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Original research article

The use of otoacoustic emission in the assessment of the organ of hearing in children and adolescents with peripheral facial nerve palsy

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ABSTRACT

Introduction: Audiological diagnostics in patients with peripheral facial nerve palsy is a very interesting issue. Despite the obvious anatomical correlations between structures of the middle and inner ear and the course of the facial nerve in the available literature only several publications concerning this issue may be found.
Aim: The aim of this work was hearing evaluation in children and adolescents with peripheral facial nerve palsy with the use of otoacoustic emission.
Material and methods: Baseline test was conducted in 15 patients with peripheral facial nerve palsy. It included transient evoked otoacoustic emission (TEOAE). Follow-up test was conducted 3 months after the first test. It included distortion product otoacoustic emission (DPOAE).
Result: In the first and follow-up test all patients achieved PASS result both on facial nerve palsy and the opposite side. Mean values of S/N ratio for the tested frequencies between healthy and compromised side did not differ both in baseline and follow-up test.
Discussion: Symptoms accompanying facial nerve palsy include sudden increase of sound perception and distortion of understanding of speech. The above phenomena are typical for cochlear function impairment. It may also be associated with extracochlear damage of the cochlear nerve.
Conclusions: Results of otoacoustic emission testing confirmed proper function of the inner ear in all of the study patients both in baseline and follow-up.

1. Introduction

Audiological diagnostics in patients with peripheral facial nerve palsy (PFNP) is a very interesting issue. Despite the obvious anatomical correlations between structures of the middle and inner ear and the course of the facial nerve within the pyramid of the temporal bone, in the available literature only several publications concerning this issue may be found. It presents mainly the use of electrophysiological methods in diagnostics.[1–4] In spite of very modern diagnostic methods, the etiology of FNP in the majority of cases is still not possible to determine. FNP is frequently considered a symptom, not a separate disease entity, similar to other disorders of unknown etiology, e.g. sudden deafness or inflammation of the vestibular neuron.[5,6] Unilateral damage of facial nerve function of unknown etiology is called idiopathic palsy and constitutes approximately 75% of all cases.[7] It is known as 'Bell's palsy', named after the English physician Sir Charles Bell, who in 1821 stated that facial nerve is responsible for the innervation of the mimic facial muscles.[7,8]

Diagnostic tests used to evaluate the organ of hearing include psychophysical and electrophysiological tests. Psychophysical methods require patients cooperation and are called subjective tests. Electrophysiological tests evaluate the organ of hearing without patients cooperation and are called objective tests. One of the methods of objective evaluation of hearing is otoacoustic emission (OAE).

OAEs are very quiet acoustic signals emerging in the cochlea due to the shrinkage of hair cells of the organ of Corti. This phenomenon was discovered by David Kemp in 1978. Mechanical processes that occur in the organ of Corti following sound activation are enhanced by summing the amplitude of vibration of outer hair cells and amplitude of oscillation of the basal membrane. This phenomena cause turbulence of endolymph that are transmitted from the cochlea through the ossicles and

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tympanic membrane into the external auditory meatus. Signal recording is made by microphone probe placed in the external auditory meatus.[9,10]

There are two types of OAEs: spontaneous (SOAE) and evoked (EOAE). SOAEs are generated without any outside sound stimulus. EOAEs occur, for example, after stimulation of cochlea by a click noise, that is a stimulus in which all the frequencies are uniformly present and the value of the volume is in the range 75–85 dBSL. This phenomenon is called transient evoked OAEs (TEOAE).[9,11]

From clinical point of view the assessment includes the S/N ratio, which is the difference between the signal and the background noise levels, which should exceed 6 dB. This parameter is evaluated for each half-octave frequency bands. The correct result according to various authors is obtained when S/N ratio is correct for 50% to 80% of frequency ranges. Such result is called PASS and is considered normal. The REFER result does not meet the above criteria and confirms hearing loss.[9,12]

Another type of otoemission is distortion product OAE (DPOAE). DPOAEs are generated when the ear is stimulated by two stimuli of different frequencies which are in the ratio f_1/f_2 from 1.20 to 1.25. Intensity of the lower tone is 10 dB louder than the higher tone. These signals are emitted simultaneously causing mechanical deformation of the basilar membrane of the cochlea in different locations, which results in emission of the new sound with frequency f_3. Results of the test are presented as a DP-gram which is the display of otoemission signals for the 1–6 kHz frequency range for f_3. DPOAE response is assessed by two quantitative parameters, such as absolute amplitude in dB and the difference between DPOAE signal and the background noise (S/N). DPOAE is present when S/N ratio exceeds 6 dB. The term PASS, which is the correct result and REFER, which is incorrect, are determined according to the same criteria as in TEAOE.[9,13,14]

2. Aim

The aim of this work is the assessment of perceptual function of the inner ear in children and adolescents with PFNP with the use of OAE.

3. Material and methods

3.1. Material

Baseline clinical and audiological test (first test) was conducted in the Center for Audiology and Phoniatrics at the Provincial Specialist Children's Hospital in Olsztyn. The study enrolled patients hospitalized in the Department of Neurology due to PFNP.

