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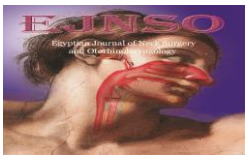

Language profile of cochlear implanted children at Assiut University, Egypt.

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Abstract:

Background: many factors either preoperative or postoperative affect the language outcome in cochlear implanted (CI) children especially the age of implantation, residual hearing, preoperative hearing aid wearing, and pre and postoperative language therapy.

Objective: to evaluate the impact of some related factors (gender, family education, pre-implanted hearing aid wearing& language therapy, age at implantation, duration& place of post-operative language therapy, and total hearing age) on language outcomes in Assiut University hospital

Design: 45 CI children (23 girls and 22 boys) with ages ranging from 20-108 months were recruited from the Phoniatric Unit, Assiut University Hospital. They underwent; (1) Pre-therapy language assessment, (2) Language therapy for a period ranging from 6 months to 2 years in the Phoniatric Unit at Assuit University Hospital, some children received language therapy (outside our unit) in non-specialized centers (3) Post therapy language re-evaluation.

Results: better results were obtained from younger age of implantation, longer duration of post-implanted language therapy, good parents education, pre-implanted language therapy, longer duration of pre-implanted hearing aid wearing, children received language therapy in Phoniatric unit Assiut University Hospital and longer total hearing age.

Conclusion: early age of implantation, longer duration of post-implanted therapy, and well-qualified place of therapy are recommended factors to improve post-CI language outcome in pre-lingual hearing-impaired children.

Keywords: Cochlear implant, language profile

Introduction

The development of speech and language in children is severely impaired by early auditory deprivation due to hearing loss. [1] Hearing loss results in alteration in the neural architecture of the cortex and brain stem. [2, 3]

Defective sensory activity of brain leads to poorer neuroplasticity. [4, 5] Sensory stimulation delivered by cochlear implantation in hearing impaired children can reverse the effect of sensory deprivation. [4]

Early identification and confirmation of youngest and vulnerable populations with hearing losses through newborn hearing screening programs across the world has resulted in early intervention using hearing aids or cochlear implants followed by early speech-language

therapy and parental education programs. [6]

Although language development in children with CI keeps the same stages of language acquisition expected for children with normal hearing, it differs in the amount of receptive and expressive vocabulary compared to children with normal hearing in the same age group. [7, 8]

In comparison between CI and hearing aid, children with CI have better results in auditory perception, language development and reading, compared to children using hearing aids. However, there is individual variation in the degree of benefits of cochlear implants. [9]

In a study by Davidson et al.,[10] several factors affecting language outcome in CI children, better results obtained with shorter periods of auditory deprivation, younger ages at implantation and greater amounts of residual hearing.

Aim of the work

The aim of this work is to assess

(1) Language development in cochlear implanted children in Assiut University Hospital

(2) The impact of some related factors (gender, level of family education, pre-implanted hearing aid wearing& language therapy, age of implantation, duration & place of post-operative language therapy either in specialized center or in non-specialized center and total hearing age) on language outcomes in order to: evaluate, improve and refine our experience in cochlear implantation, to identify potential problems that influence the effectiveness and final outcomes of CI and to modify future planning, implementation and evaluation of rehabilitation program.

Patients and methods:

This quazi experimental study included a sample of 45 prelingual hearing impairment (HI) impaired children with unilateral CI 23 girls and 22 boys. The age of participants ranged from 20-108 months. They were recruited from the ENT Department Assiut University Hospital; they were implanted in the period from January 2016 to January 2019 and were presented to the Phoniatric Unit, Assiut University Hospital for language therapy. After programming of the device in Audiology Unit, Assiut University Hospital these children received auditory and language therapy (20 minutes each session twice weekly) for a period ranging from 6 months to 2 years.

Inclusion criteria:

Bilateral sever-to-profound or profound sensorineural hearing loss (SNHL) diagnosed by full protocol of assessment of hearing impaired children

Nonverbal IQ was at least 80

Three months of minimum trial period with hearing aid (HA) before CI with at least 24 session of language therapy.

Their post-operative audiological reports revealed that they had a satisfactory aided response using pure tone audiometry with their CI (below or equal to 30 d B HL).

Six months (minimum duration) of language therapy received after CI with regular attendance.

Exclusion criteria:

Children diagnosed with additional disabilities (such as ADHD, mental retardation and autism).

Method:

Cochlear implantation;

The participants were implanted in the period from January 2016 to January 2019 at ENT Department Assiut University Hospital by E.N.T. surgeon.

