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WHY THE **SIZE** OF A HEARING AID **MATTERS** WHEN FITTING **INFANTS** AND **YOUNG CHILDREN**



INTRODUCTION

With the introduction of newborn hearing screening, a larger number of hearing impaired children are being identified at birth. This has resulted in a new group of hearing aid users who receive early intervention. The existence of a new group of hearing aid users presents novel challenges for the hearing care professionals and places new demands on the hearing aid manufacturers for designing hearing aids specifically for infant ears. Widex has taken up the challenge and designed a miniature hearing aid that fits well behind the infant ear and contains an instant-fit earmould solution.

This article discusses how the miniature size is achievable in a modern hearing aid, and why small hearing aids are preferable when fitting hearing aids to infants and young children.

EARLY INTERVENTION CAN PREVENT DELAYS IN LANGUAGE DEVELOPMENT

It is well-known that children's ability to hear is critical for their language development. They need to hear what is being said to develop understanding, and to monitor their own speech production in order for it to develop. Because of this dependence on hearing, there is a risk that children with an undiscovered hearing impairment will not develop any language at all, or that the development will be delayed, depending on the degree of impairment.

Language is a critical factor for children's ability to socialise as well as for their achievements in school. An undiscovered hearing impairment may have detrimental effects on the child's psychosocial development, cognitive abilities, and academic achievement¹⁻⁴. However, evidence has shown that if the hearing impairment is discovered early and intervention in the form of amplification and aural rehabilitation is initiated within the first few months of life, significant delays in language development can be avoided⁵⁻⁸. These findings have led to the acknowledgement that early identification and rehabilitation of hearing impaired children is extremely important.

Many countries have decided to implement a newborn hearing screening and intervention programme with the aim of identifying hearing impaired children at birth or within the first month of life. The appropriate audiological and medical evaluations are ideally received at no later than three months of age, and the intervention services should be received as soon as possible after the diagnosis and at no later than six months of age⁸. Ideally, this will result in newborns with congenital hearing loss being fitted with hearing aids somewhere between the ages of three to six months. A new group of hearing aid users have come into existence with requirements that differ notably from the traditional fittings of adults and older children.

PRACTICAL LIMITATIONS WHEN FITTING INFANTS WITH REGULAR HEARING AIDS

One of the challenges when fitting a baby of three to six months of age with a regular hearing aid is the mismatch between the hearing aid and the size and softness of the baby ear. With a small and soft baby ear, even an average-sized hearing aid seems large and heavy. The hearing aid will be uncomfortable while the baby is sleeping, being held, or fed, and the weight of the hearing aid increases the risk of the aid falling off, or being displaced when the child is playing.

Another challenge when fitting infants is the rapid growth of the ear canal, and consequently the frequent need for new moulds to prevent the leakage of sound. Sound leakage and frequent displacement of the hearing aid behind the ear often result in feedback problems, which is a particularly critical issue in baby fittings.

Experience has shown that parents tend to react by stopping the interaction with the child in order to stop the whistling. This is very unfortunate since nursing and hugging the child is very basic in the child/parent relationship. Parents must never end up believing that they are causing their child discomfort or harm because of the whistling in the ear. Nevertheless, the occurrence of feedback often leads to a negative perception of the hearing aids which may prompt the parents to remove them. This is a very understandable reaction, but also very unfortunate since the auditory stimulation of the child will be limited as a result.

A HEARING AID DESIGNED SPECIFICALLY FOR INFANTS AND YOUNG CHILDREN

Considering the limitations of a regular-sized hearing aid in connection with infants, it is clear that ensuring the best possible rehabilitation of the child is not simply a question of fitting the child with a hearing aid as early as possible. The physical fit of the hearing aid is also very important. If the child is to have the best possible conditions for auditory development and language acquisition, it is of great significance that the hearing aid fits the ear and stays on the ear for as long as possible. This calls for a hearing aid developed specifically for the infant ear. In other words, a hearing aid where the small and soft ear, as well as the growth of the ear canal, is taken into account already in the design of the aid.

