THE CHILD AFTER COCHLEAR IMPLANT: IMPLICATIONS FOR REHABILITATION IN LANGUAGE DEVELOPMENT

A cochlear implant (CI) is a technology assisted device that can be putted in the inner ear through a surgical procedure to help to provide a sense of sound for profoundly deaf or severely hard-of-hearing persons (NIDCD, 2013 and Peng et al., 2007). The present review was to uncover different (verbal and non-verbal, psychosocial, timing of implantation, and parental dilemma) challenges beyond the surgical procedures. Existing literatures in this area have been thoroughly reviewed based on eight themes. Themes were selected based on children’s developmental needs. Concluding remarks, then, forwarded which constructed from the review.

Keywords: Cochlear implant, speech perception, placement, rehabilitation, language development, vocabulary spurt, children, verbal and non-verbal integration


Introduction

Many children in many different countries have identified as having permanent profound hearing loss. In many literatures, profound hearing loss can affect cognitive development, emotional stability, learning and language acquisition (Ali and O’Connell, 2007) psychosocial adjustment, and health and well-being of those children’s (Dammeyer, 2009; Punch and Hyde, 2012; Jacobs, 2012).

For many years, as intervention, sign language has been used in alleviating those challenges of being profoundly deaf. In recent years, in developed nations, technology assisted surgical implants (Cochlear) are being implemented. The effectiveness is, however, different based on the age of the child during implantation (Gillis, Schauwers and Govaerts, 2002) and other reasons. This review is, therefore, to unveil the existing literature and issues need to be considered for future development in the area.

Verbal and nonverbal integration in speech perception and production among born-deaf children with cochlear implants

The Cat in the Hat study by DeCasper and Spence (1986), which asserted that language development starts in the womb, became a critical corner to realize how language acquisition is a complex process. The infant response to the story was not because of the semantic content; rather it was because of the rhythm and melody of the teller of tales. Being disadvantaged in auditory stimulation, therefore, starts before birth.

Schorr, et al. (2005) argued that speech is not as traditionally thought of as an exclusively auditory percept; the face of the speaker and the movement of the lips contribute powerfully to our perception of speech. This cooperative interaction between the auditory and visual modalities improves our ability to interpret speech accurately, particularly in low-signal or high-noise environments.

It is important to note that both linguistic and nonverbal information are crucial for understanding social interaction. Such auditory and visual cues are always critical, as Schlumberger et al. (2004) and Most and Aviner (2009), it is because individuals with severe and profound hearing loss miss a great deal of the verbal content, they rely more heavily on nonverbal cues during interaction. In another study, auditory impairment does
not cause a pathological delay or distortion in non-verbal development; it does produce subtle differences in certain motor and neuropsychological functions (Schlumberger et al., 2004 and Champoux et al., 2009).

For most of the children with cochlear implants, perception was dominated by vision when visual and auditory speech information conflicted (Schorr et al., 2005), which uncovers the importance of nonverbal communication among children with cochlear implants. One of the powerful phenomena in this regard was the McGurk effect, occurrence of an illusion when the auditory component of one sound is paired with the visual component of another sound, leading to the perception of a third sound (Nath and Beauchamp, 2012). The McGluk effect clearly reveals how the visual input (nonverbal clues) plays an important role in perceiving a speech.

Thus, children who have been deaf since birth and have received cochlear implants provide a unique population to examine the integration of verbal and nonverbal communication speech production and perception (Schorr, et al., 2005). Based on the studies on the visual and auditory modalities, it can be assumed that hearing loss have an impact on both verbal and nonverbal communication of children in organizing, storing, and retrieving information. The outcomes of these studies also highlight the importance of incorporating nonverbal aspects of communication into the intervention process for individuals with hearing loss with cochlear implants. The influence of visual information on auditory performance after cochlear implants would not be expected the same, for children with cochlear implants will start to integrate the auditory and visual modalities which such integration have been absent before the cochlear implants. This cooperative interaction between the auditory and visual modalities improves children ability to interpret speech accurately. As Most and Aviner (2009), children with hearing loss miss a great deal of the verbal content before the cochlear implants, they rely more heavily on nonverbal cues during interaction. This dependency to the nonverbal cues would be an asset, even after the cochlear implants. It can help to facilitate the rehabilitation process between the interaction of auditory lexicon and visual lexicon. Therefore, it would be imperative to look on how children with cochlear implants integrate the verbal and nonverbal inputs in perception and production of spoken language.

