

Development of communication and speech skills after cochlear implant in a sign language child

Sviluppo comunicativo-linguistico dopo impianto cocleare in un bambino segnante

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Key words

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Parole chiave

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Summary

In selecting patients to undergo cochlear implant, a pre-existing use of sign language gives rise to two problems that have been widely debated in the literature. First, the caution shown toward the candidacy of patients using this mode of communication, since it is considered a possible element of interference in the acquisition of speech. Secondly, refusal of the cochlear implant procedure, on the part of the deaf community, on the grounds both of cultural identity and of it being more "natural" for a deaf person to use an unimpaired visual channel rather than an impaired hearing channel. In order to establish whether knowledge of sign language does, indeed, affect speech production negatively and evaluate which mode of communication, oral or gestural, is preferred, the present investigation was carried out on a preverbal deaf child who had undergone cochlear implant at about 7 years of age and has always used both languages. His verbal skills were evaluated in the pre-cochlear implant stage, then at 6 and 12 months after, together with the changes in his use of sign language and in the relationship between the two modes. Results, besides observing the presence of linguistic evolution at each level examined and already evident at 6 months, also documented a progressive reduction in the spontaneous use of sign language. In conclusion, the present experience revealed no temporal or qualitative differences in post-cochlear implant evolution of speech skills, in comparison with that observed in patients with an exclusively aural-oral approach. Furthermore, the increased use of the hearing pathway, made possible by cochlear implant, determined a spontaneous choice of verbal language as the most natural and economic mode of communication.

Riassunto

Nella selezione dei pazienti da sottoporre ad impianto cocleare, un preesistente uso del linguaggio dei segni pone due problematiche ampiamente dibattute in letteratura. In primo luogo l'atteggiamento di cautela nella candidatura dei soggetti fruitori di tale codice che viene considerato come possibile elemento d'interferenza per la strutturazione del linguaggio verbale. In secondo, il rifiuto della procedura di impianto cocleare da parte della comunità dei sordi con motivazioni, sia d'identità culturale, che di maggiore "naturalità" per un soggetto sordo nella fruizione del canale visivo integro rispetto a quello uditivo compromesso. Allo scopo di evidenziare se effettivamente la conoscenza del linguaggio dei segni incida negativamente sulle performances verbali e di valutare quale sia la modalità comunicativa, orale o gestuale, usata in modo preferenziale, è stato selezionato un soggetto, sordo preverbale, impiantato all'età di circa 7 anni, che ha da sempre fatto uso di entrambi i linguaggi. Sono state valutate le competenze verbali in fase pre-impianto cocleare, a 6 ed a 12 mesi dall'intervento, ed i cambiamenti nell'uso del linguaggio dei segni e nel rapporto tra i due codici. I risultati ottenuti hanno consentito di evidenziare, oltre alla presenza di un'evoluzione linguistica per tutti i livelli presi in considerazione, evidente già a 6 mesi, anche una progressiva riduzione dell'uso spontaneo del linguaggio dei segni. In conclusione, è possibile affermare come, nella nostra esperienza, non si sia osservata alcuna differenza temporale o qualitativa nell'evoluzione delle competenze verbali post-impianto cocleare rispetto a quella evidenziabile in pazienti con impostazione esclusivamente verbo-acustica. In secondo luogo il maggiore uso della via uditiva, consentita dall'impianto cocleare, ha di fatto determinato una spontanea scelta del linguaggio verbale quale modalità comunicativa più naturale ed economica.

Introduction

The type of communication, approach and re-educational setting considered most appropriate to promote the acquisition of a useful system of communication and, in parallel, of good speech skills, have always been the object of passionate debate in the field of management of deafness. Today, the problem is also reflected in the sector of cochlear implants (CIs) ¹⁻⁷, where the feasibility of sign language patients truly benefiting from the use of a CI is very much under discussion. While there is, by now, almost universal agreement that post-implant rehabilitation in, pre-verbally, deaf patients of paediatric age should be oriented towards stimulation of the aural-oral skills and that this may be achieved through an aural/oral approach ^{6 8} or by means of total communication ^{9 10}, the positions regarding the influence that the pre-CI communicative and linguistic setting can have on subsequent speech production are controversial and, indeed, contradictory. In particular, as sign language is a “natural language,” endowed with a codified structure ^{3 4 7} of its own which is, in many ways, different from verbal language, it could give rise to deleterious interference in the harmonious communicative development of the patient ^{5 11}.

