Contralateral Suppression of Transient Evoked Otoacoustic Emissions in Children with Fluency Disorders

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ABSTRACT

Objective: This study was designed to investigate the auditory system functions of the medial olivocochlear efferents in children with and without fluency disorders.

Methods: Twenty-four children aged 6-10 years with fluency disorder (age mean±SD=8.1±1.2) and 15 typically developing control subjects (age mean±SD=8.2±2.5) participated in this study. After obtaining approval of the local ethical committee and informed consents, all participants underwent otoscopic examination, audiological evaluation, Transient Evoked Otoacoustic Emissions and Transient Evoked Otoacoustic Emissions with contralateral suppression. All the participants had normal hearing and middle ear function.

Results: When compared rates of TEOAE suppression effect in children with and without fluency disorders, a statistically significant difference was found in children with fluency disorder, especially in the left ear at 2 kHz frequency ($p<0.05$). There was no statistically significant difference between right and left ears in terms of mean values ($p>0.05$).

Conclusion: Our study suggests that, although there is a difference between the groups in terms of percentage of cases in which suppression is detected at 2 kHz, it is necessary to support the findings with new investigations covering more cases in order to reach a judgment on the functioning of the MOC efferent system in children with fluency disorder.

Keywords: Stuttering, efferent pathways, hearing, otoacoustic emissions, spontaneous

INTRODUCTION

Stuttering is a disorder of fluency, which is defined as voice-syllable repetitions that affect speech rhythm and speed, as voice extensions and as an interruption of speech flow because of corrections and pauses (1, 2). Although behaviors such as repeating some words time to time, making corrections, and pausing or adding some space-filling voices or words interrupt the flow of speaking, they may not always point to the presence of stuttering. Rather than the repetition of words, the repetition or extension of voices or syllables and doing this at a noticeable frequency is considered an important criterion in terms of referring to a speech fluency problem as stuttering (2, 3). Stuttering is a common problem during the pre-school period, although being a speech disorder that can be encountered at any age (4, 5). It has been reported that approximately 5% of pre-school children have a pre-6-year onset fluency problem called developmental stuttering, and 70%–80% of them spontaneously recover without any intervention (6, 7). However, in some individuals, it may be a permanent state that also continues in adulthood. It is estimated that the prevalence of stuttering ranges from 0.7% to 0.8% among individuals of all ages (2).

Although there are several opinions on the causes of stuttering, the issue is still being discussed. Among the factors causing stuttering, genetic and neurophysiological factors are particularly emphasized. In addition, emotional factors, family dynamics, personality traits, or environmental factors should be considered effective factors in the course rather than the cause of the problem (1). Studies have revealed that neural network connections are fewer in the regions associated with movement control in stuttering individuals; the presence of some structural and functional findings, such as the atypical lateralization of brain hemispheres and differences in gray and white matter structures, has also been reported (8, 5, 9). It is stated that reactions of the family and the environment to the speech fluency

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disorder and the way the child perceives this problem or negative experiences are effective on the treatment success as well as its permanency, recurrence, or worsening (10, 11). In summary, a consensus has not been attained on why some children encounter such a problem and why it spontaneously recovers in some and remains persistent in others. This suggests that all possible differences between children with fluency disorder and those who have never encountered such problems should be examined. From this viewpoint, this study aimed to investigate children with stuttering by comparing them with those who have typical speech characteristics in terms of medial olivocochlear (MOC) system function.

The olivocochlear system comprises lateral and medial fibers extending from the superior olivary complex in the brainstem to the cochlea (12). While lateral fibers having ipsilateral functioning synapse with nerve fibers in the inner hair cells of the cochlea, medial fibers contralaterally extending synapse with the outer hair cells (12, 13). It is believed that MOC fibers protect the auditory system from acoustic trauma by creating a repressive effect on the outer hair cells and facilitate the discrimination of speech in noisy environments (14). With otoacoustic emission (OAE) measurements, functions of the MOC system can be objectively evaluated (15). It is noted that OAE values reflecting the response of the outer hair cells to the voice stimulus are lower when contralateral acoustic stimuli are given at the same time during the measurement than those in the absence of contralateral stimuli, and this decrease is due to the suppressive effect of MOC system on the outer hair cells. Considering the findings that stuttering may be related to neurophysiological factors, it is reasonable to question whether there is a difference that affects the functioning of the MOC system in children with stuttering. It was seen in our survey that there was insufficient information in this regard and the only outcome we could reach included adults (17).