Dilemma of the parents for placement

When parents request for a cochlear implant for their child, the primary reason is to switch the mode of communication. And such a switch from the sign language and/or way of communication largely based on non-oral communication to oral spoken language would have a complicated result to the whole child. The cochlear implant is intended to replace (at least in assumption) the natural ear so that the child will join to educational system, which does not entertain children with special need(s). However, as Archbold et al. (2008), families of those children with cochlear implants remain concerned about future education and feel that outcomes from implantation have not met their expectations.

Even though, cochlear implants in profoundly deaf children have a positive effect on quality of life and appear to result a net saving to the society (Cheng et al., 2000), as Geers et al. (2009), only half of the children with cochlear implants exhibited spoken language standard scores within the average range for hearing age-mates. Since there is no one-to-one correspondence between communication choice and placement option, the parents, therefore, need to decide which school to send their child; either inclusive school or exclusive. Unfortunately, this important decision must be made as soon as possible so that the parents can begin the mode of communication with their child (Chute and Nevins, 2002), for age and duration of deafness found to be statistically significant predictors of placement after implantation (Archbold et al., 1998).
In one longitudinal study, done by Preisler et al. (2008), a videotaped interaction of children showed that meaningful oral communication was more easily obtained in the home setting than in the preschool setting.

Children who only detect and recognize sound patterns, children who are able to understand some speech through their implant but needs visual cues, and children who can understand speech through listening alone, as classified by Chute and Nevins (2002), could not sit together and have a class, for their performance in listening diversely affect their achievement and the dilemma remains open for clinical practitioners and parents of implanted children.

For narrowing the dilemma, Geers et al. (2009), Geers et al. (2008), Geers (2006), Francis et al. (1999) suggested that early cochlear implantation accompanied by aural rehabilitation increase access to acoustic information of spoken language and helps for higher rates of mainstreaming placement in schools and lower dependence for special education support service. Teachers, speech-language pathologists, otologists, audiologists, and parents of deaf children were suggested to consider risk factors for successful use of an implant and work together for a better end (Easterbrooks and Mordica (2000) and Marschark et. al. (2007)).

To go further into it, the study of Archbold et al. (1998) indicated that children, who are given implants early, before an educational decision has been made, are more likely to go to mainstream schools than those given implants when already in an educational setting. It would be worth, therefore, considering level of understanding of spoken language of children after the implant before sending them to a mainstream school.

**Early implantation: Implication for rehabilitation and language development**

It is already common-sense that language development is not a one-time process. The study of Hurford (1991) suggested that there is a critical, or at least a sensitive period in the language acquisition process, which ends around puberty. The existence of this period, according to the study, is explained by an evolutionary model which assumes that (a) linguistic ability is in principle (if not in practice) measurable, and (b) the amount of language controlled by an individual conferred selective advantage on it.

Even though there is a consensus language develops best at some time, as Rubinstein (2002), the best age for cochlear implantation in prelingually deaf children has been controversial since the practice began. When cochlear implant users receive their implant, they typically already have a language delay with respect to normal-hearing children and the use of a cochlear implant has had a dramatic impact on the linguistic competence of profoundly hearing-impaired children (Niparko, et al., 2010 and Geers et al., 2003).

To gain some insight about age and implantation, Snik et al. (1997) studied the speech perception abilities of implanted children at different age and they support the notion that the earlier in life implantation is performed, the better the development of speech perception. How much of early is early and what scientific ground to say so? This is an important question that needs to be addressed, for it will enable us to know the linguistic behaviour of the child subjected to be implanted.

