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# EFFECT OF AUDITORY-VERBAL REHABILITATION ON VOICE PARAMETERS IN CHILD COCHLEAR IMPLANT USERS

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ABSTRACT

This study aimed to evaluate the effects of auditory-verbal rehabilitation on voice parameters after implantation with cochlear implants 2 and 5 months after rehabilitation and compare them with normal voice children (under 12 years of age). A perceptive and electroacoustic evaluation of voice was carried out through a digital analysis after implantation and rehabilitation. The study was performed at Khorasan Cochlear Implant Center in Ghaem Hospital, Mashad University of Medical Sciences in Mashhad. There were 5 prelingually deaf children and 5 children with normal voice and hearing. Voice parameters (average pitch and intensity, perturbation, jitter and shimmer), were obtained. All patients showed better control of voice pitch and intensity and a considerable reduction of voice perturbation, jitter and shimmer after auditory rehabilitation.

This study showed no considerable difference on voice parameters between cochlear implanted children and normal children (voice and hearing). It could be concluded that auditory-verbal rehabilitation as a necessary and important training program for cochlear implanted children provides a recognizable moment-to-moment auditory control on parameters of voice.

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## INTRODUCTION

Auditory feedback (AF) could affect speech as follows:

1) It can control segmental and supra-segmental features of speech.

2) It can control moment-to-moment segmental features of speech such as: fundamental frequency ($F_0$), intensity, and quality of voice.

3) Delayed auditory feedback of voice affects the speech segmental skills and acts as a general controller on articulation, resonance, and respiration.[3,4,13,16,19,20]

The loss of AF leads to voice and speech perturbations, and the type of the perturbations depends on the period of the loss of AF and the nature of the hearing loss. The individuals who lose hearing as adults (postlingual) appear to have lack of the fine motor control necessary to regulate fundamental frequency, voice intensity and quality. Hence they tend to produce segmental errors such as distortion, omission, and substitutions of phonemes.[1,7,14,15]

Patients who lose hearing suddenly show deterioration of the suprasegmental cues earlier and more extensively than the segmental speech skills.

Patients with cochlear implants have been shown to be a clinical model for the study of the role of the AF in speech and voice production. Several reports note the longitudinal changes of speech production in these patients. There has been no study in this regard in Iran before. In this study, cochlear implanted children are being evaluated after a course of auditory rehabilitation on controlling their voice.

The aim of this study is to:

1) evaluate the effect of auditory-verbal rehabilitation on controlling fundamental frequency and intensity in cochlear implanted children.

2) assess the effect of auditory-verbal rehabilitation on Shimmer (intensity perturbation), Jitter (pitch pertur-

bation), and voice perturbation in cochlear implanted patients.

3) compare the cochlear implanted children's voice with normal hearing children's voice at the same age, after auditory-verbal rehabilitation.

## MATERIAL AND METHODS

Five congenitally deaf children under 12 years old who were implanted using a multi-channel cochlear implant prosthesis and five normal hearing children at the same age range (for comparing their voice with implanted cases) were selected for this study.

All voice evaluations and tests (measuring frequency, intensity and voice perturbation) were done using Kay Elemetrics Visi-pitch, Computer CSL and Speech lab system.

Fundamental frequency and intensity are defined within 250-300 Hz and 50-75 dB in children. Voice quality is measured as voice perturbation, frequency and intensity in which lower values indicate better quality of voice (generally, in vowel prolongation in normal cases, voice perturbation is defined as less than 2 and frequency and intensity is defined within 0-1).

Voice of all cases was measured after surgery and before starting the auditory rehabilitation program. Test material was /a/ vowel prolongation in controlled situation of devices.

All subjects underwent special auditory-verbal rehabilitation and were evaluated for the same voice parameters in two sessions within 2 and 5 months. Finally, the voice parameter changes were compared with their previous results and the control group voice using statistical analysis.

