# Indices for the determination of the degree of communication skills improvement in prelingual children with cochlear implantation

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**Received** 14 February 2016
**Accepted** 4 April 2016

**The Egyptian Journal of Otolaryngology**
2016, 32:287–297

**Introduction**
Monitoring and documenting the progress in communication skills of cochlear implanted (CI) children is important for intervention planning, conduction of evidence-based studies, and reporting parents about their children's progress.
**Aim**
The aim of the present study was to provide reliable indices that may be used to monitor a child's communication skills progress after CI and to grade his or her performance.
**Patients**
The study was carried out on 53 prelingual CI children (28 boys and 25 girls). Their ages ranged from 2.5 to 6 years. They were all of average intelligence and showed no associated disorders. They were all enrolled for verbal auditory training at the Unit of Phoniatrics.
**Methodology**
The CI children were evaluated postoperatively using the quasi-objective description of communicative ability, following scaling by transformation from the lower stages to the higher stages in communicative performance. This entailed the determination of the levels for auditory performance, receptive and expressive language, speech intelligibility, mode of communication, approximate language age, vocabulary size, and speech sounds perception. After 1 year of implantation, the children were re-evaluated and the levels achieved in each item and on the therapy program were recorded. The subjective impression of improvement was marked as poor, fair, or good, which was determined by the phoniatrician, therapist, and the parents for each child.
**Conclusion**
Expressive language development and speech intelligibility in the presence of marked speech perception are significant indicators for communication skills progress. The indices provided for various degrees of improvement are helpful to conduct evidence-based research, especially in the absence of reliable formal testing.

**Keywords:**
cochlear implantation, communication skills, degree of improvement, language, prelingual, speech

Egypt J Otolaryngol 32:287–297

1012-5574

## Introduction

Much of the researches, since the beginning of cochlear implants (CIs), have been directed toward documenting the degree and scope of speech and language benefit provided by CIs and evaluating the factors that account for individual differences in outcomes of children undergoing the implants. The acquisition of speech proficiency requires between 5 and 7 years of auditory experience in the hearing child, and, therefore, gains in speech resulting from implant experience may extend over a long period of time and require long-term longitudinal designs. Previous studies have indicated that in CI children, gains in speech production included a greater range of phonetic features and expanded consonant repertoire development [1,2]. Better speech production accuracy and small but statistically significant gains in speech intelligibility were also reported [3–5]. Several studies have examined the effect of communication mode on speech outcomes and reported better speech production outcomes for children with oral communication backgrounds than those from total communication programs [6–9]. Many studies concluded that CI children responses were advantageous as regards receptive and expressive language [10], and that the rates of language growth in the children with implants were very similar to that

expected of hearing children [11]. These studies as well as several others provide strong evidence that CIs provide an improved auditory experience for children, which supports the acquisition of spoken language.

Speech therapy has been shown to be effective in the rehabilitation of patients with CI in previous studies [12,13]. It has been thought to be one of the methods that can accelerate the learning process because deafened CI patients must adapt to both spectrally reduced and spectrally shifted speech because of the limited number of electrodes and the limited length of the electrode array after implantation. Assessment of communication skills in hearing-impaired prelingual children even with CI is challenging, especially with the very young children who do not have established spoken language skills or their level of behavior and cooperation necessary for a more formal assessment is compromised [14]. The audition difficulty affects the child's comprehension ability and thus the use of formal testing in speech and language assessment becomes questionable and unreliable. In spite of this challenge, monitory progress in communication skill is of utmost importance for intervention planning and for research purposes. Parents also look for definite explanatory simple words that reflect the child's progress in communication skills. If objective-reliable tools, which may cover detailed description of the child performance, are not available, then the use of indirect [15] quasi-objective tools such as scaling and integration of subjective impressions of management team become necessary.

## Aim of work

The aim of the present study was to provide characteristics for communication skills development of CI children and determine reliable indices that may be used to monitor the child's communication progress after CI and grade his or her performance.

### Patients

The study was carried out on 53 children (28 boys and 25 girls) with CI attending the Unit of Phoniatrics, Otorhinolaryngology Department, Faculty of Medicine at Alexandria University after the parents' consent for data use for publication was obtained. Their ages ranged from 2.5 to 6 years, with a mean of 4.47 ±1.09 years. They were all of average intelligence and showed no associated motoric or visual handicaps or evident signs of behavioral or attention disorders. They were all enrolled for verbal auditory training at the Unit of Phoniatrics.