Gillis et al. (2002) studied about the impact of early implantation on speech and language development and they argued that the audiological outcome of young implantation at the age of 18 months has an advantage. The assertion of Gills and his associates goes in line with the finding of Ali and O’Connell (2007) who argued that implantation between 12 - 18 months of age increase the immediate outcome of the implant. To sum up, even though there are some scholars (e.g. Geers et al., 2003) argued that there is no statistical significant difference between typically developing children and children with cochlear implants on comprehension and production of English after 4-7 years of age, it seem very clear to take side and argue that age of implantation matters on the linguistic behaviour of
the child. Results show that deaf children who receive cochlear implants at an early age are capable of reaching the standard (understanding through listening) in a shorter time than children implanted after 18 months of age.

Clinical Implications: Implantation prior to the age of 18 months may increase the effectiveness of cochlear implantation in terms of immediate outcomes such as communication skills (as Ali and O’Connell, 2007 and Ouellet and Cohen, 1999) and it should be one of the considerations when weighing up the harms and benefits associated with cochlear implantation in this age group. Other issues to be considered are how we can diagnose children about their status of hearing before 18 months.

Influence of the implant on changes of intonation in speech

A cochlear implant (CI) is an auditory prosthetic device that is surgically implanted in the inner ear and stimulates primary auditory nerve fibres to elicit sound sensation in individuals with a severe-profound sensorineural hearing loss (Peng et al., 2007). As Kirk and Hill-Brown (1985) deaf speakers frequently demonstrate differences in pitch and intonation. Poorer performance on labial consonants suggests that scores were affected by the lack of visual cues such as lip closure (Dillon et al., 2004). Dillon et al. (2004) argued that oral communication users tended to perform better than total communication users, indicating oral communication methods are beneficial to the development of pediatric cochlear implant users' phonological processing skills.

Because current CI devices provide only restricted access for the recognition of prosodic components of speech that signify linguistic contrasts, these devices can be limited in facilitating the acquisition of the prosodic components, that is, lexical tones and speech intonation in prelingually deafened children who must rely on a CI to develop spoken language (Peng et al., 2007). The study of Cleary et al. (2002) indicated that the present paediatric CI recipients did not show mastery of using rising intonation in their imitative speech production, although these CI users exhibited some progress in their production of appropriate rising intonation contours with increasing device experience.

In a review to see the particular aspect of speech and language development following CI, by Ouellet and Cohen (1999), showed that there is a great variability in post-implant linguistic improvement: for some, a cochlear implant allows the full development of linguistic competence and provides marked benefits in a wide range of psychological and social abilities, whereas others remain language-delayed or develop a functional but imperfect command of language.

When compared to their normal hearing peers, deaf children’s syntactic constructions are rigid and stereotyped (Kirk and Hill-Brown, 1985). The finding of Chin et al. (2012) suggest that the development of speech intelligibility progresses ahead of prosody in both children with cochlear implants and children with normal hearing; however, children with normal hearing still perform better than children with cochlear implants on measures of intelligibility and prosody even after accounting for hearing age. Problems with interrogative intonation may be related to more general restrictions on rising intonation, and the correlation results indicate that intelligibility and sentence intonation may be relatively dissociated at these ages.

How does intonation production compare in children with cochlear implants and children with normal hearing? Peng et al. (2008) examined intonation in 7- to 20-year-old children with 5-17 years of cochlear implant experience and children with normal hearing. Children were asked to produce sentences with declarative syntax using both declarative and interrogative intonation. These sentences were recorded and played for adult listeners with normal hearing who judged the productions in a two-alternative forced-choice (question vs. statement) task of accuracy and a contour appropriateness task using a rating scale (1-5). The result indicated that mean accuracy for the children with cochlear implants was significantly lower than for the children with normal hearing.
In contrary to the above finding, Cleary et al. (2002) and Snow and Ertmer (2009), by using nonword repetition task, reported that children with CIs are, like normal-hearing children, able to use their knowledge about the phonological patterns present in their ambient language to reproduce novel sound patterns.

In summary, findings on the impact of CI and changes of intonation are correlated. There was an observed variation among children with cochlear implant. The observed variation was attributed to chronological age at implantation (Snow and Ertmer, 2009). Hence, as Peng et al. (2007), it is reasonable to hypothesize that the acquisition of speech intonation can be challenging for prelingually deafened children with a cochlear implant.

