip sekreta u srednjem uvu**

The objective of this survey was to establish the significance of monitoring TEOAEs in children with serous otitis media by analyzing their correlation with the results of tympanogram, characteristics of the effusion in the middle ear and the hearing threshold.
difference is statistically significant ($\chi^2 = 9.953; df = 2; p = 0.007$) (Table 3).

When we compared the measurability of TEOAEs in the group with the threshold of 16 to 30 dB HL (38.3%) and the group with the threshold greater than 30 dB HL (24.3%), we found no statistically significant difference ($\chi^2 = 1.853; df = 1; p = 0.173$).

**Discussion**

Serous otitis is a disease most frequently found in pre-school children and early-school-age children, mostly boys. In this research, 64% of the total number of patients were boys.

A previous research has shown that type B tympanogram is an objective parameter of high specificity and sensitivity in diagnostic procedures for serous otitis.

This research shows that there is a statistically significant correlation between measurable TEOAEs and tympanometry results. In patients with type B tympanogram, there is a predominant absence of TEOAEs, which is in accordance with the research of other authors.

By studying the significance of presence of effusion in the middle ear and its effects on the dynamic characteristics and transmission of acoustic energy, we have found statistically significant differences in the measurability of TEOAEs. Where effusion is absent, the observed parameters are predominantly neatly measurable.

These findings lead to the conclusion that TEOAEs are not measurable in a considerable number of patients with type B tympanogram. This information may be of relevance in pre-surgery procedures for the assessment and monitoring of patients with serous otitis media.

When the effects of the viscosity of effusion on the measurability of TEOAE are regarded, this research shows that the measurability is reduced in patients with mucous effusion in the middle ear, but with no significant statistical difference. Such findings are in accordance with the results of research carried out by other authors showing a significant reduction of TEOAEs where the effusion is non-mucous.

It is evident that two factors in the middle ear are closely related to the absence of TEOAEs, the presence and viscosity of effusion. Clinicians must take into consideration that TEOAEs may be absent in patients with normal hearing range or with a tympanogram indicating negative pressure in the middle ear (A and C).

By analyzing the correlation between the hearing threshold and the presence of transient-evoked otoacoustic emissions, this research shows a statistically significant presence of measurable TEOAEs in patients with normal hearing threshold (up to 15 dB HL). These findings are in accordance with the claims of other authors according to whom TEOAEs may be observed in patients with normal hearing threshold, i.e. with the hearing threshold up to 20 dB HL.

The results of this research show that, although TEOAEs are absent in most patients with the hearing threshold exceeding 16 dB HL, they may be detected even in some patients with the hearing threshold greater than 30 dB HL. A research carried out by other authors also points to the possibility of detecting TEOAEs in patients with serous otitis and the hearing threshold of 40 dB HL. According to the results of this research, TEOAEs are measurable in 38.3% of patients with the hearing threshold up to 30 dB HL and in 24.3% of patients with the hearing threshold exceeding 30 dB HL. This difference is not statistically significant and we may conclude that TEOAEs will be present in patients with normal hearing threshold TEOAEs, while their absence may be expected in patients with the hearing threshold greater than 16 dB HL, especially if the threshold exceeds 30 dB HL.

**Conclusions**

1. Transient-evoked otoacoustic emissions are predominantly absent in patients with serous otitis and type B tympanogram.

2. The presence of effusion in the middle ear in patients with serous otitis leads to the disruption of measurability and absence of transient-evoked otoacoustic emissions, especially if the effusion is mucous.

3. There is a statistically significant absence of transient-evoked otoacoustic emissions in patients with serous otitis and the hearing threshold greater than 15 decibel hearing level, thus indicating the relevance of changes in the dynamic characteristics of the middle ear.

4. Monitoring of transient-evoked otoacoustic emissions in children with serous otitis media is of a diagnostic significance for this disease, especially in the assessment of presence of effusion in the middle ear, dynamic status and hearing threshold.
Špirić S, et al. Transient-evoked otoacoustic emissions

Sažetak

Ključne reči: Tranzitorna otoakustička emisija; Kohlea + patologija; Serozni otitis media; Dijagnoza; Timpanometrija; Dete; Predškolsko dete; Prag sluha

Uvod
Tranzitorne otoakustičke emisije omogućavaju objektivno, jednostavno i neinvazivno funkcionalno ispitivanje kohlearne funkcije. Dinamičke karakteristike srednjeg uva određene mobilnošću transmisionog sistema faktori su koji kontrolisu tranzitorne otoakustičke emisije.

Materijal i metode

Rezultati
Tranzitorne otoakustičke emisije bile su merljive kod 73,3% uzoraka s timpanogram tipa A i C, te kod 30,8% s tipom B. Ova razlika je statistički visokoznačajna \( (c^2=9,740; df=1; p=0,002) \). Zabeležene tranzitorne otoakustičke emisije ima 61,76% pregledanih ušiju bez sekreta, 22,5% u slučaju prisustva mukoznog sekreta, a nemukoznog u 27,3%. Ova razlika je veoma statistički značajna \( (c^2=13,363; df=2; p=0,001) \). Tranzitorne otoakustičke emisije su merljive kod 75% uzoraka s nalazom sluha do 15 dBHL, 38,3% s pragom sluha od 16 do 30 dBHL i 24,3% s pragom lošijim od 30 dBHL. Ova razlika je statistički značajna \( (c^2=9,953; df=2; p=0,007) \).

Zaključak
Prisustvo sekreta u srednjem uvu kod pacijenata sa seroznim otitismom rezultira poremećajem merljivosti i izostankom tranzitornih otoakustičkih emisija, posebno ukoliko je sekret mukozan. Odsustvo tranzitornih otoakustičkih emisija kod ovih pacijenata uočava se već ukoliko je prag sluha lošiji od 15 dBHL.

Zaključak

Referenca