Implante coclear: audição e linguagem em crianças deficientes auditivas pré-linguais****

Cochlear implant: hearing and language in pre-lingual deaf children

Adriane Lima Mortari Moret *
Maria Cecilia Bevilacqua**
Orozimbo Alves Costa***

* Fonoaudióloga. Doutora em Ciências: Distúrbios da Comunicação Humana. Docente do Departamento de Fonoaudiologia da Faculdade de Odontologia de Bauru da Universidade de São Paulo, Campus Bauru. Endereço para correspondência: Alameda Doutor Octávio Pinheiro Brisolla, 9-75 - Bauru - SP - CEP 17012 -901 - Caixa Postal 73 (dri.m@fob.usp.br).

**Fonoaudióloga. Professora Titular do Departamento de Fonoaudiologia da Faculdade de Odontologia de Bauru da Universidade de São Paulo - Campus Bauru.

***Médico Otologista. Professor Livre-Docente do Departamento de Fonoaudiologia da Faculdade de Odontologia de Bauru da Universidade de São Paulo.

****Pesquisa Realizada no Centro de Pesquisas Audiológicas do Hospital de Reabilitação de Anomalias Craniofaciais da Universidade de São Paulo - Campus Bauru.

Artigo de Pesquisa

Artigo Submetido a Avaliação por Pares

Conflito de Interesse: não

Recebido em 24.08.2006.
Revisado em 06.11.2006; 05.04.2007; 10.07.2007.
Aceito para Publicação em 18.07.2007.

Abstract
Background: cochlear implant in children, speech perception and oral language, hearing and oral language performance in children with pre-lingual profound sensory-neural hearing impairment, users of cochlear implant. Aim: to study the hearing and oral language performance of children with pre-lingual bilateral profound sensory neural hearing impairment, users of multi-channel cochlear implant considering the following aspects: age of the child when the research was carried out, time of hearing sensorial privation, time of cochlear implant use, type of cochlear implant, type of speech coding strategy used, familial permeability level in relation to the therapeutic process and cognitive style of the child. Method: participants of this study were 60 children who were assessed according to hearing and language categories. All of the variables were statistically analyzed. Psycho-social aspects, considering the child's cognitive style and the family's permeability level were also assessed. Results: regarding the hearing and language performance with the use of cochlear implant, the intermediate and advanced hearing categories were accomplished by more than half of the children. The statistically significant aspects in the performance of hearing and oral language were: the age of the child upon evaluation, time of hearing sensorial privation, time of cochlear implant use, type of implant, speech sounds coding strategy and familial permeability. Conclusion: the cochlear implant as a treatment for children with pre-lingual sensory-neural hearing impairment is highly effective, although complex, owing to the interaction of variables which interfere in the implanted child's performance. Further studies are needed for the understanding of the implantation complexity in young children.
Key Words: Cochlear Implants; Speech Perception; Language.

Resumo
Tema: implante coclear em crianças, percepção de fala e linguagem oral, desempenho de audição e de linguagem oral em crianças com deficiência auditiva neurossensorial profunda pré-lingual usuárias de implante coclear. Objetivo: estudar o desempenho de audição e de linguagem oral de crianças portadoras de deficiência auditiva neurossensorial profunda bilateral pré-lingual, usuárias de implante coclear multicanal, quanto aos seguintes aspectos: idade da criança na época da realização da pesquisa, tempo de privação sensorial auditiva, tempo de uso do implante coclear, tipo de implante coclear, estratégia de codificação de fala utilizada, grau de permeabilidade da família no processo terapêutico e estilo cognitivo da criança. Método: as 60 crianças estudadas foram avaliadas quanto às categorias de audição e de linguagem. Todas as variáveis foram analisadas estatisticamente. Os aspectos psicossociais, considerando o estilo cognitivo da criança e o grau de permeabilidade da família também foram variáveis investigadas. Resultados: quanto ao desempenho de audição e de linguagem com o uso do implante coclear, as categorias auditivas intermediárias e avançadas foram alcançadas por mais da metade do grupo de crianças. Os aspectos estatisticamente significantes no desempenho de audição e de linguagem oral foram: a idade da criança na avaliação, o tempo de privação sensorial auditiva, o tempo de uso do implante coclear, o tipo de implante, a estratégia de codificação dos sons da fala e a permeabilidade da família. Conclusão: o implante coclear como tratamento de crianças com deficiência auditiva neurossensorial pré-lingual é altamente efetivo, embora complexo pela interação de variáveis que interferem no desempenho da criança implantada, desafiando novos estudos na compreensão da complexidade da implantação em crianças pequenas.
Palavras-Chave: Implante Coclear; Percepção da Fala; Linguagem.

Referenciar este material como:
MORET, A. L. M.; BEVILACQUA, M. C.; COSTA, O. A. Cochlear implant: hearing and language in pre-lingual deaf children (original title: Implante coclear: audição e linguagem em crianças deficientes auditivas pré-linguais). *Pró-Fono Revista de Atualização Científica*, Barueri (SP), v. 19, n. 3, p. 295-304, jul.-set. 2007.

