SPEECH INTELLIGIBILITY DEVELOPMENT IN SEVERE TO PROFOUND HEARING-IMPAIRED CHILDREN AND ESTABLISHMENT OF A DATA COLLECTION FOR EARLY INTERVENTION IN HEARING-IMPAIRED CHILDREN

N. Daneshmandan[1]* and P. Borghei[2]

1) University of Social Welfare and Rehabilitation Sciences, Tehran, Iran
2) Otolaryngology Research Centre, Medical Sciences/University of Tehran, Tehran, Iran

Abstract- The main goal of early detection of hearing impairment in children is early intervention. There is growing interest in early detection of hearing impairment in developing countries. The main purpose of this study was to investigate the spoken language development in severe to profound hearing impaired children and compared their speech intelligibility with normal hearing children at the same age. Nine severe to profound hearing impaired children below 2 years old out of the primer 42 cases were selected for this survey. They receive aural habilitation and also speech therapy after beginning the speech production. Speech intelligibility test of these children was recorded on audio-tape, when they read five questions which can be answered with one word only, at the age of 4, 5 and 6 in comparison with 27 normal hearing children at the same age. At the age of 4 the mean speech intelligibility score of the studied group was 31.77% (SD 12.17) and the control was %96 (SD 2.23). At the age of 5, this score was %51.22 (SD 14.42), the control one 97.85% (SD 1.93). Finally at age 6 it was 72% (SD 18.97) for hearing–impaired group and 99.22% (SD 1.18) in control one. Severe to profound hearing impaired children acquired spoken language but not at the same level. In general, their speech development showed about 2 to 3 years delay. Their speech intelligibility was acceptable for severe group around the age 6 but almost semi–intelligible for profound group at the same age.

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Key words: Speech intelligibility, development, score, language acquisition, hearing, impaired, children

INTRODUCTION

The main goal of early detection of hearing impairment in children is early intervention. Moreover, providing early intervention in hearing impairment is more difficult than early detection.

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*** Corresponding Author:**
N. Daneshmandan, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran
Tel: +98 21 22420765
Fax: +98 21 88963350
E-mail: daneshmandan@uswr.ac.ir

There is a strong belief that early intervention results in oral language development. Although there is a growing serious interest in early detection of hearing impairment in developing countries, but pilot studies are necessary in these countries to provide empirical data that will guide healthcare providers who wish to intricate a program at any level of healthcare delivery (1).

In Iran, deaf education by means of sign language began about 80 years ago, but new methods of aural habilitation dates back to the last decade. There is a great debate about spoken language development in severe to profound hearing impaired children in our

deaf education system, specifically, the main core of this challenge is around low intelligibility of spoken language in these children. However, the other choice for a deaf child is cochlear implant, but is not available for every case. As aural habilitation is being done in sporadic non- organized style, many pilot studies are needed to evaluate how our previous method, sign language, can be substituted by oral language in Persian. Like other countries, such as Sweden, a great deal of work should be done on improving and developing efficient and individualized auditory speech training and its assessment methods (2)

Language acquisition is very complicated. The complexity of learning a language arises from a synthesis of the many influences and activities that enable a child to become linguistically engaged. Children learn language by developing and assembling together four systems of skills. The pragmatic, phonology, semantic and syntax are separate but inter related systems that comprise the foundation of language acquisition (3, 4). Except for the semantic system, acquisition of each of these systems is subject to a critical period after which full mastery of language is unlikely (4).

Studies on speech perception and speech production of profoundly deaf children after cochlear implant inform us about the developmental plasticity of the auditory system (5). In the first year of life, the neurons in the auditory brain stem are maturing and billions of major neural connections are being formed. During this time, the auditory brain stem and thalamus are just beginning to connect to the auditory cortex (6). The neurons in the cortex mature during the first 3 years of life, and after that the brain's general organization dose not change significantly (7). Unfortunately, the delay in exposure to appropriate language models is often reflected in poor language outcomes (8).

Consequently, most hearing impaired children often exhibit significant departures in acquisition of the system of skills needed to develop language optimally. Besides, they show delay not only in the production of oral language but in other important aspects of development such as visual attention and behavioral control (9). The degree of oral speech communication skills of the hearing impaired children can be tested by means of speech intelligibility (10). Oral language acquisition is highly dependent upon what the deaf child can hear. Hence, appropriate amplification and cochlear implants provide deaf children with a means of accessing the auditory information that are essential for language development (11-12). Speech intelligibility is one of the important features of spoken language development in severe to profound hearing- impaired child. Intelligibility refers here to "the degree to which the speaker's intended message is recovered by the listener" (13) or "the comprehensibility of the specifically linguistic information encoded by a speaker's utterances" (14). Measuring speech intelligibility, however, is problematic because intelligibility metrics are affected by a number of factors, including articulation/ phonological aspects, suprasegmental factors, contextual, and semantic/morphologic/ syntactic feature (15-16). Analysis of individual speakers' intelligibility data revealed that sentence intelligibility scores were higher than word intelligibility scores (17).

