Clinical management of the child receiving a second (bilateral) cochlear implant

(Short title: Management of the child receiving a second implant)

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The purpose of this article is to share knowledge gained through close monitoring of 54 children with sequential bilateral implants. Sharing such knowledge will help other clinicians to manage their own caseload in a way that maximises benefits for children receiving sequential implants. Objective and subjective assessment results for the 54 children are reported elsewhere (Galvin et al., 2007a; Galvin et al., 2007b; Galvin, in press).

**How is the family’s situation different when considering a second implant?**

The situation of the family considering a second implant is different to that of families considering a first implant because the child will usually have demonstrated functional hearing and will already be developing oral speech and language skills. The family is also likely to have moved on from the initial stages of grief experienced at diagnosis of the hearing loss. Many families will be ambivalent about the necessity or urgency of further intervention that will cause significant upheaval. The family and child will also have knowledge and experience of hearing impairment and cochlear implants, and are likely to have many expectations regarding the pre-operative process and post-operative outcomes of a second implant. Nevertheless, it is absolutely vital that clinicians do not assume that, because the family has been through the process of obtaining an implant, they are sufficiently informed to make a decision. The family and child may actually hold limited accurate information because the family may have been too emotional and/or fearful to absorb the information provided by their clinician and, particularly if the first implantation was not recent, the information provided previously may be out-of-date, may no longer be appropriate for the child’s age, or may have been forgotten. If the child had limited language at the time of the first implant they would not have been able to describe to the family the experience of learning to listen to a new device. In addition, there is also information that is specific to sequential bilateral implants that must be provided.
How is the decision regarding a second implant different?

The decision to be made differs from that for a first implant for a number of reasons. In deciding to have any implant, families must balance risks and disadvantages against potential benefits. For a second implant, the potential benefit is relatively small compared with that for a first implant, and limited evidence is available for predicting individual benefit. There are also additional disadvantages specific to bilateral implants. Some families have cosmetic concerns, and feel that two implants “take up” the child’s whole head. The use of two processors is often a practical concern, especially if two ear-level processors are not appropriate. Families may also struggle with the decision because the second implant potentially destroys any remaining residual acoustic hearing; families may value this hearing even if the child cannot or will not wear a hearing aid, and may also be hoping that future technology could repair that ear.

Conversely, some families find the second implant decision easier. If the child is not using a hearing aid, families may consider there is ‘nothing to lose’ with regard to residual hearing. Families of older children usually report that the child’s involvement in, or responsibility for, the decision helps them to feel they are ‘doing the right thing’.

What should be discussed to ensure families can make an informed decision?

Clinicians need to acknowledge that future developments cannot be predicted, and families should be encouraged to seek information regarding alternative options. Families also need to be aware of the potential effects of auditory deprivation, should they decide not to implant the second ear.

The clinician needs to explain the primary advantages of listening with two ears for people with normal hearing, viz: improved speech perception, particularly in noisy environments, sound
localisation, and having a choice of ears. The clinician should also clarify that some advantages are due to true binaural hearing and some due simply to the capacity to listen with either ear. It is particularly important for families to understand that there are significant limitations which may affect the two-ear benefits available to a child using cochlear implants, particularly for those with a congenital hearing loss. Families need to know that the effects of early-onset deafness on auditory system development are unknown, and that the child’s limited binaural listening experience will have affected the development of the binaural listening system. Aside from these child-based limitations, research with bilaterally-implanted adults has demonstrated limitations in the auditory cues transmitted by implants. For example, timing cues, which contribute significantly to locating sound sources for the normally hearing person, are poorly presented by current speech processing schemes (van Hoesel & Tyler, 2003; van Hoesel, 2004).

There is insufficient evidence so far to predict progress with sequential bilateral implants for an individual child. Nevertheless, when considering a second implant, families need to receive up-to-date information regarding the worldwide experience. At the time of writing, the outcomes for children ranged from no evident benefit and subsequent rejection of the second implant to significant objective and subjective benefit, including, but not limited to, improved speech perception in groups and noisy environments, and improved sound quality. Although there is insufficient objective evidence to determine the factors that influence outcomes, accumulated evidence from studies of children using unilateral implants (Dowell et al., 2002; Sarant et al., 2001) combined with clinical experience so far with children using bilateral implants suggests that the following may be important:

- age at implantation,
- performance with the first implant,
o pre-operative use of a contralateral hearing aid,

o the child’s motivation,

o consistency of second implant use,

o amount and quality of rehabilitation using the second implant alone, and

o listening skills with the second implant alone.

