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Speech Perception after Early Cochlear Implantation

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Abstract

Objective: The aim of this study was to evaluate the influence of age on speech perception in children implanted before 5 years of age over the first 3 years after surgery.

Material and Methods: A total of 31 children are divided into 2 groups; 12 were implanted before 2 and 19 implanted between 3 and 5 years of age. Assessment battery designed to measure speech perception was used to evaluate recipients at 12, 24 and 36 months after implantation. We used the following tests: 1. Closed and open-set for monosyllabic and polysyllabic words in quiet and noise 2 and Open-set sentence in quiet. Testing was performed with recorded voice in free field.

Results: The mean value on the open-set for monosyllabic words for all patients increased with time. The difference between the values for each group at 12, 24 and 36 months was significant ($p<0.001$). As duration of cochlear implant use increased, speech perception also improved. The mean value on the open-set with polysyllabic words at 36 months for all patients (82.7%) was significantly higher than the mean value at 24 months (77.2%) ($p=0.10$). The mean value for this parameter at 36 months in children aged 3 to 5 years of age (82.1%) was significantly higher than the mean value at 24 months (74.2%) ($p=0.08$). Improvement in speech perception is faster if implantation occurs at a younger before 2 years of age.

Conclusion: Age at time of implantation has a positive effect on speech perception, especially in situations such as background noise. Children implanted before 2 years of age have faster improvement in speech perception. Those who are implanted between 3 and 5 years of age showed delay 2 years postoperatively and significant improvement after this time. Three years after cochlear implantation there was no significant differences among them.

Keywords: Speech perception; Speech intelligibility; Children; Cochlear implant.

Introduction

Children born with severe and profound hearing loss have achieved good results in listening and speaking skills when undergoing cochlear implantation before the age of five according to the literature [1]. The findings show that the improvement is faster if implantation occurs at a younger age [2]. In addition, speech perception is better in quiet conditions, although it is seen to improve over time. The longer they are implanted, the better results they will receive [3].

The purpose of this study is to analyze speech perception and speech intelligibility results in regard to the age at the time of implantation and the length of habilitation in months. We compare speech perception development and abilities in different listening conditions for children implanted before 2 and between 3 and 5 years of age.

Material and methods

Study design

Retrospective review of the speech perception development of 12 children implanted under age of two and 19 children implanted between the ages of three and five. The following inclusion criteria were applied to all subjects: congenital, non-syndromic, bilateral, profound, sensorineural hearing loss. All patients had at least six months experience wearing bilateral, digital hearing aids at the time of implantation, at which point they entered the same habilitation protocol with exclusively oral communication. All subjects were provided with MedEl cochlear implants with processor Tempo$^+$ and Opus I. Audiological assessments included transient otoacoustic emissions (TEOAE), statoacoustic reflex (STAR) and auditory brainstem response (ABR) before implantation. All patients underwent speech perception and intelligibility tests 1, 2 and 3 years after we switched on the implant, with both "closed" and "open" set, age-appropriate phonetically balanced words. We used the following tests: 1. Closed-set monosyllabic words in quiet and noise 12 months after switching on the implants. 2. Open-set monosyllabic and polysyllabic words in quiet, 12, 24 and 36 months after we switched on the implants. 3. Open-set for polysyllabic words in noise, 24 and 36 months after we switched on the implants. 4. Open-set sentence perception 36 months after switching on the implants. All patients

were tested in the free field with recorded voice and signal to noise ratio +20dB.

The ethical committee of Clinical Center Banja Luka gave consent for carrying out this research.

Statistical Analysis

In the statistical processing of the results, standard methods of descriptive statistics have been used (arithmetic mean with the standard deviation and the numerical range from minimum to maximum value). For testing the statistical significance of differences among the examined groups Student's t test for paired samples and Wilcoxon W test for paired samples test were used. Statistical hypotheses were tested at the significance level of $\alpha = 0.05$, i.e., the difference $P<0.05$ was considered statistically significant. SPSS 17.0 (SPSS Inc, Chicago, IL) statistics software was used for the data analysis.

Results

In this study, we analyzed 31 patients. Children were divided into two groups, according to age, up to two years (12 patients or 38.7%) and three to five years (19 patients or 61.3%).

For all participants before implantation TEOAE and STAR were absent. AABR showed profound bilateral sensorineural hearing loss.

The mean score 12 months postoperatively for all patients on the closed-set test was 66.5%. The mean value for children under two years of age was 69.9% which was higher than the group of older children 64.3%, though not statistically significant (p=0.167).

