# Comparison of Speech Perception Performance in Children Using a Cochlear Implant with Children Using Conventional Hearing Aids, Based on the Concept of "Equivalent Hearing Loss"

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## Introduction

Within the cooperating paediatric cochlear implant team Instituut voor Doven and the ENT department of University Hospital Nijmegen an auditory speech perception test battery was developed. The test incorporates subtests for a basal speech perception level as well as subtests for more complex levels, up to open set speech recognition. This in order to assess the performances of children with a wide range of auditory perception skills.

A problem of the use of such a broad range of subtests is that individual performance might be above chance level at one subtest and not at another, and this might change over time. This complicates the interpretation of the individual test results. Another problem is the mismatching that inevitably occurs when control groups are used for comparisons.

More straightforward quantifications are necessary to summarize the results obtained with such an elaborated test battery. For this reason a measure in terms of "equivalent hearing loss" was developed.

In this paper firstly the "equivalent hearing loss" concept will be discussed and secondly the performance of 17 children with a cochlear implant will be described based on this concept of equivalent hearing loss.

## The concept of equivalent hearing loss

The concept of equivalent hearing loss implies matching individual speech perception scores, with reference data based on the auditory speech perception performance of a group of hearing aid users. The matched speech perception performance is expressed in the equivalent hearing loss value.

*Subjects*

In order to obtain the equivalent hearing loss reference data, the "Gestel-Nijmegen test" was administered to a reference group of 47 severely and profoundly hearing impaired children that use well fitted conventional hearing aids. Their average hearing losses at 500, 1000 and 2000 Hz (the pure tone average) ranged from 70 to 135 dB. Their ages ranged from 4 to 8 years.

*Method*

The subtest scores of the children of the reference group were clustered into three composite scores that quantify the increasing complexity in auditory speech perception tasks; firstly a Basal Speech perception score (BS), consisting of the average of word- and vowel discrimination and suprasegmental word identification. Secondly a Word Identification score (WI) consisting of segmental word identification, monosyllable and spondee identification. Thirdly an