### Methodology

The current research was approved by the IRB/Ethics committee. At the initial stage of the research, all studied children were assessed after implantation to select children candidate for research and to obtain a baseline for communication level. This stage included the following:

(1) Determination of nonverbal abstract intelligence quotient using the Stanford Binet [16].
(2) Quasiobjective description of communicative ability using a questionnaire and following scaling and grading by transformation from the lower stages to higher stages in communicative performance to cover the following aspects:
   (a) Level of auditory performance, which reflects everyday auditory performance in a more realistic way [17].
      (1) No awareness of environmental sounds.
      (2) Awareness of environmental sounds.
      (3) Response to speech sounds.
      (4) Identification of environmental sounds.
      (5) Discrimination of some speech sounds without lip-reading.
      (6) Understanding of common phrases without lip-reading.
      (7) Understanding of conversation without lip-reading.
      (8) Use of telephone with a known listener.
   (b) Level of receptive language skills [18].
      (1) Demonstrates awareness that the mouth and/or voice convey information.
      (2) Demonstrates comprehension of a few words or expressions.
      (3) Demonstrates the ability to learn new words.
      (4) Demonstrates the ability to acquire new comprehension vocabulary in phrases and sentences.
      (5) Demonstrates comprehension of successive phrases and sentences.
   (c) Level of expressive language skills [18].
      (1) Demonstrates awareness that vocalizations are used to communicate.
      (2) Demonstrates the ability to use a few syllables, words, or expressions.
      (3) Demonstrates the ability to learn new expressive vocabulary.
      (4) Demonstrates the ability to acquire new expressive vocabulary fairly readily.
      (5) Demonstrates the ability to join two or three words together.
      (6) Demonstrates the ability to combine verbs and nouns in phrases or sentences.

(7) Demonstrates the ability to use sentences containing a modifying word or phrase.
(8) Demonstrates the ability to use sentences containing more than one type of modifying word or phrase.
(9) Demonstrates the ability to use sentences.

(d) Level of speech intelligibility with reference to everyday situation response and use of lip-reading ability [14]: this is a time-effective global outcome measure of speech intelligibility in real-life situations.
(1) Connected speech is unintelligible to all listeners.
(2) Connected speech is intelligible to family members when context and lip-reading cues are available.
(3) Connected speech is intelligible to strangers when context and lip-reading cues are available.
(4) Connected speech is intelligible to all listeners.
(5) Child is understood easily in everyday contexts.
(6) Use of lip-reading ability for names and familiar words, and/or for words that differ in vowels and/or for words that differ in consonants.

(7) Mode of communication used by the child, which were categorized into the following:
(a) Only gestures.
(b) Combined verbal/gestures.
(c) Only verbal.

(8) Determination of approximate language age using test of acquired communication skills (Elhakem E., Abo-Ras Y., El-Banna M., Unpublished thesis). Approximate language age was categorized into five levels.
(a) Less than 12 months.
(b) 12–18 months.
(c) 18–24 months.
(d) 24–30 months.
(e) More than 30 months.

(9) Vocabulary size was guided by the semantic part in an Arabic language test [19] and the feedback from parents and the therapist; the approximate number of words were determined and classified into five ranges:
(a) Less than 50.
(b) 50–100.
(c) 100–300.
(d) 300–600.
(e) More than 600.

(10) The auditory listening ability of children for various vowels and consonants was tested using the Ling sounds. The isolated /m/, /a/, /i/, /u/, /Ê /, /s/ speech sounds were presented auditorily using a live female voice with no visual cueing at a distance of 20 cm at 60 dB in a quiet room. The sound consistently recognized without visual cues after three trials was marked [20].

(11) Inclusion of all children in an auditory verbal training program twice per week for half an hour sessions using modified Speech Perception Instructional Curriculum and Evaluation and starting from the first level [21].The four levels of therapy in Speech Perception Instructional Curriculum and Evaluation were as follows:
(a) Detection.
(b) Suprasegmental perception.
(c) Vowels and consonants.
(d) Connected speech.

(12) After 1 year of implantation, the children were re-evaluated using the same battery.
(1) The number of levels achieved in each item were recorded and marked as difference in levels.The current mode of communication was noted.The language age changes were classified into the following:Less than 6 months.6–12 months.More than 12 months.Change in vocabulary size were also categorized as follows:Less than 100 words.100–300 words.More than 300 words.The level achieved in the therapy on the used program was determined when 90% accuracy criterion was reached for all tasks encountered in each level.The degree of improvement was marked as poor, fair, or good response according to the subjective impression of the phoniatrician, the therapist, and parents for each child. Statistical analyses were carried out using Past (PAleontological Statistics, University of Oslo, Oslo, Norway), version 3.10 [22]. The $\chi 2$-test was used for categorical variables, to compare between different groups.The F-test [analysis of variance (ANOVA)] was used to calculate the mean between more than two studied groups. Pearson's coefficient was used to determine any correlations between the groups' variables.Multiple regression analysis was used for predicting the unknown value of a variable from the known variables (also called the predictors).The data were described

using range (minimum and maximum), mean, SD, and median (25th–75th percentiles).Significance of the obtained results was judged at the 5% level.

