Effect of cochlear implantation on language development and assessment of the quality of studies in this field: A systematic review

Soodeh Khoramian¹, Zahra Soleymani*¹, Nasrin Keramati², Masoud Motasaddi Zarandy²

Received: 13 Aug 2018 Published: 7 Oct 2019

Abstract

Background: Cochlear implantation (CI) is an achievement that facilitates the acquisition of language skills in deaf children throughout the world. The use of this technology has a positive effect on all components of language acquisition (syntax, semantic, pragmatic, etc.). However, this positive impact is influenced by various factors. Understanding the strengths and weaknesses of studies on the development of language abilities can help improve these studies. Consequently, in the future, it will lead to the improvement of language rehabilitation in these children. Limited studies on children with CI in have been done so far. This article summarized the outcomes of scientific articles on the clinical efficacy of CI on Persian speaking children. This study also provided a clear picture of these studies by examining the quality of their methodologies and tools.

Methods: Articles indexed in Google Scholar, Web of Science, Medline, Scopus and Iranian databases (Danesh Gostar, Magiran, and SID) were searched using keywords “language,” “Cochlear implant”, “Persian/Farsi” in English and Persian languages with “and/or”. Original articles investigated on children younger than 13 years old with hearing impairment and CI were included.

Results: Five hundred and twenty-three articles were found based on the keywords. Among all of these, 485 were excluded due to the title and the abstract; we selected 38, of which 24 were repeated. Finally, 14 articles remained. We reviewed the articles based on the preferred reporting items for systematic review and meta-analysis (PRISMA) and checklist and Grading of Recommendations, Assessment, Development, and Evaluations (GRADE).

Conclusion: Similar to international studies, Persian speaking children with CI have slower language development than their peers with normal hearing, but they are better than their peers who use hearing aids. The results of reviewing on quality of the articles showed that the studies could not meet reasonable quality because of the lack of a standard test in different aspects of Persian language and the absence of patients’ databanks. These results also can be used by other nationalities that recently have started surveys on children with CIs.

Keywords: Cochlear implant, Child, Language, Iran, Developmental language disorders, Persian

Introduction

Hearing impairments is seen in 3.5 neonates out of 1,000 live births (1). In Iran, it is considered to be 2-3 in

↑What is “already known” in this topic:
• Previous studies showed progress of language skills, communication, and speech abilities in English-speaking children with hearing impairment after cochlear implantation (CI).
• There is no systematic review on Farsi-speaking children with CI.

→What this article adds:
• Cochlear implant surgery is an effective way for the development of language skills in Persian-speaking children, as well as English-speaking children.
• Many other aspects of language such as pragmatics, semantics and several subcategories of grammar need to be studied in Persian speaking children with CI.
A systematic review of language development in children with cochlear implant

1000 (2). Being deprived of hearing in children is a major challenge for learning and using language (3, 4). Language is an indispensable tool for social interaction. Speech and language are fundamental to the development of emotional and social skills in children. Literacy is a consequence of language development. Therefore, language impairment might lead to educational, social, and behavioral problems. Language is highly important for children as it paves the path to a wide range of training, culture, and job opportunities in the future. In addition, language is the primary predictor of learning capability in young children with severe to deep hearing impairment (5). For this reason, the main objective of the rehabilitation of children with hearing impairment is to achieve speech and language skills (6, 7).

The past few decades have been featured with outstanding advances in the potential of developing and utilizing language for children with severe to deep hearing impairment (3) and of these advances is the introduction of cochlear implant (CI) as one of the most effective hearing aids (8). Several studies all around the world have examined and compared different fields of languages in individuals with CI, normal individuals, and those using hearing aids. In general, the results of studies in this field have indicated that the pace of language development of the children using standard amplifiers such as hearing aid or touch amplifiers is one-half of the normal children (9–12). On the other hand, children with CI demonstrate capabilities almost identical with those of their normal peers at different linguistic levels (phonology, morphology, words, etc.) (13).

Recent years have witnessed notable advances in permanent CI technology so that many children, who had to rely only on sign language in the past, now can acquire language skills (14).

To search for more accurate and better research on the language system, the language was divided into its main components: form, content, and use (15). Form includes morphology, syntax, and phonology; content includes semantics, and use includes pragmatics (16). Many studies have been conducted on CI in Iran; however, sharing of linguistic studies in this field is rare. Most studies have been conducted on Persian language children in the field of voice, speech, communication and auditory skills of these children (17-25). Currently, clinical decision making in linguistic fields are pertinent to the studies in English speaking children.