Within this project, we have been discussing the following questions:

Do severe to profound hearing- impaired children develop spoken language? Does spoken language of these children show enough intelligibility? Is language development in severe to profound hearing impaired children comparable with normal hearing children? And does our early intervention provide a hearing-impaired child to take part in regular schools?

Therefore the main purpose of this study was to examine one of the language skills, speech intelligibility, in severe to profound hearing impaired children received aural habilitation at a very young age (mean age 17 months) and then to compare the result with normal hearing children at the same age (4, 5 and 6 years).

MATERIALS AND METHODS

A prospective longitudinal study was undertaken on a consecutive group of children with severe to profound deafness.

Nine severe to profound hearing-impaired children, out of the primer 42 cases, who were detected below two years old were selected for the study to receive aural habilitation. We obtained informed consent from parents of all participants. Among 42 cases, 5 children who had visual impairment and cerebral palsy were excluded. In the rest 37 children only 9 cases could stay with us for 4-5 years. Their mean average hearing thresholds was (78. 8 dB) in the better ear. The mean age at the beginning of auditory habilitation was 17 months (age range 7-24 months) (Table 1).

Two children (case 3 and 6) had no measurable unaided hearing above 2000 HZ in the left ear, but about 90 dB HL in the right. All children were programmed in the continuous auditory training by Erber method for one session per week (45 minutes). They receive speech therapy for 45 minutes a week after beginning the speech production. Program optimization and auditory language growth was monitored on a routine basis by the video tape recording and regular reports from the therapist and parents, in conjunction with scoring speech intelligibility at the age of 4, 5 and 6, then they were compared with matched normal hearing children at the same socio- economic status. All children had normal intelligence and cooperative parents. Workshops for parents, therapists and educators were presented by the department of Deaf Education of Social Welfare Rehabilitation University on auditory-aural enhancement techniques to facilitate oral language learning. Since mainstream schools are- verbal environments, we put them in the regular kinder garden from 4 to 6 years old.

Test Procedure

The procedure that can asses one of the aspects of language skills such as speech intelligibility score was designed. Testing was performed via each child's preferred mode of communication: either total communication (sign Persian language plus speech and audition) or oral communication (audition, speech and lip-reading). Although the auditory perception and speech production in these children were monitored by video tape recording every 3-6 months up to 4 years, but the mentioned test procedure was done at age 4, 5 and 6 years. The intelligibility test of the children was recorded on audio-tape, when they read five questions, such as "what is your name?'' which can be answered with one word only. These questions read by each child were presented via headphones at a comfortable level to two groups of normal hearing persons (experienced and inexperienced in listening to the speech of prelingually deaf children) to objectively evaluate the speech intelligibility. The listeners had the possibility of repetition. The listener's task was to write down, in Persian orthography, the answer to the question with one word. Only completely correctly understood questions were counted as correct.

Listeners were 20 normal hearing persons who had listened to the speech materials. 15 persons were inexperienced and the rest five were experienced, who had more than 2 years of experience in listening to the speech of deaf children. These scores were compared with speech intelligibility of 27 matched normal hearing children at the same age who attended the center for young

Table 1. Descriptive status of studied group

				SI 4 years		
Case Number	**Gender**	**Age**	**Hearing Loss**	**BIT**	**SI 5 years**	**SI 6 years**
Case 1	F	21	90	17%	30%	40%
Case 2	M	18	90	14%	38%	50%
Case 3	M	21	80	42%	61%	90%
Case 4	F	7	70	30%	54%	70%
Case 5	F	18	70	25%	42%	66%
Case 6	M	20	80	52%	80%	100%
Case 7	F	12	80	40%	56%	80%
Case 8	M	24	70	30%	48%	68%
Case 9	F	12	80	36%	52%	84%

Abbreviations: SI, speech intelligibility; BIT, Beginners' intelligibility test; F, female; M, male.

children, a day-care facility for children of welfare organization. Children were recruited by letters to parents requesting their children's participation as member of a comparison group in a study examining the "development of speech'' in children with hearing impairments. In the first part of the study at age 4 the intelligibility scores of experienced and inexperienced showed a considerable difference. Therefore we substituted those five experienced by other five inexperienced listeners. Our reasoning was that we train these children to take part in normal hearing population and probably regular schools, so the scores of in-experienced normal hearing listeners are more important.