## Results

Table 1 summarizes the communicative performance of children at initial and 1 year follow-up assessments as regards auditory perception, receptive and expressive language, and speech intelligibility.

Table 2 summarizes the communicative performance of children at initial and 1 year follow-up assessments as regards mode of communication, language age, vocabulary size, and therapy level.

The total number of Ling sounds recognized without visual cues at initial assessment were 59, with a mean of 1.11±0.72 and a range of 0–3. At the follow-up assessment, the total number reached 192, with a mean of 3.62±0.72 and a range of 1–6 ($t$=12.68 and $P$=00001), as shown in Fig. 1.

The subjective impression of the phoniatrician, therapist, and parents were consistent and showed insignificant difference using the ANOVA test ($P$=0.7672).

Table 3 shows the significant correlations between the raters.

Pearson's correlation coefficient indicated a significant correlation between the degree of improvement and difference in auditory perception ($r$=0.89981), difference in receptive language ($r$=0.82247), difference in expressive language ($r$=0.9085), difference in speech intelligibility (0.85615), difference in language age ($r$=0.84388), difference in vocabulary size ($r$=0.83544), Ling sound ($r$=0.5425), and difference in therapy levels (0.85371).

Table 4 summarizes the performance of CI children in relation to the degree of improvement.

The mean of Ling sounds consistently recognized for the poor performing CI group was 2.17±0.63, 3.65 ±0.71 for the fair performing group, and 5.46±0.66 for

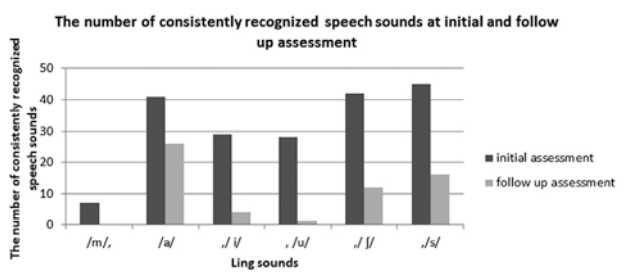
**Table 1 The communicative performance of children at initial and 1 year follow-up assessments as regards auditory perception, receptive and expressive language, and speech intelligibility**

| | Initial assessment [$n$ (%)] | Follow-up assessment [$n$ (%)] | $\chi^2$ | $P$ |
|---|---|---|---|---|
| Auditory of perception | | | 60.529 | 0.0001 |
| (i) | | | | |
| (ii) | 1 (2) | 0 (0) | | |
| (iii) | 34 (64) | 12 (23) | | |
| (iv) | 14 (26) | 13 (25) | | |
| (v) | 4 (8) | 8 (15) | | |
| (vi) | 0 (0) | 10 (19) | | |
| (vii) | 0 (0) | 7 (13) | | |
| (viii) | 0 (0) | 3 (5) | | |
| Receptive language | | | 72.95 | 0.0001 |
| (i) | 39 (74) | 3 (5) | | |
| (ii) | 13 (25) | 16 (30) | | |
| (iii) | 1 (2) | 12 (23) | | |
| (iv) | 0 (0) | 15 (29) | | |
| (v) | 0 (0) | 7 (13) | | |
| Expressive language | | | 73.886 | 0.0001 |
| (i) | 26 (49) | 2 (4) | | |
| (ii) | 27 (51) | 8 (15) | | |
| (iii) | 0 (0) | 14 (26) | | |
| (iv) | 0 (0) | 10 (19) | | |
| (v) | 0 (0) | 8 (15) | | |
| (vi) | 0 (0) | 8 (15) | | |
| (vii) | 0 (0) | 3 (6) | | |
| Speech intelligibility | | | 95.5 | 0.0001 |
| (i) | 50 (94) | 0 (0) | | |
| (ii) | 3 (6) | 21 (40) | | |
| (iii) | 0 (0) | 19 (36) | | |
| (iv) | 0 (0) | 4 (7.5) | | |
| (v) | 0 (0) | 6 (11) | | |
| (vi) | 0 (0) | 3 (5.5) | | |