The primary objective of this systematic review study is to survey studies performed on the Persian speaking children with CI that was compared with peers who use hearing aids and normal hearing (NH) peers to estimate clinical efficacy of CI. Another objective of this study is to achieve a comprehensive point of view about the components (e.g., phonology, syntax, morphology, semantics, and pragmatics) of language in these children that need further study. Finally, a survey of the quality of the tools and methodology of these studies was used to identify the shortcomings. Hoping to address these deficiencies and improve quality in future studies in this area. In fact, our goals are to answer the following questions:

How does the language of children with hearing loss improve after cochlear implantation?
What are the specifications and features of studies on Persian children with CI?
The focus of studies on which components of language (e.g., phonology, syntax, morphology, semantics, and pragmatic) is less?

Methods

This systematic review was designed and carried out based on preferred reporting items for systematic review and meta-analysis (PRISMA), which is a checklist with 27 statements that ensures transparency of a systematic report (26). Articles were analyzed using a GRADE critical form (27).

The search strategy was performed according to Prisma. Research on Persian speaking children with CI was included. All articles in this field published up to 21/4/2018 and indexed in Danesh Gostar, SID-Which is a reliable Persian bank of scholarly articles published in Iran-, Google Scholar, Web of Science, MEDLINE via PubMed, Scopus, and publisher databases (Springer, Science Direct) were included. Additional articles were discovered by a monthly search update. Articles on speech therapy and audiology conferences were reviewed by a manual search. Multiple different combinations of the following keywords were used in the search queries: “language, cochlear implant, Persian, and Farsi, language development, grammar, vocabulary, morphology, syntax, pragmatic and reading” (in Persian and English) using “or/and” (Appendix 1).

No time limitation was added to the search, and the articles were searched independently by two researchers, and the inconsistencies were solved by a third researcher. Inclusion criteria were participants' strategy, intervention, outcomes, and study design (PI-COS), which are; children under 13 years of age with any degree of hearing loss (hearing aids or implants) and normal hearing(Participants), CI (Intervention), children with normal hearing / hearing aids (Control), study of the language including: vocabulary, semantics, syntax, pragmatics and reading (Outcomes) and randomized controlled trials, non-randomized controlled trials, cohort studies, and repeated measures(Study designs).

Only the studies on language development in Persian speaking children younger than 13 years old and with CI were examined.

Two researchers carried out the search task, so that titles and abstracts were examined first and then the fulltext of the articles that met the inclusion criteria entered the study. Finally, 38 out of 523 articles were selected and out of which 24 were excluded as they were repetitive. Hence, this study was carried out on 14 reminding articles (Fig. 1).

Inclusion criteria

1. Studies on Persian speaking children with CI.
2. Studies on one or more fields of language including morphology, syntax, phonology, semantics, and pragmatics.

All studies in the Persian/ Farsi and English language
were included in our review.

Studies on children with CI compared with normal children or children with hearing aids.

Exclusion criteria: Studies focused on CI comorbid with other disorders such as genetic and neuropathy disorders; Review articles; Studies focused only on acoustic aspects of speech; Studies on non-verbal communications; Studies focused on adult with CI; Studies without full text.

Each paper was screened and checked by two reviewers that had master in Speech and Language Pathologist. Chance adjusted inter-rater agreement was calculated for agreement between two raters (Cohen’s kappa =0.93) (28). Independently and probable disagreements were settled through discussion under the supervision of a third reviewer, who was Ph.D. of Speech and Language Pathology and an expert in the field.

Table 1 lists brief information of the articles including authors’ names, year of publication, title, number of participants, statistical methods, tools, and the results of each paper.

| Study | Design | Population/Sample size (n) | Age | Randomization | Target (What studied) | Data collection | Validity and reliability stated | Statistical analysis explained | Results |
|-------|--------|---------------------------|-----|---------------|-----------------------|-----------------|--------------------------------|--------------------------------|---------|
| Weisi et al., 2013 (29) | Cross-sectional study | 12 CI and 12 HA | Second grades student | NR | Evaluation of phonological awareness among children with CI and children with hearing aids | phonological subtests of NAMA reading test | Yes | T-test | Children with CI have better performance than the children with hearing aids on phone. Nonword reading tasks weren’t significantly different between the two groups |
| Rahimi et al., 2013 (30) | Cross-sectional study | 30 CI 30 NH | 5-8 years | NR | Study of Linguistic Skills of Persian CI and Normal Hearing Children | Language, Phonological Skills, Semantic Skill | Yes | T-test | Normal children have better performance than CI in all language skills |

