Analysis of the cochlear implant as a treatment technique for profound hearing loss in pre and postlocutive patients

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Abstract: Introduction: These are the objectives planned for this study: 1. To evaluate the results from a communicative perspective. 2. To evaluate the impact cochlear implants (CI) have on quality of life. 3. To evaluate the medical complications and technical failures of cochlear implants. 4. To assess the direct and indirect costs of the different phases of a cochlear implantation program. 5. To determine which factors have the greatest impact on clinical evolution and financial cost. Materials and Method: We studied a population of 877 patients, including post-lingual and prelingual subjects, adults and children, who had been treated in five Spanish centers with cochlear implantation programs. Audiometric tests and comprehensive quality-of-life questionnaires were used. The medical and technological complications of CI were also recorded. The direct and indirect economic costs of a cochlear implantation were calculated. Results: Post-lingual implanted patients reached thresholds of 40 dB SPL in the pure-tone audiometry test, and this result remained stable over the course of a 12-year evolution. In the vowel test, their scores increased from 30% in the pre-operative test to 80-90%, in the Disyllables test they increased from 10% to 50-60%, and in the CID Sentences test from 18% to 60-70%. In the prelingual population, the results were decisively influenced by the child’s age at implantation. The best results were obtained by the children who had been implanted at the youngest age. Thus, those implanted between 0 and 3 years of age showed an improvement in the Vowels test from 0% in the pre-operative test to 95%, from 0% to 90% in the Disyllables test and from 0% to 90-95% in the CID Sentences test. The acquisition and development of speech of the pre-lingual population was also influenced by the age at implantation. Approximately 80% of post-lingual adult patients reported an improvement in their mood and sociability subsequent to cochlear implantation. They did not experience any deterioration in their general state of health, nor did they require more attention than usual from relatives and friends. Severe medical-surgical complications were recorded in 3.42% of the cases, mild medical-surgical complications in 7.06% and technical breakdowns of the internal components of the CI in 3.07%. The financial cost of implantation for a post-lingual adult ranged from €36.912 to €37.048, and from €37.689 to €44.273 for a pre-lingual child. Conclusions: Cochlear implants clearly enhance the communicative abilities of implanted patients. The results obtained amongst the prelingual population justify the creation of hearing-loss screening programs in newborns. The post-lingual adults expressed satisfaction with the results obtained, although they did perceive some limitations in situations of unfavorable acoustic conditions. We have made an analysis of the direct and indirect costs, which may be useful for producing reports on the cost-benefit ratio in this field. The low incidence of complications observed shows that cochlear implantation has adequate safety margins. The factors that have the greatest influence on evolution are: the duration of hearing deprivation, age at the time of implantation, the cochlear anatomy and the functionality of the auditory canal, the patient’s degree of motivation and that of their relatives, and the coexistence

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INTRODUCTION

Our aim is to carry out a comprehensive review of the results obtained after cochlear implantation in a large group of patients, both children and adults, with pre- or post-lingual deafness. Specifically, the objectives of this project are directed towards establishing the impact this technique has on communication and quality of life, as well as its reliability and economic cost. These objectives can be structured in the following manner:

1. Evaluation of the results in the area of communication: our purpose is to evaluate the capacities developed by implanted patients for social communication in a verbal environment. The study includes the evaluation of auditory perception, from both a tonal and a vocal point of view, and of expression, through the acquisition of oral language, in those patients with hearing loss that began during the pre-lingual period of life.

2. Evaluation of the impact of cochlear implants on health-related quality of life. Within this objective, special emphasis will be placed on evaluating the influence of this technique on the degree of integration of the adult population into the world of work, and, amongst the child population, its repercussions on integration into school-life.

3. Evaluation of the medical complications and the technical failures of the system, both of its external (microphone, processor, cables and transmitter) and internal (antenna, receptor-stimulator and electrode array) components.

4. Evaluation of the direct and indirect costs generated in the different phases of a cochlear implantation program (selection, surgery, programming, rehabilitation and follow-up). We will determine the cost-utility of the process in the different populations implanted.

5. To determine which factors have a significant effect on clinical evolution and on economic cost.

METHOD

Environment and subjects of study

A total of 877 patients were evaluated. 399 patients were operated on in the University Clinic of Navarra, 259 in the Hospital Materno Infantil of las Palmas, Gran Canaria, 137 in the University Hospital La Fe of Valencia, 44 in the Jiménez Díaz Foundation of Madrid, and 38 in the Hospital San Pedro de Alcántara of Cáceres.

With respect to the demographic characteristics of these patients, 52% of the implanted patients were women and 48% men. 56% had pre-lingual hearing loss, 40% post-lingual and 4% perilingual. 81.3% had used hearing aids prior to implantation and 18.7% had not. In the post-lingual subjects the average age at which they were implanted was 47.49 years (SD 17.64 years) and the time of duration of hearing loss was 11.96 years (SD 12.25 years). In the prelingual patients the average age at implantation was 8.46 years (SD 10.24 years) and the time that transpired before implantation was 7.57 years (SD 9.31 years). In the subjects with perilingual hearing loss the average age at implantation was 21.39 years (SD 19.72 years) and the time that transpired before implantation was 14.33 years (SD 16.60 years).

In relation to the etiology of the hearing loss in the whole group, the origin of their condition was unknown in 382 subjects, genetic in 159, otosclerosis in 54, a consequence of a postnatal infection (meningitis, cases of chronic otitis media, etc.) in 74 cases, of a prenatal infection (toxoplasmosis, cytomegalovirus, rubella, etc.) in 32 subjects, ototoxicity in 54, traumatism in 13, and in 108 it was due to another cause or the sum of several of those mentioned. In 87% of the total number of patients the cochlea did not have any morphological alteration. In 3.6% we were able to observe an ossification that affected the first four millimeters of the basal scala, in 3.9% the first eight millimeters, and in 0.9% of cases the ossification was total. In 2.7% of the ears operated on there was a congenital malformation (cochlear hypoplasia 0.8%, common cavity 0.5%, absence of cochlear compartmentalization 0.8%, and malformations of the posterior labyrinth 0.4%). In 1.3% the subjects had already undergone surgery on their ears, through open mastoidectomies.