An educational setting, based exclusively on sign language, necessarily implies “exclusion” from the world of sound, for which, if this setting is not modified and the decision to do so is not shared by all those revolving around the child, there is no indication for CI ^{6 8}. A bilingual, bicultural approach, instead, would not appear incompatible with CI, if the child’s relatives are genuinely motivated in supporting his/her intensive auditory/speech stimulation. In examining the different levels of speech production in patients rehabilitated through an exclusively oral method and others with a previous knowledge of sign language, the differences observed in the course of the first post-implant year tend to progressively decrease, disappearing after 3 years ² if CI is suitably programmed (first 3-4 years of life). Vieu et al. ⁷, on the other hand, have reported significant differences even at 3 years after the procedure, but upon observing the mean age of the patients studied (7.11 years), it emerges once again that the determinant factor, more than the educational setting prior to CI, is the age at which the operation is performed.

The aim of the present investigation is to demonstrate how, even in an environment characterized by strong cultural resistance (all of the child’s maternal relatives are deaf and members of the National Association of Deaf-Mutes, whose guiding philosophy they have embraced) and in which the child is simultaneously exposed to two opposite communication models, a choice for CI may be made, bringing the deaf child closer to the world of the otologically unimpaired, as well as to

show how the use of the hearing pathway offered by CI, can influence the two communication modes, leading to more or less evident modifications in the modes themselves and in their interrelationship.

Patients and methods

The case examined is that of a child affected by Waardenburg’s syndrome, with severe deafness, diagnosed at 13 months of age. The child benefited so little from his hearing aid (amplified tone threshold 63 dB HL, no speech recognition, minimal verbal competence) that, at 7 years of age, he underwent CI. The child was fitted with a prosthesis at approximately 14 months of age, but although he underwent an oralist re-education programme, he has always made use of a dual communication mode due to his particular family background: oral with his father, during his speech therapy sessions and at school; and by means of Italian Sign Language (ISL) with his mother and the other deaf members of her family. The little patient was studied from the time of referral for CI, at 6 months and at 12 months after the operation.

Three aspects were monitored, during the entire observation period:

Speech perception skills, by means of the following tests:

- *First perception categories* (P.Ca.P.) ¹²;
- *Infant word identification test* (T.I.P.I.1 and T.I.P.I.2) ¹².

Speech production, with regard to the following levels:

- *Phonetic/phonologic level*, by means of:
 - the *Phonologic evaluation of infant language tests* (PFLI) ¹³;
- *Lexical-semantic level*, by means of:
 - the *Peabody test* ¹⁴, for the passive verbal lexis;
- *Analysis of spontaneous production and MacArthur questionnaire* ¹⁵ for the active verbal lexis;
- *Morphosyntactic level*, by means of:
 - *Grammar comprehension test for children* (TCGB) ¹⁶, for all the syntactical aspects in comprehension;

Non-verbal communication ¹¹, for the evaluation of which no formal instrument of evaluation has been produced, as yet. To establish its nature and the competence of the patient in using it, 1-hour video-recordings, filmed in the pre-implant stage and at 12 months after the procedure, are, therefore, analysed.

Results

Perception skills

In the pre-implant stage, the patient scored 7 points on the first P.Ca.P. sub-test (Pattern Perception), thus

Table I. Percentage of correct replies on verbal perception test in different periods.