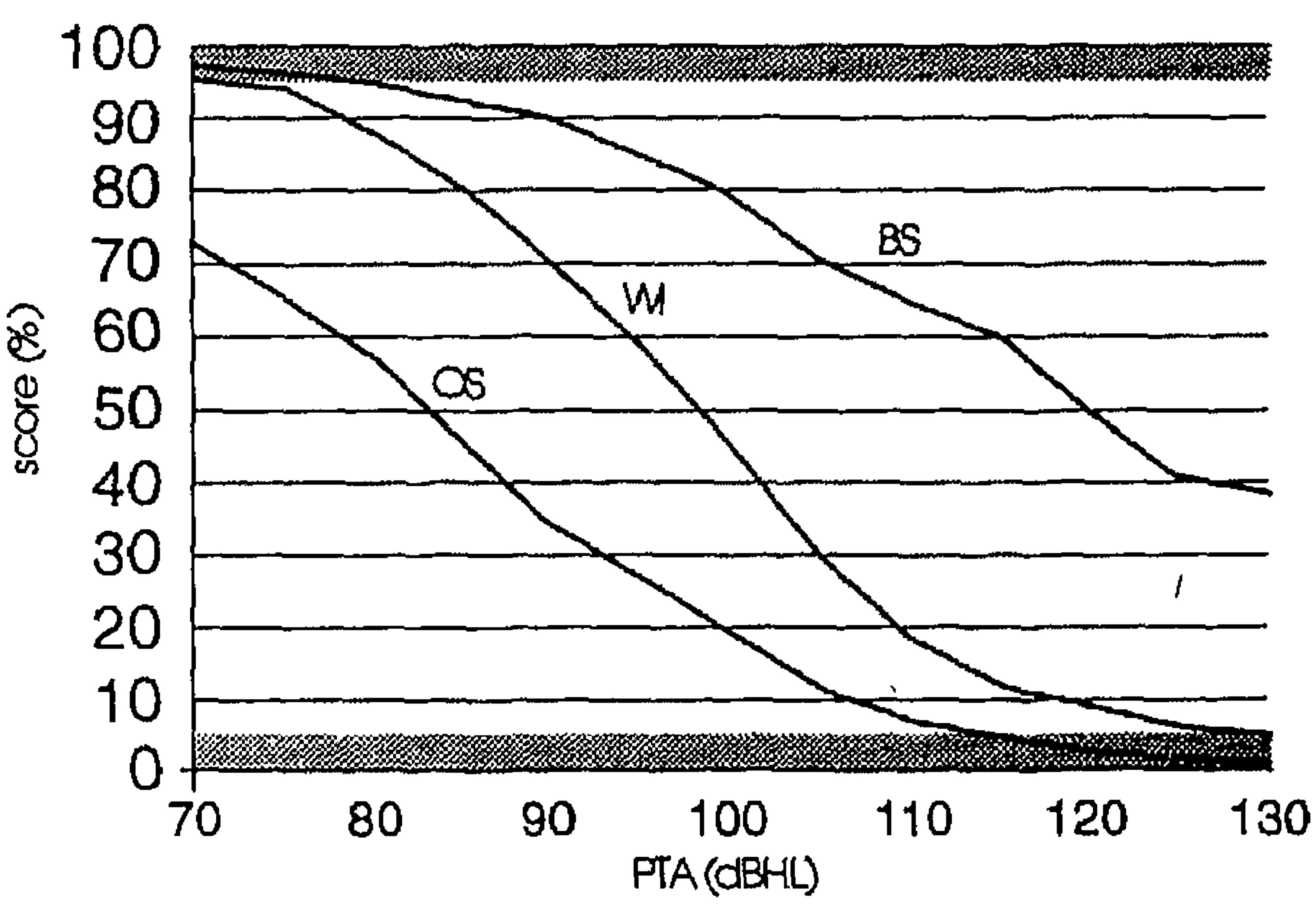


*Fig. 1.* Three composite reference scores as a function of hearing loss; BS: Basal speech perception, WI: Word Identification, OS: Open-set Speech recognition.

Open-set Speech recognition score (OS) consisting of the open set monosyllable recognition.

These three composite scores of all children of the reference group were computed and plotted as a function of the individual hearing loss. Next the best-fit curves (with a Probit analysis) were determined for the BS, WI and OS scores. In this way the scores of the reference group are expressed as a function of the degree of hearing loss, shown in Fig. 1. In order to derive equivalent hearing loss values from these reference data, the following procedure is used. Based on individual subtest scores (adjusted for chance level) the three composite scores have to be computed. Subsequently these have to be transformed backwards into an equivalent hearing loss value. For example, a BS perception score of 80% leads to a corresponding equivalent hearing loss value of 100 dB.

These curves were used in a study including 3 children with a cochlear implant. This study revealed that the equivalent hearing loss values derived from either the Basal Speech perception score, the Word Identification or the Open-set Speech recognition score were rather similar. That is, a child that obtained a Basal Speech perception score of 80 % (with an equivalent hearing loss value of 100 dB) would obtain a Word Identification and Open-set score with the same equivalent hearing loss value (50% and 15%). For that reason in this presentation the individual average equivalent hearing loss values are presented, referred to as "Overall equivalent hearing loss".

## Speech perception performance of 17 children using a CI

According to the method described, the speech perception development over time of 17 children that attend the paediatric cochlear implant programme of Instituut voor Doven and University Hospital Nijmegen will be discussed, expressed in terms of overall equivalent hearing loss.

*CI subjects*

The subjects all had become profoundly deaf before the age of three and the age at implantation was less than twelve. The group comprises 13 children who were deafened by meningitis. In three children, all deafened by meningitis, only a partial insertion of the electrode array had been possible (8 to 10 electrodes inserted), due to severe ossification of the cochlea. The group comprised 4 congenitally deaf children, who had both a longer duration of deafness and a higher age at implantation than the meningitis group. All children were using a Nucleus multi channel device with an MSP processor. The children were attending either schools for the hearing impaired, schools for the deaf or were mainstreamed. Some children attended schools that use total communication, others were in an oral setting.

*Method*

Assessment was done before implantation (with the use of conventional hearing aids) and at regular intervals up to 36 months after implantation. The "Gestel-Nijmegen speech perception test" was administered to all children. The composite test scores were computed as described and the Overall Equivalent Hearing Loss has been derived. These values were plotted as a function of the follow-up.

## Results

Fig. 2 shows the overall equivalent hearing loss values (on the vertical axis) of the meningitis group, with a full insertion of the electrode array. The horizontal axis shows the evaluations during follow-up (in years).

Before implantation, using conventional hearing aids, these children performed quite poor. The children obviously did not benefit from the use of conventional hearing aids. Within this group there is a trend towards an equivalent hearing loss of 70 to 80 dB after 2 or 3 years of implant use.

