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# Does the degree and duration of hearing loss affect cochlear implantation side selection? Language and speech outcome evaluation

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**Abstract: Background:** A cochlear implant (CI) is an electrical auditory device used for stimulating the primary auditory nerve fibers to induce sound perception in individuals with severe-to-profound sensorineural hearing impairment. The development of language and speech skills is achieved by using CIs. **The aim:** this paper aims to study the effect of the preimplant degree and duration of hearing loss on side selection to be implanted, by evaluating language outcome, in order to reach the better decision of the side to be implanted for better language and speech outcome. **Methods:** A retrospective study is used to assess language outcome of (30) patients with pre lingual severe to profound sensori-neural hearing loss. These patients were classified into (3) groups each has (10) patients. The first group has been implanted in the worse and short duration of deafness, the second group has been implanted in the worse and long duration of deafness and the third group has been implanted in the better ear regardless of the duration of deafness. All patients were subjected to personal history taking, psychometric evaluation and language assessment by Pre-school Language Scale test (PLS-4) "Arabic edition". **Results:** it reveals that there was a significant increase in total language raw score in groups III than group I and also a significant increase in total language raw score in groups I than group II. **Conclusion:** The comparison between the three studied groups illustrates the superiority of implanting in the better functional ear over the worse functional ear was validated objectively and subjectively and there is an inversely proportional relationship between the language outcome and duration of deafness.
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## 1. Introduction

A cochlear implant (CI) is an electrical auditory device used for stimulating primary auditory nerve fibers to initiate sound perception in individuals with severe-to-profound sensori-neural hearing impairments. In several studies, the importance of using CIs is illustrated to encourage language and speech development skills for children who are prelingually deaf (born deaf or become deaf before 3 years of age) [1, 2]. The maximum benefit for patients with a residual hearing in the low frequencies is the electroacoustic stimulation in case of using the hearing aids without any benefits. So, during cochlear implantation, it is very important to preserve the residual hearing [3].

In the clinical field, the choice of the ear to be implanted may be one of the most puzzling issues. As, a person involved with CI always (patients, caregivers, and professionals) faces a challenge in choosing which ear to be implanted (better or poor hearing ear). Regarding hearing and language outcomes, implanting poorer ear gives a chance for bimodal stimulation by utilizing a contralateral hearing aid (HA) [4]. However, on the other hand, implanting the better ear has an obvious advantage because the better ear may have more functional residual neural tissue. So, theoretically, implanting the better ear may induce higher speech discrimination [5]. Conversely, implantation the poorer ear may spare the ear with better vestibular function; therefore decreasing the probability of having post-operative dizziness, because of the invasive nature of implantation that can lead to peripheral vestibular dysfunction. Studies have revealed an incidence of transient dizziness and imbalance in more than 20% of subjects, regardless of implant type and also permanent vestibular symptoms are rare [6, 7]. It is very important to take in consideration that implanting poorer ear raises concerns as the implant could be less beneficial in an auditory system that has been long deprived of auditory stimulation [4]. So, the choice of the ear to be implanted is usually performed on the basis of patient preference and perception of the poorer ear, but most of the times it is an arbitrary decision because of the invasive nature of CI and if there is some residual hearing in at least one ear, being a hearing aid user or not, the decision may be even more demanding [5].

Age at implantation has a great effect to expect the spoken language outcome performance. There is an inverse relationship between the duration of deafness and the outcome of language and speech [8,9,10]. The long duration of deafness leads to degradation of peripheral neural structures [11] (spiral ganglion cells [12,13] and the cochlear nucleus [14]). According to the outcomes that were observed in several young implanted children, age prior to three years, it seems that the simulated sense of hearing represented by a CI may offer an excellent chance for a child to proceed in language "developmentally" rather than "remedially" [15]. AS, the first three years in a child's life are critical for acquiring information about the world, communicating with family, and developing cognitive and linguistic information. Moreover, the early implantation for children (before 18 months) is the best for normal developing of spoken language. So, an early diagnosis commonly helps to fit the hearing aids at a younger age and longer duration to improve the auditory perception through amplification. It also provides possible earlier and longer period of language and speech instruction as well as the opportunity for earlier cochlear implantation [16]. On the other hand, children who are deprived of sufficient amount and/or quality of language input in their earliest years of life (such as hearing impaired children) are at risk for poor outcomes in both language and academic achievement later in childhood [17].