Several aspects must be taken into consideration during the development of a hearing aid for the infant ear. First of all, the aid should contain all relevant audiological features for an infant fitting. It should also be discreet and comfortable for an infant to wear. It must stay in place, and, if possible, the hearing aid should contain an instant-fit earmould solution to prevent frequent impressions of the ear for new moulds. The instant-fit solution should be a priority area to ensure a good physical fit of the hearing aid, but also to minimise the period of waiting for new earmoulds. The shorter the waiting time, the shorter the period where wrong-sized moulds have to be used with the risk of frequent feedback issues.

Another important factor in the development of a hearing aid for infants is ensuring that the hearing aid sits securely. There is always the risk that babies will put the hearing aids into their mouths, which may lead to the swallowing of or choking on hearing aid parts. Therefore the development of securing features is a critical issue in connection with the development of hearing aids for infants.

Finally, the caregivers of the child should be able to ascertain whether the hearing aid is functioning as intended when turned on or when adjustments are made using the remote control.

Widex took up the challenge of designing a hearing aid specifically for the infant ear. All of the above-mentioned critical factors were taken into account during the design of WIDEX BABY440. The advanced miniature hearing aid offers sound processing in fifteen channels, optional features such as noise reduction based on the Speech Intelligibility Index (SII), an adaptive directional microphone system, feedback cancellation, and a bandwidth of 10 kHz (figure 1). The size and weight of the hearing aid have been reduced remarkably compared to a regular hearing aid (see table 1), and the aid is discreet and fits well behind a small and soft baby ear (see pictures 1 and 2). Besides the small size, the hearing aid also offers an instant-fit solution with a soft ear-tip and anchor. Adhesive tape and a retention string were developed especially for WIDEX BABY440 to ensure a stable fit behind the ear. Finally there is a built-in LED (Light Emitting Diode) on the hearing aid, which flashes briefly when either of the hearing aids is turned on or when the remote control is activated.

	WIDEX mind440 9 BTE	WIDEX BABY440
Weight	2.7 g	1.0 g
Length	32 mm	24 mm
Width	10 mm	7 mm

Table 1: Comparison of Widex mind440 9 BTE and WIDEX BABY440 in terms of weight, length and width.



Figure 1: Illustration of the miniature WIDEX BABY440 hearing aid with the instant ear-tip.



Picture 1: WIDEX BABY440 worn by a 3 month old baby.



Picture 2: A regular-sized hearing aid worn by a 3 month old baby.

To make sure that the miniature hearing aid designed specifically for infants lives up to expectations in the real world, a study was conducted with 16 infants and young children. The children were enrolled from two audiological clinics as part of their normal hearing aid fitting process. During the study, the children were fitted with WIDEX BABY440 hearing aids and monitored closely for a two-month period. The children visited the clinics 4-8 times, and data were collected by means of questionnaires, which were filled out by both parents and hearing care professionals. The results, which will be reported elsewhere, are excellent¹⁵.

HOW THE SMALL SIZE IS ACHIEVABLE IN A MODERN HEARING AID

There are several ways in which a hearing aid can be reduced in size. The approach taken by Widex involved moving the receiver of the hearing aid from the housing to the concha of the child's ear. Moving the receiver not only permits a reduction of the size of the housing, but also has a positive influence on the frequency response of the hearing aid. When the receiver is placed at the concha, the amplified sound is transmitted through a wire instead of through a tube into the child's ear. This is an advantageous design that makes it possible to avoid the resonances and disturbing peaks in the frequency response of the hearing aid which are created when sound is transmitted through a tube. Another benefit is that it makes it possible to avoid the creation of a high-frequency roll-off which will limit the high-frequency abilities of the system.