CI= cochlear implant; HA=hearing aid; NH= normal hearing; NR = Not reported; NR= Not reported
A systematic review of language development in children with cochlear implant

| Study | Design | Population/ Sample size (n) | Age | Randomization | Target (What studied) | Data collection | Validity and reliability stated | Statistical analysis explained | Results |
|-------|--------|-----------------------------|-----|---------------|-----------------------|------------------|-----------------------------|-------------------------------|---------|
| 3 Ghaemi et al., 2014 (31) | Cross-sectional study | 10 CI and 10 NH | Mean age of 5.5 years | NR | Evaluation of comprehension and using passive verbs in children with hearing loss with CI and normal children | passive verb's comprehension | Yes | T-test | comprehension and using passive verbs in normal children is better than CI |
| 4 Mohseni et al., 2015 (32) | Cross-sectional study | 35 CI and 35 NH | 4-7 Years | Yes (Multistage cluster) | Study of Cochlear Implanted Children and Children with Normal Language Development | scale of language development | Yes | Pearson Correlation Coefficient & covariance analysis | CI children had high scores in the scale of language development, but normal children have better performance than CI |
| 5 Weisi et al., 2012 (33) | Descriptive - analytic study | 24 CI and 24 NH | Second and the third grades of elementary | NR | study of reading skills between CI and normal hearing children in second and third grade elementary | NAMA reading test | Yes | T-test, linear regression and Pearson correlations | normal children have better performance than CI in reading skills |
| 6 Mahmoodabadi et al., 2014 (34) | Cross-sectional study | 18 CI and 18 NH | Mean age of 5.5 years | Yes | Comparison of phonological awareness skills between CI and normal hearing children | auditory-visual modality (2010) and visual modality | Yes | Mann Whitney & Spearman non-parametric tests | normal children have better performance than CI in both Visual - Auditory and Auditory phonological awareness tests. |
| 7 Rastegar-Ianzadeh et al 2014 (35) | Cross-sectional study | 48 CI and 30 NH | 70-95 mon | NR | Comparison of phonological awareness skills between CI and normal hearing children | phonological awareness test | Yes | Mann-Whitney & Kruskal-Wallis | Age of children had a significant influence on phonological awareness, but there was not any influence for sex. Children with CI had better function than NH children in the area of phonological awareness, but there was no significant difference between the two groups. |
| 8 Tavakoli et al; 2015 (36) | Cross-sectional study | 20 CI and 20 NH | 60-72 months | Yes | Study of language of CI and normal hearing children | Action picture stimuli: analysis of MLU, NDW, and NTW | Yes | Descriptive statistics | Children with CIs and their normally developing age-matched children were significantly different for all measures, whereas there were no differences between CI children and their normally developing children that matched based on hearing age |
| 9 Dastan et al, 2015 (37) | Cross-sectional study | 30 CI and 30 NH | 6-11 years | NR | Study of phonemic awareness of CI and normal hearing children | phonological awareness test | Yes | t-test | Children with CI had lower performance in phonemic awareness than normal-hearing children |
| 10 Soleymani et al; 2016 (38) | Cross-sectional study | 18 CI and 18 NH | 5.0-5.5 years | Yes | Comparison of language and phonological awareness skills between CI and normal hearing children | Test of Language Development-Primary, third edition & phonological awareness (PA) | Yes | Kolmogorov–Smirnov comparison & t-test & Pearson’s correlation Coefficient | Children with NH and CI had significant differences in language skills and phonological awareness. Different skills of language including semantics, syntax, listening, spoken language, organizing, and speaking | Predicted phonological awareness result. |
Results
All articles were cross-sectional with sample size range 20 to 174 subjects. The participants in the examination group were the children with CI, and those in the control group were their peers with normal hearing or children with hearing aid. Participants were aged 5-13 year old. Random sampling method was used by four articles (32, 34, 36, 38). One article reported that children with CI in visual stimuli perform better than visual-auditory stimuli (34). MLU in children with CI and NH children is not significantly different (36). When the level of the vocabulary is higher, the child will have better performance in the syntax (36). Another study in this area indicates that the understanding and expression "passive verb" in CI children is considerably weaker than NH children (31). The results of the study of sentence comprehension skills suggest that children with CI have phonological processing and sentence comprehension impairments, but by improving the experience in sound processing, the sentence comprehension improves (40). A study for the morpho-syntactic skills of these children showed that children are able to express simple structure, but in using complex structures, they may experience difficulties in phonological processing and sentence comprehension. In children with CIs, with increasing their experience in processing of sound, sentence comprehension skills improved. There is a relationship between the NWR and sentence comprehension.