Neural plasticity is responsible for the auditory system's ability to learn to interpret the degraded and impoverished information conveyed to it by a cochlear implant; it is also the reason that unused portions of the auditory system are reorganized and colonized by other sensory systems, rendering late implantation much less useful. In clinical practice, early implantation has now become widespread, resulting in better overall outcomes for cochlear implant recipients [18] So, the importance of interaction with other sensory and cognitive system is necessary to support spoken language.

Optimization of the benefit from implants depends not only on the implant signal but also on its coupling to the central auditory system and other related brain systems to learn how to most efficiently obtain meaning from that signal [19].

## 2. Material and methods

A retrospective study was used to assess language outcome of (30) patients with pre-lingual severe to profound sensori-neural hearing loss. They were fitted with their first hearing aid before the age of 3 years with at least 6 months with extensive auditory training without any response. Patients had been implanted and came for follow up at the phoniatric out patients' clinic at Menoufia University and Galaa Military Hospitals. They were classified into (3) groups according to the characteristics (duration and threshold) of hearing loss for the implanted ear before the implantation process. The classification process aims to describe the patients according to their demographic data (age, mental age "IQ", the age at implantation and side selection) as follows:

**The first group (GI)** has been implanted in the worse and short duration of deafness ear, **the second group (GII)** has been implanted in the worse and long duration of deafness ear and **the third group (GIII)** has been implanted in the better ear regardless of the duration of deafness.

All patients passed the exclusion criteria which represented in autistic spectrum disorders (i.e Autism, Asperger, etc), attention deficit hyperactive disorder, mental retardation, Down's Syndrome and any defect in sensory channels responsible for language acquisition other than hearing (i.e. visual impairment and brain damage motor handicapped).

All patients were subjected to language assessment by Preschool Language Scale (PLS-4) "Arabic edition" [20] which filled after six months to one year from the device activation. The PLS-4 "Arabic edition" is a standardized language test, which was standardized on normal Arabic speaking children from Upper and Lower Egypt. It is composed of two subscales, Auditory Comprehension (AC) and Expressive Communication (EC) so; the Receptive, Expressive and Total language raw score and its standard scores could be calculated. Each case was subjected to the test in quiet, well lit and ventilated room with few distracting objects in clinical settings (45 minutes - 1 hour) with break time around 10 minutes and some of these children were subjected to the test with their mothers and the others were alone. The results were analyzed according to suitable statistical tests.

**The test component and Materials include:**

Picture manual contains the color picture stimuli necessary for administering many of the test items, record form contains abbreviated directions for administering, recording and scoring test, manipulatives were used to facilitate interactions with the child, parents' questionnaire, and articulation screening test. Manipulatives should be used for testing purposes only under the strict supervision of a professional. Items required for test administration were a ball, five blocks, a box with lid, one small car, infant rattle, three spoons, teddy bear, keys (examiner's own keys), and a towel.

The collected data were revised, coded, tabulated, and introduced into a personal computer using the statistical package for the social sciences (SPSS 15.0, 2001; SPSS Inc., Chicago, Illinois, USA) [21] for Windows. Data were presented and suitable analysis was performed according to the type of data obtained for each parameter.

**Descriptive statistics include:**

Mean, standard deviation (SD), minimum and maximum values (range) for numerical data, and frequency and percentage of non-numerical data.

The independent samples t-test was used to assess the statistical significance of the difference between the mean of the three studied groups, the $x^2$-test was used to examine the relationship between the three qualitative variables, and *P*-value was used to determine the level of significance; *P*-value more than 0.05 was considered non-significant (Non Sig), *P*-value less than 0.05 and more than 0.01 was considered significant (Sig), and *P*-value less than 0.01 was considered highly significant (High Sig).

## 3. Results

The Total language raw score (Total. LRS), Receptive language raw score (REC.L.R.S), Expressive language raw score (EXP.L.R.S) and their standard scores (S.S) are calculated by applying the PLS-4 "Arabic edition" to all patients. The results declared that there is an inversely proportional between the duration of deafness (age at implantation) and language outcome as shown in (Fig.1).