It is important for clinicians to explain that, although these factors may be influential, experience has shown that successful use of sequential bilateral implants does not require pre-operative use of a contralateral hearing aid, or the receipt of the second implant at a young age, or extensive experience or rehabilitation using the second implant (Galvin et al., 2007a; Galvin et al., 2007b; Galvin, in press). On the other hand, success appears to require that the child is motivated to use the second implant and does so consistently, even if this is usually in combination with the first implant.

Given the likely influence of the child’s motivation on outcomes, it is important to discuss who wants the second implant and why. This is more important for a second implant for three main reasons. Firstly, more candidates will be old enough to contribute to the decision making and be responsible for their own device use. Secondly, parents are often more reluctant to enforce use of a second implant than a first, possibly because they do not see as great a need for the second device as for the first, and they may be influenced by the child who is now able to articulate their reluctance to use the device. Thirdly, device rejection is more likely for a second implant than a first because sound is still accessible via the first implant when a second implant is removed. If consistent device use or cooperation with programming have been issues in the past, these should be discussed. If the reason for considering a second implant is the hope of a superior outcome,
the family and child need to understand that this is only likely if there is a specific cause related only to the first ear, such as a poor insertion due to unilateral malformation.

To make an informed decision families also need to know that establishing an optimal map is typically not faster for a second implant, age-related improvements in cooperation aside. They also need to understand that the second implant will not sound like the first, especially in the early months. Effort and persistence will be required to develop listening skills with the new implant, with the first implant likely to remain superior.

**What else should be discussed once the decision is made?**

Practical issues, such as differences in implant types and processor combinations, should be discussed pre-operatively. Processor loss is an important issue because a child may be unaware if the processor for a second implant falls off as sound input continues via the first implant. A body-worn device, which is easier to keep in place, may be preferred for the second implant as this processor is more likely to fall off unnoticed, particularly in the early months when the input from the first implant will be especially dominant. Processors, especially ear-level devices, can be physically connected (e.g., by a loop of fishing wire) to minimise the chance of loss.

The clinician should provide information about the switch-on and early post-operative period prior to the operation, to avoid initial disappointment colouring the family or child’s view of the second implant and negatively affecting motivation. The most important information to impart relates to sound quality and the child’s listening skills in the early months. Clinicians will need to work on the development of expectations that are appropriate and not based only on experience with the first implant. It is important to explain that sound quality is likely to be very poor, possibly such that only a beeping or buzzing is perceived, and the child may struggle with very basic tasks such as detection of sound and recognition of sounds as voices. The inability to
perform higher level listening tasks with the second implant that are already easily performed with the first can be difficult to understand. Conversely, it is also important to explain that this poor sound quality is unlikely to affect sound quality in the bilateral condition due to the dominance of the first implant; especially early on when there is a limited amount of sound presented via the second implant. Strategies for maintaining post-operative motivation and to encourage appropriate patterns of device use should also be discussed (examples are provided below).

The operation

The majority of families report that the second operation is less stressful the second time because they know what to expect. Clinicians can advise on age-appropriate techniques and resources to maximize the child’s understanding of what to expect, as what is age-appropriate may differ significantly from the time of the first implant.

Programming sequential bilateral cochlear implants

The process of programming sequential bilateral implants is similar to that for a unilateral implant (Rance et al., 1997), though there are a number of unique issues to consider.

The family is likely to expect the child to respond in a similar fashion to that demonstrated during programming of the first implant. This occurs for some children and the process is very straightforward because they are familiar with the task. Other children provide inconsistent responses during programming. This inconsistency may be due to the percept via the second ear being significantly different; in some instances so different that the child does not recognise it as sound. More complex processes of adaptation to input via the second ear after a significant period of unilateral deprivation or limited input may also be occurring.
When selecting a speech processing strategy, the same strategy and stimulation rate are most likely to preserve the interaural level cues, which are the primary information for the improved localisation demonstrated by adults using bilateral implants (van Hoesel & Tyler, 2003). For children unable to provide reliable feedback, the same speech processing strategy should be used for both implants. However, if an alternative, possibly more advanced, strategy is selected to optimise performance using each implant alone, this may maximise the child’s perception of speech presented from either side or in background noise when the child will be able to attend to the ear with the better signal-to-noise ratio.