In 67% of the cases the implant was inserted into the right ear and in 33% the left. The insertion of the electrodes of the implant was carried out by through a cochleostomy in the round window in 3.8% of the ears, in the promontory region in 93.4%, and of another kind in the remaining 2.8%. In 73.7% the insertion was carried out by conventional techniques and in 26.3% following the principles of atraumatic surgery for the preservation of hearing. In 85.1% a Nucleus type cochlear implant was used (Nucleus 22, Nucleus 24M, Nucleus 24K, Nucleus Contour, Nucleus Contour Advance, Nucleus 24 11+11); in 9.2% a Medel (Med-El Combi 40+, Med-El Combi 40+ short, Med-El Bifurcated); in 3.7 a Clarion (Clarion HFI, Clarion HFII, Clarion 90X); and in 1.8% another type of implant was used. The stimulation strategies programmed in these implants were the following: MPEAK in 4.7% of the cases, SPEAK in 39.1%, ACE in 44.2%, CA in 0.2%, CIS in 10.3%, SAS in 1.1%, HiR in 0.2% and of another kind in the remaining 0.1%.
Evaluation of hearing

A common protocol was used, one that has been used for years by each one of the groups of Huarte et al. This protocol included pure-tone audiometry and speech audiometry tests carried out in a closed context (vowel test) and an open context (Disyllables and CID sentences). In this way, comprehensively, and considering the results obtained in these tests, auditory evolution was classified according to the stage of rehabilitation: detection, discrimination, identification, recognition and comprehension.

Language studies

In the child population suffering from prelingual hearing loss, linguistic development will be studied by means of specific tests, such as the Reynell language scales for measuring expression and comprehension.

Quality of life studies

The Glasgow Benefit Inventory (GBI) questionnaire was used to evaluate quality of life. The version of this questionnaire used in this study includes 18 questions about four principal aspects: social benefits afforded by the treatment, changes in the implanted patient’s state of mind, changes in their general state of health, and changes in the support given by family members. We also used a quality of life questionnaire more specific to the area of people with hearing disabilities who have received an auditory prosthesis. This was the Abbreviated Profile of Hearing Aid Benefit, APHAB, also applied to users of cochlear implants.

Reliability studies

The Hoffman and Cohen classification was used to identify the medical and surgical complications that occurred during the surgical procedure of implantation and during the postoperative period. Secondly, the technical failures of the cochlear implants were analyzed and classified according to the parts affected - external components (microphone, processor, connection cables, transmitter), and internal (antenna, receptor-stimulator, electrode carrier).

Cost-utility studies

Cost-utility analysis provides the most appropriate measurement tool for the classification of the relative effects associated with costs. In said studies a standard measuring unit denominated Quality Adjusted Life Year, QALY is used. A QALY provides a measurement of the estimated quality-of-life benefit subsequent to intervention. In this paper a study of the direct and indirect costs related to cochlear implantation was made, focusing on two population groups: post-lingual adults and pre-lingual children.

Collection and analysis of data.

The data relating to the valuation of hearing, language and the reliability of the cochlear implants was extracted, retrospectively, from the clinical histories of the patients in each one of the centers that participated in the project. The questionnaires designed to measure quality of life were sent by mail to the implanted population and their families. As a previous step to the inclusion of subjects in this study, their authorization or that of their legal representatives was requested in writing. All the data was treated informationally with the confidentiality demanded by the Data Protection law.

The data was stored and statistically processed in the SPSS program, version 11.0. In the result evolution studies, only populations of more than 10 subjects are shown and analyzed.

RESULTS

1. Evaluation of the results in the area of communication

Post-lingual Population

In the data given below we can see the results that correspond to the total number of post-lingual implanted patients, only excluding those that had any type of anatomical abnormality of the cochlea. For this reason, no distinctions were made between them with respect to the type of implant, stimulation strategy, time of auditory deprivation, etc.

Pure-tone audiometry: The average tonal hearing loss (0.5-4 kHz) prior to implantation was of 107.82 dB HL; this dropped post-implantation to around 40 dB SPL and stayed at this figure over the course of 12 years of follow-up. This represents a significant improvement in the detection of sounds and in particular of those related to the human voice. Similarly, it is important to stress the stability of the results over the 12-year follow-up period (Figure 1A).

Speech Audiometry: The results reveal a significant improvement in the recognition of the different speech audiometry materials used. Thus in the Vowel test these went from 30% in the preoperative test to 80-90% (Figure 1B), from 10% to 50-60% in the Disyllables (Figure 1C), to 50-60% and in the CID Sentences from 18% to 60-70% (Figure 1D).

Prelingual Population

In the data provided below we can see the results corresponding to the total number of prelingual
implanted patients, excluding only those that had any type of anatomical abnormality of the cochlea. Therefore, as with the post-lingual population, no distinctions were made with respect to the type of implant, stimulation strategy, time of auditory deprivation, etc. The results were analyzed according to age at implantation, as this is, a priori, a principal factor in the prognosis made subsequently to implantation in people with hearing loss of prelingual onset.

- Children implanted between 0 and 3 years old

A total of 109 children are included in this group.

**Pure-tone audiometry:** The average auditory tonal loss (0.5-4 kHz) prior to implantation was of 115.9 dB HL; this dropped post-implantation to around 30 dB SPL and remained at this level over the course of 8 years of follow-up (Figure 2A).

**Speech Audiometry:** The results reveal a significant improvement in the recognition of the different speech audiometry materials used, achieving and maintaining, over the course of the follow-up, levels of recognition of oral language close to those that would be considered normal. Thus in the Vowel test the results went from 0% in the pre-operative test to 95% (Figure 2B), in the Disyllables test from 0% to 90% (Figure 2C) and in the CID Sentences from 0% to 90-95% (Figure 2D).

**Rehabilitation stages:** Over the course of the post-implantation period the children progressed in their level of communication until reaching stage 5, that of comprehension, which represents the maximum level of

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**Figure 1.** Results observed in the group of post-lingual implanted patients. A: Average threshold obtained in the pure-tone audiometry after calculating the average air conduction thresholds at frequencies of 0.5, 1, 2 and 4 kHz. B: Identification of Vowels. C: Recognition of Disyllables. D: Recognition of Sentences.
development. The results are shown in figure 3A. By way of a reminder we shall say that stage 1 corresponds to that of Detection, 2 to that of Discrimination, 3 to that of Identification, 4 to that of Recognition, and stage 5 to that of Comprehension.

- Children implanted between 4 and 6 years of age. A total of 55 children were included in this group.

Pure-tone audiometry: The average auditory tonal loss (0.5-4 kHz) pre-implantation was 112.08 dB HL, dropping post-implantation to 30-40 dB SPL and maintaining thresholds of around this level over the course of the 7 years of follow-up (Figure 4A).