The correlations between the three studied groups were studied according to several factors as follows:

**The first factor** is represented in the comparison between Age, IQ, and age at implantation (duration of deafness). Table 1 shows that there was no statistically significant difference found between the three studied groups regarding the age of the studied patients and IQ score with p-value = 0.165 and 0.807 respectively while there was highly statistically significant difference found between the three groups regarding the age at implantation with p-value < 0.001.

**The second factor** is represented in the comparison between the three studied groups regarding REC.L.R.S and its standard score. There was a statistically significant increase in REC.L.R.S in G III (49.40±2.59) than G I (46.40±1.96) with p-value = 0.043 and also highly statistically significant increase in REC.L.R.S in G I than G II (37.20±4.42) with p-value < 0.001. While no statistically significant difference was found between the three studied groups regarding standard score of REC.L.R.S with *P*-value = 0.527 as shown in (Fig.2).

**The third factor** is represented in the comparison between the three studied groups regarding EXP.L.R.S and its standard score. There was a statistically significant increase in EXP.L.R.S in G III (39.30±4.00) than G I (35.40±2.55) with p-value = 0.037 and also highly statistically significant increase in EXP.L.R.S in G I than G II (27.60±5.02) with p-value < 0.001. While no statistically significant difference found between the three studied groups regarding standard score of expressive language with p-value = 0.354 as shown in (Fig.3).

**The fourth factor** is represented in the comparison between the three studied groups regarding the Total. LRS and its standard score. There was a statistically significant increase in the Total. LRS in G III (88.70±6.20) than G I (81.80±3.52) with p-value = 0.029 and also highly statistically significant increase in the Total. LRS score in G I than G II (64.80±9.14) with p-value < 0.001. While no statistically significant difference found between the three studied groups regarding standard score of total language with *P*-value = 0.083as shown in (Fig.4).

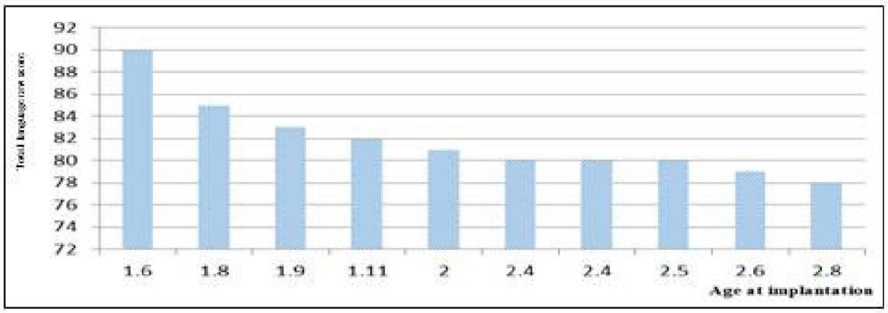
**The fifth factor** is represented in the correlation of age at implantation of the studied groups with the other studied parameters as illustrated in table 2. There is a highly statistically significant negative correlation between age at implantation and receptive, expressive and total language raw scores and also a negative correlation with age equivalent of receptive, expressive and total langue raw scores.

**Table 1.** Comparison between the three studied groups regarding age, IQ, and age at implantation

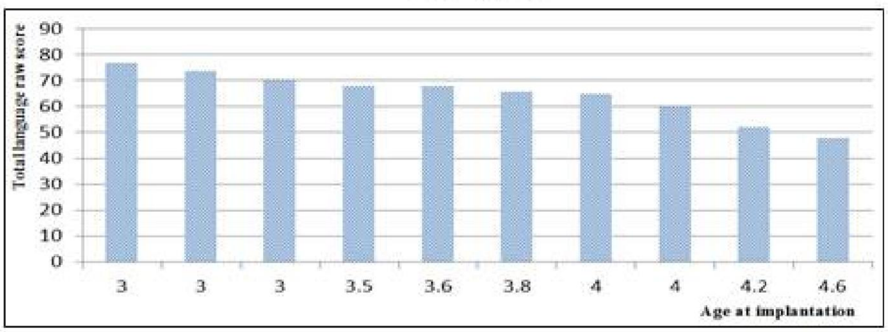
| | **Age (years)** | | **I.Q** | | **Age at Implantation** | |
|---|---|---|---|---|---|---|
| | **Mean±SD** | **Range** | **Mean±SD** | **Range** | **Mean±SD** | **Range** |
| **G I No.=10** | 5.18± 0.39 | 4.5 – 5.8 | 97.70± 7.85 | 90-111 | 2.11± 0.52 | 1.11-2.8 |
| **G II No.=10** | 5.01± 0.64 | 4 – 5.6 | 98.60± 4.79 | 90-105 | 3.67± 0.55 | 3-4.6 |
| **G III No.=10** | 5.40± 0.15 | 5.2 – 5.6 | 96.70± 6.38 | 90-111 | 2.81± 0.70 | 2-4 |
| **Test value** | 1.926 | | 0.216 | | 17.188 | |
| **p-value** | 0.165 | | 0.807 | | 0.000 | |
| **Sig.** | Non Sig. | | Non Sig. | | High Sig. | |