| Study | Design | Population/ Sample size (n) | Age | Randomization | Target (What studied) | Data collection | Validity and reliability stated | Statistical analysis explained | Results |
|-------|--------|-----------------------------|-----|---------------|----------------------|-----------------|-------------------------------|-------------------------------|---------|
| Rezaei et al; 2016 (41) | Cross-sectional study | 24 CI 24 HA 24 NH | Second and the third grades of elementary | NR | Study of reading skills between CI and normal hearing children in second and third grade elementary | NAMA reading test | Yes | T-test, linear regression and Pearson correlations | Normal children have better performance than CI in reading skills |
| Aminra-souli et al; 2017 (40) | Cross-sectional study | 20 CI 20 NH | 4 to 6 years | NR | A comparison phonological processing and sentence comprehension of cochlear implant and normal hearing children | - Non-Word Repetition (NWR) task  - Persian Syntax Comprehension Test (PSCT);  - Persian version of TOLD-P: 3 | -Yes -Yes -Yes | T-test Pearson correlation | Children with CIs may experience difficulties in phonological processing and Sentence comprehension. In children with CIs, with increasing their experience in processing of sound, sentence comprehension skills improved. There is a relationship between the NWR and sentence comprehension. |
| Zamani et al; 2018(41) | Cross-sectional study | 54 CI 60 HA 60 NH | 10–13 years | NR | A comparison Spoken and Written Narrative of cochlear implant and Hearing Aid and normal hearing children | a pictorial story (The Playful Little Elephant) | Yes | ANOVA on repeated measures ANOVA Bonferroni adjustment test | Students with hearing impairments had significantly lower scores in all of the microstructure components of narratives than normal hearing. No significant difference found among different groups in macrostructure components of narratives. |
| Golestani et al; 2018(42) | Cross-sectional study | 22 CI 11NH | 5 years | NR | Morpho-syntactic skills in CI children and children with NH were compared | Language samples analysis (via; PDSS) | Yes | Mann-Whitney U test were | Children with CIs probably exhibit poor abilities for using complex sentences and essential morphology items. |

CI are significantly lower than NH children (30, 32, 38). However, the language skill scores of these children are in the normal range, which indicates an acceptable level of language (38) Phonological skills studies show that children with CI in all phonological awareness abilities, including phonemic blending, recognizing words with the same initial phonemes, naming and deletion the final phoneme and recognizing words with the same final phoneme, are weaker than NH children (29, 34, 35, 37, 38).
have poor skills, especially in morphology (42). A study that examined some of the semantic skills mentioned that among indicators NTW, NDW, and TTR, all indices except TTR were better in normal children, but there was no significant difference (36). This indicates the appropriate level of vocabulary in CI children. And finally, studies that examined children with CI's reading skills reported that the performance of normal children was better than CI children reading skills. Both studies showed that the reading skills of nonwords in CI children with NH children were not significantly different (33, 39). A study that examined the narrative skills of these children announced that CIs had significantly lower scores in all of the microstructure components of narratives, but no significant difference was found in macrostructure components of narratives between CIs and normal children (41). One of these studies represented that although word and non-word reading and word comprehension skills are similar in children with CI and hearing aid, text comprehension is better in CI children (39).

The final 14 articles were examined using the Grades recommendations, assessment, development, and evaluation (GRADE) (27), which is designed to score the general quality of the evidences of each finding. From GRADE point of view, judge quality of evidences including study design, study quality, consistency, and accuracy.

### Study design

According to GRADE, studies can be categorized into two general categories of clinical trial and observation studies. The articles under study here were all observational and cross-sectional.

### Study quality

Ten metrics including random study, control group, computation factor, blindness of study, clear inclusion criteria, complete results report, sample size, and parameters of research tool (e.g., validity, reliability, and normality) were taken into account. Table 2 shows the scores of quality and evidence levels for the articles included in the present study.

To evaluate the articles, we used the Cochran’s guideline, and it was assessed based on the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) methods.

Computation factors of Cochran’s guideline were used, in which the factors are a function of the following elements:
- Definition of measurement (method of diagnosis, name of scale, definition of limits, and type of behavior);
- Time schedule;
- Scale (upper/lower limits and if the upper/lower score is suitable); and
- Measurement unit.

### Table 2: The scores of quality and evidence levels for included studies

| Author                  | Randomization | Control | Blinding | Outcome measure reporting | Power Calculation | The sample size is appropriate? | Inclusion/exclusion criteria is clearly-stated? | Reliability | Validity | Normalised | Total score | Level of evidence |
|-------------------------|---------------|---------|----------|----------------------------|-------------------|---------------------------------|---------------------------------------------|-------------|----------|------------|-------------|------------------|
| Weisi et al., 2012 (33) | 0             | 2       | 0        | 1                          | 0                 | 2                              | 0                                          | 2           | 2        | 2          | 2           | Low              |
| Rahimi et al., 2013 (30) | 0             | 2       | 0        | 1                          | 0                 | 2                              | 2                                          | 2           | 2        | 2          | 2           | Moderate         |
| Weisi et al., 2013 (29) | 0             | 2       | 0        | 1                          | 0                 | 2                              | 0                                          | 2           | 2        | 2          | 2           | Low              |
| Mahmoodabadi et al., 2013 (34) | 1 | 2       | 0        | 1                          | 0                 | 1                              | 2                                          | 2           | 2        | 2          | 2           | Moderate         |
| Rastegarianzadeh et al 2014 (35) | 0 | 2       | 0        | 1                          | 0                 | 1                              | 1                                          | 2           | 2        | 2          | 2           | Low              |
| Ghaemi et al., 2014(31)       | 0             | 2       | 0        | 1                          | 0                 | 2                              | 1                                          | 1           | 1        | 1          | 1           | Low              |
| Mohseni et al., 2015(32)       | 2             | 2       | 0        | 1                          | 0                 | 2                              | 2                                          | 2           | 2        | 2          | 2           | Moderate         |
| Tavakoli et al; 2015(36)    | 1             | 2       | 0        | 1                          | 0                 | 2                              | 1                                          | 2           | 2        | 2          | 2           | Moderate         |
| Dastghofei; 2015(36)         | 0             | 2       | 0        | 1                          | 0                 | 2                              | 1                                          | 2           | 2        | 2          | 2           | Moderate         |
| soleymanis' et al; 2016(38) | 1             | 2       | 0        | 1                          | 0                 | 1                              | 2                                          | 2           | 2        | 2          | 2           | Moderate         |
| Rezaei 2016 (39)             | 0             | 2       | 0        | 1                          | 0                 | 2                              | 1                                          | 2           | 2        | 2          | 2           | Low              |
| Aminrasouli 2017 (40)        | 0             | 2       | 0        | 1                          | 0                 | 2                              | 2                                          | 2           | 2        | 2          | 2           | Moderate         |
| Zamani et al; 2018 (41)      | 0             | 2       | 0        | 2                          | 0                 | 2                              | 2                                          | 2           | 2        | 2          | 2           | Low              |
| Golestan et al; 2018 (42)    | 0             | 2       | 0        | 1                          | 0                 | 2                              | 2                                          | 2           | 2        | 2          | 2           | Moderate         |