**Table 2 Summarizes the communicative performance of children at initial and 1 year follow-up assessments as regards mode of communication, language age, vocabulary size, and therapy level**

| | Initial assessment [*n* (%)] | Follow-up assessment [*n* (%)] | $\chi^2$ | *P* |
|---|---|---|---|---|
| Mode of communication | | | 36.332 | 0.0001 |
| Only gestures | 38 (71) | 18 (34) | | |
| Combined verbal/gestures | 3 (5.5) | 26 (49) | | |
| Only verbal | 2 (3.5) | 9 (17) | | |
| Language age (months) | | | 43.244 | 0.0001 |
| <12 | 37 (70) | 8 (15) | | |
| 12–18 | 11 (21) | 11 (20) | | |
| 18–24 | 5 (9) | 13 (25) | | |
| 24–30 | 0 (0) | 13 (25) | | |
| >30 | 0 (0) | 8 (15) | | |
| Vocabulary size | | | 57.133 | 0.0001 |
| <50 | 42 (79) | 6 (11) | | |
| 50–100 | 11 (21) | 19 (36) | | |
| 100–300 | 0 (0) | 17 (32) | | |
| 300–600 | 0 (0) | 7 (13) | | |
| >600 | 0 (0) | 4 (8) | | |
| Level on therapy program | | | 66.862 | 0.0001 |
| Sound detection | 53 (100) | 12 (23) | | |
| Suprasegmental perception | 0 (0) | 21 (40) | | |
| Vowel and consonants | 0 (0) | 11 (21) | | |
| Connected speech | 0 (0) | 9 (17) | | |

**Figure 1**




The performance of CI at initial and final assessments as regards the Ling test. CI, cochlear implantation.

the good performing group. The ANOVA test revealed a marked significant difference ($F$=29.94 and $P$=0.0001).

Table 5 shows the results of multiple regression analysis and significant indicators for improvement.

Figure 2(a)–(h) represent the plot diagram of the dependent variables against the degree of improvement.

Table 6 shows the mean, SD, median, and ranges (25th–75th) percentiles in various assessed parameters in relation to the degree of improvement.

## Discussion

Development of age-appropriate linguistic competence is the most desirable potential outcomes of CI. Use of a CI is proven to have a dramatic impact on the linguistic competence of profoundly hearing-impaired children [23]. The literature on language development in children after CI has established that children who use CIs develop language at a faster rate than do children with similar degrees of hearing loss who use hearing aids [24].

The current longitudinal study was carried out in five steps. The first step entailed the provision of evidence of improvement in the selected items assessed. The present study integrated formal and informal tools for the assessment to avoid bias of test induction by depending on collecting information through questionnaires and marking the levels of performance on a scaled basis. The item assessed included audition proficiency, receptive and expressive skills, and speech perception and production tasks. The present study reported a significant improvement for all tested items, using the suggested battery. The cochlear (CI) performance after 1 year of implantation, irrespective of the factors that may affect their linguistic achievement, was significantly better. The current study emphasized the results of the previous studies, indicating the benefit of CI as regards its role in speech and language development. Studies monitoring speech and language development in the literature proved that CI performance is advantageous and that efficient communication in real life could be achieved. Geers

**Table 3 Shows the correlations between raters using various models**

| | ANOVA table | | | |
|---|---|---|---|---|
| | Sum of squares | *d.f.* | Mean square | *F* |
| Between raters | 1.37107 | 2 | 0.685535 | 4.661 |
| Between cases | 72.0252 | 52 | 1.3851 | 9.418 |
| Within cases | 16.6667 | 106 | 0.157233 | |
| Residual | 15.2956 | 104 | 0.147073 | |
| Total | 88.6918 | 158 | | |
| 95% confidence | | | | |
| Model 1 | | | | |
| Individual [ICC(1,1)] | 0.7225 [0.6049–0.8173] | | | |
| Mean [ICC(1,k)] | 0.8865 [0.8212–0.9307] | | | |
| Model 2 | | | | |
| Individual [ICC(2,1)] | 0.7241 [0.6038–0.8195] | | | |
| Mean [ICC(2,k)] | 0.8873 [0.8205–0.9316] | | | |
| Model 3 | | | | |
| Individual [ICC(3,1)] | 0.7373 [0.6235–0.8279] | | | |
| Mean [ICC(3,k)] | 0.8938 [0.8325–0.9352] | | | |

ANOVA, analysis of variance; ICC, intraclass correlation coefficient. ICC=1 indicate perfect reliability. Model 1: the raters rating different objects are different, and randomly sampled from a larger set of raters. Model 2: the same raters rate all objects, and the raters are a subset of a larger set of raters. Model 3: no assumptions about the raters.