**Table 2.** Correlation of age at implantation of the studied cases with the other studied parameters

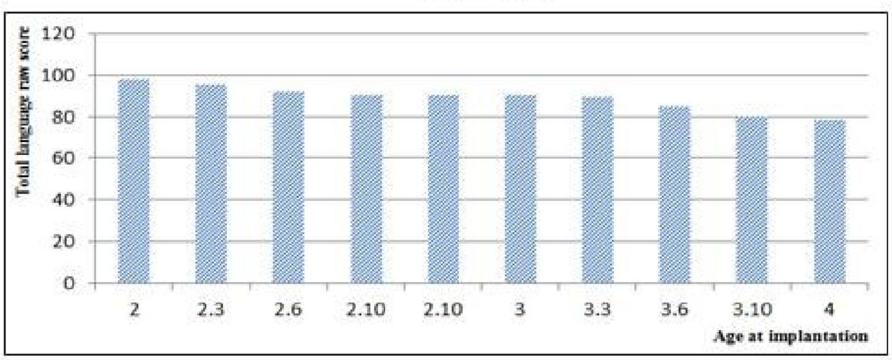
| | Age at implantation | |
|---|---|---|
| | Significant correlation (**) | |
| | **Range** | **p-value** |
| **REC.L.R.S** | -0.667** | 0.000 |
| **S.S of REC.L** | -0.165 | 0.384 |
| **EXP.L.R.S** | -0.683** | 0.000 |
| **S.S of EXP.L** | 0.084 | 0.660 |
| **Total L.R.S** | -0.725** | 0.000 |
| **S.S of total. L** | -0.242 | 0.197 |
| **Age equivalents of REC language** | -0.625** | 0.000 |
| **Age equivalents of EXP language** | -0.592** | 0.001 |
| **Age equivalents of total language** | -0.699** | 0.000 |