Most of devices were MEDEL (SONNET) The processing strategy was FS (FINE STRUCTURE), few number were COCHLEAR(Smart Sound IQ in the Nucleus 6 system). All received left CI after fulfilling the criteria of Egyptian insurance protocol which is sever to profound hearing loss, trial period of at least 3 months of hearing aid and language therapy.

Programming Stage:

This is performed after the fourth week following the completion of surgery to allow wound healing and also to ensure a stable thickness of the cutaneous cover which does not obstruct the communication between the transmitter and CI antenna.it was done in Audiology Unit, Assiut University Hospital by expert audiologist. The patient needs four times of programming session to reach 25-30 dB in free field (1 session every month) to complete the programming stage.

These children were subjected to the following protocol in Phoniatric Unit;

I.Elementary diagnostic procedure: these include;

-Personal data, developmental history, illness of early childhood, subjective impression of hearing, intelligence, motoric, and socially,

-Detailed history about parents' education, pre-implanted hearing aid (age of wearing, duration, regularity of wearing), pre-implanted language therapy (duration and regularity), age at implantation, post-operative language therapy (duration and regularity), place of post-operative language therapy (either in phoniatric unit or outside) and total hearing age (duration of hearing aid and CI).

-General ENT and neurological examination.

II- clinical diagnostic aids:

a)Psychometry: Psychometric evaluation by Stanford Beinet test (4th version) 11 was done by one trained psychometrist. Children with IQ less than 80 were excluded

b) Language test:

Standardized Arabic Language Test 12 was applied immediately after complete programming by an expert Phoniatrician to determine the following:

Receptive language:

(b) Expressive language.

(c) Semantic.

Rehabilitation program;

The rehabilitation was done in Phoniatric Unit Assiut University Hospital by expert speech therapists in a group session 1hour for each session for at least 6 months with regular attendance twice weekly (some children received therapy in non-specialized centers outside the phoniatric unit due to far distance from the hospital).

It consists of two stages auditory training and language therapy.

a- Auditory training: including Sound awareness, sound discrimination between different acoustic features of speech sounds, identification, recognition and auditory comprehension.

b- Language therapy program: this was adapted according to child level of language abilities.

Post-therapy reassessment of the language was done by Arabic Language test to determine the expressive& receptive language quotients and semantics at least 6th months after language therapy.

Assessment of the improvement in language acquisition was done by calculating receptive and expressive language quotients before and after language therapy. We did not calculate language age as most –if not all- children's language age were less than 2 years. In spite of their improvement in semantics, receptive and expressive language after therapy, they are still in

the area of approximately 2 years language age.

Determination of the following variable on language outcomes of CI children was done

- Gender.
- Degree of parents' education- Pre-operative hearing aid use
  - Pre operative therapy
  - Age of implantation
- Post operative therapy
- Place of language therapy
  - Total hearing age (hearing aid duration + CI duration)

Statistical analysis

Data were collected, tabulated and analyzed using SPSS, version 22 (SPSS Inc., Chicago, Illinois, USA). Numerical data were expressed as mean and SD. T-test and ANOVA test were used to compare between different groups of the same variable. P-value less than 0.05 were considered significant and that more than 0.05 was considered not significant.

Results

This study was conducted on 45 CI children 22 male (49%) 23 female (51%) with age ranged from 20-108 month &mean age 64 months.

(1) Demographic data (descriptive statistics): Table (1) showing descriptive statistics of the participants according to sex, parents education (mother & father), pre-operative hearing aid use, pre-operative therapy, age of CI operation, post-operative therapy, place of therapy, total hearing age (duration of hearing aid use plus duration of CI).

(2) Comparative analysis:

Table (2) showing Comparison of the results of the Arabic Language test of pre-operative & 6 months or more after active language therapy.

There were significant differences regarding the expressive language, receptive language and semantics between both groups.

Variables affecting language outcome in CI children:

Effect of sex on language outcome: Table (3) shows insignificant difference between the males and females group in all language parameters scores. However the females group obtained a high score in expressive and receptive language than male group. The semantics is nearly equal in both sexes

Effect of educational level of the parents on language outcome after CI

a) **Educational level of the mother**:

ANOVA test was done and revealed high scores in group 3 (University level) in expressive, Perceptive language than group 1&2 but these differences were insignificant (p value are 0.791-0.308-0.428) table (4).

b) **Educational level of the father:**

ANOVA test was done and revealed high scores in group 3 (University level in all language parameters than group 1&2 but these differences were insignificant (p value are 0.648, 0.702, 0.658); table (5).

