Development of Spoken Language Grammar Following Cochlear Implantation in Prelingually Deaf Children

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Objectives: To assess the development of grammar comprehension in spoken language in prelingually deaf children following cochlear implantation and compare their grammatical abilities with those of their hearing peers.

Design: A prospective study of 82 consecutive prelingually deaf children up to 5 years following implantation. The children were less than 7 years old at the time of implantation (mean age ± SD, 4.2 ± 1.3 years). All received the same multichannel cochlear implant system. No child was lost to follow-up and there were no exclusions from the study.

Setting: Tertiary referral cochlear implant center.

Methods: The children were assessed using the Test for Reception of Grammar. This individually administered, multiple-choice test designed to assess the understanding of grammatical contrasts in the English language also allows direct comparison of grammar comprehension between test subjects and their normal-hearing peers.

Results: Before implantation, only a small proportion (2%) of prelingually deaf children were above the first percentile of their normal-hearing peers. This percentage increased to 40% and 67%, respectively, 3 and 5 years after implantation; and 5 years after implantation, 20% of the children performed between the 25th and the 75th percentile or better. In the subgroup of children who received their cochlear device before the age of 4 years, this percentage reached 36%.

Conclusions: Spoken language grammar acquisition in prelingually deaf children with a cochlear implant was found to be considerably delayed. However, there was a clear trend toward the development of grammar skills following cochlear implantation, and the greatest advance was made by children who received their implant at a younger age. These findings support the present trend toward early implantation.


Children with profound congenital or prelingual deafness have been shown to experience substantial delays in their mastery of all aspects of the spoken language.1,2 When hearing aids provide little or no benefit, cochlear implants seem to provide oral access to language.3 Because the acquisition of spoken language by young deaf children is a lengthy process, measuring outcomes in those with implants requires time. Hence, the results of research on spoken language acquisition by these children are just emerging. Preliminary data suggest that they have better spoken language skills than if they had not received implants.4-6

But what about grammar and its development? Grammar in spoken language is the regulative system by which relations are established between particular sound systems, sound sequences, rules of syntax, and the associated meanings of sound sequences. Grammar may be regarded as a set of rules that describes how the realm of sound is related to the realm of meaning. For example, everybody knows the difference between “cats running after dogs” and “dogs running after cats,” and that “after running cats dogs” is meaningless. Grammar is so important that language can be regarded as the product of grammar.7 Language competence can be said to be dependent on the development of grammatical understanding.8 Even in normal-hearing children grammar acquisition is a lengthy process, and many may not master the more complex linguistic structures until the ages of 10 or 11 years.9 Those who acquire language later than usual are likely to be at a disadvantage with regard to the development of grammatical competence, which can restrict the later acquisition of reading and writing,10 so critical to the development of a child’s educational potential. In spite of its importance, the literature on grammar comprehension in children with cochlear implants is limited.
This prospective study involved 82 children who received the same pediatric cochlear implant through the same program. All were profoundly deaf (unaided thresholds ≥103 dB at 2000 and 4000 Hz) and received the Nucleus (Cochlear, Lane Cove, Australia) multichannel implant system; speech-encoding strategies were upgraded as new programs became available. The children were referred from all over the country and represented a full range of social, communication, and educational environments. All were prelingually deaf (age at onset of deafness <3 years and age at implantation <7 years). Forty-two (51%) were congenitally deaf, and 33 (40%) had been deafened by meningitis and 7 (9%) from other causes. Only children who did not have a known disability or learning difficulty and whose primary language was English were included. Of the 82, 43 (48%) were boys and 39 (52%) girls. Of the 82, 30 had reached the age of 4 years and were thus within the age limits (4-13 years) appropriate for TROG. The remaining 38 children were younger than 4 years and therefore could not be tested. At the 3-year interval all 82 children had reached the required age and were assessed using the TROG percentiles. Of the 82 children in the study, 30 had reached the 5-year interval at the time of the study and, prospectively, 3 years following implantation. None were lost to follow-up 3 years following implantation. Moreover, 30 of the 82 children had reached the 5-year interval at the time of the study and their TROG data were investigated as well.

### METHODS

The test is based on the scores of normal-hearing children. Data are given as numbers or number (percentage).

The aim of this study was to assess the development of spoken language grammar comprehension by prelingually deaf children following cochlear implantation, and to compare their grammatical abilities with those of their normal-hearing peers. We focused on the grammatical development of spoken English, rather than that of sign language, because one of the major aims of cochlear implantation is to give profoundly deaf children access to spoken language through hearing restoration.