Speech Audiometry: The results reveal a significant improvement in the recognition of the different speech audiometry materials used, reaching and maintaining, over the course of the follow-up, functional levels in the recognition of oral language. Thus in the Vowel test the results went from 1.6% in the pre-operative test to 80-90% (Figure 4B), in the Disyllables test from 6.1% to 70% (Figure 4C) and in the CID Sentences from 1% to 70% (Figure 4D). These results can be considered satisfactory, but they are lower than those reached by the previous group.

Rehabilitation stages: Over the course of the post-implantation period we were able to observe a progressive evolution in communicative abilities,
situated between stages 4 and 5, those of recognition and comprehension. Remember that stage 1 corresponds to that of Detection, 2 to that of Discrimination and 3 to that of Identification (Figure 3B).

- Children implanted between 7 and 10 years of age
  A total of 46 children were included in this group.

  Pure-tone audiometry: The average auditory tonal loss (0.5-4 kHz) pre-implantation was of 111.45 dB HL, dropping post-implantation to 35-40 dB SPL and maintaining stable levels over the course of 10 years of follow-up (Figure 5A).

  Speech audiometry: The results show an improvement in the recognition of the different speech audiometry materials used. Nevertheless, over the course of the follow-up the levels reached were not sufficient for the patient to interact in a conversation without the visual support of lip-reading. Thus, in the Vowels test the scores went from 17% in the preoperative test to 70-80% (Figure 5B), in Disyllables from 12.54% to 15-35% (Figure 5C) and in the CID

Figure 3. Levels reached in different stages in the rehabilitation process (Stage 1: Detection; Stage 2: Discrimination; Stage 3: Identification; Stage 4: Recognition; Stage 5: Comprehension) according to the age at implantation in prelingual children (A: 0-3 years; B: 4-6 years; C: 7-10 years; D: 11-14 years).
Figure 4. Results observed in the group of children with prelingual hearing loss, implanted between 4 and 6 years of age. A: Average threshold obtained in the pure-tone audiometry after calculating the average air conduction thresholds at frequencies of 0.5, 1, 2 and 4 kHz. B: Identification of Vowels. C: Recognition of Disyllabic words. D: Recognition of Sentences.

Sentences from 6% to 30-40% (Figure 5D). These results are clearly lower than those reached by the previous groups.

Rehabilitation stages: As an average value the children implanted between the ages of 7 and 10 years remained in stage 3 - identification- not showing any progress while using the cochlear implant (Figure 3C).

- Children implanted between the ages of 11 and 14 years
  A total of 28 children were included in this group.

Pure-tone audiometry: The average auditory tonal loss (0.5-4 kHz) pre-implantation was 111.64 dB HL, dropping post-implantation to around 40 dB SPL and maintaining stable auditory thresholds over the course of 6 years of follow-up (Figure 6A).

Speech audiometry: The results reveal an improvement in the recognition of the different speech audiometry materials used. Nevertheless, these were not high enough for the patient to be able to interact in a conversation without the visual support of lip-reading. Thus in the Vowel test the results went from 14% in the
preoperative to 50-60% (Figure 6B), in Disyllables from 6.3% to 10-20% (Figure 6C) and in the CID Sentences from 0% to 7-15% (Figure 6D). These results are clearly lower than those recorded for the previous groups.

Rehabilitation stages: As an average value, the children implanted between the ages of 11 and 14 years remained at stage 3 - identification- not showing any progress over the course of time while using the cochlear implant (Figure 3D).

Implanted after 14 years of age
A total of 65 patients were included in this group.

Pure-tone audiometry: The average auditory tonal loss (0.5-4 kHz) pre-implantation was of 108.5 dB HL, dropping post-implantation to around 40 dB SPL and maintaining stable auditory thresholds over the course of 10 years of follow-up (Figure 7A).

Speech Audiology: The results show an improvement in the recognition of the different speech
Figure 6. Results observed in the group of children with prelingual hearing loss implanted between 11 and 14 years of age. A: Average threshold obtained in the pure-tone audiometry after calculating the average air conduction thresholds at frequencies of 0.5, 1, 2 and 4 kHz. B: Identification of Vowels. C: Recognition of Disyllabic words. D: Recognition of Sentences.

• Linguistic results with respect to the age at implantation

As with hearing, the results in the Reynell scales of comprehension and expression of oral language were influenced by the age at implantation. As can be seen in figure 8, the youngest group (0-3 years) was that which came closest to the diagonal dotted line, a reference of the results obtained by a normal population of children over the course of their development during childhood.
On the contrary, the oldest group analyzed (7-10 years) moved away from said reference of normality, maintaining a plateau in their evolution.

2. Evaluation of the impact of cochlear implants on health-related quality of life

The evaluation of this aspect was carried out through the APHAB and GBI questionnaires. These were sent by mail to the group of post-lingual adults; 116 patients, 34.1% of the total, responded.

**APHAB Questionnaire**

The quality of hearing of the implanted patients in different situations of daily life is analyzed by means of this questionnaire, composed of 24 questions. These can be grouped into 6 blocks. The first, which we call “Silence-Proximity”, refers to the quality of communication...
Figure 8. Results registered in the Reynell scales for comprehension and expression in relation to the age at implantation of children with prelingual hearing loss. The diagonal dotted line represents the evolution maintained by a population of normal-hearing children considering the chronological age and the attributed age according to the Reynell scale.

Figure 9. Results recorded in the APHAB questionnaire corresponding to a population of post-lingual implanted subjects. The levels of satisfaction perceived by the implanted patients in different “listening” conditions are indicated separately.
perceived by the implanted subject when maintaining a conversation with a nearby interlocutor in an environment of relative silence. The second, denominated “Silence-Distance”, studies the same aspect but when the interlocutor is at a certain distance from the implanted subject. The third, called “Noise-Proximity”, evaluates the discrimination of the spoken word in a noisy environment when the interlocutor is close by. The fourth, denominated “Noise-Distance” repeats these circumstances but with the interlocutor far away. The fifth block, entitled “Audiovisuals”, records the perception of implanted patients when presented with some kind of audiovisual medium. Finally, the sixth block, “Discomfort-Noise”, refers to the sensation of discomfort that the implanted patient experiences on hearing determined intense or loud noises. As can be seen in figure 9 the opinion of the patients who answered the questionnaire is favorable in the case of hearing in an environment of relative quiet. The results are also positive in noisy environments but with lower scores than in the previous condition. On the contrary, implanted patients have significant difficulties in discriminating words through audiovisual media.

Finally, opinions on the discomfort experienced on exposure to intense noises from the surrounding environment are widely contrasting.