Effect of pre-implanted hearing aid use on language outcome:

T- Test was done and revealed high scores in group 2 in all language parameters than group 1 however these differences were insignificant (p value are 0.39, 0.458,0.859); Table (6).

Effect of the duration of the pre-operative therapy on language outcome after CI:

ANOVA test was done and revealed high score in group 3 in all language parameters but these differences were insignificant (p value is 0.074, 0.206, and 0.310); Table (7).

Effect of age of implantation on language outcome;

T-test was applied and revealed significant differences between both groups at all language parameters (Expressive, Perceptive, Semantic) (p value are 0.049 -0.024-0.038); Table (8).

Effect of the duration of the post-operative therapy on language outcome: T- Test was done and revealed high scores in group 2 in all language parameters than group 1 and these differences were significant in Perceptive and Semantic (p value are 0.02, 0.038) but insignificant in Expressive language (p value was o.141); Table (9).

Effect of the place of post-operative language therapy on language outcome: There were significant difference between both group regarding all language parameters (p value is 0.022, 0.013, 0.01); Table (10).

Effect of total hearing age on language outcome; T-test was applied and revealed significant differences between both groups in all language parameters (p value are 0.028 -0.023-0.011); Table (11).

Table (1) Demographic data (descriptive statistics)

	No.	%
Sex		
• Male	22	48.9%
• Female	23	51.1%
Mother education		
• Illiterate	13	28.9
• Pre-U	29	64.4
• Univ.	3	6.7
Father education		
• Illiterate	15	33.3
• Pre-U	22	48.9
• Univ.	8	17.8
Pre-operative Hearing aid		
• < 1year	23	51
• >1year	22	49
Pre_op_therapy		
• No	13	28.9
• ≤ 6 months	20	44.4
• > 6 months	12	26.7
Age of CI		
• ≤ 3.5 year	17	37.8
• > 3.5 year	28	62.2
Post-op therapy		
• ≤ 12 months	18	40
• > 12 months	27	60
Place of therapy		
• Ph. Unit	31	68.9
• Outside	14	31.1
Total Hearing age		
• < 50 months	28	64
• >50 months	17	36

Table (2): language evaluation (Pre-therapy and 6 mo. after therapy)

	Pre-language therapy Mean.	SD		6 months after language therapy Mean.	SD		P value
Expressive language	3.50%	±	0.71%	35.49%	±	21.55%	0.048*
Perceptive language	6.00%	±	1.41%	47.07%	±	25.19%	0.027*
Semantic	3.00%	±	7.07%	53.96%	±	26.30%	0.019*

t-test, significant level at $p < 0.05$

Table (3): Effect of sex on language outcome

Sex	Male (n = 22) Mean.	SD		Female (N = 23) Mean.	SD		P value
Expressive language	33.50%	±	20.60%	37.39%	±	23.55%	0.559
Perceptive language	42.68%	±	27.25%	51.26%	±	22.85%	0.258
Semantics	54.05%	±	23.58%	53.87%	±	29.19%	0.982

Table (4): Effect of educational level of the mothers on language outcome

Mother	Group 1 Illiterate (N = 13) Mean SD	Group 2 Pre-U (N = 29) Mean SD	Group 3 Univ. (N = 3) Mean SD	P value
Expressive language	34.46% ± 16.53%	35.07% ± 21.86%	44.00% ± 46.81%	0.791
Perceptive language	38.69% ± 25.31%	49.59% ± 24.09%	59.00% ± 35.04%	0.308
Semantics	45.85% ± 22.20%	57.34% ± 25.93%	56.33% ± 47.35%	0.428

PRE-U (pre-university education), univ. (university education)

Table (5): Effect of educational level of father on language outcome

Father	Group 1 Illiterate (N = 15) Mean SD	Group 2 Pre-U (N = 22) Mean SD	Group 3 Univ. (N = 8) Mean SD	P value
Expressive language	31.87% ± 17.10%	36.00% ± 25.29%	40.88% ± 21.76%	0.648
Perceptive language	42.80% ± 25.95%	48.36% ± 26.19%	51.50% ± 22.73%	0.702
Semantics	49.47% ± 22.66%	54.86% ± 27.93%	59.88% ± 29.88%	0.658

Table (6): Effect of the hearing aid use on language outcome

Duration of HA use before CI	≤ 1 year (N=23) Mean. SD	> 1 year (N=22) Mean. SD	P value
Expressive language	32.70% ± 14.87%	38.41% ± 27.64%	0.390
Perceptive language	44.30% ± 24.54%	49.95% ± 26.11%	0.458
Semantic	53.26% ± 23.23%	54.68% ± 29.70%	0.859