Introduction

The cochlear implant is the most important progress in the treatment of prelingually deaf children, especially if it is done during their early years (Miyamoto et al. 2003, Willstedt-Svensson et al. 2004, Harrison et al. 2005, Tomblin et al. 2005). The high technology of the cochlear implants have increased the complexity of the children deafness treatment (Li et al. 2004), requiring new behaviors and decision-makings from both parents and professionals, although there is no doubt of the benefits provided by the implant for it enables the hearing-impaired child to acquire incidental oral language.

Longitudinal studies of pre-lingual children groups who are already users highlight that, besides not presenting serious implications, the implantation on children progressively improves their quality of life. However, there are still several questions about the outcomes of this device regarding children, and its indication is a complex and multi dimensional process (O'Neill et al. 2002, Bevilacqua et al. 2003).

Studies about the communication style of the child, type of implant used, educational profile, social aspects, parents' expectation, cognitive development, among others (Richter et al. 2002, O'Neil et al. 2002, Holt e Kirk 2005) have been reported. Studies also focus on attendance protocols (Houston et al. 2003, Nikolopoulos et al. 2005), whose objective is to help professionals to choose the best intervention strategies (Nikolopoulos et al. 2005).

In the 90's, several studies presented the good results of the speech sounds auditory perception and the oral language acquisition for implanted children. In Brazil, Bevilacqua's precursor study (1998) reported the results of 38 prelingually deaf children implanted, highlighting that all the children achieved an improvement regarding the hearing and oral language performance due to the cochlear implant. Recently, studies about the contribution of the cochlear implant for the oral proficiency of prelingually deaf children in more than one language have been conducted (Waltzman et al. 2003, McConkey Robbins et al. 2004).

The age at the period of the surgery has been relevant for the outcomes of cochlear implant on children. The studies of Kirk et al. (2002) and Baumgartner et al. (2002) showed that the children who were under 3 years old when they were implanted achieved faster outcomes if compared with children who were older at the time of the surgery. Other studies indicated that, besides achieving better speech sounds auditory perception and incidental oral language acquisition, younger children achieved better speech intelligibility (Manrique et al. 2004, Colletti et al. 2005, Manrique et al. 2006). The O'Neill et al. (2002) study about the hearing performance of implanted children and their age at the period of the surgery indicated that the children acquired, at least, 4 auditory categories, reasoning that cochlear implant programs must prioritize younger children.

In regards to the relation between the speech auditory perception and the speech codification strategies, studies show higher scores on the recognition of phonemes (Psarros et al. 2002), words and sentences with the Advanced Combination Encoders (ACE) strategy (Pasanisi et al. 2002; Psarros et al. 2002; Frederigue and Bevilacqua 2003), either under silence or under noise. Psarros et al. (2002) also found improvement of the consonant scores with the ACE strategy, and considered that the improvement of the speech perception obtained with the conversion of the Spectral Peak (SPEAK) strategy to the ACE strategy was significant, and that this improvement was more significant under noise, suggesting that the conversion of the SPEAK strategy to the ACE strategy is beneficial for children, and the ACE strategy may be an initial choice for them.

Quittner et al. (2004) emphasized that few studies investigate the effects of the cochlear implant on the multiple skills of the child, such as cognition and behavior. They highlighted that as far as the implant provides hearing access to the speech sounds and the child begins to respond to them, her ability to control her attention and behavior increases considerably, leveraging the interaction parents-child thus enriching the communication experiences. However, Santana (2005) considered the hearing can not be accepted as the single factor in the language acquisition process and stressed the quality of the social interactions as also a significant factor in the formation of the child as the subject of the language.

The results presented in this study were obtained from clinic experiences of the Cochlear Implant Interdisciplinary Work Group of the Audiological Research Center of the Hospital de Reabilitação de Anomalias Craniofaciais of the University of São Paulo (CPA-HRAC/USP, campus Bauru - SP), that assists prelingually deaf children who have been implanted for 14 years, since their candidacy, during the surgery and subsequently after the implantation. The assistance requires the monitoring of the hearing and language performance, both in clinical and daily contexts, since the assessment of the speech sounds perception allows the achievement of sensitive scores in order to precisely assess the hearing capacity of each child.

The objective of this study was to assess the hearing and language behavior of children with pre-lingual, bilateral profound sensory-neural hearing impairment, users of multi-channel cochlear implant, regarding the following aspects: age of the child when the research was carried-out, time of hearing sensorial deprivation, time of cochlear implant use, type of cochlear implant, speech coding strategy used, familial permeability degree in the therapeutic process and cognitive style of the child

Method

This study was approved by the Ethics Committee of the HRAC/USP, according to document number 87 / 98 - CEP - UEP. All the responsible guardians signed the Free and Informed Consent Term to participate in this study.