For all patients, we noticed that the mean value for the closed-set test at 12 months postop was 66.5%, which was higher than the mean value for the open-set test at 12 months postop 59.3%. However, this difference was not statistically significant (p=0.091).

The mean value for the closed-set monosyllabic words test at 12 months postop was higher for both groups of patients (69.9% and 64.3%) than the mean open-set scores (63.8% and 56.5% respectively). These differences were not statistically significant (p=0.594 and p=0.071).

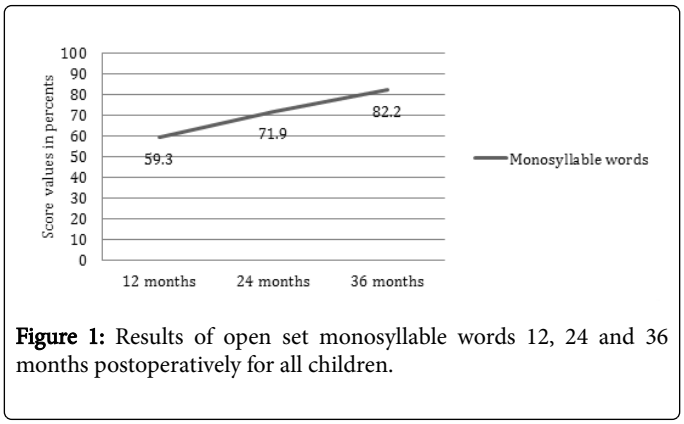

Figure 1: Results of open set monosyllable words 12, 24 and 36 months postoperatively for all children.

The mean value for the open-set monosyllabic words test 12 months postop for all patients was 59.3%. The mean value in children under two years was 63.8%, which was higher than in children aged three to five years (56.5%). This difference in respect the age group of the patients is not statistically significant (p=0.466).

We found that the patients' mean values on the open-set monosyllabic words test increased with time (59.3%, at 12 months, 71.9% at 24 months and 82.2% at 36 months postoperative), p<0.001 (Figure 1).

The subjects under two years of age scored higher at 24 months (mean 81.7%) and 36 months postop (mean 83.7%) than the children in the three to five year-old group (mean 74.2% and 82.1%) on the polysyllabic word test. However, the differences were not statistically significant (p = 0.449).

The mean value for all patients on the open-set polysyllabic word test at 36 months postop was (82.7%) which was significantly higher than the 24-month mean of (77.2%) (p=0.01). Results are shown in Table 1.

For children under two years of age, there was no statistically significant difference between the mean values of open-set polysyllables at 24 and 36 months (p = 0.366). The mean value of this parameter after 36 months in children aged three to five years of age (82.1%) was significantly higher than the mean value at 24 months (74.2%) (p=0.008). These results are shown in Table 1.

The children in the three to five year-old group showed greater improvement on the open-set polysyllabic word test between 24 months and 36 months postop than the children in the younger group, but this difference was not statistically significant (p = 0.307).

	24 months		36 months		
Patients	**Mean (SD)**	**Range**	**Mean (SD)**	**Range**	**p**
all children (n=31)	77.1 (21.2)	40-100	82.7 (16.4)	39-100	= 0.01†
≤ 2 year-old children (n=31)	81.7 (22.6)	40-100	83.7 (19.1)	39-100	= 0.36†
3-5 year-old children (n=19)	74.2 (20.4)	40-100	82.1 (15)	58-100	= 0.008†
†Wilcoxon W test for paired samples; SD Standard Deviation					

Table 1: Results of open set polysyllable words 24 and 36 months postoperatively.

The mean values on the test in noise were higher at 24 months postop (60.4%) as well as 36 months (67%) in the children under two years of age than the mean value of this parameter in children aged three to five years (48.5% and 60.7%). However, these differences were not statistically significant (p = 0.052 at 24 months postop), (p = 0.364 at 36 months postop).

The average value for all patients on the open-set in noise test at 36 months postop 63.2% which was significantly higher than the average value at 24 months (53.1%) (p<0.001). The aforementioned results are shown in Table 2.

For children under two years of age, there was no statistically significant difference between the mean values on the open-set in the noise at 24 months and 36 months postop (p=0.161). The children in the tree to five year-old group demonstrated a statistically significant difference between 24 months (48.5%) and 36 months (60.7%) postop on the open-set in noise test. These results are shown in Table 2.