Group 1




Group 2




Group 3

**Fig.1.** The relationship between age at implantation and total language raw score in the three groups.

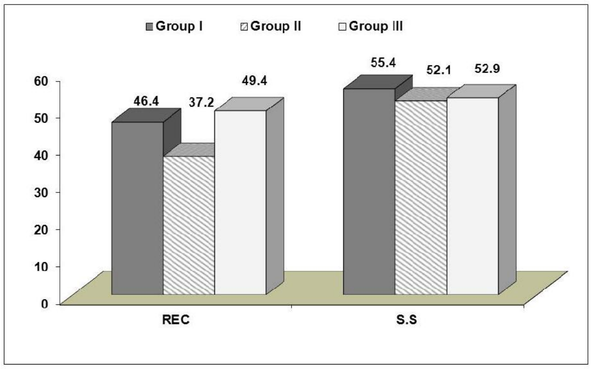



**Fig.2.** Comparison between the three studied groups regarding REC.L.R.S and its S.S

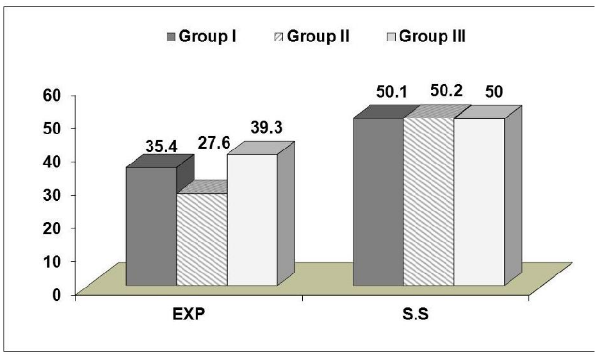



**Fig.3.** Comparison between the three studied groups regarding EXP.L.R.S and its S.S.

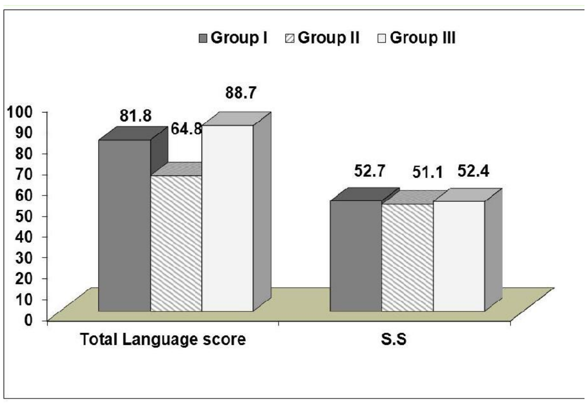



**Fig.4.** Comparison between the three studied groups regarding total L.R.S and S.S.

## 4. Discussion

The results from applying the PLS-4 "Arabic edition" to the (30) patients indicate the following:

The first group (poor functional ear with short duration of deafness) shows better total language outcome than the second group (poor functional ear with long duration of deafness) due to the short duration of deafness in the first group that provides more residual neural tissue for electrical stimulation that leads to better speech recognition but long duration of deafness leads to degradation of peripheral neural structures, spiral ganglion cells, and the cochlear nucleus. These results have been approved by other several studies [18, 22, 23].

Duration of deafness is likely considered to be one of the most predictors of cochlear implantation outcome, as shorter duration of deafness leads to higher performance in speech recognition, presence of long duration of unilateral sound deprivation significantly appears to have negative impact on implantation outcome. By this study, the poorer outcome was obtained in case of implantation in the ear which was deafened at birth or in early childhood that is approved by other studies [8-13, 22-24].

The third group (better functional ear) is announced to be the best group as it shows better total language outcome compared with the other groups because it contains more residual neural tissue which has an experience to the world of sound and higher speech discrimination i.e., introduced to the world of sound.

These results are approved by the study of Francis 2005 [5]. Conversely, implantation of the poorer ear may spare the ear with better vestibular function, therefore decreasing the probability of having post-operative dizziness. However, the permanent vestibular symptom that results from implanting better functional ear is a rare but seen only as a transient symptom in 20% of subjects [6, 7].

## Conclusions

When unilateral CI is only available in case of bilateral asymmetrical severe to profound hearing loss, the better functional ear should be selected for better language and speech outcome. As the comparison between the three studied groups illustrates the superiority of implanting in the better functional ear over the worse functional ear was validated objectively and subjectively.

There is an inversely proportional relation-ship between the degree/duration of deafness and language outcome.

## Recommendation

For more accurate results the future work should be prospective studies and should be done in specific conditions as follows:

Patients should have the same inclusion criteria except for only one criterion (duration of deafness "age at implantation" or degree of hearing loss "better/poor" functional ear).

All patients should undergo the same training conditions (post-implantation auditory rehabilitation -

language therapy) i.e., in the same center and the same trainer for the same period.

Patients who had been implanted in poor function ear should be aided with contralateral hearing aid during the period of study i.e., bilaterality is important for sound localization even if the sound is different in physical properties.

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**Conflicts of Interest:** No Conflicts of Interest declared.

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**The Statement of Ethics:**

The subject's parents' had given and signed written informed consents according to legal guardians and the study protocol was approved by Research Ethics Committee of Menoufia University before enrollment.