Score criteria: 0 = inadequate or no information for making an assessment, 1 = low data or absence of detail for making an assessment, 2 = suitable usage and reporting. The score of quality = calculation of study validity scores that are methodical and training-specific criteria. 1. Evidence level: scores of quality for study are 0-5 = very low, 6-10 = low, 11-15 = moderate, 16-20 = high (adapted from the GRADE Working Group, 2004 [35]).
The results of the measurements and surveys are summarized in Table 2 based on the study’s quality score. As listed, none of the articles are categorized at a high level based on the GRADE metrics and only four papers had an average level.

**Consistency of study**

From GRADE point of view, consistency is related to statistical heterogeneity, contradictory results, inconsistency with other studies, and inconsistent results. According to GRADE and PRISMA, consistency is measured for meta-analysis studies, and since the articles in this study were different in terms of sample size, objectives, and language fields under study and thus considered as heterogenic studies, it was not possible to perform a meta-analysis. Given the fact that each of our studies looked at one of the linguistic areas; the data from these studies did not allow aggregation and meta-analysis.

As seen in Table 2, all studies except one of them used a valid and reliable tests or indicators, all of them had control group, most of them (11 out of 14 studies) had appropriate sample size, Half of them (7 out of 14 studies) clearly stated their inclusion/exclusion criteria. None of the studies reported blindness or power calculation. Altogether the quality of all studies, based on GRADE, was graded as moderate and low (According to Table 2).

**Study accuracy**

The accuracy of the study depends on the factors influencing the bias of the study, such as the skill of the viewer, blindness, some aspects of test accuracy, and some aspects of measurement (e.g., confidence interval, p-value, and effective size) are effective on the accuracy of the test. Publication bias analysis was not applied here due to the limited number of qualifying studies. Table 3 shows test & measurement features for included articles. Summary of the results are presented in Table 4.

All tests used in the articles were reliable except for one test used by Ghaemi (expression of passive verbs) (31). The rest of the tests were also valid. In terms of normality and cut point only one test in phonological awareness field (29, 34, 37, 38), one test on the perception of passive verbs (31) and TOLD test (30, 38, 40) met the required condition.

All the articles used expert viewer, which is a strong point for all of them. With regard to measurement indices, all the articles but one indicated p-value to determine the significance of the results and only one study calculated the effect size (41); however, none of them mentioned confidence interval. Randomized grouping of the test and control groups was only done by Mohseni, randomized grouping of the control group was only done in two studies, and randomized grouping of the test group was only done by Tavakoli (32, 34, 36, 38).

**Discussion**

To obtain a clear picture of the Iranian studies on language development of children with CI, that was our first goal, the selected articles were examined using relia-
A systematic review of language development in children with cochlear implant

| Table 4. The summary of the appraisal result |
|---------------------------------------------|
| **measure**               | **Number of articles conveyed** | **studies conveyed this measure** |
|---------------------------|---------------------------------|----------------------------------|
| Sufficient sample size    | 11 out of 14                    | All studies                      |
| Randomization             | 4 out of 14                     | Except 4, 5 and 10               |
| blindness                 | 0                               |                                  |
| Power                     | 0                               |                                  |
| Calculation               | 0                               |                                  |
| Control                   | 14 out of 14                    | All studies                      |
| Skill examiner            | 14 out of 14                    | All studies                      |
| Validity                  | 14 out of 14                    | All studies                      |
| Reliability               | 14 out of 14                    | All studies                      |