**Table 1. Test for Reception of Grammar (TROG) Percentile Distribution of Children With a Cochlear Implant**

<table>
<thead>
<tr>
<th>Study Children</th>
<th>Children Within the Age Limits for TROG</th>
<th>Children Scoring Below the 1st Percentile</th>
<th>Children Scoring Between the 1st and 25th Percentiles</th>
<th>Children Scoring Between the 25th and 75th Percentiles</th>
<th>Children Scoring Between the 75th and 100th Percentiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before implantation</td>
<td>82</td>
<td>44</td>
<td>43 (98)</td>
<td>1 (2)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>At 3 years</td>
<td>82</td>
<td>82</td>
<td>49 (60)</td>
<td>27 (33)</td>
<td>3 (3.5)</td>
</tr>
<tr>
<td>At 5 years</td>
<td>30</td>
<td>30</td>
<td>10 (33)</td>
<td>14 (47)</td>
<td>5 (17)</td>
</tr>
</tbody>
</table>

*The test is based on the scores of normal-hearing children. Data are given as numbers or number (percentage).*

The results of TROG percentiles are shown in Table 1. Before implantation, 44 of the 82 children had reached the age of 4 years and were thus within the age limits (4-13 years) appropriate for TROG. The remaining 38 children were younger than 4 years and therefore could not be tested. At the 3-year interval all 82 children had reached the required age and were assessed using the TROG percentiles. Of the 82 children in the study, 30 had reached the 5-year postimplantation interval and all of them were within the required age limits for TROG percentiles. The results revealed that, before implantation, only 1 child (2%) scored above the lowest percentile of normal-hearing peers. This percentage increased to 40% (33/82) and 67% (20/30) 3 and 5 years following implantation (Table 1).

To investigate the effect of age at implantation on grammar comprehension, the children were divided into...
Table 2. Test for Reception of Grammar (TROG) Percentile Distribution of Children Who Received a Cochlear Implant After the Age of 4 Years*

<table>
<thead>
<tr>
<th>Study Children</th>
<th>Children Within the Age Limits for TROG</th>
<th>Children Scoring Below the 1st Percentile</th>
<th>Children Scoring Between the 1st and 25th Percentiles</th>
<th>Children Scoring Between the 25th and 75th Percentiles</th>
<th>Children Scoring Between the 75th and 100th Percentiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before implantation</td>
<td>44</td>
<td>43 (98)</td>
<td>1 (2)</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>At 3 years</td>
<td>44</td>
<td>34 (77)</td>
<td>9 (21)</td>
<td>1 (2)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>At 5 years</td>
<td>16</td>
<td>8 (50)</td>
<td>7 (44)</td>
<td>1 (6)</td>
<td>0 (0)</td>
</tr>
</tbody>
</table>

*The test is based on the scores of normal-hearing children. Data are given as numbers or number (percentage).

Figure 1. Performance of children with cochlear implants who were older than 4 years regarding the comprehension of the grammar of spoken language (Test for Reception of Grammar results) compared with their normal-hearing peers.

Figure 2. Performance of children with cochlear implants who were younger than 4 years regarding the comprehension of the grammar of spoken language (Test for Reception of Grammar results) compared with their normal-hearing peers.

Language development is one of the most important outcomes of cochlear implantation for prelingually deaf children. Most of the research reported in the literature has evaluated speech perception or speech production skills. However, unless the child understands the grammar of the language, good perception and production skills are of little use. The ability to repeat intelligibly what is heard does not necessarily imply understanding or mastery of the language.

Hearing is essential in learning grammatical rules. For instance, a child who cannot hear the sound “ss” will not understand the use of the plural form. However, by enhancing speech perception, cochlear implantation has allowed children to develop their use of spoken language.

Studies addressing the language development of children with implants have used the Reynell Developmental Language Scales to assess improvement in language skills 6 and 12 months after implantation. However, these studies did not assess long-term language development and did not report specifically on the critical issue of grammar development. Svirsky et al found that the rate of language development after implantation exceeded that expected from deaf children without an implant and was similar to that of normal-hearing children. They included data collected up to 2½ years after implantation. Tomblin et al compared 29 children using a cochlear implant with 29 children who, although
candidates, had not received an implant. They used simultaneous communication, ie, 2 different modalities, oral and gestural. The assessment tool was the Index of Productive Syntax as a measure of expressive English grammar. They found that children with implants outperformed those without implants. However, the stories used varied, and children who were assessed with longer stories were more likely to obtain higher scores because they had more opportunities to use new grammatical tokens and types.