	T.I.P.I.1	T.I.P.I.2	OPEN SET
Pre-CI	24%	–	–
6 months	64%	52%	24%
12 months	80%	84%	52%

CI: cochlear implant; T.I.P.I.: Infant Word Identification Test.

classified as Perception Category I (no perception of speech structure) as defined by Moog and Geers. The T.I.P.I.1 score of 24% was possibly associated with the degree of randomness in the answers. No significant replies were obtained with the T.I.P.I.2. At 6 and 12 months after implantation, the patient achieved scores, on the P.Ca.P., that classified him, respectively, in Perception Category III (both as far as concerns the identification of high spectrum differentiation words in closed set items and the identification of low spectrum differentiation words). Correct answers were 64% and 80% on the T.I.P.I.1, and, 52% and 84%, respectively, on the T.I.P.I.2. Finally, while it had not been possible to obtain even one correct answer in the open set, prior to implantation, reliable replies, in the open set recognition of two-syllable words, were given both at 6 and 12 months after CI, thus further confirming the progress made by the patient, who, respectively, recognized 24% and 42% of the correct answers (Table I).

PHONETIC-PHONOLOGICAL ASPECTS

Prior to implantation, the sample of speech obtained during the PFLI was not very wide (100 words), as the patient's production was considerably limited. The consonant inventory was limited to the stable presence of the /p/, /t/, /f/, /v/, and /m/ phonemes and the occasional presence of the /b/ and /d/ phonemes. A sample of 250 words was obtained both at 6 and at 12 months. At 6 months, the phonemes /b/, /k/, /v/, /S/ and /tS/ appeared stable, while /d/ and /s/ were still uncertain. Phoneme omissions, in general, decreased,

while substitutions increased, now presenting as systematic and coming progressively closer, phonetically and, in terms of articulation, to the target phoneme, with only limited deviations. At 12 months, the /s/ and /d/ phonemes had stabilised, and the child's phonetic patrimony had increased with the addition of stable /z/ and /l/, and unstable /r/, /N/ and /L/; while /ts/, /dz/ and /dZ/ were still absent (Table II).

LEXICAL-SEMANTIC LEVEL

Before implantation, the patient's score on the Peabody test was 28, characteristic of normal values in hearing children at 2 years and 11 months of age. Due to the extremely low score, it was impossible to quantify the child's verbal I.Q. Despite these results, in interactive communication contexts, the patient demonstrated the ability to decodify the lexical element in a given context, thus overcoming many of the impediments specifically connected with his very limited vocabulary.

Despite the evolution, the child's competence, both at 6 and 12 months after the procedure, still remained relatively insufficient, if one considers his intellectual capacity and the improvements recorded at other levels: at 6 months, he scored a lexical age of 3 years and 11 months and his lexical I.Q. was 56; at 12 months, there was practically no modification, as his performance was that of a lexical age of 3 years and 10 months and an I.Q. of 58.

With regard to speech production, completion of the MacArthur Questionnaire, prior to implantation, revealed a vocabulary comprising 210 lexical items, corresponding to that of a otologically unimpaired child of 22-23 months of age. The qualitative analysis showed a prevalent composition of nouns (62.8%) and adjectives/modifiers (16.7%), while verbs were altogether absent (0%) and the functors were extremely low (1%).

Re-evaluation of the patient's lexis, at 6 and 12 months, revealed an increase, bringing his vocabulary to 314 and 590 terms, a mean value comparable to that of a normal hearing child >30 months of age. The qualitative analysis showed a significant reorganisation of the lexis, with the appearance of verbs,

Table II. Phonetic inventory.

	Phonemes present	Phonemes occasionally present	Phonemes absent
Pre-CI	p, t, f, m	b, d, v, n	k, g, s, z, S, ts, dz, tS, dZ, N, l, L, r, w, j
6 months	p, b, t, k, f, v, m, n, S, tS, j	d, s, w	g, z, ts, dz, dZ, N, l, L, r
12 months	p, b, t, d, k, g, f, v, m, n, l, s, z, S, tS, j, w	r, N, L	ts, dz, dZ

Table III. Percentual use of different elements of speech.

