ORIGINAL ARTICLE

Evaluation of pediatric cochlear implantation results

Evaluation des résultats d'implantation cochléaire chez l'enfant

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Abstract

Background: Cochlear implantation is an effective method of auditory rehabilitation. Nevertheless, the results show individual variations depending on several factors.

Aim: To evaluate cochlear implantation results based on the APCEI profile (Acceptance, Perception, Comprehension, Oral Expression and Intelligibility) and audiometric results.

Methods: This was a cross-sectional study including children under 18 years of age who had a unilateral cochlear implant and whose implants had been activated at least 1 year prior to the start of the study. During this study period, 75 children underwent unilateral cochlear implantation. Among them, 44 patients had reached one year after the activation of the implant at the time of the evaluation and were then included in the analytical part. A speech-language pathology assessment using the APCEI scale was conducted for 44 cases. Thirty-eight cases had an audiometric assessment (free-field tone audiometry and speech audiometry). We assessed the results of the APCEI profile based on various factors.

Results: The mean cochlear implantation age was 5 years and 2 months. The electrode insertion was complete in all cases. The APCEI profile average was 3.6. Four children had poor results, 27 children had good results, and 13 children had excellent results. The average hearing threshold in tonal audiometry was 39dB. In voice audiometry, the average intelligibility threshold was 65% with the cochlear implant versus 75% with the cochlear implant and the contra lateral hearing aid. According to the statistical study, only two factors were considered to have a positive influence on the success rate of cochlear implantation: the regular use of preoperative amplificative prostheses and the follow-up of speech therapy sessions in pre-operative.

Conclusion: The effectiveness of cochlear implantation depends on several factors. Multidisciplinary management improves the results.

Key words: Cochlear implantation, Deafness, Child, APCEI profile, Results

Résumé

Introduction: L'implantation cochléaire est une méthode efficace de réhabilitation auditive. Cependant, les résultats montrent des variations individuelles en fonction de plusieurs facteurs.

Objectif: Évaluer les résultats de l'implantation cochléaire sur la base du profil APCEI (Acceptation, Perception, Compréhension, Expression Orale et Intelligibilité) et des résultats audiométriques.

Méthodes: Il s'agit d'une étude transversale incluant des enfants de moins de 18 ans ayant eu un implant cochléaire unilatéral et dont les implants avaient été activés au moins 1 an avant le début de l'étude. Durant cette période d'étude, 75 enfants ont subi une implantation cochléaire unilatérale. Parmi eux, 44 patients avaient atteint un an après l'activation de l'implant au moment de l'évaluation et ont alors été inclus dans la partie analytique. Une évaluation orthophonique selon l'échelle APCEI a été réalisée auprès de 44 cas en fonction de divers facteurs. Trente-huit cas ont eu une évaluation audiométrique (tonale en champ libre et vocale).

Résultats: L'âge moyen d'implantation cochléaire était de 5 ans et 2 mois. L'insertion des électrodes était complète dans tous les cas. La moyenne du profil APCEI était de 3,6. Quatre enfants ont eu de mauvais résultats, 27 enfants ont eu de bons résultats et 13 enfants ont eu d'excellents résultats. Le seuil auditif moyen en audiométrie tonale était de 39 dB. En audiométrie vocale, le seuil d'intelligibilité moyen était de 65 % avec l'implant cochléaire contre 75 % avec l'implant cochléaire et l'aide auditive contra latérale. Selon l'étude statistique, seuls deux facteurs ont été considérés comme ayant une influence positive sur le taux de réussite de l'implantation cochléaire: l'utilisation régulière en préopératoire de prothèses amplificatrices et le suivi des séances d'orthophonie en préopératoire.

Conclusion: L'efficacité de l'implantation cochléaire dépend de plusieurs facteurs. La gestion multidisciplinaire améliore les résultats.

Mots clés: Implantation cochléaire, Surdité, Enfant, Profil APCEI, Résultats

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Introduction

The cochlear implant is an implanted hearing aid that electrically stimulates the origins of the auditory nerve by passing the sensory organ of Corti. The effectiveness of cochlear implantation has been well -established. The restoration of hearing after cochlear implantation allows for school integration and improves the quality of life for the child and the family. The contribution of the family in the identification of the child's needs and in the therapeutic protocol is of great help (1). There are several evaluation protocols. The results of cochlear implantation vary among individuals depending on several factors (2).
The purpose of this work is to evaluate the results of cochlear implantation according to the APCEI profile and audiometric results to identify the factors influencing the results after cochlear implantation.