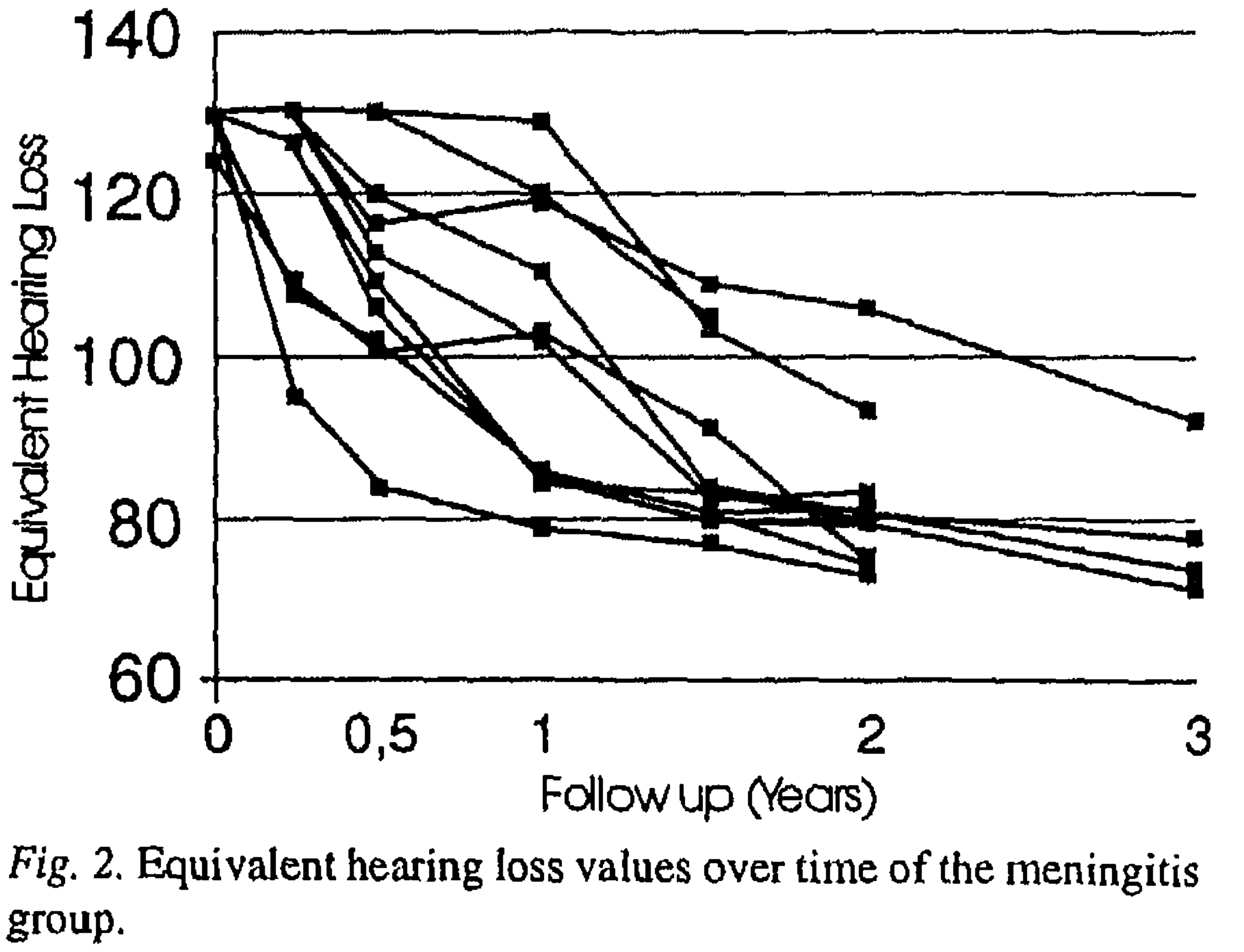


*Fig. 2.* Equivalent hearing loss values over time of the meningitis group.

