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Research Article

Influence of Cleft lip and Palate on Characteristics of Hearing Loss

Abstract

Objectives: To find out and evaluate and compare hearing threshold of the cleft-side vs. non-cleft side in children with unilateral cleft lip and palate (UCLP), to find out if the severity of the morphological and functional changes on the cleft lip and palate side correlate with severity of the hearing loss, to find out if ears of cleft vs.non cleft side show difference in improvement of the hearing loss with aging.

Method: Tympanometry and pure tone audiometry performed in study group of 76 children with UCLP of the left side and median age of 6 years. All of the children previously have undergone operatively repaired left cleft lip and palate under the standard conditions. Tested children have long term history of hearing loss and no ear surgery. Results of tonal audiometry were evaluated for speech frequencies (500Hz, 1000Hz, 2000Hz and 4000 Hz) according to age subgroups of 1-3, 4-7, and 8-12 years. Hearing loss was considered of mild, moderate or severe level. Ears of the non-cleft side with no morphological structural defect, served as control in the evaluation of the hearing thresholds of the ears of cleft side.

Results: Highest average of hearing loss across speech frequencies showed youngest age group of 1-3year. There was no difference between levels of hearing loss between cleft and non-cleft side. At the age of 4-7 yr. cleft side ears showed highest hearing loss average and medians for separate frequencies, if compared with non/cleft side ears. Cleft side ears showed higher incidence of ears with moderate and severe hearing loss which do not improve hearing threshold with aging. Increase of ears with normal hearing is not significant with aging. Ears on cleft side showed mild level ears. Ears of non-cleft side ears showed increase of ears with normal and mild hearing loss with aging.

Conclusion: Ears of cleft side ears in unilateral cleft lip and palate children are more pronounced for hearing loss and have less improvement of hearing threshold with aging, because of negative influence of structural defects in the region of the Eustachian tube of the of cleft lip and palate side.

Introduction

Non-syndromic cleft lip and palate are accompanied by developmental changes of cranial base, retrognathic maxilla, increased pharyngeal width, smaller middle ear cavity, changes in the petrous portion of the temporal bone, short and high position of the cleft hard palate, hypoplastic and malposed cleft muscles [1,2]. This sequence of pathoanatomical changes causes otitis media with effusion (OME) and peripheral hearing deficit. Recurrent episodes of OME lead to impairment of the central auditory pathways, behavior, cognition, speech, language and social adaptation [3,4]. Otitis media with effusion is found more often in children with unilateral cleft lip and palate (UCLP) than in non-cleft population [5-7]. Poor mastoid pneumatisation in cleft palates is considered as an additionally etiological factor for high incidence of OME[8,9]. We presumed that different characteristics of craniofacial bony parameters, which are related to the side and severity of the cleft, can predict severity and improvement of the hearing loss with age. The aim of the study was to find out if ears of the cleft side have higher severity of hearing loss and slower dynamic of improvement in dependence with age and different audiometric frequencies.

Patients and Methods

The clinical study included 76 children (29 female and 47 male, median ages of 6, 0 yr) with unilateral cleft lip and palate of the left side (UCLP) (L). All of them have undergone cheiloplasty and palatoplasty under the same standard conditions. At the time of their visit to audiology department all of the patients have had history of conductive hearing loss and of recurrent episodes of upper respiratory pathways infections. All of the patients had undergone otomicroscopy, pure tone audiometry, tympanometry and nasopharyngeal fyberoptic endoscopy. Tympanograms were classified according to Jerger as type A, B or C. Children were subdivided into age groups: 1-3yrs, 4-7yrs, 8 -12yrs and >12 yrs. Pure tone audiometry for audiometric threshold was analyzed