FIGURE 1. Distribution of children according to the type of cochlear implant and the speech coding strategy utilized (n=60).

type of CI and speech coding strategy	Med-El CIS	16
	Nucleus 24 ACE	16
	Nucleus 22 SPEAK	28
ear operated	right	37
	left	23
insertion	total	56
	partial	4
etiology	idiopathic	29
	meningitis	12
	rubella	12
	genetic	6
	cytomegalovirus	1

Subjects

This study was conducted with 60 prelingually deaf children who were implanted and underwent the eligibility institutional criteria (Bevilacqua e Moret, 2005) in the preoperative phase. The age of the 60 children evaluated ranged from 2 years and 6 months to 10 years and 8 months old. The time of hearing sensorial deprivation ranged from 5 months to 6 years and 3 months, and the time of cochlear implant use ranged from 3 months to 7 years and 7 months. Figure 1 presents the distribution of children according to the type of cochlear implant, the speech coding strategy, the ear operated, the electrodes insertion and the etiology of the hearing impairment.

Procedures

The 60 children studied were assessed for the assignment of hearing and language categories and psycho-social aspects (child's cognitive style and family's permeability degree in the therapeutic process) for statistical analysis with the variables investigated.

The procedures for the assignment of hearing categories were: medical evaluation of hearing behavior; TACAM: Assessment Test for Minimum Hearing Capacity (Orlandi and Bevilacqua 1999); IT-MAIS - Infant Toddler: Meaningful Auditory Integration Scale (Castiquini and Bevilacqua 2000); Procedure for the Assessment of Profound Hearing Impairment Children (Bevilacqua and Tech 1996); List of everyday sentences of the Portuguese language (Valente 1998); and List of words as procedure for assessment of speech sound perception (Delgado and Bevilacqua 1999). After the application of these procedures, the hearing ability of these children was classified according to hearing categories (Geers 1994).

The procedures for the assignment of language categories were: assessment of the oral communication behavior under playful interaction situation and under special activities with the audiologist and the adult responsible for the child; MUSS - Meaningful Use of Speech Scales (Nascimento 1997). After the application of these procedures the language of the children was classified according to expressive language categories, used in internal protocols, such as: category 1 - child does not speak and may present indistinct vocalization; category 2 - child speaks only few words; category 3 - child makes simple sentences; category 4 - child makes complex sentences; category 5 - child is fluent in oral language.

All the children were assessed in regard to their cognitive style for the observation and report of some behaviors that are part of the development of the child and for others that, when present, may indicate pathologies or specific difficulties that prevent the full development of the child. The families were assessed according to the reference criteria regarding permeability degree in the therapeutic process that were developed in internal protocols at the CPA - HRAC/USP.

Material

The application of the Assessment Test for Minimum Hearing Capacity (TACAM) and the lists of words from the index of language recognition for phonemes was conducted in an acoustic booth, with loudspeaker in free field system, 60 dB of intensity, with a Midimate MA 622 audiometer calibrated to 100 dB NA, with amplifiers positioned at 45º AZIMUTH angle, at a 23,6 in distance from the child's ear, sound directed to the implanted ear. The other procedures were conducted in an acoustic room, with sounback level ranging from 47.8 to 72.9 dB, measured by a Brüel & Kjaer sound level meter, 2236 model.

Data analysis

For the ordinal categorical data multi-varied analysis of hearing and language categories, the chi-square statistical test was performed, and the significance level considered at 5%. Subsequently, a Multi-varied Logistic Model was applied to ordinal categorical data.

Results

The age of the 60 children when the research was carried-out, the time of hearing sensorial deprivation and the time of cochlear implant use are presented in Table 1, and Table 2 shows the distribution of the 60 children regarding hearing categories.

Table 3 shows the comparison of the hearing categories with the age of the children when the research was carried-out, time of sensorial deprivation and time of cochlear implant use, and Table 4 shows the comparison of the hearing categories with the type of implant and speech codification strategies.

TABLE 1. Distribution of the 60 children regarding the age when the research was carried-out, time of hearing sensorial deprivation and time of cochlear implant use.

Distribution of Casuistic (n =60)			
	Age (Months)	Time of Hearing Sensorial Deprivation (Months)	Time of Cochlear Implant Use (Months)
average	70,06	41,23	25,53
DP	24,54	14,0	20,12
median	63,5	42,0	19,5
minimum	30,0	5,0	3,0
maximum	128,0	75,0	91,0

TABLE 2. Distribution of the 60 children regarding hearing categories.

Hearing categories	N	%
1. detection of the speech sounds	04	07
2. standard of perception	06	10
3. begin the identification of the words	16	26
4. words identification by vowel recognition	07	12
5. words identification by consonant recognition	12	20
6. words recognition in open set	15	25
TOTAL	60	100

TABLE 3. Comparison of the hearing categories with the age of the children when the research was carried-out, time of sensorial deprivation and time of cochlear implant use for the 60 children assessed.

Hearing Categories	n	Age	Time of Sensorial Deprivation	Time of Cochlear Implant Use
1 – 6	60	p = 0,0116*	p = 0,0239*	p = 0,0011*

* Statistically significant ($p < 0,05$)

TABLE 4. Comparison of the hearing categories of the 60 children assessed with the type of cochlear implant and speech codification strategies.

Type of Cochlear Implant and Strategy	Hearing Categories						TOTAL
	1	2	3	4	5	6	
Med-El (CIS)	4	3	7	1	1	-	16
Nucleus 24 (ACE)	-	2	5	-	5	4	16
Nucleus 22 (SPEAK)	-	1	4	6	6	11	28
TOTAL	4	6	16	7	12	15	60

$p = 0,0007$ (Statistically significant $p < 0,05$)

TABLE 5. Comparison of the hearing categories and the familial permeability degree in the therapeutic process of the 60 children assessed.