In this study identical test materials were presented in exactly the same order to all of the children to prevent scoring inconsistencies. Moreover, we used exclusively the spoken language modality, although this may have led to underestimate the overall grammatical achievements of the children. Preliminary work in our department showed encouraging results in the grammar development of deaf children with cochlear implants. However, it studied a mixed population of prelingually and postingually deaf children and did not take into account age at implantation. The present study of a homogeneous group of young prelingually deaf children with cochlear implants further explored the issue and investigated age at implantation as a factor. Moreover, using strict entry criteria, it followed up longitudinally specific groups of children—as shown in Figures 3, 4, and 5.

One limitation of TROG is that 38 of the 82 children in the present study could not be assessed before implantation because they were younger than 4 years. However, this limitation would occur with any grammatical test because of the difficulty of assessing grammar development in very young children. Moreover, most profoundly deaf young children without an implant who would be administered TROG in the spoken modality only would score below the lowest percentile of normal-hearing children. In addition, TROG compares the outcomes of the studied children with the standardized outcomes of normal-hearing children of the same age, and therefore allows direct comparisons at all intervals irrespective of the children's performance at previous intervals. Nevertheless, in the present study, the outcomes of children who received their implant after the age of 4 years (and who were thus within the required age limits at all intervals) were presented separately (Table 2 and Figures 1 and 4). This allowed for the investigation of age at implantation, which is a known determinant of cochlear implant outcomes, and verified that children who receive a cochlear implant before the age of 4 years perform closer to their normal-hearing peers than those who receive their implant later (Table 3 and Figures 2 and 5).

Assessing the effects of cochlear implant use on language development is difficult because some improvement occurs over time as a result of maturation, even without an implant. If deaf children wearing a cochlear implant catch up with their normal-hearing peers with regard to spoken language at preset intervals following implantation, it follows that the device enables them to use audition effectively. This reasoning is in agreement with

Table 3. Test for Reception of Grammar (TROG) Percentile Distribution of Children Who Received a Cochlear Implant Before the Age of 4 Years

<table>
<thead>
<tr>
<th>Study</th>
<th>Children Within the Age Limits for TROG</th>
<th>Children Scoring Below the 1st Percentiles</th>
<th>Children Scoring Between the 1st and 25th Percentiles</th>
<th>Children Scoring Between the 25th and 75th Percentiles</th>
<th>Children Scoring Between the 75th and 100th Percentiles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before implantation</td>
<td>38</td>
<td>0</td>
<td>15 (40)</td>
<td>18 (47)</td>
<td>2 (5)</td>
</tr>
<tr>
<td>Active at 3 years</td>
<td>38</td>
<td>38</td>
<td>15 (40)</td>
<td>18 (47)</td>
<td>2 (5)</td>
</tr>
<tr>
<td>Active at 5 years</td>
<td>14</td>
<td>14</td>
<td>2 (14)</td>
<td>7 (50)</td>
<td>4 (29)</td>
</tr>
</tbody>
</table>

*The test is based on the scores of normal-hearing children. Data are given as number or number (percentage).
Svirsky et al., who suggested that patterns of language development can be strongly affected by the acoustic input and with Geers et al., who found that cochlear implants have a dramatic impact on the linguistic competence of profoundly deaf children. However, the effect of maturation cannot be totally excluded.

Nevertheless, the studies that compare, with encouraging results, profoundly deaf children using implants with normal-hearing children may signal that the time has come to move from comparisons between deaf children using implants or hearing aids.

The present study showed that deaf children using implants got “closer” over time to normal-hearing children of the same age with regard to comprehension of grammar. Before implantation, only a few (2%) of the prelingually deaf children were above the lowest percentile of their normal-hearing peers. Five years after implantation, the proportion increased to 67% (Table 1). Furthermore, 36% of the young children using implants who reached this interval performed at a level similar to or better than that of a normal-hearing child of the same age. Although the progress of children with implants is evident, the results also indicate significant delays in spoken language development in the years following implantation. Szagun, after 2 interesting preliminary reports on language development in 2 children with implants, studied longitudinally 22 children following implantation. Ten of the children showed grammatical progress in spoken language at pace with normal-hearing children while 12 remained well behind. The latter children may require more intensive rehabilitation or continue to rely on sign language for everyday communication after implantation.

In conclusion, spoken language grammar acquisition in prelingually deaf children using cochlear implants was found to be considerably delayed. However, there was a distinct trend toward the development of grammar skills following implantation. Improvement was greatest in children who received an implant under the age of 4 years, and this finding supports the trend toward device implantation at a younger age if grammatical competence in spoken language is to be achieved.