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during 6 weeks. Tonal audiometry established median hearing loss thresholds (MHL) for 250Hz, 500Hz, 1kHz, 2kHz, 4kHz and the average five-frequency pure tone hearing loss threshold (AHL) for left and right ears respectively. Average hearing loss audiometric threshold groups were classified as mild (11-20dB), moderate (21-40 dB), severe >40 dB and normal (0-10dB). All of UCLP patients who have the established diagnosis of otitis media with effusion (conductive hearing loss presented for 6 weeks on pure tone audiometry accompanied by tympanograms of B type) had undergone insertion of the ventilatory tubes on both tympanic membranes. Tonal audiograms performed before the insertion of ventilatory tubes were taken and analyzed. A comparison between study groups of ears was made by Kruskal Wallis and Mann-Whitney tests. The correlations between variables were analyzed using Spearman correlation coefficient. Chi-square test was performed to evaluate statistically significant differences between proportions. All applied tests were two-sided. P values ≤ 0.05 were considered as statistically significant. Tests were performed using software Stat Soft Statistical 7.1.

Results

None of tested ears had sensorineural hearing loss. No gender differences for average hearing loss threshold (AHL) were found between tested groups of ears. Highest median hearing loss (Md) was found at 500 Hz on non-cleft side (p=0.043). At age group 4-7yr cleft side had higher AHL (25.0 dB, p=0.039) than non-cleft side. The highest significant difference between Md if compared cleft side with non-cleft side was found for 500 kHz at 1-3 yr (10.0 dB, p=0.043). At age 8-12yr there were no differences for Md and AHL between cleft vs. non-cleft side across all of the tested frequencies. At the age of >12yr cleft side ears showed higher values of Md for 2 kHz (17.0 dB, p=0.043) (Table 1).

At age of 1-3 yrs both cleft and non-cleft side have higher rate of ears (80,0%) with moderate average hearing loss threshold (AHL) than other age groups. Horizontal comparison (inter-group) of non cleft side showed significant frequency difference for mild (p=0,014) and moderate category (p<0,001) while on cleft side difference was showed only for moderate category (p<0,001). Vertical comparison (intra-group) of non cleft side (p<0,001) and cleft side (p<0,001) showed significant frequency difference only for 4-7 yr (Figures 1,2)

Non cleft side ears reached significant improvement of AHL (-14 dB) between 1-3 yr and 4-7yr while cleft side showed significant improvement of AHL between 4-7yr and 8-12 yr (-7,5 dB). The improvement of at least 10dB for Md was found at 500Hz, 1 kHz, 2 kHz and 4 kHz on non cleft side, while on clef side the same improvement was found at 500Hz, 1 kHz, and 2 kHz. The lowest improvement with aging was found for Md at 250Hz for both sides. The highest significant improvement of Md (-15 dB) was found on non cleft side ear at 500Hz (p=0.009) between 1-3 yr and 4-7 yr, while the highest significant improvement of Md (-10 dB) on cleft side was found at 500 kHz between 4-7 yr and 8-12 yr (p=0.013). Negative correlation was found between all tested frequencies and aging, AHL and aging on both sides, which means that hearing improves with aging. When sorted categorically, only moderate AHL of the ears on non-cleft side, showed significant negative correlation with aging (rho = -0.409, p=0.016). Cleft side ears showed AHL improvement continuously till the age of 12 yr, when non clefs side ears achieves improvement till the age of 7 yr (Table 2).

Discussion

Previous studies of UCLP patients described changes in the length and angulations of the cranial base, a more backward and upward position of the maxilla and smaller sphenopalatine angle as contributing etiological factors for OME. Frequent otologic problems were described to be correlated to pathologic clearance and pathoanathomical changes of the Eustachian tube cartilage and increasing pharyngeal width [8-10]. Previous data on cleft lip and palate patients suggested laterality of the ears to have no effect on the hearing loss [11]. Until now there have been no recent studies comparing hearing threshold according to audiometric frequencies between cleft and non cleft side and possible changes over time.

At age of 1-3yrs cleft and non-cleft side ears are characterized by a flat tonal audiometric curve of moderate to severe average hearing loss threshold across speech frequencies with no signs of laterality.

Table 1: Median (Md) hearing levels, range between minimum and maximum hearing. (min-max) level for average hearing loss (AHL), 250Hz- 4000Hz for left (L) and right (R) ears. Significant differences are expressed like (p<0.05) and (p<0.001).