*The numbers are the number of articles in Table 1*

Quality examinations showed that the issues such as negligence of blindness, failure to obtain test power, failure to randomize, failure to report the whole measurement process, and failure to use normalized tests decreased the quality score of the articles. Blindness was not a priority for the authors, as the studies were not observational. The reason for failure to select the participant randomly is lack of a patients’ databank in Iran and lack of access to the patients; so that many authors adopt convenient sampling method instead. Availability of patients’ databank improves quality and quantity to studies. In addition, more standard tests are needed to improve the quality of Persian studies. However, one of the strengths of Persian studies is to be committed to using valid and reliable tests. Another one is the use of indicators such as MLU, NTW, NDW and PDSS (Persian developmental sentence scoring), which examines the spontaneous speech of children and those that cannot be measurable in the standard tests. In the report section of the study results, only p-value had been reported by the articles, while this metric only determines if there is a significant difference between the two groups (44, 45). Reporting confidence interval enables the reader to estimate the actual amount of difference between the groups; however, none of the articles reported this metric. Confidence interval also indicates if repeating the study with a larger sample group is clinically valid (46). Moreover, the effect size is another metric that covers shortages of the sample size and makes it possible to use the study for systemic review and meta-analysis; this index can also be a start point for studies with larger sample groups (47). We could not perform a meta-analysis because there was not enough information in literature to do that.

Another objective of the study was to determine the fields of language examined or neglected by the studies on Persian speaking children with CI. The articles examined language as a unified concept or different components of language, such as phonology awareness, grammar, and reading skills. Many other fields of language such as pragmatics, semantics and several subcategories of grammar have not been studied in Persian speaking children with CI yet. It is recommended that these areas be considered in future studies.

One of the most important limitations of this study was the small number of available articles; it was not possible to carry out a meta-analysis because of the small number of studies and high diversity of data and specifications of subject groups. Increase in the number of research works would help to overcome these limitations.
might give us a better chance to carry out systemic review and meta-analysis studies in the future.

A cochlear implant is an advanced technology that has helped the hearing impaired all over the world to acquire language. This technology is progressing every day, and its use expands in the world. The results of this study can be used in linguistic studies of countries that have recently come to this technology. The outcomes of this study lead to language studies to pay attention to all aspects of language, such as pragmatics and semantic. In addition, it reminds us that it will increase the quality of the articles, such as taking random sampling, blindness of the study, expressing the confidence interval and the effect size, etc.

A summary of the quality of the articles based on GRADE’s critical form is as follows: The articles were all observational and cross-sectional in terms of design. From the point of view of quality scores, all papers were ranked low and medium. In terms of consistency, our studies were heterogeneous, as stated in the results. From the accuracy point of view, studies were at moderate levels, although the tests that were used were not standard, they were valid and reliable. In the result measurements, the skilled examiner was used, the P value was reported, but the confidence interval and effect size were not reported. In spite of all the limitations that have been identified in the Persian language for researching the language of children with CI, research had much strength that could be cited as follows; the assessment was conducted by expert staff in all studies. Almost all studies were committed to valid and reliable tests, and they had a good sample size. These strengths have caused most GRADE grading studies (9 out of 14 studies) are on a moderate level, and no studies at the level are very low.

Common standard tools are in English language. While providing a standard tool has become popular in recent years to language tests in Iran, the number of Persian tests is still very low. In English, there are different types of studies such as longitudinal, experimental and case study design (48, 49), but in Persian, major studies are cross-sectional, and there are fewer studies of the other type. In all aspects of language such as semantics, pragmatics, and morphology, the study is conducted in English (50–53). Of course, most of these differences are due to the widespread use of English language and a longer history of cochlear implantation in English-speaking countries, and it seems that the study of Persian is also progressively expanding.

**Conclusion**

Cochlear implantation in language acquisition is very effective in Persian-speaking children with hearing impairment. Some aspects of language such as pragmatics and semantics have not been considered in studies that are helpful in improving treatment. The results of the present study showed that we need to develop standard language tests in the Persian language for accurate assessment and comparison of children in different language component (Such as the standard tests of vocabulary, semantics, phonology, syntax, morphology, and pragmatic assessment). This review demonstrates that there is the necessity for further in-depth studies, with the aim of standardizing the assessment tools in order to provide clarity of language development children with CIs. Using these tools increases the accuracy of the information on children and improves quality of the treatment and rehabilitation. The existence of such tools will lead to more extensive and credible studies on these children. There is also a need for more studies with stronger statistical ground which have computations such as the confidence interval and the effect size. Using accurate statistics will increase the validity of the study. Finally, development of a patients’ database facilitates wider, deeper, and more accurate studies on a larger group of participants.

**Conflict of Interests**

The authors declare that they have no competing interests.