Methods

This was a cross-sectional study including children under 18 years of age who had a unilateral cochlear implant and whose implants had been activated at least 1 year prior to the start of the study.
During this study period, 75 children underwent unilateral cochlear implantation. Among them, 44 patients had reached one year after the activation of the implant at the time of the evaluation and were then included in the analytical part.
The mean age of implanted children was 5 years and 2 months. The sex ratio was 1.58. Fifty-five percent of the cases were from consanguineous marriages. A family history of deafness was found in 53.3% of cases. All children had a prelingual hearing loss. There were no major comorbidities in the children implanted in our series: two cases of epilepsy, one case of hyperactivity with a quadri-pyramidal syndrome, one case of hyperactivity with moderate intellectual disability, and one case of developmental disability. The diagnosis of deafness and the degree of hearing loss were confirmed in all cases by auditory evoked potentials. All children in our series had a preoperative radiological workup including CT and MRI, which did not reveal any contraindications to cochlear implantation. A conventional hearing aid and speech therapy were indicated as soon as deafness was discovered. Conventional aids were worn bilaterally in 43 cases, regularly in 33 cases and irregularly in 9 cases. Thirty-five children underwent preoperative speech therapy.
All children had unilateral cochlear implantation. The insertion of the electrode array was complete in all cases. Surgery was followed by adjustment and regular speech therapy. The average duration of speech therapy was 13 months.
The Implant assessment scale APCEI (Acceptance, Perception, Comprehension, Oral Expression and Intelligibility) was developed by the ENT team at Robert-Debré Hospital in 2006 (1) to assess the audio phonological performance of children deaf people rehabilitated with a conventional hearing aid or with CIs. The different areas of the APCEI profile have been translated into Arabic by two sworn translators/interpreters, fluent in both languages, recognized by the Consulate General of France in Tunisia. The APCEI profile was used in Arabic for the first time in Tunisia by the Rabta ENT service team (3), the one who translated and validated this Arabic version (Fig.1).


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Figure1. Arabic version of APCEI profile

A speech and language assessment according to the Arabic version of the APCEI profile was conducted for 44 children. Five domains were addressed: implant Acceptance (A), auditory Perception (P), listening Comprehension (C), oral Expression (E), and Intelligibility (I). Each of these domains was scored on a scale ranging from 0 to 5: 0 corresponds to no performance and 5 to the maximum performance required in the domain. We conducted a direct individual interview with the parents of the implanted children, scored each domain from 0 to 5, and calculated the averages (the sum of the 5 domains divided by 5) of the APCEI profile. Then we classified the domain scores and calculated averages into: "Poor" for a score < 3, "Good" for a score ranging from 3 to 4 , "Excellent" for a score >= 4.
Thirty-eight out of 44 patients had an audiometric evaluation (free-field tone audiometry and speech audiometry). The other remaining patients had a speech therapy evaluation only, and they did not show up for their appointment for the audiometric evaluation despite several reminders.
We evaluated the results of the APCEI profile according to different factors.
The study of the different variables was carried out in univariate analysis by non-parametric tests (Mann-Whitney test and Kruskal-Wallis test). The significance level was set at 0.05.

Results

During this study period, 75 children underwent unilateral cochlear implantation. Among them, 44 patients had

reached one year after the activation of the implant at the time of the evaluation and were then included in the analytical part.

A speech and language assessment according to the Arabic version of the APCEI profile was conducted for 44 children. Forty one out of 44 patients had an audiometric evaluation (free-field tone audiometry) and thirty-eight had speech audiometry. The other remaining patients had a speech therapy evaluation only, and they did not show up for their appointment for the audiometric evaluation despite several reminders.

The average APCEI profile was 3.6 with extremes ranging from 1.8 to 4.8. The average of the different domains was higher than 3 except for the oral expression domain (Table 1).

Table 1. Distribution of cases according to APCEI profile results

Score	0	1	2	3	4	5	Average
A	0	0	3	8	1	32	4,4
P	0	0	1	13	17	13	3,95
C	0	0	2	30	10	2	3,27
E	0	1	13	19	8	3	2,97
I	0	0	8	14	19	3	3,38

A: implant Acceptance ; **P**: Perception ; **C**: Compréhension ; **E**: Oral Expression ; **I** : Intelligibility of speech

Of the 44 children, 4 (9.1%) had poor outcomes with an average APCEI of less than 3, 40 (90.9%) had functional success with "good" or "excellent" results, 23 had good outcomes, and 13 had excellent outcomes. The average implant acceptance score (A) was 4.4 [2-5], with a majority of children accepting the continuous wearing of their implants.