	Sounds	Names	People	Routines	Verbs	Adjectives	Funcctors	Adverbs
Pre-CI	2.4	62.8	7.6	3.3	0	16.7	1	6.2
6 months	1.8	57.2	6	3.2	6.8	2	22	1
12 months	1.3	25.4	4.7	1.4	16.6	10.5	34	6.1

the frequency of which rose to 16.6%, with an increase in the funcctors, from 1% to 34% (Table III).

MORPHOSYNTACTICAL LEVEL

During the preoperative workup, the patient's overall error score, on the T.C.G.B., was 57, placing him well below the 10th centile: this level would correspond to the lower limit, i.e., that of a child of 3.5 years.

At 6 and 12 months, the overall error score on the T.C.G.B. improved, dropping to 23.5 and 14.5, corresponding, respectively, to the 50th centile for a child of 4 years and 3 months and 5 years of age.

With regard to production, a sufficiently wide sample of speech production was not obtained, due to the poor collaboration of the child. It was, however, possible to effect an initial analysis of the material obtained, from which the production of utterances consisting of 2-3 items emerged, some still of a telegraphic nature (2-3 nouns, with no verb), others with a basic subject-verb-object (S.V.O.) simple or "nuclear" structure, often, however, incomplete (tendency to omit the first item). The verb is prevalently used in the singular forms of the present indicative or in the form of the past participle.

Already at 6 months, a considerable improvement had been made in terms of expression, confirming the effective acquisition of many of the structures previously absent and now mastered in a sufficiently stable manner. This evolution was also evident in a greater speech production, which was almost entirely absent before CI. The average length of utterance ranged from 2.7 (pre-CI stage) to 6.2 (6 months) to 7.6 (12 months). The complexity and variety of the structures also increased (Fig. 1).

While the earlier production was comprised prevalently of active phrases of a very basic type (simple or "nuclear"), constituted by 1-2 items without all of the items being expressed, 2-3 item active phrases later appeared, amplified both by adverbs and by adjectival modifiers, together with the first implicit and relative complex sentences and co-ordinate (correlative) and subordinate compound constructions (the majority, incidental). The first free grammatical morphemes were used spontaneously:

- articles, in a closed set context were almost always produced: the percentage of omission, previously 60%, dropped to 3.6% at 6 months and 1.7% at 12 months;
- prepositions ("of", "to", "with", "on") were hardly ever omitted (12.5% at 6 months, 0% at 12 months); substitutions with articles or other prepositions were, however, present (31.2% at 6 months, 15% at 12 months).

Personal pronouns (subject, reflexive and clitic) continued to be omitted (Table IV).

NON-VERBAL LANGUAGE

To study the relationship between verbal language and sign language, in terms of the expressive/communicative mode preferred, three situations of spontaneous play were observed: with a normal hearing cousin of the same age (A), with a deaf cousin of the same age (B), and with both (C). Analysis of the patient's production was effected by calculating the percentage of exclusively spoken utterances, utterances produced exclusively by signing, those produced using both systems simultaneously, and, finally, those produced by means of a complementary use of both modes. The results obtained reveal a signifi-

Table IV. Frequency of errors of omission and substitution involving grammatical funcctors (%).

	Articles	OMISSION Prepositions	Clitics	Relative pronouns	SUBSTITUTION Prepositions	Articles
Pre-CI	60	100	100	100	0	37
6 months	3.6	12.5	100	100	31.2	4.8
12 months	1.7	0	100	100	15	2.3

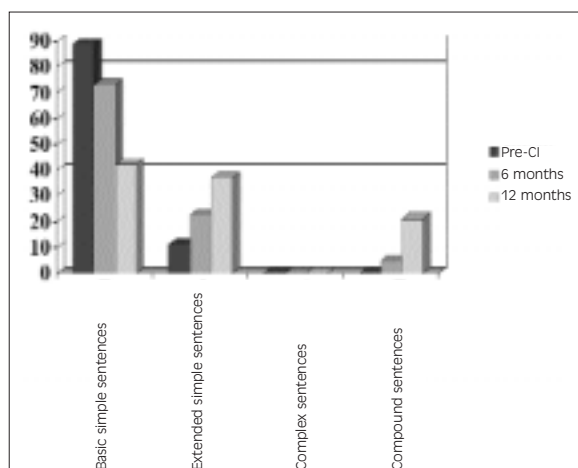


Fig. 1. Overall percentages of spontaneous production of different kinds of sentences.

cant reorganisation in the little patient's communication (Table V).