Familial Permeability	Hearing Categories						TOTAL
	1	2	3	4	5	6	
excellent	1	1	4	-	6	11	23
satisfactory	-	2	7	3	2	4	18
low	3	3	5	4	4	-	19
TOTAL	4	6	16	7	12	15	60

p = 0,0143 (Statistically significant p < 0,05)

TABLE 6. Comparison of the hearing categories and cognitive style of the 60 children assessed.

Cognitive Style	Hearing Categories						TOTAL
	1	2	3	4	5	6	
excellent	1	1	8	2	6	10	28
satisfactory	-	3	3	1	2	4	13
insufficient	3	2	5	4	4	1	19
TOTAL	4	6	16	7	12	15	60

p = 0,1810 (Statistically non-significant p > 0,05)

TABLE 7. Distribution of the 60 children regarding language categories.

Language Categories	N	%
1. do not speak	10	16,5
2. emission of single words	13	21,5
3. emission of simple sentences	18	30
4. emission of complex sentences	14	23,5
5. fluency	5	8,5
TOTAL	60	100

TABLE 8. Comparison of the language categories with the age of the children when the research was carried-out, time of sensorial deprivation and time of cochlear implant use for the 60 children assessed.

Language Categories	N	Age	Time of Sensorial Deprivation	Time of Cochlear Implant Use
1 – 5	60	< 0.0001*	p = 0,1033	p = 0,0006*

* Statistically significant (p < 0,05)

Regarding the comparison of the hearing categories and the psycho-social aspects (Tables 5 and 6), significant result was obtained only on the familial permeability degree in the therapeutic process.

Table 7 shows the distribution of the 60 children regarding the language categories, and Table 8 shows the comparison of these categories with the age of the children when the research was carried-out, time of sensorial deprivation and time of implant use.

The results of the comparison of the language categories with the type of cochlear implant and the speech codification strategies are shown in Table 9.

In regard of the comparison of the language categories with the psycho-social aspects (Tables 10 and 11), significant result was obtained only on familial permeability degree in the therapeutic process.

Discussion

The cochlear implant as an alternative in treating prelingually deaf children presents many particularities. Initially, it is not just a surgical procedure after which the child can be conducted, exclusively, by its own electronic device (O'Neill et al. 2002; Costa et al. 2006). In fact, the cochlear implant in children is a multiple process that occurs basically in three distinct stages: in the preoperative evaluation, in the surgical process and in the monitoring of the follow up. Although different, these stages have aspects that interact with themselves and can be related to the time of sensorial deprivation, time of device use, psycho-social aspects, among others. The results of the interaction of these aspects may, indeed, interfere with the development of the child. For example, it is known that children with cognitive delay can benefit from the implant, but they present limited results when compared with their peers without cognitive delay (Holt and Kirk 2005).

In the present study, 56 out of 60 children assessed were implanted before they were 5 years old, which is the time of hearing sensorial deprivation for most part of the group because for 48 out of 60 children assessed the hearing impairment was caused by congenital anomalies and for 12 children it was caused by meningitis in early years.

During the preoperative stage, the 60 children assessed belonged to hearing category 0 (no detection of speech sounds) or to 1 (detection). Table 2 shows that 10 children belonged to first categories 1 and 2, 23 children achieved intermediate categories 3 and 4, and 27 children achieved hearing categories 5 and 6, which are more advanced and more difficult. Therefore, intermediate and advanced hearing categories were achieved by more than half of the whole group. This is an effective result and it is similar to what was described by O'Neill et al. (2002), who showed the gain of 4 hearing categories. Taking into account that hearing categories represent the perception of speech sounds, we can consider that the results obtained by the children in this study were similar to what is found in the literature, which reports the benefits of the cochlear implant for children (Kirk et al. 2002, Myamoto et al. 2003, Colletti et al. 2005).

It was also observed in this study that 37 out of 60 children presented progress in oral language, which is represented by the gain in language categories 3, 4 and 5 (Table 7), while 23 children remained in category 1 or achieved category 2 (Table 7), which represents a more limited progress. It is important to highlight that most of the children in language categories 1 or 2 represented the youngest and the ones with less time of cochlear implant use in this study.

Some authors consider it is necessary approximately two years of cochlear implant use to prove its benefits for young children. Richter et al. (2002) only considered the results of speech and language perception of a group of implanted children after this period, as well. Table 1 shows the average value and the median regarding the time of cochlear implant use were approximately 25 months; therefore, the hearing and language results achieved occurred within the expected time described in the literature.

Table 1 also shows that both the median and average values regarding the time of hearing sensorial deprivation were not over 42 months, and the longest time of hearing sensorial deprivation was 75 months. Considering this was not a longitudinal study, this is a relevant learning because it suggests the progress observed in the hearing categories of the group assessed must not be taken as the final result of the cochlear implant use. Probably, these children will still improve the gain in the hearing and, consequently, in the language categories. According to Gross (2002), by 6 years old the oral language development is completed and, as of this age, under adverse situations such as hearing impairment, it is not easy to achieve progress. Present studies investigate the existence of a crucial period of high hearing neuronal plasticity (Harrison et al. 2005) to guide decisions regarding the indicated age for the surgery. Even so, the biggest challenge is to find out the reasons why some children obtain better results than others when the same criteria are followed.