Auditory perception (P) determines auditory thresholds and sound discrimination, the mean P was 3.95 [2-5]. The mean for listening comprehension was 3.27 [2-5]. The mean for oral Expression was 2.97 [1-5]. Intelligibility is a determinant of good social integration, the mean was 3.38 [2-5].

Forty one cases had free-field tone audiometry. Hearing thresholds ranged from 25 to 50 dB with a mean threshold of 39 dB (Fig.2).

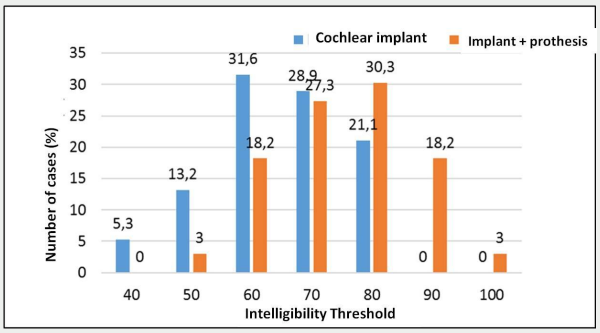

Figure 2. Distribution of intelligibility thresholds

Improvement in hearing thresholds with the implant and hearing aid pair was noted in 13 cases.

Thirty-eight cases were evaluated by speech audiometry. The intelligibility threshold was evaluated at 45 dB with the cochlear implant alone in 5 cases, and with the cochlear implant and the contralateral hearing aid in 33 cases. The average intelligibility threshold was 65% with the cochlear implant and 75% with the contralateral hearing aid. More than 50% of the cases achieved an intelligibility threshold of 80% or more with the concomitant wearing of their implants and contralateral hearing aids. A maximum threshold of 80% was achieved in only 21.1% of patients with the implant alone (Fig. 3).

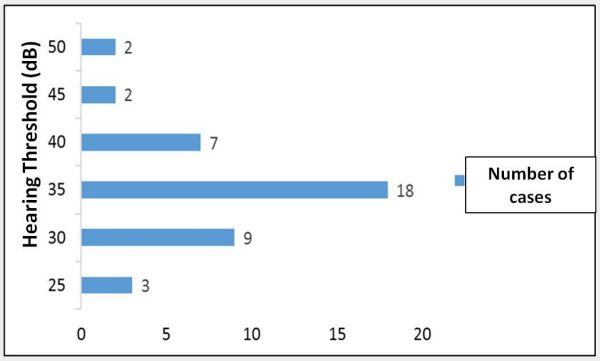

Figure 3. Distribution of hearing threshold in free field

According to the statistical study, only two factors were found to have a positive influence on the success rate of cochlear implantation: regular preoperative wearing of amplifying prostheses and follow-up of preoperative speech therapy sessions. For the other factors, the absence of a significant statistical relationship could be explained by the small sample of groups tested (Table 2).

Table 2. Summary of the different factors influencing the post implant results

Factor	Significance level	p-value
Early age of cochlear implantation	non	0,895
Gender	non	0,815
Absence of comorbidities	non	0,054
High parental involvement	non	0,167
Schooling in a regular school	non	0,489 Post operative 0,208 preoperative
Hearing remnants	non	0,665
Etiology of the deafness	non	0,38
Absence of cochlear malformations	non	0,302
Regular wearing of amplifying prostheses before surgery	oui	**0,011**
Preoperative speech therapy	oui	**0,027**
Duration of postoperative speech therapy	non	0,674

Discussion

Cochlear implantation has become the gold standard in hearing rehabilitation among the pediatric population. There is no standardized protocol for outcome evaluation. However, the effectiveness of cochlear implantation has been well established in the literature (4,5).

In this work, we evaluated speech outcomes according to the Arabic version of the APCEI profile and audiometric outcomes after cochlear implantation. Our results showed an average APCEI profile of 3.6 with extremes of 1.8 to 4.8. The mean hearing threshold in pure tone audiometry

was 39 dB. In speech audiometry, the mean intelligibility threshold was 65% with the cochlear implant versus 75% with the cochlear implant and the contralateral hearing aid.