*et al.* [25] concluded that children with average learning ability who receive a CI at or before 5 years of age have the potential to produce and understand the English language at a level comparable to that of their hearing age mates. Zhou *et al.* [23] conducted a longitudinal study on CI children and concluded that auditory perception categories and speech intelligibility rating are nonlinear, but still increased percentages of children achieving higher levels during follow-up assessment were noticed. The study demonstrated an improvement in CI children's performance on speech sound perception, which was expected as children who obtain greater auditory benefit from their implant achieve more normal language levels than do children who have poor speech perception after the implant [26]. Therefore, the dramatic increases in auditory speech perception afforded by the CI [27] should make the achievement of optimum language skills easier for profoundly hearing-impaired children. Their difficulties were still observed when visual cues where eliminated as in the /m/ sound, even through the sounds correctly perceived covered the whole range of audition. Their mode of communication, overall language age, vocabulary size, and their performance during training sessions also showed improvements.

The second step in the data analysis aimed at the provision of gold standard to determine the degree of improvement. This was achieved through comparison of raters' impression as regards the child's performance. The phoniatrician's professional opinion and therapist/parent's feedback for each child was recorded and then correlated. This allowed coverage of the child's performance in structured sessions during training sessions as well as during daily life situations. A significant correlation between raters was found and thus the commonest impression about the degree of improvement among raters was then marked for each child for further categorization.

We believe that improvement is a dynamic process and thus the difference in performance and calculation of the levels achieved by subtracting the initial levels from the follow-up ones are more representing of improvement. The Ling test results and mode of communication were not categorized into levels and the follow-up assessment was used in further phases of the study. A significant difference between groups, referring to the degree of improvement, was recorded for all items except for the receptive skills, speech intelligibility, and mode of communication in the third step of the study. Receptive language skills, which represent the ability of language comprehension, exceed the spoken language in normal development, even though the language output is more representative of effective communication; thus, the insignificant difference between groups, signifying the various degrees of improvement, may represent this observation. This does not overlook, though, the importance of receptive language in CI development, as it certainly signifies the benefit of CI as regards listening and audition ability even in cases of poor language output. Speech intelligibility is only countable if connected speech is developed – that is, higher levels of oral communication proficiency. This may explain the insignificant difference between groups representing the degree of improvement and speech intelligibility. Mode of communication was

**Table 4 Summarizes the performance of cochlear implanted children in relation to degree of improvement**

| | Poor (*n*=16) [*n* (%)] | Fair (*n*=24) [*n* (%)] | Good (*n*=13) [*n* (%)] | *F* | *P* value |
|---|---|---|---|---|---|
| Difference in auditory perception | | | | 28.27 | 0.0001 |
| One level | 14 (87) | 0 (0) | 0 (0) | | |
| Two levels | 2 (3) | 17 (71) | 0 (0) | | |
| Three levels | 0 (0) | 7 (29) | 1 (7) | | |
| Four levels | 0 (0) | 0 (0) | 7 (55) | | |
| Five levels | 0 (0) | 0 (0) | 4 (32) | | |
| Six levels | 0 (0) | 0 (0) | 1 (7) | | |
| Difference in receptive language | | | | 1.089 | 0.3016 |
| One level | 3 (19) | 0 (0) | 0 (0) | | |
| Two levels | 13 (81) | 12 (50) | 0 (0) | | |
| Three levels | 0 (0) | 8 (33) | 1 (8) | | |
| Four levels | 0 (0) | 4 (17) | 7 (54) | | |
| Five levels | 0 (0) | 0 (0) | 5 (38) | | |
| Difference in expressive language | | | | 11.5 | 0.0013 |
| One level | 6 (38) | 0 (0) | 0 (0) | | |
| Two levels | 10 (62) | 0 (0) | 0 (0) | | |
| Three levels | 0 (0) | 16 (67) | 1 (15) | | |
| Four levels | 0 (0) | 6 (25) | 6 (46) | | |
| Five levels | 0 (0) | 2 (8) | 4 (31) | | |
| Six levels | 0 (0) | 0 (0) | 2 (8) | | |
| Difference in speech intelligibility | | | | 0.7969 | 0.3761 |
| One level | 53 (100) | 6 (25) | 0 (0) | | |
| Two levels | 0 (0) | 18 (75) | 6 (46) | | |
| Three levels | 0 (0) | 0 (0) | 5 (38) | | |
| Four levels | 0 (0) | 0 (0) | 2 (15) | | |
| Current mode of communication | | | | 4.825 | 0.0325 |
| Only gestures | 15 (94) | 3 (22) | 0 (0) | | |
| Combined verbal/gestures | 1 (6) | 21 (88) | 4 (31) | | |
| Only verbal | 0 (0) | 0 (0) | 9 (69) | | |
| Language age gained (months) | | | | 24.96 | 0.0001 |
| <6 | 6 (38) | 9 (38) | 0 (0) | | |
| 6–12 | 9 (56) | 14 (58) | 3 (23) | | |
| >12 | 1 (6) | 1 (4) | 10 (77) | | |
| Vocabulary size gained | | | | 51 | 0.0001 |
| <100 words | 16 (100) | 0 (0) | 1 (8) | | |
| 100–300 words | 0 (0) | 16 (75) | 4 (30) | | |
| >300 words | 0 (0) | 8 (25) | 8 (62) | | |
| Difference in therapy levels | | | | 12.45 | 0.0006 |
| No levels | 7 (54) | 1 (4) | 0 (0) | | |
| One level | 6 (46) | 16 (67) | 4 (31) | | |
| Two levels | 0 (0) | 7 (29) | 9 (69) | | |