**GBI Questionnaire**

The Glasgow Benefit Inventory (GBI) questionnaire includes, in the version used in this paper, 18 questions about four principal aspects: social benefits afforded by the treatment, changes in the implanted patient’s state of mind, changes in their general state of health and modifications in the support of family members.

Each question has 5 possible responses: the results are shown in figure 10. We can see that approximately 80% of the post-lingual implanted adults consider that their social life and their personal perception of their state of mind improved substantially subsequent to implantation. A minimal percentage of them considered that they had deteriorated in said aspects. The greater part of them believe that the implant has not influenced their state of health or, expressed in other words, has not led to the appearance of collateral health problems. Nor has the attitude of their family and friends towards them changed in any way.

**3. Evaluation of medical complications and the technical failures of the system**

As was mentioned in the Methodology section, complications in cochlear implants can be classified into two large groups -serious or minor- including amongst
the former those necessitating the patient’s admittance to hospital for their treatment, those requiring surgery or those that generate a relevant functional alteration. At the same time, in both groups we can distinguish between medical/surgical complications and those related to the system implanted and its external components.

Serious medical/surgical complications: A rate of complications of 3.42% was recorded. With respect to the total, facial paralysis was recorded in 0.1%, the electrode array was erroneously placed outside of the cochlea in 0.1%, in 0.4% there was an emigration of the electrode array away from its original position, in 0.6% there was contamination of the implant necessitating its ex-plantation, in 0.6% there was an ulceration of the cutaneous flap that covers the receptor-stimulator-antenna, in 0.4% a cerebrospinal fluid fistula, and other types of complications in 0.9. In this series of patients, no case of meningitis attributable to the process of cochlear implantation was identified. The average time that transpired between surgery and the appearance of these complications was 11.18 months, with a range of 0 to 48 months. These complications were resolved by means of medical/surgical procedures that required hospitalization, requiring in 1.4% of the total number of cases an ex-plantation-re-implantation of the cochlear implant.

Minor medical/surgical complications: These were seen in 7.06% of the total number of cases studied. With respect to the total number of patients, in 0.2% a new case of tinnitus appeared or an existing case of tinnitus intensified significantly, in 1.2% vertiginous symptomatology was observed, in 1% facial stimulation on activating one of the electrodes of the implant, in 0.2% retroauricular subcutaneous emphysema, wound seroma in 2.05% and in another type of complication (transient facial paresis, etc.) 2.2%. The average time that passed between surgery and the appearance of these complications was 6.66 months, with a range of 0 to 60 months. These complications were resolved without resorting to another surgical intervention or hospitalization. They required ambulatory cures, pharmacological treatment or the revision of the programming of the cochlear implant.

Serious complications caused by a failure of an internal component of the cochlear implant: Failure of the implanted device occurred in 3.07% of the total number of the cases included in this study, with a post-implantation follow-up that ranged from 1 to 15 years. In all the cases a re-implantation was carried out.

Minor complications caused by a failure of an external component of the cochlear implant: In this case only the population of 399 patients implanted in the University Clinic of Navarra was evaluated. This group includes both children and adults, monitored over a period of 4 years, between 2000 and 2004. During this time 113 (28.32%) of them experienced some failure in one of the external components of the implant. In 23.9% the failure affected the microphone, in 24.8% the processor, in 5.3% the transmitter coil, in 44.2% the cables that link the processor to the transmitter coil or to the microphone (in the case of the body processors) and in 1.8% the protective frame of the processor. All of these failures were repaired by the maintenance services of the different suppliers of cochlear implants.

4. Evaluation of the direct and indirect costs of the implanted system

Tables 1 and 2 show an evaluation of the direct and indirect costs of the different phases of the implantation process. These include selection, surgery, programming, rehabilitation and follow-up. This evaluation was made for both the adult and the child populations.

5. Determination of the factors that affect clinical prognosis and economic cost.

Not all the patients who receive a cochlear implant achieve the same results. There is a series of factors that affect clinical evolution subsequent to implantation. Awareness of these factors is fundamental in order to inform and orient patients and their families adequately on post-implantation evolution, to establish appropriate guidelines for rehabilitation and follow-up, and to analyze questions related to the cost-benefit of this technique.

The prognostic factors can be grouped into the following categories:

- Factors dependent on technology.
- Factors dependent on the implanted patient.
- Factors dependent on the quality of the device implanted.

Considering the different variables or factors analyzed in this project, included in the data collection sheets of the different annexes, the following proved to have a significant prognostic value:

- Duration of hearing loss. What is understood by this factor is the time that transpires between the onset of hearing loss and the time of implantation. This factor had significant influence on both the pre- and post-lingual populations, though in the first group the time of auditory privation was more critical than in the second. Figure 11 shows a study of the correlation between the age at implantation and the results obtained by the prelingual population after 5 years of follow-up. We should point out that when this population group is analyzed, the age at implantation practically coincides with the time of duration of the hearing loss.
### Table 1: Evaluation of the costs in adults (euros)