Age (years) UCLP	N (76)	Ear Side	Hearing level (dB)						Kruskal-Wallis test (p value)
			AHL	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	
			Md (Min-Max)	Md (Min-Max)	Md (Min-Max)	Md (Min-Max)	Md (Min-Max)	Md (Min-Max)	
1-3	10	R	p=0.683 35.0 (16-41)	p=0.398 30.0 (20-40)	p=0.043 40.0 (20-50)	p=0.866 32.5 (15-50)	p=0.906 30.0 (15-45)	p=0.612 30.0 (10-50)	p=0.057
		L	33.0 (20-42)	27.5 (20-45)	30.0 (15-40)	32.5 (15-45)	32.5 (15-50)	32.5 (15-50)	p=0.601
4-7	37	R	p=0.039 21.0 (10-47)	p=0.387 25.0 (10-45)	p=0.062 25.0 (10-55)	p=0.064 20.0 (10-45)	p=0.410 20.0 (10-45)	p=0.003 20.0 (10-55)	p=0.001
		L	25.0 (10-47)	25.0 (10-50)	30.0 (10-45)	30.0 (10-50)	25.0 (10-50)	25.0 (10-50)	p=0.003
8-12	17	R	p=0.906 20.0 (10-41)	p=0.790 20.0 (10-45)	p=0.650 25.0 (10-35)	p=0.979 20.0 (10-50)	p=0.875 20.0 (10-30)	p=0.382 20.0 (10-55)	p=0.294
		L	18.0 (10-47)	20.0 (10-45)	20.0 (10-45)	20.0 (10-55)	15.0 (10-40)	20.0 (10-55)	p=0.028
>12	12	R	p=0.110 16.0 (10-42)	p=0.787 12.0 (10-35)	p=0.866 15.0 (10-50)	p=0.590 17.5 (10-40)	p=0.043 10.0 (10-40)	p=0.075 10.0 (10-45)	p=0.269
		L	18.0 (10-44)	17.5 (10-40)	15.0 (10-40)	17.5 (10-50)	17.0 (10-50)	17.5 (10-60)	p=0.972

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Table 2: Significance of changes in hearing levels (differences between medians) with aging for left and right ears of children with UCLP. Significance of improvement of hearing level between age groups and comparation between ears of cleft and non cleft side. Spearman's correlation coefficient and Kruskall-Wallis test were performed for average hearing loss (AHL), 250Hz, 500Hz, 1 kHz, 2 kHz, 4 kHz for different age groups for cleft and non cleft side ears. Significant differences are expressed like † (p<0.05) and ‡ (p<0.001)

Groups (years)	AHL R	AHL L	250 Hz R	500 Hz R	1 kHz R	2 kHz R	4 kHz R	250 Hz L	500 Hz L	1 kHz L	2 kHz L	4 kHz L
(1-3) – (4-7)	-14†	-8	-5	-15†	-12.5†	-10†	-10†	-2.5	0	-2.5	-7.5	-7.5
(4-7) – (8-12)	-1	-7.5†	-5	-2.5	0	-2.5	- 2.5	-5	-10†	-10†	-12.5	-7.5†
(8-12) – (>12)	-4	0.5	0	-7.5	-5	-7.5	-12.5	-5	-5	-5	+ 2.5	-2.5
Correlation coefficient	-0.471‡	-0.459‡	-0.419‡	-0.511‡	-0.423‡	-0.446‡	-0.327†	-0.384†	-0.466‡	-0.418‡	-0.361†	-0.404‡
Kruskall-Wallis test (p value)	0.003	0.006	0.036	0.002	0.015	0.003	0.014	0.033	0.005	0.024	0.029	0.017

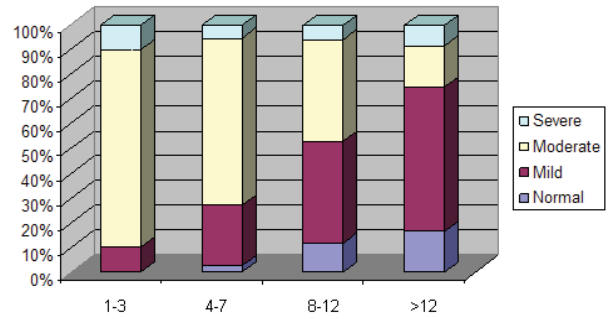

Figure 1: Cleft- side ears: proportions of the ears with mild, moderate and severe hearing levels for different age groups (1-3, 4-7, 8-12, >12). At inter-group comparison significant difference was found for moderate category and at intra-group comparison in age group 4-7.