not significantly different among groups. The use of gesturing even in a good language achiever may be related to environmental habits of caregivers as it is believed that the sign facilitates comprehension or it may simply signify that their communication skills are not yet sufficient to help them in being efficient communicators in real situation as these have not been addressed in their intervention program. The communication modes the children are exposed to in everyday situations best reflect their overall language abilities [28]. The benefit of a CI is best reflected in the child's ability to communicate using speech with the world at large in which sign language is not generally used. Children who use oral communication typically have more intelligible speech and higher levels of speech perception and are thus better oral communicators [11]. Spoken language appears to be an important outcome, even for children enrolled in programs that also include sign [23].

The fourth step entailed carrying out multiple regression analysis to determine the contribution of assessment items to the degree of improvement. The analysis showed that the improvement in expressive language, speech intelligibility, and speech sound perception were the only significant indicators of improvement. One could conclude that language output represented by expressive language together

**Table 5 The results of multiple regression analysis and significant indicators for improvement**

| Multiple regression analysis | | | | | |
|---|---|---|---|---|---|
| Dependent variable | Degree of improvement | | | | |
| *N* | 53 | | | | |
| Multiple *R* | 0.96647 | | | | |
| Multiple $R^2$ | 0.93407 | | | | |
| Multiple $R^2$ adjusted | 0.92027 | | | | |
| ANOVA | | | | | |
| *F* | 67.688 | | | | |
| *d.f.*1, *d.f.*2 | 9, 43 | | | | |
| *P* | 0.0001 | | | | |
| | Coefficient | SE | *t* | *P* | $R^2$ |
| Constant | 0.47522 | 0.12578 | 3.7781 | *0.00048132* | |
| DAP | 0.095437 | 0.056731 | 1.6823 | 0.099765 | 0.80966 |
| DRL | 0.058956 | 0.060608 | 0.97274 | 0.33612 | 0.65112 |
| DEL | 0.12686 | 0.040447 | 3.1365 | *0.0030817* | 0.81259 |
| DSI | 0.12081 | 0.052044 | 2.3214 | *0.025075* | 0.72701 |
| FMC | 0.056854 | 0.094966 | 0.59868 | 0.55253 | 0.71895 |
| DLA | -0.029714 | 0.05714 | -0.52 | 0.60573 | 0.2376 |
| DVS | 0.023464 | 0.058312 | 0.40238 | 0.68939 | 0.24012 |
| Ling sounds | 0.15034 | 0.042454 | 3.5412 | *0.00097238* | 0.77279 |
| DTL | 0.030906 | 0.067442 | 0.45827 | 0.64907 | 0.72215 |

ANOVA, analysis of variance; DAP, difference in auditory perception; DEL, difference in expressive language; DLA, difference in language age; DRL, difference in receptive language; DSI, difference in speech intelligibility; DTL, difference in therapy level; DVS, difference in vocabulary size; FMC, follow-up mode of communication. $P = 0.001$ indicate the significance value for multiple regression analysis.

with speech production proficiency supported by marked speech sounds perception covering broad range of audition encounter for evident improvement. This may lead us to more understanding of the insignificant importance of therapy levels achieved as this may enhance the idea that the success of structural sessions do not actually mean success in real-life situation as an efficient communicator or guarantee improvement of spoken language. Thus, there is a need to pay more attention to generalization and maintenance of therapeutic takes during conduction of intervention programs. In contrast, Kirk *et al.* [29] showed that linguistic competence was associated with placement in educational environments that emphasized the development of speech and auditory skills. It was also argued that the hour of exposure does not account for spoken language but that speech perception and production do [25]. One should refer to the short duration of sessions applied to the studied children.