<table>
<thead>
<tr>
<th>1. Selection</th>
<th>Cost (€)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORL consultation</td>
<td>180</td>
</tr>
<tr>
<td>Pure-tone audiometry</td>
<td>102</td>
</tr>
<tr>
<td>Vocal Audiometry</td>
<td>74</td>
</tr>
<tr>
<td>Tympanogram</td>
<td>41</td>
</tr>
<tr>
<td>Otoacoustic emissions</td>
<td>76</td>
</tr>
<tr>
<td>Auditory evoked potentials</td>
<td>210</td>
</tr>
<tr>
<td>Review of adaptation of hearing aids</td>
<td>205</td>
</tr>
<tr>
<td>Lip-reading test</td>
<td>47</td>
</tr>
<tr>
<td>Language tests</td>
<td>90</td>
</tr>
<tr>
<td>Cranial CT</td>
<td>350</td>
</tr>
<tr>
<td>Inter-consultation Psychiatry Department</td>
<td>70</td>
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<tr>
<td>Inter-consultation Anesthesiology Department</td>
<td>64</td>
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<tr>
<td>Preoperative tests</td>
<td>297.5</td>
</tr>
<tr>
<td>Anti-pneumococcal vaccination, one dose of Pneumovax or PNU-immune</td>
<td>23</td>
</tr>
<tr>
<td>2. Surgery</td>
<td>Cost (€)</td>
</tr>
<tr>
<td>Device implanted</td>
<td>24641</td>
</tr>
<tr>
<td>Surgery, anesthesia, operating room, hospitalization (48-72 h)</td>
<td>4500</td>
</tr>
<tr>
<td>3. Programming of the CI</td>
<td>1400</td>
</tr>
<tr>
<td>4. Rehabilitation: This refers to the logopedic support received during the process of programming the CI</td>
<td>2500</td>
</tr>
<tr>
<td>5. Follow-up</td>
<td></td>
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<tr>
<td>• At one month:</td>
<td></td>
</tr>
<tr>
<td>- Pure-tone audiometry</td>
<td>102</td>
</tr>
<tr>
<td>- Revision of CI programming</td>
<td>116</td>
</tr>
<tr>
<td>• At three months:</td>
<td></td>
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<tr>
<td>- Pure-tone audiometry</td>
<td>102</td>
</tr>
<tr>
<td>- Revision of CI programming</td>
<td>116</td>
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<tr>
<td>• At six months:</td>
<td></td>
</tr>
<tr>
<td>- Audiological test</td>
<td>129</td>
</tr>
<tr>
<td>- Revision of CI programming</td>
<td>116</td>
</tr>
<tr>
<td>• At one year:</td>
<td></td>
</tr>
<tr>
<td>- Audiological tests</td>
<td>129</td>
</tr>
<tr>
<td>- Revision of CI programming</td>
<td>116</td>
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<tr>
<td>Total partial first year</td>
<td>926</td>
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<tr>
<td>• One annual revision:</td>
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<tr>
<td>- Audiological tests</td>
<td>129</td>
</tr>
<tr>
<td>- Revision of CI programming</td>
<td>116</td>
</tr>
<tr>
<td>- cost of annual revision</td>
<td>245</td>
</tr>
<tr>
<td>- Average time of follow-up 25-30 years (4, 5): Cost calculated: 245X1.0325 = 512.05</td>
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</tr>
<tr>
<td>Batteries</td>
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<td>- daily cost</td>
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<td>- consumption: 365 per year</td>
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</tr>
<tr>
<td>- Average time of follow-up 25-30 years (4, 5): Cost de (365X1.0325)^* to (365X1.0330)^*</td>
<td>764-885</td>
</tr>
<tr>
<td>Spare parts</td>
<td></td>
</tr>
<tr>
<td>- Cables:</td>
<td></td>
</tr>
<tr>
<td>- cost/unit</td>
<td>45</td>
</tr>
<tr>
<td>- consumption: 1 per year</td>
<td></td>
</tr>
<tr>
<td>- average time of follow-up 25-30 years (4, 5) Cost of (45X1.0325)^* to (45X1.0330)^*</td>
<td>94-109</td>
</tr>
<tr>
<td>*Application of an annual update rate of 3%</td>
<td></td>
</tr>
<tr>
<td>Total cost in adults:</td>
<td>36912.94-37048.94</td>
</tr>
</tbody>
</table>
Table 2: Evaluation of the costs in children (euros)

<table>
<thead>
<tr>
<th>1. Selection</th>
<th>180</th>
</tr>
</thead>
<tbody>
<tr>
<td>ORL Consultation</td>
<td>180</td>
</tr>
<tr>
<td>Audiometric tests</td>
<td>503</td>
</tr>
<tr>
<td>Language tests (&gt;3 years)</td>
<td>43.5</td>
</tr>
<tr>
<td>Cranial CT</td>
<td>350</td>
</tr>
<tr>
<td>Anesthesia to carry out petrous bone CT</td>
<td>175</td>
</tr>
<tr>
<td>Consultation with Neuropediatrics Department</td>
<td>63</td>
</tr>
<tr>
<td>Consultation with Anesthesiology Department</td>
<td>64</td>
</tr>
<tr>
<td>Preoperative tests</td>
<td>297.5</td>
</tr>
<tr>
<td>Vaccination:</td>
<td></td>
</tr>
<tr>
<td>• Anti-Haemophilus influenza/dose (In non-vaccinated patients)</td>
<td>16</td>
</tr>
<tr>
<td>- From 6 to 12 months of age: 3 doses of vaccine</td>
<td>48</td>
</tr>
<tr>
<td>HibTITER</td>
<td>48</td>
</tr>
<tr>
<td>- From 1 to 5 years of age: 1 dose</td>
<td>16</td>
</tr>
<tr>
<td>Total cost of Anti-Haemophilus influenza</td>
<td>16-48</td>
</tr>
</tbody>
</table>

Antipneumococcal

1. In children between 2 months and 2 years of age:
Prevenar at 2, 4, 6 and 18 months: 78 euros X 4= 312
2. In children between 2 and 5 years of age
One dose of Prevenar | 78 |
Two months after Pneumovax 23 | 14 |
Total | 92 |
3. In children older than 5 years of age
One dose of Pneumovax 23 or PNU-immune | 23 |
Booster shot at 5 years (optional). Total cost of anti-pneumococcal drugs | 23-312 |

2. Surgery
Device implanted | 24641 |
Surgery, anesthesia, operating room, hospitalization (48-72 h) | 4500 |

3. CI programming
4. Rehabilitation (This refers to the logopedic support received during the programming process of the CI)

5. Follow-up
- Logopedic therapy in children implanted at ages younger than 5 years, for 5 years following implantation:
  - 2-3 weekly sessions of 30 minutes (Cost per session 16-20)
    - annual cost (50 weeks): from 1600 to 3000
    - average time of follow-up: 5 years. Total cost of (1600x1.035)* to (3000x1.035)* | 1854.8-3477.8 |
    - Logopedic therapy in children implanted over the age of 5 years, for 7 years post-implantation:
      - 3 weekly sessions of 30 minutes (Cost per session 16-20)
      - annual cost (50 weeks): from 1600 to 3000
      - total cost of (1600x1.037)* to (3000x1.037)* | 1967.8-3689.6 |
    - annual progress revision (audiometric tests, programming) | 245 |

Average follow-up:
- 12-15 years*: (245X1.0312)*-(245X1.0315)* | 349.3-381.7 |
- 17-20 years*: (245X1.0317)*-(245X1.0330)* | 1939.8-2119.7 |
- Batteries: daily cost 1/ annual cost: | 365 |
- average time of follow-up:
  - 12-15 years*: (365X1.0312)*-(365X1.0315)* | 520.4-568.6 |
  - 70-73 years*: (365X1.0370)*-(365X1.0373)* | 2890-3158 |
- Spare parts: Cables (Cost/unit 45. Average consumption 3/year): | 135/year |
- average time of follow-up 15 years (6, 7):
  Cost 135X1.0315 = | 210.3 |
  - average: 1 per year when they reach adulthood
  - average time of follow-up 55 years (7): 45X1.0355 = | 228.7 |
  - Applying an annual update rate of 3%

Total cost in children: 37698-44273
Figure 11. Correlation curves between results obtained in speech audiometry tests (Disyllables and CID Sentences) and age at implantation, corresponding to the group of patients with prelingual hearing loss. Note how the best results correspond to implantations carried out in the first years of life.