If the child is not comfortable with the sound percept when the two implants are activated together, a global modifier can be applied to the MAP of the second implant so that the more familiar sound from the first implant dominates. This global modifier involves reducing the comfortable-level on each electrode by a specified percentage of the dynamic range on that electrode (i.e., the difference between threshold-level and comfortable-level). The modifier should be incrementally reduced in subsequent programs as interaural amplitude differences provide important perceptual cues, and the aim should be for the listener to perceive the sound from each implant as being of equal overall intensity.

Children able to provide feedback can judge if the intensity of sound is balanced when listening with both implants in live mode. Appropriate adjustments can then be made to the comfortable-levels of either MAP. For other children, the potential for loudness discrepancy between the implants can be minimised by using a consistent approach when setting levels. Although the perceived loudness when listening with either implant alone may be appropriate, loudness summation may occur when listening with both implants, so that the combined sound is perceived as too loud. For children unable to provide such feedback, the reaction to loud stimuli
should be observed. If discomfort is evident, a small global reduction can be applied to the comfortable-levels of both MAPs to avoid the distortion of interaural level cues. This may be continued in the long term if binaural loudness summation remains an issue.

Given the inevitable increase in required programming time, the programming of the first implant should be reviewed prior to the second implant operation, so that the post-operative focus can be on the second implant. After the second implant MAP has stabilised, sessions would ideally involve programming both implants to increase the likelihood of consistent judgments.

**What to expect & do in the early post-operative period**

The switch-on session and the early post-operative period are crucial to establishing good patterns of device use and a positive attitude that will set the child up for later success. The expectation should be for full-time bilateral implant use from the time of switch-on. Some children do not easily accept the change to two implants and may require significant encouragement and support to continue wearing both devices. The younger child who does not understand the differences between the implants may describe the second implant as ‘broken’ because it does not sound like the first implant.

Clinical experience with adults and children using an implant plus a hearing aid or sequential bilateral implants suggests that time spent using a new device alone may fast-track the development of listening skills. Typically, a child may use the second implant alone for ½ to 1 hour per day in less challenging listening situations. Others may be happy to use the second implant alone for longer periods, though if the child is young or has delayed language families should take care not to overly limit the amount of time in which the child is receiving quality sound input via the first implant. Given that the ultimate aim is bilateral implant use, second implant alone use would cease if daily listening performance was similar with either implant.
alone. Some children are very resistant to using the second implant alone, particularly children aged around 4 to 15 years. Younger children generally adapt more easily, and older teenagers may be self-motivated to persist. It is important to balance the child’s concerns with the need for second implant alone experience so that a positive attitude to the second implant is developed and maintained. Overly challenging situations that the child may perceive as a ‘test’ of their listening abilities with their new implant should be avoided. The second implant can be used alone for brief periods by, for example, always putting the second implant on first, not immediately replacing flat batteries for the first implant, and using the second implant alone whilst watching familiar television shows or listening to readings of familiar books.

If the child is unable to determine if each implant is functioning correctly, families should be encouraged to perform a daily listening skill test with each implant alone, as it is very easy for a fault in one implant to go unnoticed in the bilateral condition. This will require familiarity with the child’s current perceptual ability using each implant alone.

**What to expect & do further down the track**

The goals remain maintaining a positive attitude towards the second device, encouraging some use of the second implant alone, and using both implants together for the majority of the time. Six to nine months is a typical time frame in which to develop useful listening skills with the second implant, though some children achieve this within weeks and others take longer. It can be more difficult to maintain motivation during this time than in the early post-operative period, as the second implant is no longer novel and expectations may have increased. Ongoing rehabilitation using the second implant alone can provide positive reinforcement by demonstrating the child’s listening skills with the second implant.
Conclusions

Research has clearly demonstrated the potential for children to gain more from two implants than one, and the rate of bilateral implantations is likely to increase. Many currently implanted children will receive sequential bilateral implants, and clinicians need to be aware of their special needs in order to maximise the benefit they gain from the second implant.

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