According to the statistical study, only two factors were found to have a positive influence on the success rate of cochlear implantation: regular wearing of amplifying prostheses and follow-up of preoperative speech therapy sessions.

The advantage of the APCEI profile over other questionnaires is that it scores 5 important areas separately: hearing aid wearing and acceptance, perception, comprehension, speech production and speech intelligibility. The APCEI profile enables the monitoring of implanted children over time, and allows comparisons to be made according to different criteria. The majority of children in our series (40 cases) had functional success with "good" or "excellent" results. Four of the 44 children had poor results with an average APCEI of less than 3.

Hssaine showed in his study that implant acceptance improved with the increase in the duration of cochlear implant wear. The A-domain increased from 4 to 4.8 at one year and after 3 years after cochlear implantation, respectively (6). The average implant acceptance in our series was 4.4.

The P-domain is a clinical assessment of speech perception and is used to evaluate the hearing thresholds of the child with the cochlear implant. The evaluation of auditory perception has been done by different means according to the studies. The mean P in our series was 3.95. It was 3.25 at 1 year and 4 after 3 years in the series of Hssaine (6). Lu, in his study, used the ITMAIS/MAIS and MESP scores for the evaluation of speech perception and comprehension. The ITMAIS/MAIS score was 30% at 3 months and 75% at 12 months. At 2 years, 20% of the cases had an MESP category 5 and 70% had a category 6 (7). According to the study by Le Roux, 68.3% of cases had a CAP score of 5 or more (8). The evolution of oral comprehension is directly related to the auditory message perceived by the child. The data in the literature confirm the progressive and parallel improvement of the perception and comprehension of the oral message; these two domains are sometimes confused and evaluated by the same means of assessment (7,9).

In our series, the mean C was 3.27. In spite of the development of auditory performance by cochlear implantation, these children still have difficulties in using their phonological abilities, and therefore present with difficulties in oral expression, with individual differences. A gap in performance with the hearing child persists and closes with time. The variability of results is multifactorial (10). The mean E in our series was 2.97. It was 2 at one year and 3.33 after 3 years in the series of Hssaine (6). In Lu's series, 90% of the cases had normal skills between 18 and 24 months (7). In Leigh's series, the mean score during picture identification was 89% (11).

Speech intelligibility is an important determinant of successful social integration. It is generally evaluated according to the Nottingham classification. It evolves progressively according to the duration of stimulation. The average I in our series was 3.38. It was 2 at one year and 3.33 after 3 years in the Hssaine series (6). In the Calmels series, the mean SIR score was 1.85 at one year and 3.75 at 5 years (9).

The development of oral communication after cochlear implantation is secondary to the partial or total restoration of hearing. Indeed, pure audiometric results are poorly described. Forty-one children in our series had a free-field tone audiometry, the average hearing threshold was 39dB. Improvement in hearing thresholds with the addition of contralateral hearing aids was noted in 13 cases. In the Matines series, the mean hearing threshold in pure tone audiometry was 48 dB at 12 months, and 43 dB at 18 months (12).

Thirty-eight cases in our series had a speech audiometry in silence, the average intelligibility threshold was 65% with the cochlear implant versus 75% with the contralateral hearing aid. Speech audiometry can be performed in quiet and in noise. Hearing performance in noise remains limited with inter-individual discrepancies, hence the interest of speech audiometry in noise (13). Hearing ability in a noisy environment conditions the quality of life of children (14). In our series, voice audiometry in noise was not performed because of material constraints.

The language learning of cochlear implanted children is identical but delayed in time compared to a normal hearing child with inter individual differences (15). The results are better and can be close to normal for children implanted before the age of 2 years. The earlier the implantation, better are the results. This concept was at the origin of the generalization of neonatal hearing screening (16,17). The evolution of linguistic performance in implanted children is progressively favorable according to the duration of stimulation (4,5,7,9). The results show inter-individual variations according to several factors (2,18). Age of implantation is a major predictor of the benefit of pediatric cochlear implantation. This is because auditory system development and brain plasticity change with age (2). The improvement of auditory perception by cochlear implantation allows the development of oral language (19). The SFORL recommends cochlear implantation before the age of 12 months for congenital profound deafness (20). In our study, there was no statistical relationship between age of implantation and outcome. This could be explained by the small sample size and the interference of other factors.