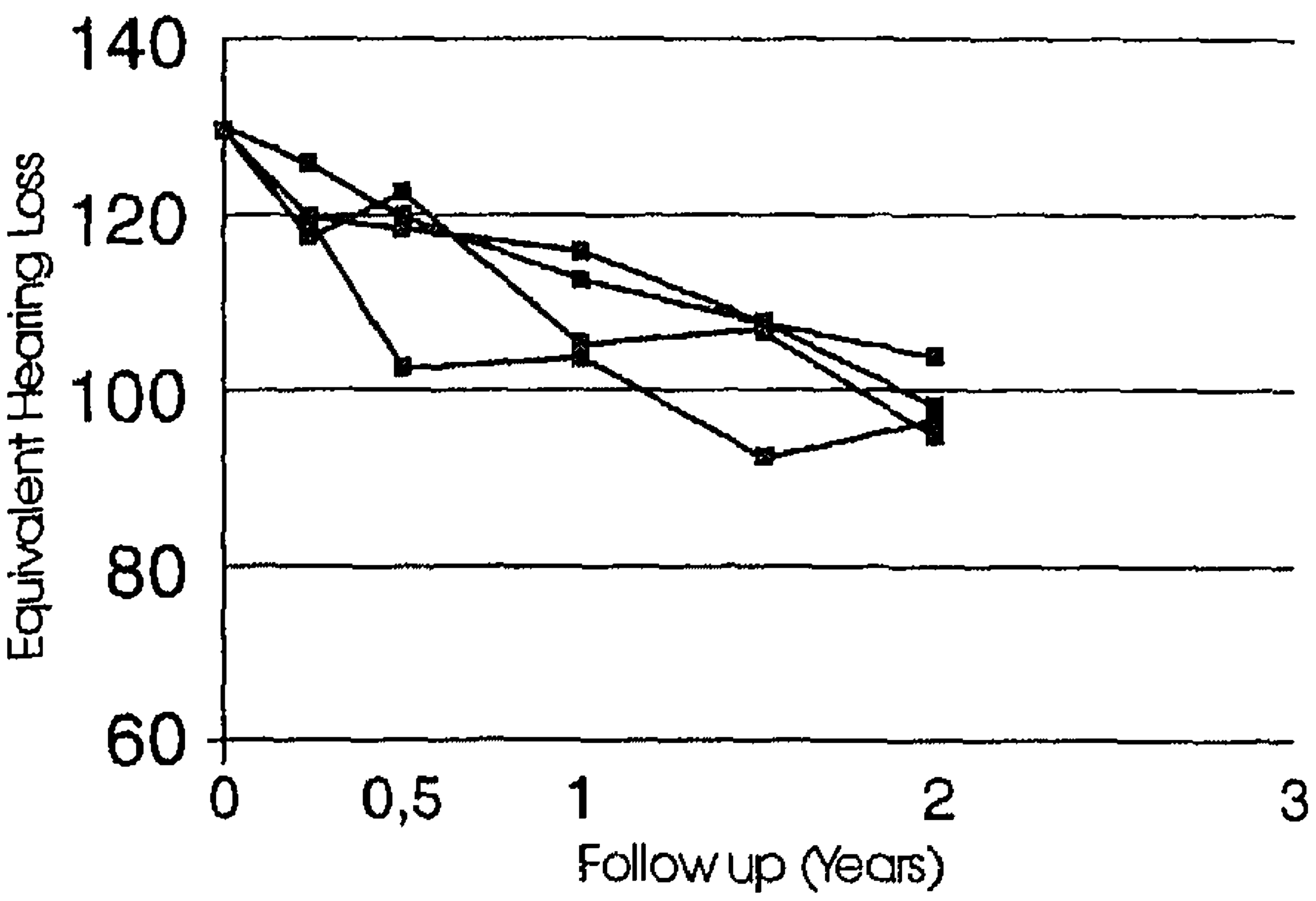


*Fig. 3.* Equivalent hearing loss values over time of the congenitally deaf group.

Fig. 3 shows the overall equivalent hearing loss values of the congenitally deaf children (who all had a full insertion of the electrode array). The overall equivalent hearing loss of this group improved from 130 dB to 100 dB within 2 years of implant use. The group showed less and a slower improvement than the meningitis group.

The overall equivalent hearing loss values of the children that had a partial insertion of the electrode array (these children were deafened by meningitis) are shown in Fig. 4. This group showed the poorest results. Only very slight progress was made.

Within the groups with a full electrode insertion, a considerable range in performance was observed between the pre-operative test and the evaluation after two years of implant use. Some children showed an improvement within the first 6 months while others commenced to improve after 1 year of implant use. The actual rate of improvement did not seem to have