Another confounder was getting familiar with these children's pronunciation. Each listener who answered to these nine tapes gave better scores to the later tapes. In this regard, we asked 180 students of Social Welfare and Rehabilitation University to take part in this study. Each child's tape was given to 20 students of one class; the other tape was presented to another 20 students.

RESULTS

For the 9 children with severe to profound hearing-impairment, speech intelligibility ranged from 14% to 52% by the age 4 years, 30% to 80% at the age of 5 and 40% to 100% for the age 6 years (Table 1). The mean of speech intelligibility of studied group at age 4 was %31.77 (SD, 12.17), at age 5 was %51.22 (SD, 14.42) and finally at the age of 6 was recorded %72 (SD, 18.97) (Table 2). These scores for 27 normal hearing children were recorded 92% to 100% at the age 4, 94% to 100% at the age 5 and 97% to 100% for the age 6 (Table 2).

In the studied group, except cases (3-6) who showed about 2 years delay in their speech intelligibility at age 4, others had more than 2 years delay (Table 1). After a forced speech therapy and putting them in main stream, their speech intelligibility by age 5 improved but didn't reach acceptable level of peer group. All of them except case 6 had a score below 66% and showed speech difficulty at age 5.

After one year (at age 6), their speech was near to semi-intelligible (50%-63%) in profound hearing-impaired group, while speech difficulty of severe hearing-impaired ones recovered around this age (Table 1), speech intelligibility was near to normal for case 3, and normal speech for case 6 (Fig. 1). Therefore in the best condition only two of the severe group achieved near to normal speech intelligibility by age 6 that shows at least 2 years speech delay and other 5 severe hearing-impaired cases achieved acceptable speech intelligibility with more than 2 years delay. In profound group these scores were not favorable.

All in all, at age 4, all of the studied group had speech difficulty, at age 5 except case 6 the rest of the severe group didn't recover and profound ones showed low intelligibility and at age 6 speech difficulty of all of the severe group members recovered, but profound ones changed to semi-intelligible speech.

Table 2. Descriptive statistics for SI score of the studied and control groups

Age	Number	Min	Max	Mean	SD
Studied Group					
Age 4	9	14	52	31. 77	12. 17
Age 5	9	30	80	51. 22	14. 42
Age 6	9	40	100	72. 00	18. 97
Control Group					
Age 4	27	92	100	96	2.23
Age 5	27	94	100	97.85	1.93
Age 6	27	96	100	99.22	1.18

Abbreviations: Min, minimum; Max, maximum; SD, standard deviation.

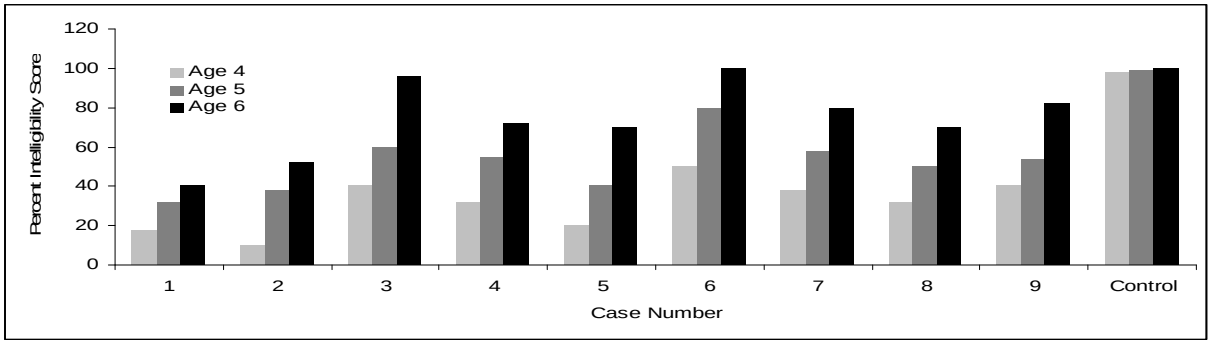

Fig. 1. Histogram for speech Intelligibility of the studied group and also its control group at age 4, 5 and 6 years.

DISCUSSION

In this study, speech intelligibility, as one of the aspects of language skills, in 9 severe to profound pre lingual hearing-impaired children was investigated. First we compared the results among hearing-impaired children; in the second part of the study, we compared them with matched normal hearing children.