TABLE 9. Comparison of the language categories of the 60 children assessed with the type of cochlear implant and speech codification strategies.

Type of Cochlear Implant and Strategy	Language Categories					TOTAL
	1	2	3	4	5	
Med-El (CIS)	9	5	2	-	-	16
Nucleus 24 (ACE)	1	5	5	4	1	16
Nucleus 22 (SPEAK)	-	3	11	10	4	28
TOTAL	10	13	18	14	5	60

$p < .0001$ (Statistically significant $p < 0,05$)

TABLE 10. Comparison of the language categories and the familial permeability degree in the therapeutic process of the 60 children assessed.

Familial Permeability	Language Categories					TOTAL
	1	2	3	4	5	
excellent	3	1	5	11	3	23
satisfactory	2	7	5	2	2	18
low	5	5	8	1	-	19
TOTAL	10	13	18	14	5	60

$p = 0,0072$ (Statistically significant $p < 0,05$)

TABLE 11: Comparison of the language categories and the cognitive style of the 60 children assessed.

Cognitive style	Language categories					TOTAL
	1	2	3	4	5	
excellent	5	3	7	10	3	28
satisfactory	1	5	2	3	2	13
insufficient	4	5	9	1	-	19
TOTAL	10	13	18	14	5	60

$p = 0,0714$ (Statistically non-significant $p > 0,05$).

In this study, the first aspects compared with the hearing and language categories were the age of the children when the research was carried-out, the time of sensorial deprivation and the time of device use. Regarding the hearing categories, results were statistically significant on the three aspects assessed, as shown in Table 3. Regarding the language categories, significant results were observed relative to age and time of cochlear implant use (Table 8). The fact that the time of sensorial deprivation was not statistically significant was very curious, since this has been appointed as one of the most relevant aspects in the literature (Costa e Bevilacqua 2006). It is possible that the evaluation of the language used in this study, which rated the language in 5 categories (in category 1, the child do not speak, and category 5 represents the oral language fluency), may have concealed nuances of the language that the children eventually presented, such as vocalization increase and specific vowels production, which were not taken into account in this assessment protocol. In this study, only 7 children were implanted before 3 years old, which may not be a significant figure to modify this variable.

Regarding the comparison between the time of deafness and the hearing categories, the result obtained was already expected because the literature indicates that this aspect indeed influences the behavior of the implanted children (O'Neill et al. 2002, Manrique et al. 2004, Colletti et al. 2005). Certainly, this result may be associated to the existence of a crucial period of neuronal plasticity, which occurs intensely and dynamically in the first 5 years of age.

The result of the comparison between the language categories and the time of hearing sensorial deprivation (Table 8) was statistically non-significant, although it has been statistically significant in the hearing behavior of the children assessed. This learning is different from the result presented by Richter et al. (2002), which showed that the age by the implantation was the aspect that most influenced the results of expressive and receptive language in a group of implanted children. Everything indicates that the language category is more related to the time of device use, which was significant when compared with the language categories (Table 8). It was also significant when compared with the hearing categories (Table 3). It is noticeable that this aspect must be analyzed together with the aspect age when the research was carried-out, also significant either in the comparison with the hearing categories (Table 3) or in the comparison with the language categories (Table 8). Naturally, the more the use of the cochlear implant and the more they mature the children perform satisfactorily on the speech perception tests (Bevilacqua 1998; Miyamoto et al. 2003).

Comparing the hearing and language categories with the type of cochlear implant, statistically significant result was observed in the whole group assessed (Tables 4 and 9, respectively). Although the type of cochlear implant is not deeply investigated in the related literature, the influence of this aspect in the speech sounds perception seems to be controversial. Not only the type of cochlear implant use was significant, but also was the speech codification strategy compared with he hearing categories (Table 4) and with the language categories (Table 9). The influence of both can not be analyzed separately because there are other interactive related factors. The group who used the Nucleus 22 type of implant with the SPEAK strategy was the group who used the device longer, which is highly significant in this study. This suggests there is a strong interaction between these aspects, and the performance of the child may be under the influence of their combination (O'Neill et al. 2002; Richter et al. 2002, Clark 2003).

Other aspect that showed statistically significant result when compared with the hearing and language categories was the familial permeability degree in the therapeutic process (Tables 5 and 10, respectively). In fact, this result is aligned with studies about parental participation in the (re)habilitation of implanted children (Quittner et al. 2004, Li et al. 2004). The existing relation between the performance of the children in the hearing and language categories and the familial permeability in the therapeutic process reaffirms the importance of the family adequacy as eligibility criteria for the cochlear implant candidacy, especially in regards of the treatment motivation and of the children use of the device. Bevilacqua and Formigoni (2005) reported that the family is a modifying agent for the children reality, either positive or negatively. Considering parent's expectations towards the treatment are dynamic and change with time, depending on how they adjusted to the child's deafness, moments of anxiety and distress may intersperse other stages of the treatment. The anxiety of the parents may lead to a feeling of dissatisfaction towards the results of the implantation, which in extreme circumstances may lead the child not to use the device.