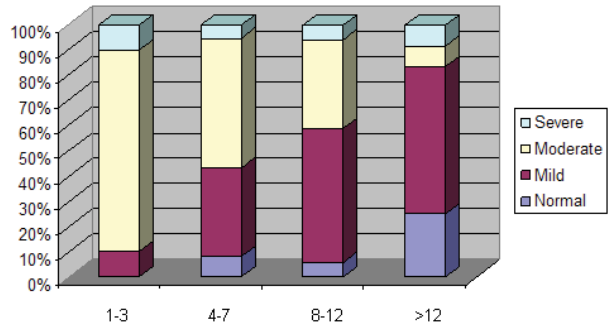

Figure 2: Non cleft side ears - proportions of the ears with mild, moderate and severe AHL and normal hearing level by age groups(1-3, 4-7, 8-12, >12). At inter-group comparison significant difference was found for mild and moderate category and at intra-group comparison only in age group 4-7.

Differences between hearing loss of cleft vs. non-cleft ears became significant at age 4-7yrs. The developmental characteristics of that age are faster growth of the soft tissues and proportionally slower growth of nasopharyngeal bony parameter. Disproportion between volume of the soft tissue and volume of bone surrounding space, whose size is defined by the growth of bony parameter, contributes to the mechanical obstruction of the Eustachian tube. An expected increase in the nasopharyngeal area, which is related to the descent of the hard palate, is additionally disrupted by the presence of a cleft palate and contributes to severe dysfunction and mechanical obstruction of the Eustachian tube, which is in its part also a contribution to the onset of the hearing loss, making cleft side ears pathoanatomicaly more vulnerable for hearing loss. In age group of 4-7 yrs. cleft side ears had middle frequencies register of 1 KHz, 2 KHz, and 4 KHz more affected. Experimentally such effect was explained by accumulation of the fluid in the middle ear which covers and increases tympanic membrane mass and causes impairment of middle register. Otitis media with effusion causes reduction in the sound transmission to the inner ear and interaural time delay impairment in binaural processing abilities with a consecutive deficit in sound localization, which leads to central auditory impairment [3,4]. Contrary to cleft side, at the age of 4-7 years non-cleft ears showed more severe hearing loss for low register of 250 Hz to 500 Hz. According to experimental findings mechanism of hearing loss in such ears was explained by more prominent edema of mucosa and smaller amount of the middle ears effusion [12]. It seems that non-cleft side has better pathoanatomical characteristics and middle ear effusion is not as often as for ears on cleft side. Accordingly it can be presumed that etiology of hearing loss is somewhat different for cleft vs. non-cleft ears [13].

At age >12yrs cleft side ears had significantly more impairment of median hearing loss threshold for frequencies of 2 kHz and 4 kHz probably as a residual sign of recurrent presence of the middle ear effusion in previous age groups and it might be first sign of future sensorineural hearing loss in adult age. Most of children in out tested group were males who are known to have higher percentage of hearing loss than females [14,15].

Conclusions

The cleft side showed a significantly higher rate of ears with moderate and severe hearing loss if compared with non-cleft ears. Furthermore, the moderate average of hearing loss across frequencies and median hearing loss for each frequency were more present for the cleft side ears only at age 4-7yr. Non-cleft ears showed lower incidence of ears with moderate hearing loss which showed normalization but only on level of mid hearing loss level. Cleft side ears showed normalization of moderate and mid hearing loss but it are not significant. Cleft and non cleft lip and palate sides showed structural differences which are developmentally derived and directly influenced on the function of whole region of the Eustachian tube and middle ear function too.

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