Frequency and intensity perturbation were calculated during /a/ vowel prolongation. Every sample spectrograph was shown by the CSL device as well. Other voice parameters were measured by Visi-pitch device during /a/ vowel prolongation, separately. For this purpose, the system was setup as follows:

- time: 4½ sec.
- measuring pitch and intensity simultaneously
- C or D position (frequency spectrum) of the device, which is specified for children voice.
- Three centimeter distance of the microphone from the mouth

In this study, a questionnaire was used to collect data and information. Two statistical methods were implemented to analyze collected data:

1- Descriptive: mean and frequency distribution

2- Analytical:

a) Pearson correlation for comparing the subject's voice with the control group voice.

b) One-way variance analysis for comparing the subject's voice after rehabilitation with their previous results.

## RESULTS

All subjects were under 12 years old and congenitally deaf. Each subject's voice was compared with the control group (same age). For analyzing and describing data, descriptive and analytic statistical methods were used. Figure 1 shows frequency distribution of voice, frequency, and intensity perturbation in /a/ vowel prolongation at three stages of cochlear implanted children rehabilitation.

The variables have been reduced, considerably, after going through the rehabilitation stages. Frequency distribution of voice, frequency and intensity perturbations were 78.19%, 42.53%, and 43.75%, respectively, before rehabilitation. These amounts were reduced to 16.46, 33.21, and 34.5, after two months of rehabilitation. Having five months of rehabilitation the frequency distribution of these variables was decreased to 5.23%, 24.24%, and 21.75%, respectively.

Figures 2, 3, and 4 show the frequency distribution of voice, frequency, and intensity perturbation of /a/ prolongation in three stages of cochlear implanted children rehabilitation compared with the control group, respec-

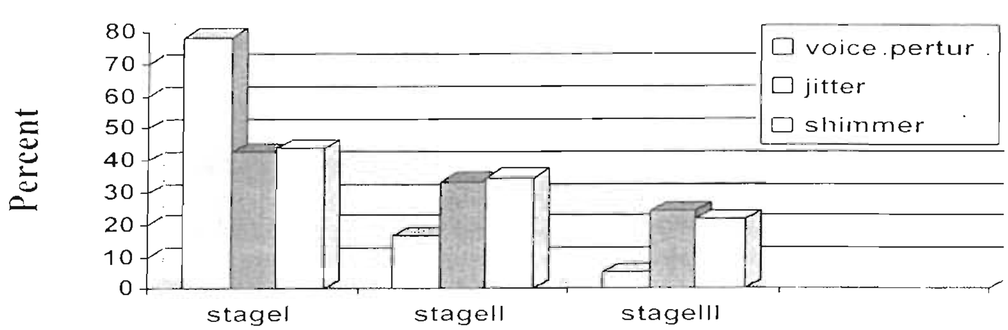


**Fig. 1.** Relative frequency of voice, frequency, and intensity perturbation of /a/ prolongation at three stages in CI children.

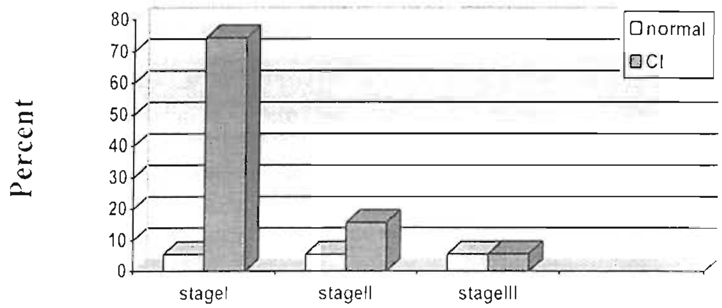


Fig. 2. Relative frequency of voice, perturbation of /a/ prolongation at three stages in CI and normal children.