Table (7): Effect of the duration of the pre-operative therapy on language outcome after CI

Pre-op therapy	No (N = 13) Mean SD	≤6 months (N = 20) Mean SD	>6mo (N = 12) Mean SD	P value
Expressive language	29.38% ± 17.47%	32.15% ± 19.60%	47.67% ± 26.68%	0.074
Perceptive language	42.46% ± 16.56%	43.40% ± 27.47%	58.17% ± 27.41%	0.206
Semantics	52.31% ± 20.21%	49.15% ± 27.37%	63.75% ± 29.60%	0.310

Table (8): Effect of age of implantation on language outcome

Age of CI	≤ 3.5 (N = 17) Mean. SD	> 3.5 (N = 28) Mean. SD	P value
Expressive language	38.82% ± 15.26%	33.46% ± 15.98%	0.049*
Perceptive language	52.53% ± 13.06%	42.18% ± 16.68%	0.024*
Semantics	57.82% ± 16.90%	51.61% ± 18.13%	0.038*

Table (9): Effect of the duration of the post-operative therapy on language outcome

Post-op therapy	≤ 12 months (N = 18) Mean. SD	> 12 months (N = 27) Mean. SD	P value
Expressive language	29.56% ± 19.45%	39.44% ± 23.03%	0.141
Perceptive language	36.56% ± 20.63%	54.07% ± 25.84%	0.020*
Semantics	44.06% ± 21.23%	60.56% ± 27.61%	0.038*

Table (10): Effect of the place of therapy on language outcome

Place	Outside (N = 14) Mean.	SD	Ph.unit (N = 31) Mean.	SD	P value
Expressive language	27.93% ±	10.8%	38.90% ±	11.78%	0.022*
perceptive language	40.86% ±	15.95%	49.87% ±	13.75%	0.013*
Semantics	40.00% ±	13.54%	63.55% ±	12.04%	0.010*

Table (11): Effect of total hearing age on language outcome

Total hearing age	≤ 50m (N = 28) Mean.	SD	> 50m (N = 17) Mean.	SD	P value
Expressive language	30.03% ±	8.73%	41.31% ±	9.15%	0.028*
perceptive language	42.72% ±	11.27%	51.18% ±	12.68%	0.023*
Semantics	45.00% ±	10.24%	63.69% ±	16.16%	0.010*

Discussion :

In our study there were significant differences between pre-therapy& 6 months post-therapy regarding all language parameters. This can explained by that CI enable children to benefit from dead area in the cochlea and to tolerate to loud sound, such benefits not present in hearing aids.[13,14] These results were in consistent with other studies. [15, 16] They claimed that auditory skills and language outcome improved significantly in CI children

In this study there was a high score in female than male for receptive and expressive language measures but with insignificant differences (P value 0.559 and. 0258). The semantics is nearly equal in both sexes. These results can be explained by the superiority of females in language acquisition as a result of earlier maturation of the left cerebral hemisphere.[17] This result is in agreement with [18,19] however they stated that this gap in language ability between boys and girls in early life closes with increasing age.

The present study found high scores in all language parameters in the group of high educated parents than other 2 groups of pre- university and illiterate ones but these differences were insignificant. This finding may be explained by the excessive involvement of the highly educated parents with their children in language rehabilitation. For instance, parent's reading for their children is a very good source of vocabulary development. Also as there is relation between educational level of parents and socioeconomic status (SES) in the form that high educated parents have high SES. These families provide more vocabulary, more complex language structures which gives the children better opportunities to pick up language. [20, 21] A similar role is played by SES in the case of CI children.[22, 19]

Many authors agree with our results, [23, 19] mentioned that there is significant effect of time parents spent reading to their children in their vocabulary and language scores .

On the other hand, **Geers** stated that the higher level of parents' education did not significantly result in better language outcomes after implantation.[24]

Our study revealed, insignificant difference between children with pre-operative hearing aid use for one year or less and those children used hearing aid for more than one year in language acquisition post-operative. This

insignificant differences may be due to small number of participants in our study however the insignificant higher score in the group received hearing aids for more than one year can be explained by the fact that early identification of hearing loss and early exposure to acoustic signals has been identified as a factor that contributes to better language and speech outcomes.