Other factors that have a positive influence on language performance after cochlear implantation have been described in the literature: the absence of co-morbidities; parental involvement and mode of oral communication with the child, parental involvement is directly related to the IQ, education level and socioeconomic level of the parents; the presence of residual hearing; the etiology of the deafness and the presence or absence of cochlear malformations (2,7,18) Hearing aids and preoperative speech therapy allow access to oral language and are predictive factors of good results (20). This was confirmed in our study. Speech therapy is indicated at the same time as conventional hearing aids, as soon as the deafness is discovered and must be continued after implantation (17). In our series, the conventional preoperative fitting was bilateral in 43 cases, regular in 33 cases and irregular in 9 cases. Thirty-five children underwent preoperative

speech therapy. Post-operatively, attendance at speech therapy sessions and the mode of oral communication were associated with good results (21). In our series, the average duration of postoperative speech therapy was 13 months.

The literature corroborates the positive effect of residual hearing on language acquisition after cochlear implantation (18,22, 23). Post-operatively, for children who have had a unilateral cochlear implantation, wearing a contralateral hearing aid improves speech perception in silence and in noise, sound localization, sound quality differentiation and music perception. It therefore improves performance in daily life (24,25). This improvement is marked for children with residual hearing in the non-implanted ear and for short periods of unilateral stimulation (26,27). The SFORL recommends contralateral hearing aids for unilateral cochlear implantation in children with residual hearing (20). In the absence of residual hearing, bilateral cochlear implantation is recommended. The literature is unanimous regarding the beneficial effect of bilateral cochlear implantation compared to unilateral implantation (2,28,29).

The strengths of our study were: the simplicity of the APCEI profile, which allowed the assessment of the audio phonatory performance of the implanted children. The evaluation was done by the same physician during a direct individual interview with the parent and the implanted child.

Free field audiometric evaluation and speech audiometry allowed the measurement of auditory thresholds without implant, with implant, and with implant and contralateral conventional hearing aid. This assessment was not a standard practice and was used to refine the implant setting and to encourage children to use their contralateral hearing aids.

The main limitations of the study were: The evaluation of the results was done at a given time without being repeated over time; A re-evaluation would have confirmed the results of the literature in terms of the evolution of the results over time. The small sample size limited the statistical analysis of certain factors and the evaluation of the different factors in multivariate analysis.

Conclusion

Pediatric cochlear implantation is a safe and effective method of hearing rehabilitation when used in properly selected populations. Management is multidisciplinary. Results are better when the management is done early, and when the educational and parental support before and after the surgery is correct. Awareness campaigns for the population and primary care physicians and the development of neonatal hearing screening programs should help further improve results. While waiting for the diffusion of bilateral cochlear implantation in our country, it seems essential to us to promote the use of contralateral hearing aids.