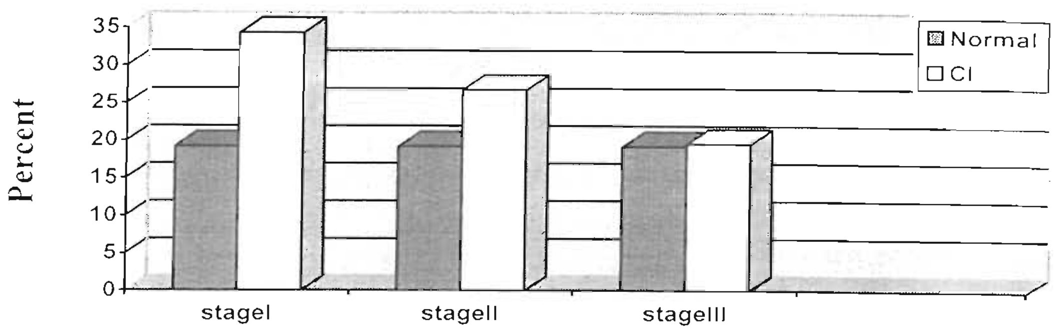


Fig. 3. Relative frequency of frequency perturbation of /a/ prolongation at three stages in CI & normal children.

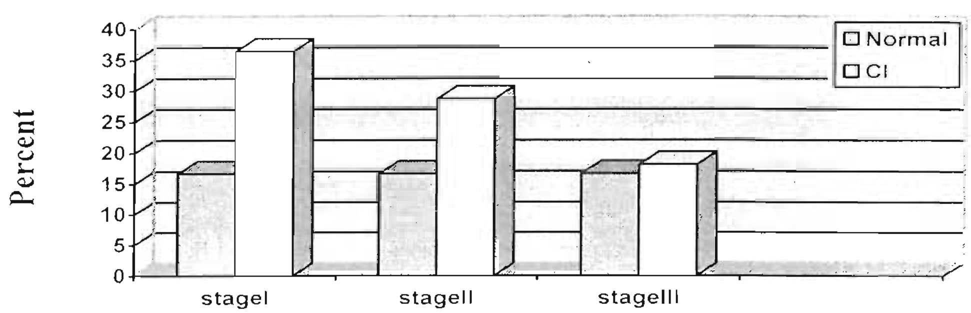


Fig. 4. Relative frequency of intensity perturbation of /a/ prolongation at three stages in CI & normal children.

tively.

The values showed in Figures 2, 3, and 4 indicate that the measures of variables such as voice, frequency, and intensity perturbation were decreased considerably after a five month period of rehabilitation as there was no considerable difference between subject results and control group values (subjects: 5.07%, 19.55%, 18.125%, control: 5.06%,19.19%, and 16.66%, respectively).

These figures indicate that auditory verbal rehabilitation could decrease voice, frequency and intensity perturbation after five months rehabilitation. In other words, auditory verbal rehabilitation improves the voice of cochlear implanted children up to normal level.

Table I shows Pearson correlation of voice parameters in articulation of /a/ vowel between subjects and the control group in three stages of evaluation (pre-rehabilitation, after 2 months and five months of rehabilitation). Voice pitch level was variable and sometimes out of the habitual pitch range (250-300 Hz) in pre-rehabilitation stage (Pearson correlation = 0.1). After 5 months of rehabilitation the subjects were able to control their voice pitch using auditory feedback up to the normal level.

Pearson correlations of average pitch parameters in three stages of evaluation (pre-rehabilitation, two months and five months of rehabilitation) were weak, average and considerable, respectively.