Artières et al., [25] agree with this result as they showed that there was association between earlier age of hearing aids fitting and better language outcome when compared to children who were fitted later, however this association was significant. Other studies conducted by **Nicholas & Geers** [26], **Holt & Svirsky** [27]; showed that children who identified within the first six months and who fitted with hearing aids early had better overall speech intelligibility at later ages.

Jang et al. [28] found that there was a negative relation between duration of hearing aid use and post CI language outcome. This may explained by that, in their study, the preoperative hearing losses more than 90 dB. So in this condition CI could be better than the prolonged use of hearing aid.

In our study there is a difference although insignificant between the pre-operative therapy and post-operative language outcome and this can be explained by the fact that early speech and auditory skill development achieved by early preoperative training, may have a later positive impact on the child's ability to maximize the use of the auditory information provided by the cochlear implant to improve speech intelligibility. [29]

Our results are in agreement with a study conducted by Bruijnzeel et al., [30] who found a positive correlation between the preoperative language therapy and the post implantation auditory abilities of the studied children. However, the duration of preoperative language therapy did not reach statistically significant levels. The authors explained their results to the fact that the pre implantation language therapy is a good predictor of post implant auditory speech processing abilities.

Regarding the age of implantation our study revealed high score in group 1 (implanted before or at 3.5 years) in all language parameters than group 2 (implanted after 3.5 years) and these differences were significant. This can be explained by the fact that children with early implants are exposed to the sensitive period for language auditory development. The development of a particular brain function is very sensitive to external stimuli during this period. This sensitive period is very important in spoken language development and it will be maximum till the end of the first 3.5 years. After age of 7 years it decrease dramatically and by age of 12 year it may be completely closed. The development of neural circuit for this particular function will be prevented by the external input deprivation during the sensitive period. The restoration of environmental input after the end of this sensitive period will not adjust the affected brain circuit. [31]

This result is in agreement with **Niparko et al**., [22] and **Geers & Nicholas** [32] who stated that an important predictor of language acquisition is the age at implantation. These findings are strong and meet general agreement in the most of literature on the receptive and expressive language of the CI children.

Also in study conducted by **Liu et al.** [33], he found that younger age of implantation was correlated with better outcomes as it helps patients to restore hearing and enable children to receive early speech therapy.

On the other hand, **Abdel Hamid et al**. [34] and **Abou- Elsaad et al**. [35] found that the age of implantation had a non-significant effect on auditory abilities and language outcomes.

Regarding to the duration of post-operative therapy, this study revealed high scores in group 2 in all language parameters than group 1 and these differences were significant for Perceptive& Semantic but insignificant for Expressive language. This may be attributed to the fact that longer hearing experience resulted in more advanced language comprehension. However, according to 32, this effect ended by the age of 10.5 years.

Our result is consistent with a study conducted by **Abou- Elsaad et al**. [35] who stated that a significant correlation was found between postoperative language therapy duration and post implant auditory abilities, post implant language age, and degree of language improvement. Also our study is in agreement with the findings of **Hwang et al.,** [36] who reported that speech intelligibility of children with CI increased with the increased duration of device use. On the other hand, **Geers** [24] found that the degree of auditory and spoken language outcome did not associate with the amount of post-operative therapy .

In this study there were significant high scores of language outcome in children who received language therapy in the Phoniatric Unit, Assiut University Hospital and this may be attributed to many factors: the experience of the therapist, well-structured rehabilitation program in our Unit, the well prepared and organized classes of therapy, the more regularity in attendance of therapeutic sessions and the more important and more effective attributing factor is the medical supervision of phoniatrician over the logopedics. This supervision produce a team who are more qualified than teachers, special educational specialists and people who have only attended brief courses or workshops in speech therapy and practice speech therapy services with no legal consequences in our community. However **Geers** found that experience of the therapist was not associated with auditory and spoken language outcome.[24]

Regarding the total hearing age, there were significant differences in all language parameters between children with total hearing age of fifty months or less (group 1) and children with longer total hearing age (more than fifty months) (group 2). This may be attributed to the longer duration of hearing experience (resulted from pre-operative hearing aid use and post-operative CI use). This leads to more advanced language comprehension. Our result is consistent with Nicholas & **Geers** [37] who claimed better language outcomes are related to pre-implant hearing aids use, longer duration of implant use and younger age at implantation.

Conclusion:

Cochlear implants enable different degree of improvement for deaf children in the areas of speech and language perception and production. This improvement depends upon many variables. The most important variables that have a significant effect on language development are; the age of implantation, post-implanted therapy duration, place of therapy and total hearing age.

Conflict of interest: There is no conflict of interest

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