The relation between the hearing and language categories gain with the family aspect reflects valuable clinical importance in terms of quantity and type of counseling given to parents in many stages of the children cochlear implant process. In fact, the indication of the cochlear implant for children is full of expectations, which are not only restricted to the team, but also to the family environment. Therefore, the more prepared the parents are to work with their children, probably the better the results they present. The more realistic parents' expectations are towards the treatment, the more peaceful it will be and the children will possibly achieve better performance in many aspects. The counseling for parents of older children cochlear implant candidates must be emphasized because it is expected that older children present a more limited performance compared to younger children and to children with other disabilities (Holt and Kirk 2005, Costa et al. 2006).

The statistically significant result between the family aspect and the hearing and language categories of the children reinforces the need for audiologist to value parents' participation in the aurioral therapy, so they can lead parents to a better familial dynamic to benefit the child when in home situations (Bevilacqua et al. 2004). This is crucial for parents to keep the motivation and enthusiasm required in the therapeutic process.

Regarding the comparison between the hearing and language categories and the cognitive style of the child, no statistically significant result was found (Tables 6 and 11, respectively). Even though, detailed studies about the child's own learning capacity must be conducted to investigate whether this factor do not influence the cochlear implant process. Quittner et al. (2004) showed that cognitive and behavioral aspects may be related to good performance among the prelingually children group. However, they call the attention to the fact that most part of the studies conducted on cochlear implant for prelingually children are based on the assessment based on traditional hearing criteria, which include a variety of speech perception tests. Regarding the oral language assessment, clinical needs have motivated researchers to study and improve the specific procedures for the assessment of young children implanted (Padovani and Teixeira 2004).

The majority of the studies are conducted with heterogeneous groups regarding age, etiology and time of sensorial deprivation. Were these variables under control, maybe many individual differences would appear among children of a same group. Studies about memory, attention and language processes can provide new theories about how children acquire language using cochlear implant (Willstedt-Svensson et al. 2004), allowing researchers and therapists others learnings related to the individual differences observed in a same group of prelingually implanted children.

Maybe some differences were noticed if the groups of implanted children followed criteria that considered better conditions for a statistical study, but this is not possible from an ethical point of view. The eligibility criteria for the cochlear implant in children follow the related ethical principles and can not be under the methodological investigation issues.

Although the cochlear implant is considered an effective treatment for prelingually deaf children, it still requires further research. The objective of the present study is to present some aspects that may guide professionals involved in cochlear implant programs and at counseling parents of children who are candidates for cochlear implant or who are already implanted. It is important to note that there is no warranty or guarantee concerning the cochlear implant in children. Each family, each child and each aspect that impacts them are widely different, thus generalizations can rarely be made.

Conclusion

The cochlear implant is a highly effective treatment for prelingually deaf children, although complex owing to the interaction of variables which interfere in the implanted child's performance. Further studies are needed for the understanding of the implantation complexity in young children. The aspects that influenced the hearing and language categories acquisition for implanted children were: child's age, time of hearing sensorial deprivation, time of cochlear implant use, familial permeability degree in the therapeutic process, type of cochlear implant and speech codification strategy used.

References

BAUMGARTNER, W. D.; POK, S. M.; EGELIERLER, B.; FRANZ, P.; GSTOETTNER, W.; HAMZAVI, J. The role of age in pediatric cochlear implantation. *Int. J. Pediatr. Otorhinolaryngol.*, Amsterdam, v. 62, n. 3, p. 223-228, feb. 2002.

BEVILACQUA, M. C. *Implante coclear multicanal:* uma alternativa na habilitação de crianças surdas. 1998. 115 f. Tese (Livre-Docência no Departamento de Fonoaudiologia) - Faculdade de Odontologia de Bauru, Universidade de São Paulo, Bauru/SP.

BEVILACQUA, M. C.; COSTA, A. O.; MARTINHO A. C. F. Implante coclear. In: FERREIRA, L. P.; BEFI-LOPES, D. M.; LIMONGI, S. C. O. *Tratado de fonoaudiologia.* São Paulo: Roca, 2004. cap. 60, p. 751-761.

BEVILACQUA, M. C.; COSTA, A. O.; MORET, A. L. M. Implante coclear em criança. In: CAMPOS, C. A. H.; COSTA, H. O. O. Tratado de otorrinolaringologia da sociedade brasileira de otorrinolaringologia. v. 2: doenças otologia, base do crânio. São Paulo: Roca, 2003. cap. 26, p. 268-277.

BEVILACQUA, M. C.; FORMIGONI, G. M. P. O desenvolvimento das habilidades auditivas. In: BEVILACQUA, M. C.; MORET, A. L. M. (Org.). *Deficiência auditiva:* conversando com familiares e profissionais de saúde. São José dos Campos: Pulso Editorial, 2005. p. 179-202.

BEVILACQUA, M. C.; MORET, A. L. M. Reabilitação e implante coclear. In: LOPES FILHO, O. *Tratado de fonoaudiologia.* Ribeirão Preto: Tecmedd, 2005. cap. 23, p. 423-436.