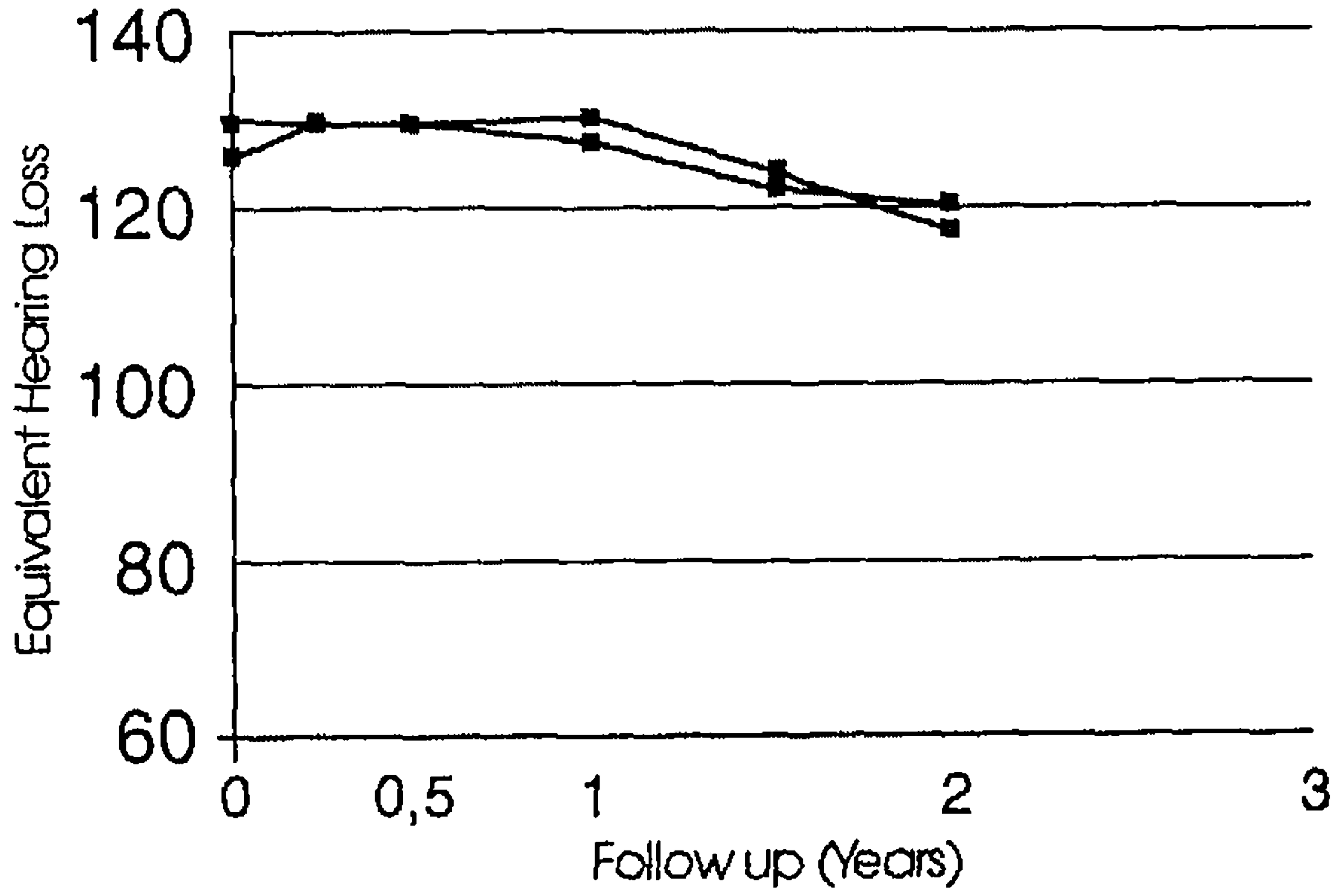


*Fig. 4.* Equivalent hearing loss values over time of the partial insertion group.

an effect on the overall equivalent hearing loss values that were obtained within the meningitis group. This group, however, improved better and faster than the group of congenitally deaf children.

In order to obtain more quantitative data for analysis, for each child with a full insertion of the electrode array the moment of surpassing an overall equivalent hearing loss of 105 dB was determined. This moment (in months) was used in repeated regression analysis to determine the effect of the variables age at onset of deafness (accounting for 37% of the variance) and communication mode. These variables together accounted for 66% of the variance. Thus the children who became deaf early in life progressed at a slower rate than the children who became deaf later in life, and children in TC settings progressed at a slower rate than those in oral/aural settings. Again, this concerns only the rate of progress and not the level that was finally acquired.

## Conclusions

Within the frame of the comparison between the implant users and the conventional hearing aid users we conclude that the CI meningitis group with a full electrode insertion reached an overall equivalent hearing loss of 70 -80 dB. This is of great importance because in general, young severely hearing impaired children (in the hearing loss range of 70-90 dB) with conventional hearing aids develop intelligible speech and fluent oral communication. More long-term data are necessary for conclusions about the development of the congenitally deaf children, the preliminary data show an improvement up to 100 dB HL. The group with a partial insertion of the electrode array showed very poor speech perception improvement. Speech production results, however, indicate that the articulation of this group developed quite well. The limited auditory information gained, mainly the consonant information seemed to be beneficial with regard to speech production.

Finally we consider the method of equivalent hearing loss, expressing the speech perception performance related to a reference group of hearing aid users, to be an adequate quantitative measure that summarizes the speech perception scores obtained with an elaborated test battery. This measure enables a comparison of the auditory speech perception skills of children that use various sensory aids.