In this study, the contralateral suppression effect that reflects to the transient-evoked OAE (TEOAE) measurements was compared in children with and without stuttering. Thus, we aimed to investigate whether there is a finding highlighting the difference in terms of the functioning of MOC system in children with stuttering.

METHODS

Participants

After obtaining the ethics committee approval of non-interventional clinical trials (TÜTF-GOAEK 2014/54) from the School of Medicine Trakya University and informed oral consent form, our study was conducted on 39 participants aged 6–10 years. The participants were examined into two groups as the patient and control groups. Twenty-four children with stuttering were included in the patient group [5 females and 19 males; age, 8.1±1.2 (mean±SD) years], whereas 15 children were included in the control group (8 females and 7 males; age, 8.2±2.5 years) without language-speech problems. The normality of hearing and dominant right hand use in tasks requiring fine motor skills (such as using a pen and holding scissors or spoon) were sought in the participants of both groups.

Evaluation of the Speech Fluency

The patient group of the study included children who presented at our clinic with problems of speech fluency and who were identified after the assessment as children with a fluency problem that would require follow-up. The key points in identifying children with stuttering, their categorization to the patient group, and essential characteristics of the patients are as follows:

- Detection of fluency disorder, which has the characteristics of developmental stuttering (based on a family interview)
- No language-speech problems other than stuttering, and no medical or developmental problems
- Observation of three or more fluency disorders in the language sample that is based on at least 100 words, and this should not have the feature of a fast-bad speech.

Language and speech were evaluated by experienced audiologists and speech disorder experts. The evaluation comprises stages of family interview and child assessment. In the family interview, information was obtained regarding the first appearance of the fluency disorder; attitudes and behaviors of the family and the child toward the situation; and medical, developmental, and educational status of the child. During the family interview, we specifically focused on the distinction between the fluency disorder that is occasionally seen or at certain times and that showing a tendency of a permanent disorder, and answers were sought for the following questions: (1) Since the fluency disorder first appeared, has it shown an occasionally repetitive feature? (2) Are parents worried or nervous about this situation? (3) Has the situation been continuing for the last 6 months and/or continuing for more than 1 month when seen again after the recession periods? (4) Is the child aware of the situation? (5) Are accompanying behaviors or avoidance behaviors (avoiding talking, avoiding talking in certain settings, avoiding words that start with some voices) observed? Our study patients were aged ≥6 years, which was considered an important finding in terms that the situation should be evaluated beyond the picture of usual fluency disorder that is seen between the ages of 2 and 5 years; therefore, an answer of "yes" to any two of the above questions was considered sufficient.

The language-speech development of children was assessed on the basis of questioning the skills expected from the age group and on the conversation. For children suspected of having problems related to language and speech other than stuttering, a more detailed investigation was conducted as required, and those who were found to have another language-speech problem (five children with a speech voice problem) were excluded. The examination of fluency disorder included obtaining the sample size that would provide sufficient data, observing conversations between the child and the parent depending on the characteristics of the child, conversing with the child, and evaluating based on having the children with reading skills read at least a 100-word text.

Evaluation of the Hearing System

Because normal hearing of participants in both groups was a criterion to which particular importance was attributed for the creation of the research sample, it was evaluated whether hearing was normal in all patients. An audiological evaluation testing the presence of normal hearing included pure sound audiometry (Interacoustic AC 40 Clinical Audiometry, Denmark) and immitansmetric measurements (Interacoustic AT 235H, Denmark). Audiometric evaluations were conducted by following audiometric evaluation procedures in standard soundproof cabinets according to the ANSI standards. All pure tone audiometric evaluations of airways were performed using Telephonic TDH-39 headphones (Telephonics, USA) with a frequency range of 250–8000 Hz, and bone conduction evaluations were performed using the Radioear B-71 (Radioear, USA) bone conduction vibrator with a frequency range of 500–4000 Hz. Immitansmetric evaluations were performed at 226 Hz probe tone using the TDH-39 headphones. Ipsilateral and contralateral stapes reflex thresholds were evaluated in the frequency range of 500–4000 Hz. The hearings of participants giving the peak curve as "A type" in a normal type tympanogram at a pressure range of +100 and −50 daPa, those of participants with stapes reflexes, and those of participants with bilateral hearing at ≤20 dB HL were evaluated as normal.