Prior to CI, the instances of verbal utterances were by far inferior to the situations in which communication was effected through sign language or even using a mode in which the two languages were fused to make up for the paucity of verbal language (complementary production of utterances), independently of the person to whom he was talking, but at 12 months post-CI, the situation had changed significantly. With his otologically normal cousin, the child used, almost exclusively, verbal language (95.6% of utterances), both in response to requests made by the other and in taking the initiative in communication, even when his cousin tried using sign language together with verbal language. With his deaf cousin, he continued to use prevalently verbal language (77% of his utterances), but also used sign language as well as the two systems simultaneously (23% overall) when he realised he had not been understood. In the situation in

which all three children were together, there was, once again, a high percentage of spoken utterances (76.2%). In this context, compared to the other two situations, the percentage of utterances produced in both modes increased significantly: the patient now adapted his communication to the needs of his partners in the conversation.

It is worthwhile stressing that, in comparison to the pre-CI scenario, the complementary use of the two languages was entirely absent, in all three contexts. For the child, now being able to rely on a less impaired verbal instrument, capable in itself of guaranteeing communicative interaction, the two systems had become independent of each other and were seen as different instruments, to be used in different contexts, with different interlocutors.

Conclusions

All evaluations, from the pre-CI workup to the situation at 6 and 12 months after surgery, confirm a global communicative and linguistic evolution in the patient. At phonetic-phonological level, he developed a more complete phonetic inventory (from which, 12 months after CI, only the phonemes /dZ/, /dz/ and /ts/ were lacking), together with greater control in articulation and better application of the phonological rules, with consequent improvement in intelligibility. At morphosyntactical level, the results obtained on the T.C.G.B. show a transition from the 10th centile, corresponding to a normal hearing child of 3 years and 6 months of age, to the 50th centile, that of a child of 5 years. In terms of production, there was a considerable increase in the average length of the utterance (from 2.7 to about 7.6) and in sentence structure, with initial experimentation in the use of complex and compound (co-ordinate and subordinate) sentences. This occurred in parallel with the development of morphological skills, with permanent difficulty confined exclusively to the use of the plural forms and changes in tenses of verbs and in the use of clitics and relative pronouns, subordinate conjunctions, and temporal and

Table V. Frequency of different types of utterances (U.) Produced in different contexts at pre-CI stage and 12 months after procedure (%).

	U. produced verbally		U. produced using I.S.L.		U. produced using both modes (simultaneous use)		U. produced using both modes (complementary use)	
	Pre-CI	12 months	Pre-CI	12 months	Pre-CI	12 months	Pre-CI	12 months
A	38.1	95.6	25.8	4.4	13.4	0	22.7	0
B	11.2	77	39.3	17.3	10	5.7	29.5	0
C	12	76.2	45.2	4.7	13	19.1	29.8	0

interrogative adverbs. At lexical-semantic level, evolution was slower, but, nonetheless, present.

With regard to the knowledge of two different communication modes, no negative interference was observed: on the contrary, the ISL-based mode, used by the patient to compensate his severely impaired oral language, seems to be progressively replaced by the latter as his communication channel of choice in situations of normal interaction. This preference is also reflected in his continuously seeking otologically normal playmates and in his strong motivation to improve, in order to come closer and closer to their target model. It would even appear that the two modes

have mutually enriched each other and that they are currently seen as two different instruments of interaction, the correct use of which depends on the people he is talking to and the communicative context. In conclusion, CI is associated with a rapid evolution of the communicative-linguistic skills, as widely reported in the literature. The findings appear to support those who consider that, in a favourable educational context, the knowledge of sign language does not affect the evolution of speech production negatively, if the post-CI re-educational programme is adapted to the needs of the child and his/her communicative requirements.

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