BEVILACQUA, M. C.; TECH, E. A. Elaboração de um procedimento de avaliação de percepção de fala em crianças deficientes auditivas profundas a partir de cinco anos de idade. In: MARCHESAN, I. Q.; ZORZI, J. L.; GOMES, I. C. D. (Ed.). *Tópicos em fonoaudiologia.* São Paulo: Lovise, 1996. p. 411-433.

CASTIQUINI, E. A. T.; BEVILACQUA, M. C. Escala de integração auditiva significativa: procedimento adaptado para a avaliação da percepção da fala. *R. Soc. Bras. Fonoaudiol.*, São Paulo: v. 4, n. 6, p. 51-60, jun. 2000.

CLARK, G. M. *Cochlear implants:* fundamentals & applications. New York: Springer, 2003. 830 p.

COLLETTI, V.; CARNER, M.; MIORELLI, V.; GUIDA, M.; COLLETTI, L.; FIORINO, F. G. Cochlear implantation at under 12 months: report on 10 patients. *Laryngoscope*, St. Louis, v. 115, n. 3, p. 445-449, mar. 2005.

COSTA, O. A.; BEVILACQUA, M. C. Implantes cocleares. In: COSTA, S. S. *Otorrinolaringologia:* princípios e prática. Porto Alegre: Artmed, 2006. cap. 11, p. 447-453.

COSTA, A. O.; BEVILACQUA, M. C.; MARTINHO A. C. F. (Re)Habilitação auditiva por implante coclear . In: LOPES, A. C. *Tratado de clínica médica.* v. 3. 2006. cap. 563, seção 25, p. 5137-5138.

COSTA, O. A.; BEVILACQUA, M. C.; TABANEZ, L. N. Implantes cocleares em crianças. In: LAVINSKY, L. *Tratamento em otologia.* Rio de Janeiro: Revinter, 2006. cap. 79, p. 478-484.

DELGADO, E. M. C.; BEVILACQUA, M. C. Lista de palavras como procedimento de avaliação da percepção dos sons da fala para crianças deficientes auditivas. *Pró-fono R. Atual. Cient.*, Carapicuiba (SP), v. 11, n. 1, p. 59-64, jan.-abr. 1999.

FREDERIGUE, N. B.; BEVILACQUA, M. C. Otimização da percepção da fala em deficientes auditivos usuários do sistema de implante coclear multicanal. *R. Bras. Otorrinolaringol.*, Rio de Janeiro, v. 69, n. 2, p. 227-233, mar.-abr. 2003.

GEERS, A. E. Techniques for assessing auditory speech perception and lipreading enhancement in young deaf children. *Volta R.*, Washington, v. 96, n. 5, p. 85-96, nov. 1994.

GROSS, A. Ideal age to receive a cochlear implant: what is the ideal age for a deaf child to receive a cochlear implant? San Antonio: Healthy Hearing, 2002. Disponível em: <http://www.healthyhearing.com/healthyhear...root/askexpert/displayquestion.asp?id=111>. Acesso em: 03 out. 2002.

HARRISON, R. V.; GORDON, K. A.; MOUNT, R. J. Is there a critical period for cochlear implantation in congenitally deaf children? Analyses of hearing and speech perception performance after implantation. *Dev. Psychobiol.*, Nova York, v. 46, n. 3, p. 252-261, apr. 2005.

HOLT, R. F.; KIRK, K. I. Spoken word recognition development in children with residual hearing using cochlear implants and hearing aids in opposite ears. *Ear. Hear.*, Baltimore, v. 26, n. 4, p. 82S-91S, aug. 2005.

HOUSTON, D. M.; PISONI, D. B.; KIRK, K. I.; YING, E. A.; MIYAMOTO, R. T. Speech perception skills of deaf infants following cochlear implantation: a first report. *Int. J. Pediatr. Otorhinolaryngol.*, Amsterdam, v. 67, n. 5, p. 479-495, may 2003.

KIRK, K. I.; MIYAMOTO, R. T.; LENTO, C. L.; YING, E.; O'NEILL, T.; FEARS, B. Effects of age at implantation in young children. *Ann. Otol. Rhinol. Laryngol. Suppl.*, St. Louis, v. 111, n. 5, p. 69-73, may 2002. supl. 189.

LI, Y.; BAIN, L.; STEINBERG, A. G. Parental decision-making in considering cochlear implant technology for a deaf child. *Int. J. Pediatr. Otorhinolaryngol.*, Amsterdam, v. 68, n. 8, p. 1027-1038, aug. 2004.

MANRIQUE, M.; CERVERA-PAZ, F. J.; HUARTE, A.; MOLINA, M. Advantages of cochlear implantation in prelingual deaf children before 2 years of age when compared with later implantation. *Laryngoscope*, St. Louis, v. 114, n. 8, p. 1462-1469, aug. 2004.

MANRIQUE, M.; RAMOS, A.; MORERA, C.; CENJOR, C.; LAVILLA, M. J.; BOLEAS, M. S.; CERVERA-PAZ, F. J. Analysis of the cochlear implant as a treatment technique for profound hearing loss in pre and postlocutive patients. *Acta. Otorrinolaringol. Esp.*, Madrid, v. 57, n. 1, p. 2-23, jan. 2006.