**References**

1. Mohammed AA, and Sarwat SA. The side of cochlear implantation and speech intelligibility in pediatric and adult cochlear implantees. The Egyptian Journal of Otolaryngology. 2014; 30 (4):362.
2. Tobey EA, Geers AE, Brenner C, Altuna D, and Gabbert G. Factors associated with development of speech production skills in children implanted by age five. Ear and hearing. 2003; 24 (1):36S-45S.
3. Guimarães AC, Carvalho GMd, Duarte AS, Bianchini WA, Sarasty AB, and Gregorio MFd. Hearing preservation and cochlear implants according to inner ear approach: multicentric evaluation. Brazilian journal of otorhinolaryngology. 2015; 81 (2):190-6.
4. Angelika Bojanowicz M, Lesinski-Schiedat A, Lenarz T, and Büchner A. Evaluation of the bimodal benefit in a large cohort of cochlear implant subjects using a contralateral hearing aid. Otology & Neurotology. 2014; 35 (9):e240-e4.
5. Francis HW, Yeagle JD, Bowditch S, and Niparko JK. Cochlear implant outcome is not influenced by the choice of ear. Ear and hearing. 2005;26 (4):7S-16S.
6. Chiong CM, Nedzelski JM, McIlmoyl LD, and Shipp DB. Electro-oculographic findings pre-and post-cochlear implantation. The Journal of otolaryn-gology. 1994; 23 (6):447-9.
7. Higgins KM, Chen JM, Nedzelski JM, Shipp DB, and McIlmoyl LD. A matched-pair comparison of two cochlear implant systems. Journal of otolaryngology. 2002; 31 (2).
8. Friedland DR, Venick HS, and Niparko JK. Choice of ear for cochlear implantation: the effect of history and residual hearing on predicted post-operative performance. Otology & Neurotology. 2003; 24 (4):582-9.
9. Lazard, D. S., Vincent, C., Venail, F., Van de Heyning, P., Truy, E., Sterkers, O.,... & Mawman, D. Pre-, per-and postoperative factors affecting performance of post-linguistically deaf adults using cochlear implants: a new conceptual model over time. PloS one. 2012; 7(11):e48739.
10. Gomaa NA, Rubinstein JT, Lowder MW, Tyler RS, and Gantz BJ. Residual speech perception and cochlear implant performance in postlingually deafened adults. Ear and hearing. 2003; 24 (6):539-44.
11. Shepherd RK, Coco A, and Epp SB. Neurotrophins and electrical stimulation for protection and repair of spiral ganglion neurons following sensorineural hearing loss. Hearing research. 2008; 242 (1):100-9.
12. Nayagam BA, Muniak MA, and Ryugo DK. The spiral ganglion: connecting the peripheral and central auditory systems. Hearing research. 2011; 278 (1):2-20.
13. Green SH, Altschuler RA, and Miller JM. Cell death and cochlear protection. Auditory trauma, protection, and repair: Springer; 2008. p. 275-319.
14. Ryugo DK, Pongstaporn T, Huchton D, and Niparko JK. Ultrastructural analysis of primary endings in deaf white cats: morphologic alterations in endbulbs of Held. Journal of Comparative Neurology. 1997; 385 (2):230-44.
15. National Environmental Policy Act of 1969, (May 15, 1969, 1994).
16. Chonchaiya W, Tardif T, Mai X, Xu L, Li M, and Kaciroti N. Developmental trends in auditory processing can provide early predictions of language acquisition in young infants. Developmental science. 2013; 16 (2):159-72.
17. Hart B, Risley TR, and Kirby JR. Meaningful differences in the everyday experience of young American children. Canadian Journal of Education. 1997; 22 (3):323.
18. Peterson NR, Pisoni DB, and Miyamoto RT. Cochlear implants and spoken language processing abilities: Review and assessment of the literature. Restorative neurology and neuroscience. 2010; 28 (2):237-50.

19. Moore DR, and Shannon RV. Beyond cochlear implants: awakening the deafened brain. Nature neuroscience. 2009; 12 (6):686-91.
20. Abo-Hasseba A. Standardization, Translation and Modification of the Preschool Language Scale-4. Faculty of medicine, Ain Shams University. 2011.
21. Nie NH, Bent DH, and Hull CH. SPSS: Statistical package for the social sciences. 1975.
22. Boisvert I, McMahon CM, Dowell RC, and Lyxell B. Long-term asymmetric hearing affects cochlear implantation outcomes differently in adults with pre-and postlingual hearing loss. PloS one. 2015; 10 (6):e0129167.
23. Caposecco A, Hickson L, and Pedley K. Cochlear implant outcomes in adults and adolescents with early-onset hearing loss. Ear and hearing. 2012; 33 (2):209-20.
24. Waltzman SB, Roland Jr JT, and Cohen NL. Delayed implantation in congenitally deaf children and adults. Otology & Neurotology. 2002; 23 (3):333-40.

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