In the fifth step we suggested the use of median and 25th–75th percentiles to put solid indices for various degrees of improvement. The following indices for improvement were concluded after of 1 year of implantation.

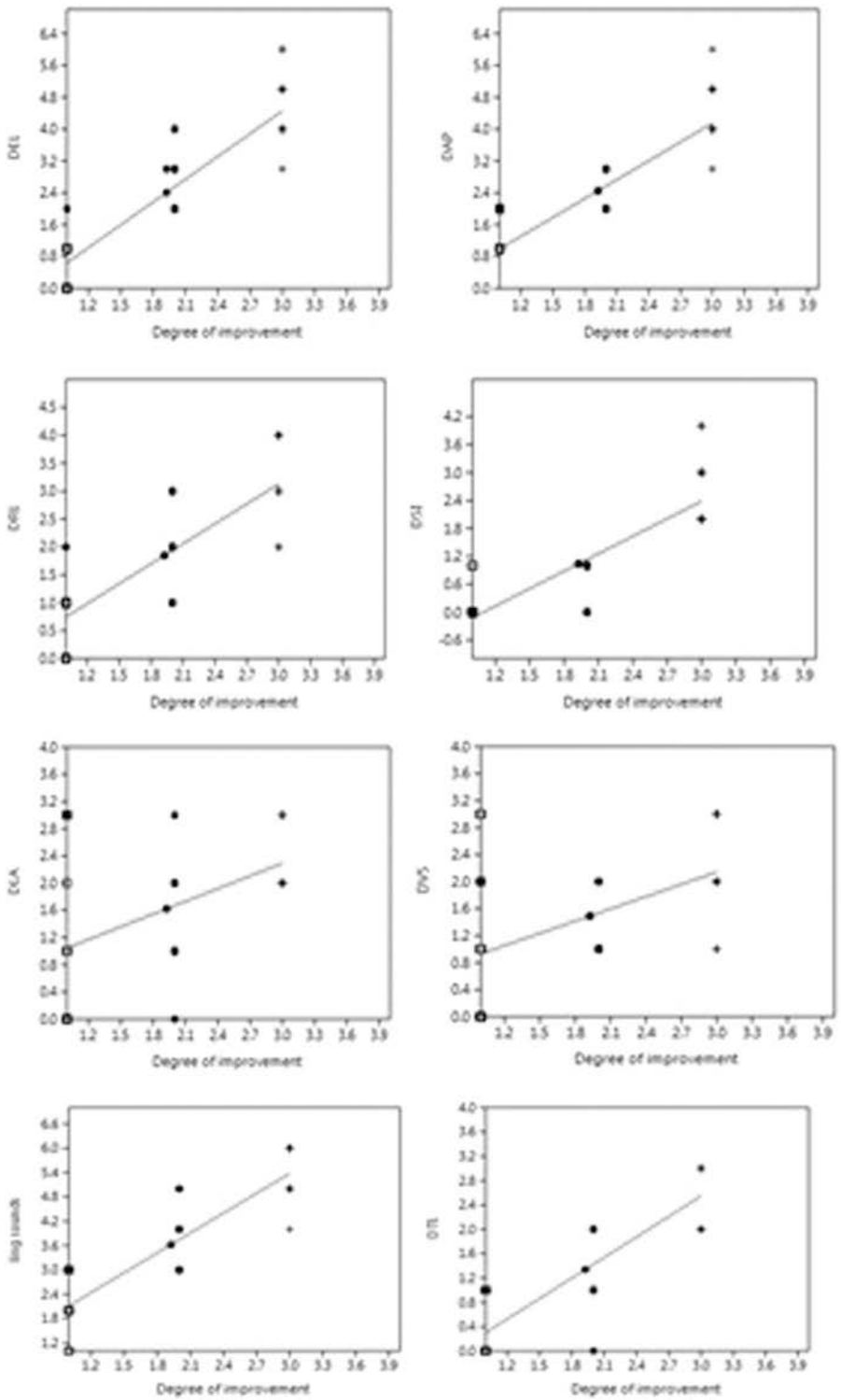
Criteria for poor response performance were as follows:

(1) Increase in auditory performance not more than two stages.
(2) Increase in the receptive language skill level not more than one level.
(3) Increase in the expressive language skill level not more than one level.
(4) Improvement of intelligibility of speech is unnoticed.
(5) Nonverbal mode of communication is used.
(6) Increase in language age is less than 12 months.
(7) Increase in vocabulary size is less than 100 words.
(8) Poor progress in one level of the therapeutic program of intervention program and no level achieved with 90% accuracy.
(9) Consistent recognition of not more than three Ling sounds.