**References**

1. Farhat AS, Ghasemi MM, Akhoundian J, Mohamadzadeh A, Esmaeili H, Amiri R, et al. Assessment of the Prevalence of Hearing Impairment in Neonates Born in Imam Reza, Ghaem and OM- Alzheimer Hospitals of Mashhad. Mashhad Uni Med Sci. 2014 Jul 1;5(2):17–20.
2. Zarandy MM, Malekpour M. Two cochlear implants: halving the number of recipients. Lancet (London, England). 2007 Nov 17;370(9600):1686.
3. Masataka N. Advances in the Spoken Language Development of Deaf and Hard-of-Hearing Children. Spencer PE, Marschark M, editors. Advances in the Spoken Language Development of Deaf and Hard-of-Hearing Children. Oxford University Press; 2005. 42-66 p.
4. Kronenberger WG, Pisoni DB. Profiles of Verbal Working Memory Growth Predict Speech and Language Development in Children with Cochlear Implants. J Speech Lang Res. 2013;56(3):805–25.
5. May-Mederake B. Early intervention and assessment of speech and language development in young children with cochlear implants. Int J Pediatr Otolaryngol. 2012;76(7):939–46.
6. Rossi DS, Holstrum WJ, Gaffney M, Green D, Oyler RF, Gravel JS. Hearing screening and diagnostic evaluation of children with unilateral and mild bilateral hearing loss. Trends Amplif. 2008 Mar;12(1):27–34.
7. Abdullahi Fakhim Sh, Nazari MR. Determination of Frequency and Causes of Hearing Loss in High Risk Neonates in Tabriz. Otolaryngology. 2007;29(3):77–82.
8. Leybaert J, LaSasso CJ. Cued speech for enhancing speech perception and first language development of children with cochlear implants. Trends Amplif. 2010;14(2):96–112.
9. Blamey PJ, Sarant JZ, Paatsch LE, Barry JG, Bow CP, Wales RJ, et al. Relationships among speech perception, production, language, hearing loss, and age in children with impaired hearing. J Speech Lang Hear Res. 2001;44(2):264–85.
10. Boothroyd A, Geers AE, Moog JS. Practical implications of cochlear implants in children. Ear Hear. 1991;12(4 SUPPL.):815-898.
11. Cleary M, Pisoni DB, Geers AE. Some measures of verbal and spatial working memory in eight- and nine-year-old hearing-impaired children with cochlear implants. Ear Hear. 2001 Oct;22(5):395–411.
12. Geers A, Moog J. Spoken Language Results: Vocabulary, Syntax, and Communication., Volta Review, 1994. Volta Rev. 1994;96(5):131–48.
13. Geers AE, Nicholas JG, Sedey AL. Language skills of children with early cochlear implantation. Ear Hear. 2003;24(1 Suppl):465–588.
14. Geers AE. Factors affecting the development of speech, language, and literacy in children with early cochlear implantation. Lang Speech Hear Serv Sch. 2002 Jul 1;33(3):172-183.
15. Owens RE, Dehn MJ, Issues T, Implications C, Haresabadi F, Ebadi A, et al. Working Memory and Academic Learning: Assessment and Intervention. Child Lang Teach Ther. 2016;32:193-204.
16. Paul R, Norbury C. Language disorders from infancy through
A systematic review of language development in children with cochlear implant

2013: 18 (2): 67–79.

http://mjiri.iums.ac.ir

Med J Islam Repub Iran. 2019 (7 Oct); 33:107.

MLU, NDW, and NTW. Int J Pediatr Otorhinolaryngol. 2015 Dec;79(12):2191–5.

Dashte-Ali, Mowzooni H, Ashi, A, Delfi M, Movallali G, Salmoni A, et al. The phonemic awareness skills of cochlear implant children and children with normal hearing in primary school. Iran Rehabil J. 2015 Dec 15;13(4):90–4.

Soleymani Z, Mahmoodabadi N, Nouri MM. Language skills and phonological awareness in children with cochlear implants and normal hearing. Int J Pediatr Otorhinolaryngol. 2016;83:16–21.

Rezaei M, Rashidi V, Morasae EK, Khedmati E. Reading skills in Persian deaf children with cochlear implants and hearing aids. Int J Pediatr Otorhinolaryngol. 2016:89:1–5.

Aminramoussli N, Mohamadi R, Jenabi MS, Kamali M. A Comparison Phonological Processing and Sentence Comprehension of Cochlear Implant and Normal Hearing Children. 2018(11):1–8.

Hadghi S, Jalilvand N, Kamali M. A comparison of morpho-syntactic abilities in deaf children with cochlear implant and 5-year-old normal-hearing children. Int J Pediatr Otorhinolaryngol. 2018;110(February):27–30.

Greenhalgh T. How to read a paper: the basics of evidence-based medicine. Wiley-Blackwell; 2010. 238 p.

Gallagher EJ. No proof of a difference is not equivalent to proof of no difference. J Emerg Med. 1994 Jul 1;12(4):525–7.

DIAMOND GA. Clinical Trials and Statistical Verdicts: Probable Grounds for Appeal. Ann Intern Med. 1983 Mar 1;98(3):385.