- State of the cochlea: worse results were seen in cases of congenital malformations or situations in which the obliteration of cochlear spaces determined the number of active electrodes used for stimulation (Figure 12).

- Stimulation strategy: in the post-lingual population, the more advanced strategies such as ACE and CIS offered better results than initial strategies such as MPEAK and SPEAK (Figure 13).

Figure 12. Speech audiometry results for Disyllables and CID Sentences, in post-lingual implanted patients, in relation to the degree of cochlear ossification.
Figure 13. Speech audiometry results for Disyllables and CID Sentences, in post-lingual implanted subjects, in relation to the type of stimulation strategy used in the cochlear implant.

**DISCUSSION**

**Evaluation of the results in the area of communication**

Hearing loss can be classified according to diverse criteria. Amongst these we should highlight the intensity of the hearing loss, the location of the lesion responsible for the hearing loss, and the time of onset of the same, both from a chronological point of view and in relation to the period of acquisition of language. With respect to this criteria we must distinguish between: prelingual hearing loss, which occurs before the appearance of language (0 to 2 years), perilingual, which appears between 2 and 4 years of age, and post-lingual hearing loss, which occurs after fundamental linguistic acquisition has been consolidated. Cases of prelingual and perilingual hearing loss, when they are bilateral and of severe or profound intensity, interfere with or impede the development of language. The insertion of a cochlear implant in one or another of these three phases will have a clear influence on the results. This is why the results of the two main populations, post and prelingual subjects, will be considered separately.

**Results in post-lingual implanted patients:** The clinical application of cochlear implants has been practiced since the end of the 80s, reaching a greater diffusion in the last 15 years. Since the beginning, one of the principal population groups treated with cochlear implants has been that with post-lingual hearing loss. The auditory results obtained by this group of patients has always been of great interest, given that, on the whole, their prior auditory experience has allowed them to reach high-level results in short periods of time. Furthermore, they are able to offer comparisons between their hearing with the implant and that perceived before the onset of hearing loss.

The results achieved by this group are highly satisfactory. In all open-set and closed-set tests a rapid and favorable evolution is observed in the first six months post-implantation (Figure 1), with statistically significant differences in relation to the initial situation. This tendency continues to be observed as the time of evolution is prolonged, reaching, on the whole, stable levels two years after implantation. In some way this data supports the existence of an auditory memory in post-lingual implanted patient, which allows them, in a relatively short period of time, to recognize the spoken word through the implant. On the other hand, it is logical to think that the speed with which the spoken message is understood is also due to the similitude between that emitted by the human voice and that perceived through the cochlear implant.

While variations can be observed from one patient to another, the results obtained in the open-set tests of sentences without the help of lip-reading or other visual clues are especially significant. This data demonstrates that these implanted patients are capable of understanding an average of 70% of words in an open
context without any kind of visual aid, even being able to use the telephone, in approximately 60% of cases.

However, it is interesting to point out the great dispersion of results that can be seen in the tests carried out in an open context, as is the case of the Disyllables test and the CID Sentences test without help. The existence of determined factors influences the prognosis. Some are related to the patient themselves (age at implantation, duration of hearing loss, state of the anatomy of the cochlea, functionality of the auditory canal, etc.), others with the development of implantation surgery (length of the insertion, absence of traumatism, etc.) and a final group relate to the properties of the device implanted and of the stimulation strategy that it can be programmed with.

In a post-lingual implanted population the duration of hearing loss, or period of time that transpired between the patient’s acquiring profound hearing loss and the time of implantation, lacks importance as an absolute individual value but is important when correlated with the age of the patient. Thus we concur with other authors14,15 in affirming that those patients whose deafness has lasted for more than 60% of their lives show a worse evolution. Let’s look at one example.

Theoretically, the prognosis is better in a person of 60 years of age who has been deaf for 15 years than that of a young person of 20 with a hearing loss acquired at the age of five.

There is a significant negative correlation between the age at implantation in post-lingual subjects and the results obtained in the CID Sentences test without visual clues/lip-reading, in such a way that when implantation is carried out in older subjects the results tend to be worse in this speech audiometry test. These results were also observed by Geier15, but as we indicated in the previous paragraph, both factors, age at implantation and duration of hearing loss, must be considered simultaneously.

In no way does this fact signify that age constitutes a contraindication for elderly candidates with post-lingual deafness. We believe that the degenerative changes related to aging do not determine the ability of these candidates to achieve satisfactory results after implantation, as demonstrated by the results presented by Butts16, who reports on how a group of 27 post-lingual implanted subjects over the age of 65 achieved 62% of correct responses in the CID Sentences test and 30% in the NU-6 word test (Northwestern University Auditory Test 6). Horn17 also, in a study based on the marks recorded in a questionnaire, indicates that 89% of the people implanted over the age of 65 years had experienced an improvement in their quality of life.

Other factors such as sex, etiology of the hearing loss, its form of onset or the prior use of hearing aids, did not influence the results achieved with a cochlear implant. With respect to the patient’s degree of motivation and that of their family and social group, it is difficult to quantify how much importance they have. In a general sense it can be affirmed that a positive attitude towards cochlear implantation, demonstrated by the will to get maximum benefit from the implant, plays an important role in evolution.

In general terms, the results obtained by post-lingual patients, both children and adults18, are favorable. They are capable of recognizing a large number of environmental sounds, of controlling the use of the voice, of increasing their understanding of the spoken word, even of managing, without the use of lip-reading, to maintain an interactive conversation. All of this makes the patients feel safer and more independent, thus improving their integration in their familial, social and occupational environment.

Results in prelingual children with respect to their age at implantation: The comprehensive evaluation of the long-term results achieved with cochlear implants in an infant population of 6 years-old or younger, reveals that the majority of the children are capable of recognizing the spoken word in an open context without the visual support of lip-reading or gestures19-22 (Figures 2-4). The results also suggest that children implanted earlier, before the age of three, have a greater possibility of achieving said capacities and obtaining a greater development of spoken language23-27. Nevertheless, it is essential to take into account that, the further the age at implantation is from the critical auditory period constituted, approximately, by the first five or six years of life - the more important individual variations derived from medical factors and from the educational and rehabilitative attention that the child receives after implantation can be seen in the results. This critical period of time corresponds to the moment in which the central nervous system, in its areas of auditory representation, has the greatest capacity to vary its pattern of development in accordance with the auditory stimuli that come from the outside world. Other studies made by different authors coincide in pointing out this important fact, according to which the results tend to be significantly better when the implantation is carried out before the age of 5-6 years28,29.