TEOAE was measured in the absence and presence of contralateral stimuli in patients who were included in the study after being determined to have normal hearing. All OAE measurements were binaurally performed using the ILO 292 Echoport USB II and ILO V6 Clinical OAE software (Otodynamics, London). TEOAE test parameters were used for the TEOAE test measurement made by giving contralateral stimulus. The measurement was bilaterally conducted, and linear click TEOAE stimulus was given from one ear at 80±4 dB SPL and white noise from the contralateral ear in linear stimulus mode at 60 dB SPL. The measurement time was selected as 20 ms and binaural measurements were made at 1000, 1400, 2000, 2800, 4000 Hz center frequencies; TEOAE responses were then compared with contralateral suppression responses. The information regarding the device used in these measurements and the procedure followed is given below. Signal amplitudes were investigated in TEOAE measurements. To calculate the suppression amplitudes, the difference between values obtained in the absence of the contralateral stimulus and those obtained in the presence of the contralateral stimulus were calculated. The situations in which When the responses measured in the presence of contralateral noise (CN) was subtracted from the measurements obtained in the absence of CN; if the result indicated +1 dB SPL (18) or higher, then it was interpreted as "there is suppression."

Statistical Analysis

Data were analyzed using the SPSS program version 17 (SPSS Inc.; Chicago, IL, USA). The normality of the distribution of suppression values was tested using the Kolmogorov–Smirnov test; for data that were not normally distributed, nonparametric methods were used. Intra-group comparisons were performed using the Wilcoxon-associated two-sample tests, and intergroup comparisons were performed using the Mann–Whitney U Test. Chi-square test was used to compare the groups in terms of rates of patients found to have suppression.

RESULTS

The mean TEOAE amplitude values obtained from the left and right ears in both groups are shown in Table 1, and the suppression values are shown in Table 2. There was no significant difference between the suppression values measured in the left and right ears for both the experimental and control groups ($p>0.05$). For this reason, in the comparison of groups, measurements obtained from the left and right ears in each group were collectively evaluated, and statistical analyses were performed on 48 ears in the experimental group and on 30 in the control group.

The patients in whom the difference between TEOAE amplitude values measured in the absence and presence of contralateral stimuli was ≥1 dB SPL were recorded as those in whom the suppression effect was observed. The percentages of patients in whom the suppression effect was present or absent in each group are given in Table 3. When the ratios of patients in whom the suppression effect was observed within the group were compared (Table 3), a significant difference was found between the groups at 2-kHz measurement frequency ($p<0.05$). Thereafter, the ratio of suppression of the present or absent cases in the experimental and control groups at 2-kHz band was separately compared for the left and right ears. While there was no significant difference between the experimental and control groups for the right ear, the presence of suppression was 54.8% and 20% in the left ears of patients in the experimental and control groups, respectively, and this difference was found to be significant (Fisher exact chi-square = 4.45, $p=0.049$). When the groups were compared in terms of TEOAE suppression values (Table 4), no statistically significant difference was found between the experimental and control groups in any of the frequency bands in which measurements were made.

The values obtained from the left and right ears in both groups are shown in Table 2. Although not presented in a separate table, comparison between the groups with respect to the left and right ears were made, and no significant difference was found (Mann–Whitney U test; p and gt, 0.05).

Table 1. TEOAE amplitude values obtained from the left and right ears in groups

Frequency (kHz)	TEOAE (dB SPL) (mean±SD)			
	Experimental group (n=24)		Control group (n=15)	
	Left ear	Right ear	Left ear	Right ear
1	6.10±10.52	8.25±4.77	4.34±5.92	6.93±7.16
1.4	8.88±7.35	10.27±7.76	7.96±4.03	9.36±5.00
2	8.48±5.30	8.53±6.81	6.35±6.07	8.74±6.27
2.8	5.68±5.88	6.55±6.30	6.24±7.63	8.82±6.55
4	4.30±5.46	3.17±6.68	6.33±9.23	7.81±7.27

TEOAE: transient-evoked otoacoustic emission; SD: standard deviation

DISCUSSION

OAE amplitudes decreases in the presence of contralateral stimulus because of the suppression of outer hair cell activation with the effect of MOC efferent system function (16). Therefore, the fact that there was no significant difference between the suppression values of children with and without stuttering suggests no difference between these two groups in terms of MOC efferent feedback. However, there is insufficient data for comparison with similar researches and to support the results obtained. In a study involving adult cases, the right ear suppression values of the group with stuttering were found to be lower than those of the group without stuttering, suggesting that the activity in the left half of the brain was less in individuals with stuttering (17).