The mean value on the open-set sentence perception test for all subjects was 77.3%. The children in the under-two age group scored higher than the children in the three to five year-old group (81.3% and 74.7% respectively). However, this difference was not statistically significant (p = 0.316).

	24 months		36 months		
Patients	**Mean (SD)**	**Range**	**Mean (SD)**	**Range**	**p**
all children (n=31)	53.1 (16.8)	20-85	63.2 (18.4)	33-90	<0.001*
≤ 2 year-old children (n=31)	60.4 (11.1)	46-76	67 (15.4)	33-85	= 0.16*
3-5 year-old children (n=19)	48.5 (18.4)	20-85	60.7 (20.1)	33-90	<0.001*
*Student's t test for paired samples; SD Standard Deviation					

Table 2: Results of open set in noise 24 and 36 months postoperatively.

Discussion

Different speech intelligibility tests could be used for the purpose of evaluating the performance of hearing device under varying listening conditions [4]. In this study, we analyzed the results of speech perception and speech intelligibility in 31 children with cochlear implants. All of them were congenitally deaf and used oral communication only with implantation performed before five years of age. According to the literature, the benefits of cochlear implant use improve significantly over the time. Furthermore, speech recognition abilities correlate significantly to age at implantation [5].

Lee et al., [6] reported significant improvement in closed-set and open-set recognition tests over the time.

In our study, mean value for the monosyllable closed-set test was higher than the mean value for the open-set test at 12 months postop 59, but difference was not statistically significant (p=0.091). Younger implanted children have higher mean percentage on the monosyllabic closed and open-set at 12 months postop then the children implanted after three years of age

These differences were not statistically significant (p=0.594 and p=0.071)

In our research, the subject mean percentage on the monosyllabic open-set recognition test increased significantly over time up to 71.9% at 24 months and 82.6% at 36 months postop (p<0.001). The patients' polysyllabic open-set recognition scores also showed statistically significant increase over time up to 77.2% and 82.6% after the same period (p=0.10). Open-set sentence perception was 77.3% three years postoperatively. Dowell et al., [7] reported similar results for speech perception tests. Xu et al., [14] confirm that speech abilities improved significantly with increased cochlear implant use. Furthermore, children implanted before five years of age who use only oral communication can achieve significant and usable open-set speech scores in the first three years after implantation. Richter at al., [8] reported similar results on 106 implanted children.

Children implanted before the age of two attain better scores in closed and open-set recognition tests than children implanted between three and five years of age. Younger children demonstrated better improvement over time on all tests. However, this difference was not significant. Lee at al., [6] demonstrated that children implanted before two years of age with more than two years of implant experience outperformed children implanted after the age of six . Kirk et al., [9] reported that there is no interaction between age at implantation and length of device use in regard to improvement in open-set recognition abilities. These results indicated that improvement in speech abilities is significantly influenced by the length of device use [10]. The patient's age at the time of implantation has a positive, but not crucial effect on the development of speech abilities in children implanted up to five years of age.

In children implanted up to two years of age, we notice a gradual improvement on open-set recognition tests over time. However, in children implanted after three years of age this improvement increased statistically after two years of implant use (p<0.001). O'Donoghue et al., [11] reported that outcomes in speech abilities are associated with longer implant use. Our study indicate that we can expect some delay in the first two years after implantation primarily in children implanted after three years of age.

Children with cochlear implants could have some difficulties understanding speech in background noise [12]. Caldwell et al., [13] suggests that listening in noise poses a disproportionately greater difficulty for children with cochlear implants than for their peers with normal hearing. Davidson et al. [3] reported on the importance of age at the time of implantation, especially in terms of listening in background noise.

The children in our study achieved a mean score of 63.2% on the open-set recognition in noise test three years following CI implantation, with significant improvement occuring at two years postop (p<0.001). This data shows that speech abilities in noise also correlate positively to longer implant experience. This significant delay in the first two years following implantation was recorded in the children implanted after three years of age according to our study. This evidence suggests that improvement in open-set abilities in noise is significantly influenced by the duration of device use as well as age at the time of implantation.

Conclusions

Children implanted before two years of age have gradual and faster improvement in their speech perception ability with benefit of cochlear implantation in the first years of life. The children who were implanted between three and five years of age showed some delay two years postoperatively and significant improvement after this time.

Development of speech intelligibility, especially if the listening conditions include demanding situations such as background noise, is much better if the implantation is performed before 2 years of age.

The likelihood that a child with bilateral profound sensorineural hearing loss will achieve better speech intelligibility score is much higher if the implantation is performed before 2 years of age.

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