The study was approved by Bioethics Committee of the Faculty of Medical Sciences of the University of Warmia and Mazury in Olsztyn, Decision No. 35/2013 of November 14, 2013.

Each time written consent from legal guardians and patients who have attained the age of 16 years was obtained. In the period from January 2012 to the end of November 2013, 15 patients aged from 3 to 17 years were examined. Median age was 10 years. The study group included 4 male (37%) and 11 female subjects (63%).

Follow-up test (second test) was conducted in patients who were able to participate in the period between 3 and 18 months after first test. It was performed in otolaryngology outpatient clinic.

3.2. Inclusion and exclusion criteria

In order to qualify for the first test, the purpose of which was to compare audiological examination parameters of healthy and impaired ear, subject was required to meet the inclusion and exclusion criteria. Results of hearing tests of the ear without FNP were used as a control group.

Inclusion criteria were as follows: unilateral PFNP, age from 3 to 17 years and normal hearing on the side with no symptoms of FNP.

Exclusion criteria included: central or bilateral FNP, hearing loss on the healthy side, acute or chronic inflammatory lesions of the healthy ear, tumors or other lesions of the parotid gland that may be the cause of palsy and time from the first symptoms of palsy to the study exceeding 30 days.

3.3. Methods

3.3.1. Audiological research tools

Audiological diagnostics in the first test was performed in audiometric laboratory of the Center for Audiology and Phoniatrics at the Provincial Specialist Children's Hospital in Olsztyn. TEOAE was performed with OtoRead Clinical device.

Second test was conducted in audiological laboratory of the Specialist Center for Diagnosis and Rehabilitation of Children and Youth with Hearing Defects, Polish Association of the Deaf in Olsztyn. It included DPOAE with OtoRead Clinical device.

3.3.2. Statistical methods

Statistical calculations were made with the use of Statistica v. 9.1 and Microsoft Excel 2007 software. Statistical data analysis was performed with the use of *t*-test to examine the differences between the means of two groups: healthy and impaired side. Previously, the assumption of normality of variables was checked by the analysis of distribution of the data and the assumption of the equality of variance with the use of *F*-test. *P* value represented probability of error associated with hypothesis of the existence of differences between means. Established critical value of *P* was 0.05. This means that if $P > 0.05$ there is no reason to reject the null hypothesis (H_0) on the lack of differences between means, while when $P < 0.05$ there is the basis to reject H_0 and accept hypothesis (alternative) on the existence of differences between means. Were conditions of normality not satisfied, prior to analysis Box–Cox transformation was applied, which is used to transform variables so that its distribution after transformation is close to normal distribution. In cases where sample size varied, Tukey's test for unequal *N* was used, at a significance level $\alpha = 0.05$.[15]

4. Results

4.1. Results of baseline OAE tests

OAE in all 15 patients in whom the test was performed gave PASS result both on FNP and the opposite side.

Comparative analysis of the mean value of S/N ratio between healthy and compromised side was performed. Based on *t*-test results for the examined frequencies no significant differences in mean values of S/N ratio between healthy and compromised side were found. Results were presented in Table 1 and Fig. 1.

For groups with uneven number Tukey's significant difference test was used to compare the S/N ratio of the affected side in patients with known cause of FNP ($n = 4$) and other patients ($n = 11$). The analysis conducted with this method shows no significant difference in the mean value of S/N ratio for the tested frequencies. The results were shown in Table 2.

4.2. Results of follow-up OAE tests

In DPOAE in all patients PASS result was obtained for both sides.

Analysis performed with *t*-test showed no significant difference of mean values of S/N ratio between healthy and affected side for almost all the tested frequencies. However, at the significance level $\alpha = 0.05$ significant difference between healthy and compromised

Table 1
Average values of S/N ratio before (raw data) and after Box-Cox transformation (BC) with indication of the level of significance (P).

Frequency, kHz	Data	Average value of S/N		t	P
		Healthy side	Pathological side		
0.7	raw	4.47	4.20		
	BC	14.25	13.91	0.12	0.902
1.0	raw	10.87	10.40		
	BC	21.93	21.38	0.19	0.849
1.4	raw	13.67	14.47		
	BC	25.37	26.42	−0.34	0.734
2.0	raw	14.93	13.60		
	BC	26.92	25.29	0.67	0.507
2.8	raw	12.27	13.53		
	BC	23.65	25.17	−0.68	0.505
4.0	raw	10.40	10.47		
	BC	21.37	21.43	−0.02	0.981

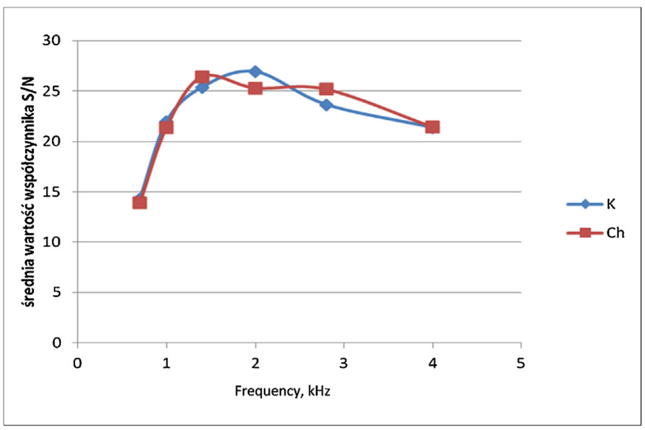

Fig. 1. Chart of the mean S/N ratio as a function of frequency for the side with (Ch) and without (K) FNP.