MCCONKEY ROBBINS, A.; GREEN, J. E.; WALTZMAN, S. B. Bilingual oral language proficiency in children with cochlear implants. *Arch. Otolaryngol. Head Neck Surg.*, Chicago, v. 130, n. 5, p. 644-647, may 2004.

MIYAMOTO, R. T.; HOUSTON, D. M.; KIRK, K. I.; PERDEW, A. E.; SVIRSKY, M. A. Language development in deaf infants following cochlear implantation. *Acta. Otolaryngol.,* Stockolm, v. 123, n. 2, p. 241-244, feb. 2003.

NASCIMENTO, L. T. *Uma proposta de avaliação da linguagem oral.* 1997. 52 f. Monografia (Especialização em Audiologia) - Hospital de Pesquisa e Reabilitação de Lesões Lábio-Palatais, Universidade de São Paulo, Bauru/SP.

NIKOLOPOULOS, T. P.; ARCHBOLD, S. M.; GREGORY, S. Young deaf children with hearing aids or cochlear implants: early assessment package for monitoring progress. *Int. J. Pediatr. Otorhinolaryngol.,* Amsterdam, v. 69, n. 2, p. 175-186, feb. 2005.

O'NEILL, C.; O'DONOGHUE, G. M.; ARCHBOLD, S. M.; NIKOLOPOULOS, T. P.; SACH, T. Variations in gains in auditory performance from pediatric cochlear implantation. *Otol. Neurotol.,* Hagerstown, v. 23, n. 1, p. 44-48, jan. 2002.

ORLANDI, A. C. L.; BEVILACQUA, M. C. Deficiência auditiva profunda nos primeiros anos de vida: procedimento para a avaliação da percepção da fala. *Pró-Fono R. Atual. Cient.,* Barueri (SP), v. 10, n. 2, p. 87-91, set. 1998.

PADOVANI, C. M. A.; TEIXEIRA, E. R. Using the MacArthur Comunicative Development Inventories (CDI'S) to assess the lexical development of cochlear implanted children. *Pró-Fono R. Atual. Cient.,* Barueri (SP), v. 16, n. 2, p. 217-224, maio-ago. 2004.

PASANISI, E.; BACCIU, A.; VINCENTI, V.; GUIDA, M.; BERGHENTI, M. T.; BARBOT, A.; PANU, F.; BACCIU, S. Comparison of speech perception benefits with SPEAK and ACE coding strategies in pediatric Nucleus CI24M cochlear implant recipients. *Int. J. Pediatr. Otorhinolaryngol.,* Amsterdam, v. 64, n. 2, p. 159-163, jun. 2002.

PSARROS, C. E.; PLANT, K. L.; LEE, K.; DECKER, J. Á.; WHITFORD, L. A.; COWAN, S. C. Conversion from the SPEAK to the ACE strategy in children using the Nucleus 24 cochlear implant system: speech perception and speech production outcomes. *Ear. Hear.,* Baltimore, v. 23, n. 1, p. 18-27, feb. 2002.

QUITTNER, A. L.; LEIBACH, P.; MARCIEL, M. S. The impact of cochlear implants on young deaf children. *Arch. Otolaryngol. Head Neck Surg.*, Chicago, v. 130, n. 5, p. 547-554, may 2004.

RICHTER, B.; EIBELE, S.; LASZIG, R.; LÖHLE, E. Receptive and expressive language skills of 106 children with a minimum of 2 years'experience in hearing with a cochlear implant. *Int. J. Pediatr. Otorhinolaryngol.*, Amsterdam, v. 64, n. 2, p. 111-125, jun. 2002.

SANTANA, A. P. O processo de aquisição da linguagem: estudo comparativo de duas crianças usuárias de implante coclear. *Dis. Comun.,* São Paulo, v. 17, n. 2, p. 233-243, ago. 2005.

TOMBLIN, J. B.; BARKER, B. A.; SPENCER, L. J.; ZHANG, X.; GANTZ, B. J. The effect of age at cochlear implant initial stimulation on expressive language growth in infants and toddlers. *J. Speech Lang. Hear. Res.*, Rockville, v. 48, n. 4, p. 853-867, aug. 2005.

VALENTE, S. L. O. *Elaboração de listas de sentenças construídas na língua portuguesa.* 1998. 155 f. Dissertação (Mestrado em Distúrbios da Comunicação) - Faculdade de Fonoaudiologia, Pontifícia Universidade Católica, São Paulo.

WALTZMAN, S. B.; ROBBINS, A. M.; GREEN, J. E.; COHEN, N. L. Second oral language capabilities in children with cochlear implants. *Otol. Neurotol.,* Hagerstown, v. 24, n. 5, p. 757-763, sep. 2003.

WILLSTEDT-SVENSSON, U.; LÖFQVIST, A.; ALMQVIST, B.; SAHLÉN, B. Is age at implant the only factor that counts? The influence of working memory on lexical and grammatical development in children with cochlear implants. *Int. J. Audiol.*, Hamilton, v. 43, n. 9, p. 506-515, oct. 2004.