Kamali M, Altmann DG. Statistics in Medicine Confidence intervals rather than P values: estimation rather than hypothesis testing. Br Med J. 1986;292.

Jones SR, Carley S, Harrison M. An introduction to power and sample size estimation. Emerg Med. 2003 Sep 1;20(5):453–8.

Encinas D, Plante E. Feasibility of a Recasting and Auditory Bombardment Treatment With Young Cochlear Implant Users. Lang Speech Hear Serv Sch. 2016;47(2):157–70.

Rinaldi P, Baruffaldi F, Burdo S, Caselli MC. Linguistic and pragmatic skills in toddlers with cochlear implant. Int J Lang Commun Disord. 2013 Nov;48(6):715–25.

Most T, Shina-August E, Meilijson S. Pragmatic Abilities of Children With Cochlear Implant and/or Hearing Aid. Clin Exp Audiol. 2018;1(1):1–8.

Phonological Processing and Sentence Comprehension of Cochlear Implant and Normal Hearing Children. 2018;1(1):1–8.

Boons T, De Raeve L, Langeres M, Peerlaer L, Wouters J, Van Wieringen A. Expressive vocabulary, morphology, syntax and narrative skills in profoundly deaf children after early cochlear implantation. Res Dev Disabil. 2013 Jun 1;34(6):2008–22.

Rinaldi P, Baruffaldi F, Burdo S, Caselli MC. Linguistic and pragmatic skills in toddlers with cochlear implant. Int J Lang Commun Disord. 2013 Nov;48(6):715–25.

Most T, Shina-August E, Meilijson S. Pragmatic Abilities of Children With Cochlear Implant and/or Hearing Aid. Clin Exp Audiol. 2018;1(1):1–8.

Boons T, De Raeve L, Langeres M, Peerlaer L, Wouters J, Van Wieringen A. Expressive vocabulary, morphology, syntax and narrative skills in profoundly deaf children after early cochlear implantation. Res Dev Disabil. 2013 Jun 1;34(6):2008–22.

Rinaldi P, Baruffaldi F, Burdo S, Caselli MC. Linguistic and pragmatic skills in toddlers with cochlear implant. Int J Lang Commun Disord. 2013 Nov;48(6):715–25.

Tayrani H. The comparative study of comprehension and expression of Persian deaf children with cochlear implant and normal hearing. J Pediatr Otorhinolaryngol. 2016;89(February):27–30.

Greenhalgh T. How to read a paper: the basics of evidence-based medicine. Wiley-Blackwell; 2010. 238 p.

Gallagher EJ. No proof of a difference is not equivalent to proof of no difference. J Emerg Med. 1994 Jul 1;12(4):525–7.

DIAMOND GA. Clinical Trials and Statistical Verdicts: Probable Grounds for Appeal. Ann Intern Med. 1983 Mar 1;98(3):385.

Kamali M, Altmann DG. Statistics in Medicine Confidence intervals rather than P values: estimation rather than hypothesis testing. Br Med J. 1986;292.

Jones SR, Carley S, Harrison M. An introduction to power and sample size estimation. Emerg Med. 2003 Sep 1;20(5):453–8.

Encinas D, Plante E. Feasibility of a Recasting and Auditory Bombardment Treatment With Young Cochlear Implant Users. Lang Speech Hear Serv Sch. 2016;47(2):157–70.

Rinaldi P, Baruffaldi F, Burdo S, Caselli MC. Linguistic and pragmatic skills in toddlers with cochlear implant. Int J Lang Commun Disord. 2013 Nov;48(6):715–25.

Most T, Shina-August E, Meilijson S. Pragmatic Abilities of Children With Cochlear Implant and/or Hearing Aid. Clin Exp Audiol. 2018;1(1):1–8.

Boons T, De Raeve L, Langeres M, Peerlaer L, Wouters J, Van Wieringen A. Expressive vocabulary, morphology, syntax and narrative skills in profoundly deaf children after early cochlear implantation. Res Dev Disabil. 2013 Jun 1;34(6):2008–22.

Rinaldi P, Baruffaldi F, Burdo S, Caselli MC. Linguistic and pragmatic skills in toddlers with cochlear implant. Int J Lang Commun Disord. 2013 Nov;48(6):715–25.

Tayrani H. The comparative study of comprehension and expression of Persian deaf children with cochlear implant and normal hearing. J Pediatr Otorhinolaryngol. 2016;89(February):27–30.

Greenhalgh T. How to read a paper: the basics of evidence-based medicine. Wiley-Blackwell; 2010. 238 p.

Gallagher EJ. No proof of a difference is not equivalent to proof of no difference. J Emerg Med. 1994 Jul 1;12(4):525–7.

DIAMOND GA. Clinical Trials and Statistical Verdicts: Probable Grounds for Appeal. Ann Intern Med. 1983 Mar 1;98(3):385.