Table 2
Comparison of the average value of S/N ratio of the healthy side in patients with known (Z) cause of paralysis and idiopathic (NZ).

Frequency, kHz	Cause	Data	Average value of S/N	Tukey's test P
0.7	Z	raw	3.55	
	NZ		6.00	
	Z	BC	7.89	0.587
	NZ		10.15	
1.0	Z	raw	10.27	
	NZ		10.75	
	Z	BC	13.92	0.928
	NZ		14.33	
1.4	Z	raw	14.73	
	NZ		13.75	
	Z	BC	17.83	0.858
	NZ		16.91	
2.0	Z	raw	14.18	
	NZ		12.00	
	Z	BC	17.37	0.607
	NZ		15.43	
2.8	Z	raw	13.45	
	NZ		13.75	
	Z	BC	16.75	0.919
	NZ		17.02	
4.0	Z	raw	10.36	
	NZ		10.75	
	Z	BC	14.02	0.923
	NZ		14.37	

side was shown at a frequency of 6.0 Hz ($P = 0.043$). Results were presented in Table 3.

5. Discussion

Audiological diagnostics in children is a very difficult task, frequently long-term, requiring various test and multiple repetitions. Behavioral audiometry or tonalaudiometry, which is recently performed as a basic hearing test in children, is a subjective examination, which requires patient's cooperation. Owing to technological development, currently numerous possibilities of objective tests, such as auditory brainstem response, OAE and impedance audiometry are available.[9]

In the world literature numerous authors present results of hearing evaluation in various disease entities both in children and adults. Muszyński published results of hearing tests in children and adolescents with juvenile chronic arthritis. In the study group no lowered auditory threshold in tonal audiometry and influence of the disease on the presence of stapedius reflex was found. Prolonged disease process affected tympanogram statistically significantly decreasing its amplitude and gradient.[16] Negative effects of chronic therapy on the organ of hearing in children with kidney diseases were demonstrated by Sobala et al.[17] Diagnostics of hearing in children with Down syndrome was performed by Szyfter et al. They found that hearing impairment in the study group was present in 82% of cases.[18] Topolska et al. diagnosed children with infantile cerebral palsy with the use of various audiological objective and subjective methods. In a large percentage of the study group abnormal auditory results were found. The authors indicate diagnostic difficulties and discrepancies between subjective and objective results.[19] Hearing tests in children with hydrocephalus treated with valve system were conducted by Löppönen. He confirmed the presence of hearing loss mainly at high frequencies in 34% of cases, regardless of the type and cause of hydrocephalus.[20]

Publications presented above are only chosen from numerous articles on audiological assessment in various disease entities and clinical situations. It should be emphasized that in the available literature it is difficult to find a publication on OAE results in patients with FNP. It should be determined whether hearing disorders occur in patients with FNP symptoms and if so, what is its character. Various types of hearing disorder were found in 5–20% of patients with PFNP.[21,22] Reduced tolerance to high volume sound, phonophobia and dysacusis should be mentioned.[22,23]

In case of FNP this phenomenon is associated with lack of stapedius reflex when facial nerve was damaged above the exit of the stapedius nerve. Other phenomena associated with impaired stapedius reflex are sudden and difficult to accept increase of sound perception (*pseudorecruitment*) and distortion of

Table 3
Otoemission (DPOAE) follow-up – average before (raw data) and after Box-Cox transformation (BC).

Frequency, Hz	Data	Healthy side	Pathological side	t	P
1.5	raw	11.54	11.63		
	BC	36.88	37.28	−0.09	0.928
2.0	raw	15.98	16.56		
	BC	49.06	50.41	−0.29	0.775
3.0	raw	23.02	22.78		
	BC	68.93	68.22	0.16	0.877
4.0	raw	22.95	24.83		
	BC	68.57	74.24	−1.38	0.172
5.0	raw	21.32	21.10		
	BC	63.53	62.86	0.18	0.855
6.0	raw	19.71	23.24		
	BC	59.45	69.48	−2.05	0.043

understanding of speech manifested by decreased discrimination in speech audiometry (rollover).[21]

The above phenomena are typical for cochlear function impairment.[9] In case of FNP some authors relate it to the extracochlear damage of the cochlear nerve and assign common etiology of damage of both facial and cochlear nerve.[21,24]

6. Conclusions

Results of OAE testing confirmed proper function of the inner ear in all of the study patients both in baseline and follow-up.

Conflict of interest

None declared.

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