Criteria for fair response included the following:

(1) Increase in auditory performance at least between two to three levels.
(2) Increase in receptive language skills for two stages only.
(3) Increase in expressive language skills between two to three levels.
(4) Speech intelligible increased by one level.
(5) Verbal mode of communication is used in combination with gesturing.
(6) Increase in language ages between 6 and 12 months.
(7) Increase in the vocabulary size between 100 and 300 words.
(8) Consistently recognizing 3–4 Ling sounds only.

**Figure 2**




The plot diagram of the dependent variables to the degree of improvement. □poor improvement. ■fair improvement. +good improvement.

(9) Demonstrating steady progress in one level of the therapeutic program of intervention program and achievement of one level with 90% accuracy.

Criteria for good response include the following:

(1) Increase in auditory performance on at least four levels.
(2) Increase in receptive language skill on at least three levels.
(3) Increase in expressive language level on at least three levels.
(4) Increase in speech intelligible on at least two levels.
(5) Verbal mode of communication is used consistently.
(6) Increase in language age of more than 12 months.

**Table 6 The mean, SD, median, and ranges 25th–75th percentiles in various parameters**

| | Mean±SD | Minimum–maximum | Median | 25–75 percentile |
|---|---|---|---|---|
| DAP | | | | |
| Poor | 1.18±0.39 | 1–2 | 1 | 1–1 |
| Fair | 2.30±0.47 | 2–3 | 2 | 2–3 |
| Good | 4.38±0.77 | 3–6 | 4 | 4–5 |
| DRL | | | | |
| Poor | 0.82±0.52 | 0–2 | 1 | 1–1 |
| Fair | 1.83±0.72 | 1–3 | 2 | 1–2 |
| Good | 3.23±0.72 | 2–4 | 3 | 3–4 |
| DEL | | | | |
| Poor | 0.70±0.59 | 0–2 | 1 | 0.5–1 |
| Fair | 2.42±0.65 | 2–4 | 2 | 2–3 |
| Good | 4.54±0.88 | 3–6 | 4 | 4–5 |
| DSI | | | | |
| Poor | 0.11±0.33 | 0–1 | 0 | 0–1 |
| Fair | 0.74±0.44 | 0–1 | 1 | 1–1 |
| Good | 2.69±0.66 | 2–4 | 3 | 2–3 |
| DLA | | | | |
| Poor | 0.18±1.18 | 0–3 | 1 | 1–1 |
| Fair | 1.48±0.66 | 2–3 | 1 | 1–2 |
| Good | 2.46±0.52 | 2–3 | 2 | 2–3 |
| DVS | | | | |
| Poor | 0.12±1.11 | 0–1 | 1 | 0–2 |
| Fair | 1.26±0.45 | 1–2 | 1 | 1–2 |
| Good | 2.38±0.77 | 1–3 | 3 | 2–3 |
| Ling sounds | | | | |
| Poor | 2.18±0.63 | 1–3 | 2 | 2–3 |
| Fair | 3.65±0.71 | 3–5 | 4 | 3–4 |
| Good | 5.46±0.67 | 4–6 | 6 | 5–6 |
| Therapy levels | | | | |
| Poor | 0.41±0.51 | 0–1 | 0 | 0–1 |
| Fair | 1.26±0.54 | 0–2 | 1 | 1–2 |
| Good | 2.69±0.48 | 2–3 | 3 | 2–3 |

DAP, difference in auditory perception; DEL, difference in expressive language; DLA, difference in language age; DRL, difference in receptive language; DSI, difference in speech intelligibility; DVS, difference in vocabulary size

(7) Increase in vocabulary size by more than 300 words.
(8) Consistent recognition of more than four Ling sound without visual cues.
(9) Competition of at least two therapeutic level with 90% accuracy.

The study concluded that expressive language development and speech intelligibility in the presence of marked speech perception represent indicators for CI benefit from device and intervention. The improvement in communication skills in everyday situation is a very important indicator of improvement and thus should be the main goal in intervention planning. The degree of improvement is crucial for the study of factors affecting the CI performance and conducting evidence-based research especially in the absence of reliable formal testing; thus, we recommend integration of several assessment tools and aspects to indicate improvement.

**Conflicts of interest**
There are no conflicts of interest.

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