A variety of factors including improved hardware and software devices, either hearing aids or cochlear implantation, younger ages at implantation and improvements in habilitation have led to increased expectations, so that language acquisition and development on a par with that of children with normal hearing is no longer considered unrealistic (18). The first part of the study showed that speech intelligibility growth in this group was not the same and was effected by several factors. Summarizing these factors we conclude that:

1) In profound group auditory perception and language growth, in the first year of auditory training was not the same. Case 2 showed very slow growth rate. His behavioral disorder leads us to consult with a psychologist who suggested an attention deficit hyperactivity disorder in this case. ADHD and probably accompanying central auditory processing disorder are two factors affecting auditory, speech and language growth (19). After being under supervision of a psychologist for more than one year and improvement in management of ADHD, language development in case 2 improved compared to case 1. We related this to better functional hearing of case 2 in comparison to case 1 in spite of nearly equal pure tone average in 5, 1, 2 KHz. The influence of sensitivity (degree of loss) and frequency range (configuration) will represent the most reliable audiometric information. The disorders of fidelity and other factors that are less precise reduce a clinician's ability to predict the handicap from the pure tone information. The audiologist and the client will be best served when all of the available information is used. By doing this, the audiologist may be to make general statements about the person's hearing function and probable needs (20).

2) Speech intelligibility in case 5 and 8 whose thresholds were about 70 dB was lower than other five cases (3, 4, 6, 7, 9) in spite of their better hearing. These two children had more than five attacks of serous otitis media per year. They probably couldn't receive some acoustic information. Their language development was more impeded by this function in their hearing threshold. Skinner in 1978 listed a number of detrimental "acoustic liabilities'' to a child's language learning when a hearing loss exists. One of them was lack of consistency of auditory clues when acoustic information fluctuates (21).

3) In case 3 and 6 language skills, were consistently superior to the rest severe hearing-impaired children in all aspects and at all age levels. Their medical history showed that they lost their hearing gradually and around their first birthday. Lennenberg stated that those who lose hearing after having been exposed to the experience of speech, even for as a short period as 1 year, can be trained much more easily in all language arts, even if formal training begins some years after they had become deaf (7). In the second part of the study we

compared them with normal hearing children. Direct comparisons with the high literature are not possible because the development delays of what would now be termed identified were too low to report developmental ages for the birth through live year old population (22). With this in mind, it was indicated that case 1 and 2 had the lowest scores of speech intelligibility (Fig. 1).

It is a general opinion that there is a very close relationship between degree of speech perception and speech intelligibility of deaf children; poor speech accompanies higher hearing loss (23). Language skills of case 3 and 6 were consistently superior to others in all aspects at all age levels. As showed in table 1 their speech intelligibility was about 42% and 52% at age 4, 61%, 80% at age 5 and around 80% and 100% by age 6. Score of speech intelligibility for normal hearing children has been reported 50% by age 2, 75% by age 3, and 100% by age 4 (18). More detailed expected ranges of intelligibility for young children has been reported as 26-50% intelligibility by age 2, 51% - 70% by age 2; 6 (years; months), 71% to 80% by age 3, 81% to 90% by age 3;6 and 100% intelligibility by age 4;0. (18) Another study by Coplan and Gleason indicated that the cut-off age for 50% intelligibility was 22 months, for 75% intelligibility 37 months and for 100% intelligibility 47 months (24).

In this regard, speech intelligibility of the studied group at its highest level (case 3 and 6) showed about 2 years delay at age 4 and more than 2 years delay in other severe hearing-impaired cases as illustrated in figure 1. In profound group speech intelligibility of case 1 at age 5 and 6 was below 50% or in fact with more than 4 years delay (Table 1), and the case 2 had an approximately 4 years delay too (Table 1). Gordon- Brannan and Hodson suggested that for a child of 4 years or older, a score of less than 66% (2 SDs below the mean) might be a potential indicator of speech difficulty (15, 25).

With this in mind all of the severe hearing impaired children had speech difficulty at age 4 years, and all of them recovered by forced speech therapy at the age of 6. So, several variable that are associated with differences in outcome among hearing- impaired children should be controlled while assessing the impact of intervention (cochlear implantation) (26), and also other affective factor such as visual attention skills in pre-lingually deaf children should be considered too (27).

As mentioned before, we did not have access to hearing- impaired children younger than 6 months and our studied group was chosen below 2 years old. So, the other pilot studies are needed in younger hearing- impaired children to support this study and conduct us in revising our early intervention methods for hearing- impaired children. Our other recommend is that the different aspect of language development be investigated by other studies. We hope to fallow these children in the next years and to report their social emotional development and also their personal, educational achievement.

In conclusion, severe to profound hearing impaired children who receive aural habilitation acquired oral language but not in the same level. Each case needs individual planning. Although speech intelligibility in profound group showed considerable delay in compare with normal hearing children, but was acceptable in severe hearing-impaired children. All in all severe group was more comparable with normal hearing ones and had a chance to take part in regular schools, but profound group are probable candidate for inclusive schools.

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Conflict of interests

We have no conflict of interests.

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