Transmitting the sound directly into the ear of the child permits an extended high-frequency response which is an important prerequisite for the child's speech perception and language development^{9,10}. By moving the receiver to the child's concha, and by using a broadband receiver, we were able to obtain a bandwidth of 10 kHz. Besides the size of the hearing aid, and the extended bandwidth, moving the receiver to the child's ear also increases the distance between the microphone and the receiver, which reduces the risk of feedback issues.

To further reduce the size of the hearing aid and ensure the best possible fit to the infant ear, telecoil and FM options were excluded. The limitations resulting from the exclusion of these options were carefully weighed up against the benefits of the small size of the hearing aid. Traditionally, FM has been seen as an integrated and necessary part of the fitting of hearing impaired children, but as mentioned earlier, infants comprise a new group of hearing aid users with different needs. The need for FM of this particular group of users is smaller than the need for a small hearing aid.

IS FM NECESSARY FOR INFANTS?

It is generally agreed that the use of an FM system is an effective strategy in classroom situations to improve the listening environment and reduce the problems associated with speaker-to-listener distance, poor SNR, and room reverberation¹¹. As is the case with older children, poor acoustic conditions present difficulties to infants and toddlers. FM systems are rarely used with the latter group, however. For example, Yoshinaga-Itano¹² investigated the type of amplification applied to 60 hearing impaired children between the ages of 9-40 months. Only 2% used hearing aids in combination with an FM system. Gabbard¹³ also found that it is uncommon to use FM systems with young hearing impaired children. After trying out FM systems for infants and toddlers between the ages of 15-30 months, one of Gabbard's conclusions was that the perceived benefit in listening performance was identical when the hearing aids were worn alone compared to when an FM system was included. Moeller et al.¹⁴ used formal language measures to compare two groups of two-to-four year old children. One group was encouraged to use FM as much as possible at home while the other group exclusively used hearing aids. The results did not show any significant differences between the groups. Both parents and children preferred the FM system, however, when competing noise or distance interfered with communication.

FM systems are rarely used for infants and toddlers, and the few studies conducted in this area have shown little or no benefit of using FM compared to hearing aids. This indicates that the greatest effectiveness of an FM system may not be found in this age group. Considering how language development happens in infants and young children, one might question whether the FM option is a necessity for very young children. In order to develop good listening skills, infants need to make their own experiences with surrounding sounds. They need to learn to associate specific sources with specific sounds, and learn how to estimate the distance to the sound source, and how to locate different sounds in the surroundings. When sound is transmitted through an FM system, there is a risk of the signal from the FM system being more audible than the microphone signal of the hearing aid. This means that a clear sound is sometimes transmitted to the child without a natural visual source being present. Under these circumstances, the child will have no opportunity to learn to associate the source with the sound, to estimate the distance to the sound source, or to locate specific sounds in the surroundings. This may result in limited listening skills on the part of the child.

Another limitation of using an FM system for infants is the restriction in bandwidth. Most current FM systems are restricted to a 7 kHz audio bandwidth (telecoil is restricted to 4 kHz), which – as mentioned earlier – is problematic in relation to the child’s speech development.

Finally, there is the issue of size. Most hearing aids require an FM shoe being attached to the hearing aid in order to receive the FM transmitted signal (picture 3). In some hearing aids, FM is built into the aid. However, this increases the size of the aid considerably, which makes it even harder to fit behind an infant ear.



Picture 3: Picture of an infant wearing a regular-sized hearing aid with an FM shoe attached.

Since FM systems have a number of limitations, which mean that they are rarely used with infants and toddlers, we came to the conclusion that it makes sense to prioritise the size of the hearing aid over the inclusion of FM and telecoil options until a dedicated infant FM system is available.

CONCLUSION

Fitting a hearing aid which is specifically designed for infants and young children may make an important contribution towards ensuring the best possible rehabilitation of the hearing impaired child. The miniature size of the aid and the instant-fit earmould mean that the hearing aid will be comfortable for the infant to wear and that it will remain in place on the ear for as long as possible. This, in turn, will ensure the best possible conditions for auditory development and language acquisition.

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