In this study, although the suppression values obtained from the left ear were higher than those from the right ear, particularly in the experimental group, the difference between the left and right ears was not statistically significant. Nevertheless, considering that the suppression values in normal individuals are generally higher in the right ear, it can be said that the absence of a significant difference between the left and right ears in the groups is consistent with the idea that the suppression asymmetry between the ears is a situation that may develop with age (19). In fact, in studies including children aged 4–7 years (18) and 7.5–12 years, it has been reported that there is no difference between the values obtained from the left and right ears (19). Although there was a difference between the suppression values of adults with and without stuttering in the study conducted by Uyar (17), the age factor may also have played a role in the absence of such a difference in this study. Thus, our results show parallelism with those of studies that compared children with speech voice (18) and specific language (19) disorders with peers without any speech-language problems and noted no difference in the suppression values of the left and right ears in both intra- and inter-group.

The only statistically significant difference between the groups was that the rate of the cases "having suppression" was higher in the experimental group than in the control group in the measurements made at 2-kHz frequency for the left ear. At first glance, this finding suggests the possibility that the left ear disadvantage, which can be seen in the measurements of normal individuals, is seen as the left ear advantage in patients with stuttering and has led to a difference between the groups in terms of the proportion of patients with suppression. However, the absence of difference between the left and right ears in both inter- and intra-group in terms of suppression amplitudes renders such an interpretation difficult, when considered in the light of the findings indicating the absence of suppression asymmetry in studies conducted with children (18, 19). It is also apparent that it is difficult to respond to the question of why this condition is observed at only 2-kHz frequency. Although the frequency and gender effect is mentioned among the factors that influence the suppression values (20, 21), the fact that there is no comparison between genders due to the low number of subjects and the imbalance of gender distribution is a limitation in this study.

In conclusion, although our findings indicate that TEOAE suppression values are similar in children with and without stuttering, it should be noted that there is a difference between the groups in terms of the percentage of the patients in whom suppression has been detected at 2 kHz. Therefore, to judge the

Table 2. TEOAE suppression values obtained from the left and right ears in groups

Frequency (kHz)	TEOAE suppression (dB SPL) (mean±SD)					
	Experimental group (n=24)			Control group (n=15)		
	Left ear	Right ear	p	Left ear	Right ear	p
1	3.08±5.65	0.60±3.75	0.71	0.94±2.30	0.14±1.22	0.31
1.4	1.58±6.56	0.65±3.62	0.90	0.36±1.67	0.39±0.96	0.80
2	1.82±5.56	0.61±6.36	0.79	0.38±0.42	0.44±0.59	0.66
2.8	1.34±5.24	0.29±5.23	0.61	0.29±0.57	0.39±0.72	0.55
4	1.76±9.45	−1.19±5.14	0.52	0.44±1.04	0.79±1.21	0.28

Wilcoxon-associated two-sample tests (p<0.05)
TEOAE: transient-evoked otoacoustic emission; SD: standard deviation

Table 3. Percentages of the patients with and without suppression within the groups

Frequency (kHz)	Experimental group		Control group		
	Yes (%)	None (%)	Yes (%)	None (%)	p
1	54.2	45.8	36.7	63.3	0.13
1.4	41.7	58.3	33.3	66.7	0.46
2	50	50	23.3	76.7	0.02*
2.8	31.3	68.8	16.7	83.3	0.15
4	25	75	16.7	83.3	0.38

*Chi-square test (p<0.05)

Table 4. Mean TEOAE suppression values in experimental and control groups

Frequency (kHz)	TEOAE suppression (dB SPL) (mean±SD)		
	Experimental group (n=48)	Control group (n=30)	p
1	1.84±4.9	0.54±1.85	0.30
1.4	1.12±5.26	0.38±1.34	0.53
2	1.21±5.26	0.42±0.51	0.06
2.8	0.81±5.20	0.34±0.64	0.46
4	−0.56±4.02	0.61±1.12	0.63

Mann–Whitney U test (p<0.05)
TEOAE: transient-evoked otoacoustic emission; SD: standard deviation

functioning of the MOC efferent system in children with stuttering, the findings need to be supported with new studies covering more cases.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Trakya University Faculty of Medicine Ethic Comittee of Noninvasive Clinical Researches (App No: TÜTF-GOAEK 2014/54).

Informed Consent: Verbal informed consent was obtained from the parents of the patients who participated in this study.

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