References

1. Vieira S, Dupas G, Chiari BM. Cochlear implant: the family's perspective. Cochlear Implants Int. 2018;19(4):216-24.
2. Sharma SD, Cushing SL, Papsin BC, Gordon KA. Hearing and speech benefits of cochlear implantation in children: A review of the literature. Int J Pediatr Otorhinolaryngol. 2020;133:109984.
3. Kessentini A, Marrakchi J. Implant cochléaire chez l'enfant: Evaluation des résultats par le profil acceptation de l'implant, perception auditive, compréhension orale, expression orale, Intelligibilité vocale. [Faculté de médecine de Tunis]: Elmanar Tunis; 2019.
4. Chilosi AM, Comparini A, Scusa MF, et al. A Longitudinal Study of Lexical and Grammar Development in Deaf Italian Children Provided With Early Cochlear Implantation: Ear Hear. 2013;34(3): 28-37.
5. Liu S, Wang F, Chen P, et al. Assessment of outcomes of hearing and speech rehabilitation in children with cochlear implantation. J Otol. 2019;14(2):57- 62.
6. Hssaine K, Belhoucha B, Benhommad O, et al. Evaluation des résultats de l'implantation cochléaire. Pan Afr Med J. 2015.
7. Lu X, Qin Z. Auditory and language development in Mandarin-speaking children after cochlear implantation. Int J Pediatr Otorhinolaryngol. 2018;107:183-9.
8. le Roux T, Vinck B, Butler I, et al. Predictors of pediatric cochlear implantation outcomes in South Africa. Int J Pediatr Otorhinolaryngol. 2016;84:61-70.
9. Calmels M-N, Saliba I, Wanna G, et al. Speech perception and speech intelligibility in children after cochlear implantation. Int J Pediatr Otorhinolaryngol. 2004;68(3):347-51.
10. von Muenster K, Baker E. Oral communicating children using a cochlear implant: Good reading outcomes are linked to better language and phonological processing abilities. Int J Pediatr Otorhinolaryngol. 2014;78(3):433-44.
11. Leigh J, Dettman S, Dowell R, Briggs R. Communication Development in Children Who Receive a Cochlear Implant by 12 Months of Age: Otol Neurotol. 2013;34(3):443-50.
12. Martines F, Martines E, Ballacchino A, Salvago P. Speech perception outcomes after cochlear implantation in prelingually deaf infants: The Western Sicily experience. Int J Pediatr Otorhinolaryngol. 2013;77(5):707-13.
13. Torkildsen J von K, Hitchins A, Myhrum M, Wie OB. Speech-in-Noise Perception in Children With Cochlear Implants, Hearing Aids, Developmental Language Disorder and Typical Development: The Effects of Linguistic and Cognitive Abilities. Front Psychol. 2019;10:2530.
14. Huber M, Havas C. Restricted Speech Recognition in Noise and Quality of Life of Hearing-Impaired Children and Adolescents With Cochlear Implants – Need for Studies Addressing This Topic With Valid Pediatric Quality of Life Instruments. Front Psychol. 2019;10:2085.
15. Clark JH, Aggarwal P, Wang N-Y, et al. Measuring communicative performance with the FAPCI instrument: Preliminary results from normal hearing and cochlear implanted children. Int J Pediatr Otorhinolaryngol. 2011;75(4):549-53.
16. Patel H, Feldman M. Le dépistage universel des troubles de l'audition chez les nouveau-nés. Paediatr Child Health. 2011;16(5):306-10.
17. Silva et al. Variables influençant la qualité de vie des enfants porteurs d'implants cochléaires : une revue systématique,. CoDAS 2021;33(1):e20190153 DOI : 10.1590/2317-1782/20202019153).
18. Gérard J-M, Deggouj N, Hupin C, et al. Evolution of communication abilities after cochlear implantation in prelingually deaf children. Int J Pediatr Otorhinolaryngol. 2010;74(6):642-8.
19. Hayes H, Geers AE, Treiman R, Moog JS. Receptive Vocabulary Development in Deaf Children with Cochlear Implants: Achievement in an Intensive Auditory-Oral Educational Setting. Ear Hear. 2009;30:128-35.
20. Simon F, Roman S, Truy E, et al. Guidelines (short version) of the French Society of Otorhinolaryngology (SFORL) on pediatric cochlear implant indications. Eur Ann Otorhinolaryngol Head Neck

Dis. 2019;136(5):385-91.

21. Moradi M, Fallahi-Khoshknab M, Dalvandi A, Farhadi M, Maddah SSB, Mohammadi E. Rehabilitation of children with cochlear implant in Iran: A scoping review. Med J Islam Repub Iran. 2021;35:73.
22. Niparko JK, Tobey EA, Thal DJ, Eisenberg LS, Wang N-Y, Quittner AL, et al. Spoken Language Development in Children Following Cochlear Implantation. JAMA. 2010;303:1498-506.
23. Phan J, Houston DM, Ruffin C, Ting J, Holt RF. Factors Affecting Speech Discrimination in Children with Cochlear Implants: Evidence from Early-Implanted Infants. J Am Acad Audiol. 2016;27(06):480-8.
24. Warren S, Dunbar M. Bimodal Hearing in Individuals with Severe-to-Profound Hearing Loss: Benefits, Challenges, and Management. Semin Hear. 2018;39(04):405-13.
25. Välimaa T, Kunnari S, Antti A.et al. Spoken language skills in children with hearing aids or cochlear implants. Ear & Hearing 2022;43;220–233.
26. Polonenko MJ, Papsin BC, Gordon KA. Cortical plasticity with bimodal hearing in children with asymmetric hearing loss. Hear Res. 2019;372:88-98.
27. Van Wieringen A, Wouters J. What can we expect of normally-developing children implanted at a young age with respect to their auditory, linguistic and cognitive skills? Hear Res. 2015;322:171-9.
28. Busch T, Brinchmann EI, Braeken J, Wie OB. Receptive vocabulary of children with bilateral cochlear implants from 3 to 16 years of age. Ear Hear. 2022;43(6):1866-80.
29. Lovett RES, Kitterick PT, Hewitt CE, Summerfield AQ. Bilateral or unilateral cochlear implantation for deaf children: an observational study. Arch Dis Child. 2010;95(2):107-12.