**Table I.** Pearson coefficient correlation of voice parameters in /a/ prolongation between CI & normal children.

| Voice Parameters | Pre-rehab. | After 2 months of rehab. | After 5 months of rehab. |
|---|---|---|---|
| Average Pitch | 0/1 | 0/2 | 0/75 |
| Voice Perturbation | -0/474 | -0/478 | -0/34 |
| Jitter | -0/3 | -0/2 | -0/067 |
| Shimmer | -0/36 | -0/29 | -0/040 |

**Table II.** The one-way variance analysis of voice parameters in /a/ prolongation in CI children at three stages.

| Voice Parameters | Degrees of Freedom | Sum of Squares | Mean of Squares | Calculated F | Level of Significance |
|---|---|---|---|---|---|
| Average intensity | 12 | 18.39 | 1.53 | 10.42 | 0.0024 |
| Voice perturbation | 12 | 114.37 | 9.53 | 3.67 | 0.05 |
| Jitter | 12 | 3.07 | 0.25 | 2.59 | 0.01157 |
| Shimmer | 12 | 0.14 | 0.0118 | 3.278 | 0.0731 |

According to the outcomes as shown in Table I, the results of the third stage (0.75) are closer to 1 compared to the second stage result (0.2) which concludes that the effect of five months of auditory-verbal rehabilitation on voice average pitch is more considerable.

The average intensity or vocal intensity is variable due to the respiratory flow and the air pressure applied on vocal cords (loudness of voice is increased as the air flow and the resistance of the vocal cords are increased).

Fry (1979) reported that average intensity in loud speech, conversational speech and soft speech are 75dB, 60dB and 35-40dB, respectively. Hence, according to the obtained results in the questionaires, it could be considered that the average intensity level of the samples after rehabilitation stages is within 50-70 dB (i.e., in normal limits).

Pearson correlations of variables (voice, frequency, and intensity perturbation) in pre-rehabilitation were –0.474, -0.3 and -0.36; and after two months of rehabilitation –0.478, -0.2 and –0.29, respectively. The correlation in the third stage, after five months of rehabilitation, was increased to –0.34, -0.067 and –0.040, respectively (see Table I).

Therefore, it could be concluded that five months of auditory-verbal rehabilitation training could decrease the majors of voice, frequency, and intensity perturbation in cochlear implanted children, considerably. Table II shows the comparison of one-way variance analysis results of each voice parameter in /a/ vowel prolongation in cochlear implanted children at three evaluation stages with their previous results.

**Table III.** LSD test on voice parameters of /a/ prolongation in CI children.

| Voice Parameters | After 2 months of rehab. | After 5 months of rehab. |
|---|---|---|
| Average intensity | * | * |
| Voice perturbation | | * |
| Jitter | | * |
| Shimmer | | * |

In one-way variance analysis of cochlear implanted children, voice values less than 0.05 are acceptable. According to the results (0.0024) the difference of voice intensity variable between the three evaluation stages is significant.

Table III reveals the LSD test results for evaluating the minimum significant differences.

There seems to be minimum significant difference on voice intensity variable between first and second stages and also first and third stages of evaluation. It means that the changes of voice intensity after two and five months of auditory-verbal rehabilitation are considerable and significant from a statistical point of view.

The one-way variance analysis results of other voice parameters such as voice, frequency, and intensity perturbation were 0.05, 0.01157 and 0.0731, respectively (Table II).

To reveal the significant difference of three evaluation stages, LSD test was used. The test results showed a statistically significant difference on voice, frequency and intensity perturbation of /a/ vowel prolongation between first and third stages (Table III).

## CONCLUSION

Auditory-verbal rehabilitation improves voice parameters in cochlear implanted children and it could increase with prolonging the period of rehabilitative training. As shown in this study, improving voice parameters after 5 months rehabilitation was comparable to two months training. These children were able to improve their voice quality close to the normal level after 5 months rehabilitation. In other words, cochlear implanted children could control their voice pitch after auditory-verbal rehabilitation due to the growth of auditory sensitivity and feedback to their own voice and surrounding speech and non-speech sounds.

Maximum changes could be seen on voice, frequency and intensity perturbations as these parameters reach almost the normal levels.

This study insists on the importance of implementing auditory-verbal rehabilitation following cochlear implantation (according to the prepared protocol).

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