The poor results obtained in the Disyllable test and CID Sentences test without lip-reading/visual clues by the prelingual patients implanted after the age of six years, demonstrate, not only that the duration of this period of greatest auditory neural plasticity corresponds to the first six years of life, but that the introduction of an auditory stimulus after this time has passed can not compensate for the loss of neuronal plasticity provoked by the absence of stimulation during this critical period of infancy. This clinical data was corroborated by the
experimental results of Born and Rubel\textsuperscript{30} and Leake\textsuperscript{31}, which affirm that the application of an electrical stimulus and its maintenance in very early phases, from the time of onset of the privation auditory, is capable of preventing the changes that occur in the different neurons that integrate the auditory canal, but this is no longer the case in later phases, where no reversibility is shown on reintroducing electrical stimulation.

Within this critical auditory period, located in the first six years of life, the comparison between the subgroups implanted between 0-3 years and 4-6 years of age, in all the tests used\textsuperscript{32}, shows that evolution is more rapid and better results are achieved in the subgroup of children implanted at an earlier age.

With regard to the development of language, in short we can say that prelingual children implanted early on pass through the same phases, and at the same times, as normal-hearing children. Therefore, these children are capable of using complex structures and have quantitatively and qualitatively excellent articulation. A greater tendency to learn words and daily phrases spontaneously is produced in these children, generating a natural abandonment of support from gestures and lip-reading in communication. The results obtained in the Reynell scales (Figure 8) are congruent with these affirmations and highlight the close relationship that also exists between age at implantation and the development of oral language\textsuperscript{33-35}.

The excellent results achieved by the youngest group of patients implanted (0-3 years old), which exceed even those of the post-lingual patients implanted before the age of 60, in the same Disyllable test and CID Sentences without visual clues or lip-reading, as does the magnificent development of oral language reported by diverse authors\textsuperscript{36-38}, reveal the capacity that these children have to integrate themselves, fully and satisfactorily, in an oral social environment, as long as stimulation is introduced during their first years of life. All of this corroborates the existence of a critical auditory period, which basically extends over the course of the first six years of life, with a period of excellent plasticity in the first three years\textsuperscript{39}.

Evaluation of the impact of cochlear implants on health-related quality of life

The results of the questionnaires used in this paper demonstrate the significant degree of satisfaction experienced by patients who have received a cochlear implantation. In their turn, they also reveal the limitations that these patients continue to experience in determined conditions of life. In contrast to the excellent results obtained in the perception of speech in quiet environments, with an interlocutor situated nearby, we can see the limitations from which the patients suffer in noisy environments, in conversation with several interlocutors, or when their interlocutor is at a distance from them. We consider that these limitations, apart from having their origin in the technological development of the implants itself, and in the functional state of the auditory canal and centers, also relates to the innate limitations of the auditory system in the presence of adverse acoustic situations and especially the lack of binaural stimulation that a patient implanted in only one ear has. It is logical to think that some of these indicators offer better results in those patients implanted in both ears.

In the analysis of the GBI we must highlight the fact that the majority of patients consider that their state of mind and their degree of incorporation into social life has improved since implantation. What can also be seen in the responses of the patients is that the cochlear implant has not had any negative effect on their general state of health, nor affected, therefore, any other system of their organism. Similarly, it can be concluded from another set of questions that family members and friends have not had to provide more support subsequent to the subject’s implantation.

Evaluation of the medical complications and of the technical failures of the system

The percentage of serious medical/surgical complications reached a percentage of 3.42% - a figure slightly lower than that of 3.85% reported by Roland in a population of 10,004 adult and child users of cochlear implants\textsuperscript{40}.

Minor medical/surgical complications were seen in 7.06% of the patients, a percentage also slightly lower than the 8.76% reported by Roland\textsuperscript{40}. Just as in Roland’s experience, these types of complications were transitory and were resolved by means of medical treatments or the reprogramming of the cochlear implant, admission to hospital not being necessary in any case.

3.07% of the cochlear implants needed to be replaced due to a technical failure of their internal components. This percentage coincides with the data communicated by the Cochlear Company\textsuperscript{41,42}. The comparison with this source is established on registering that 85.1% of the implants inserted in our population belonged to this company. In all the cases the re-implantations were carried out without significant complications.

With respect to failures of the external components of the cochlear implant we must point out that this number was substantially greater. While these failures have no implications on the health of the patients, they nevertheless must be taken into account in terms of cost-benefit and also indicate the importance of follow-
up and maintenance of the equipment in order to
sustain high levels of efficiency over the course of time.

In brief, we can say that in isolation, the stimulation
of the facial nerve is the most frequently reported
complication and in the majority of cases it is resolved
by the implant being re-programmed. Problems with
the cutaneous-muscular-periosteal flap are the cause of
the greatest percentage of complications, including both
serious and minor complications. With respect to the
most feared complications, the lesion of the facial nerve
is uncommon and usually transitory, while meningitis is
a truly exceptional postoperative complication. Although the devices implanted at the present time
have adequate safety and biotolerance characteristics,
they can present failures that require ex-plantation in
between 1 and 3% of cases. The improvements made in
both the implantation technique and in the devices
themselves allow for the minimization of the number of
cases of other complications, such as the migration
of the electrodes or inappropriate insertion.

It can be concluded that the different studies carried
out and the clinical experience with adults and children
shared in this paper indicate that cochlear implants
constitute a system that is both biologically safe and
suitable for application in the general population.

**Evaluation of the direct and indirect costs of the implanted system**

As is learned from a document published by the
Carlos III Health Institute in the year 2004, we currently
have at our disposal cost-utility studies of cochlear
implants that afford a perspective on this subject in
several countries. These studies have evaluated multiple
attributes of quality of life and state of health in order to
determine the utility obtained from cochlear implants.
The exact results of the cost-utility of the different
studies are variable, probably due to differences in the
methods used to value benefit, the level of benefit truly
obtained, and the differences in the costs associated
with the intervention. These valuations consistently
indicate that multichannel cochlear implants occupy a
highly favorable position in terms of their performance,
in comparison with other medical and surgical interventions used in the US

British studies have been carried out by researchers
dependent on the government, academic or industrial
centers. Hutton et al. (1995) identified an increase in
quality of life of 0.60 to 0.70 in children with cochlear
implants. This gain combined with the estimated direct
costs of the implantation of 59,343 £ (94,949 US$)
resulted in a cost-effectiveness of £16,214 /QALY
(US$25,942 /QALY). If the indirect costs and savings
derived from education and special equipment were
included, these authors found net savings of £15,906
(US$25,450), afforded by cochlear implantation. Summerfield et al. (1995) reported similar direct costs
for the children in the national cochlear implant
program of the United Kingdom. A gain in utility of
0.23 was determined, represented by the empirical
results that the authors had obtained in a study carried
out on adults that used a simple visual scale of
usefulness. These authors concluded that the resulting
cost-utility ratio fell within the range considered as
acceptable in the British Health Service.

The data provided in this paper on the direct and
indirect costs of a program of cochlear implants may be
essential when planning cost-benefit studies in our field,
as well as for establishing any type of calculation with
respect to this matter.

**Determination of the factors that affect clinical prognosis and
economic cost**

The importance of the duration of hearing loss and
the age at implantation on analyzing the results
obtained after a cochlear implantation has already been
emphasized. We will not continue to stress this point,
but will direct our attention to the impact that other
factors have on the clinical evolution subsequent to the
insertion of a cochlear implant.

**Cochlear ossification**

Ossification-obliteration of the different cochlear
scalae not only conditions a greater or lesser length in
the insertion of the electrode carrier, but also the
potential existence of alteration in the cochlear neural
population.

In the population studied we found different
degrees of cochlear ossification in patients with
antecedents of bacterial meningitis, chronic or recurrent
infection of the middle ear and otosclerosis. Except in
two cases, it was surgically possible to reach insertion
depths that permitted the intracochlear accommodation
of more than 18 rings (27.19 on average, of a total of 32
rings in the Nucleus 22 or 24M system). The auditory
results were poorer when there was a cochlear
ossification of more than 4 millimeters, from the level of
the round window (Figure 12). All of this points, as
indicated by other authors, to the fact that the
existence of cochlear ossification has a potentially
negative effect on post-implantation evolution, on
limiting the insertion of electrodes and altering the
normal state of the neural population of the cochlea.

**Malformation of the inner ear**

Congenital malformations of the inner ear are
present in approximately 20% of patients with
congenital sensorineural hearing loss. These may suffer
from hearing loss with wide ranges in intensity, from a level of hearing close to normal to total hearing loss. Patients with profound hearing loss associated with all types of malformation, excluding the most severe, can benefit from cochlear implantation. Nevertheless, it must be considered that each type of malformation, depending on its severity, presents different surgical implications that will be reviewed below.

Cochlear implantation can be carried out successfully in selected cases of cochleas with congenital malformation. Complete bilateral cochlear aplasia and the absence of both auditory nerves continue to be absolute contraindications for implantation. The traditional transmastoidal approach of the facial recess can be modified to accommodate anatomical abnormalities. The surgeon must be prepared to resolve situations involving the abnormal trajectory of the facial nerve and of cerebrospinal fluid fistula. Intraoperative monitoring of the facial nerve must be carried out in all cases. The results expected in implanted patients with minor cochlear malformation are similar to those expected in patients with similar preoperative clinical characteristics and with a normal anatomy of the inner ear. However, the prognosis is less favorable in those cases of severe malformation cochlear, with incomplete insertions of the electrodes of the cochlear implant.

Other abnormalities associated with hearing loss

There is a relatively common association between profound bilateral sensorineural hearing loss and associated deficiencies of diverse types such as sensorineural abnormalities, motor disorders, systemic diseases, etc. In fact, the prevalence of associated defects in children with hearing loss ranges between 21% and 30% in the general school population. In 8-10% of the cases there are two or more associated deficiencies. Furthermore, the associated defect is some three times more common in patients with hearing loss than in the general school population.

Children with hearing loss and associated multiple deficiencies, constitute a group that is characterized by its heterogeneity and by the presence of a wide range of intellectual, physical, social, emotional and sensory needs. Due to the presence of these deficiencies, these patients may need special support in the programming and rehabilitation processes. For this reason, implantation in this group of patients constitutes an authentic challenge for the teams dedicated to the insertion of cochlear implants, and their handling may require a multidisciplinary focus. In this sense, it is useful to have professionals with experience in the rehabilitation of the associated deficiencies that these patients suffer from on the team dedicated to the insertion of cochlear implants.

From a review of the experiences published in the bibliography, a series of interesting conclusions can be drawn. Although the development of hearing and of oral language is not so rapid or favorable in these children as that of children without associated deficiencies, they nevertheless do obtain a clear benefit from the insertion of a CI. Apart from increasing their communicative abilities, it also improves their social interaction and, in general, their connection with their surroundings. Unfortunately, the capacity to measure progress objectively in these areas is limited, but it is something that is observed in daily life. In this sense, the capacity to offer a child a greater connection with their environment, a matter in which they would otherwise be limited, is already an achievement, even when good results are not immediately observed in the audiometric tests. Children manage to optimize their abilities and, therefore, there are reasons to believe that their development will continue to progress thanks to the auditory stimulation afforded by the cochlear implant. This progression in the acquisition of auditory and linguistic abilities is slower than in implanted children without other associated deficiencies. For this reason, these authors recommend widening the criteria for cochlear implantation to include candidates with plurideficiencies.

CONCLUSIONS

The data collected shows that cochlear implants clearly benefit the communicative capacity of implanted patients, especially when their insertion is carried out at an early age. The results observed in the prelingual population justify the creation of early hearing-loss detection programs in newborns.

Through questionnaires, the post-lingual adult patients who had received a cochlear implant showed themselves to be satisfied with the results obtained, although they do perceive limitations, especially in situations in which they do perceive limitations, especially in situations in which they do perceive limitations, especially in situations in which they do perceive limitations, especially in situations in which they do perceive limitations.

An analysis is shown of the direct and indirect costs related to the different phases that structure a cochlear implantation program; this could be useful to the carrying out of cost-benefit studies in our field.

The low incidence of complications observed, as well as the nature of the same, demonstrates that the technique of treatment with cochlear implantation falls within adequate safety margins.

The individual evaluation of each patient is necessary when it comes to establishing the prognosis of a cochlear implantation. Amongst the factors of greatest influence on evolution are the time of duration of auditory privation, age at implantation, the morphology of the cochlea and the functional state of the auditory
canal, the degree of motivation of the patient and their relatives, and the coexistence of other, associated, disabilities.

References


42. Von Wallenberg EL, Brinch J. Long term reliability of Nucleus Cochlear Implants. 5th European Symposium on Paediatric Cochlear Implantation; Antwerp 2000, June 4-7.