**Psychosocial adjustment of children after cochlear implantation**

Any person living with a disability faces inordinate cognitive and social challenges; maximizing their social and professional opportunities therefore needs a unique understanding of human potential (Jacobs, 2012). Research has shown that the cochlear implant may improve deaf children’s speech and communication skills. However, as Bat-Chava et al. (2005), little is known about its effect on children’s ability to socialize with hearing peers and how they are psychologically adjusted. This social and psychological factor includes socio-emotional well-being, peer relationships, and social inclusions on children with CI daily functioning (Dammeyer, 2009 and Punch and Hyde, 2012).

In a comparative study of deaf and hearing children of Danish population, the prevalence of psychosocial difficulties among deaf children was 3.7 times greater than normal hearing children (Dammeyer, 2009). This study highlights the importance of communication for the psychosocial well-being of hearing impaired children and invites to see the psychosocial characteristics of children after implantation.

Even though cochlear implant has the potential to improve deaf children communication skills and relationship with hearing peers, children with implants still face communication obstacles, which hinder their social interaction and overall psychosocial adjustment (Bat-Chava et al., 2005 and Bat-Chava and Deignan, 2001).

On social integration Bat-Chava et al. (2005) criticize mainstreaming of deaf children after implantation. They argued that, unless their language skills match those of hearing children, deaf children with implants do not have an equal opportunity to develop satisfying relationships with their peers and cannot be fully integrated into the hearing children. Jacobs (2012) also support the notion of Bat-Chava et al. (2005) as children with cochlear implants lacks tactical knowledge about relationships and communication compared with hearing children. Jacobs (2012) associated such tactical lag and adjustment problem to the onset of deafness and time of implantation.

By controlling socio-demographic variables through hierarchical multiple regressions, Most et al. (2011), speech intelligibility of children with cochlear implants were correlated with social competence and sense of loneliness. Punch and Hyde (2011) interviewed parents, teachers, and children with CI and found that children with cochlear implants were unable to meet social skill standards and worries around friendships, dating, and their future in the work place. Martin et al. (2010) administered Peer Entry Task and found that duration of implant use were correlated with higher self-image and better performance, meaning cochlear implant by itself found to be not a problem for socialization and developing a positive self-image.

In another psychological study, by Moog et al. (2011), identification of oneself to the hearing or deaf children was not associated with personal or social adjustment problems and 75% of CI children participated very well in all aspect of life and possess good communication skill. They also reported that the majority of early-implanted children have strong social skills, high self-esteem, and at least mixed identification with the hearing world. Nicholas and Geers (2003) also studied about the impact of cochlear implant on psychosocial adjustment. They concluded that children implanted for 4-6 years are coping
demands of social and school environment successfully, regardless of their speech and language achievements after implantation. The study of Percy-Smith et al. (2008) shows that children with cochlear implant scored equal to or better than their normal-hearing peers on a scale about self-esteem and social well-being, which is a surprise finding and the positive impact of cochlear implants.

To sum up, the findings of all reviewed articles shows that the benefits of cochlear implantation in the areas of psychosocial well-being of children. The cochlear implant found to have no impact on the psychosocial development of children. The duration of implantation, age at the time of implantation, and additional skill based training are identified areas to be intervened to enhance implanted children’s social competence and well-being.

**Influencing factors in visual–motor integration skills in prelingually deaf children with cochlear implant**

Motor skills play a crucial role in the social and emotional functioning of a child and may impact quality of life and well-being (Ilic-Stošovic and Nikolic, 2012). From the other side vision plays an important role in motor skill performance as vision guides and controls the acquisition, differentiation and automatization of motor skills (Houwen et al., 2009). The influence of cochlear implant on children language acquisition and development is well documented in literature. However, the effectiveness of cochlear implants may vary widely and is influenced by different factors. Speech perception and speech productions are multi-modal (Holt et al., 2011). Therefore, the present paper addressed how children with cochlear implant integrate visual inputs and how they integrate the visual inputs with the motor skills and contributing influences in the process.

To determine the core of behavioural assessment, Horn et al. (2005a) employed Vineland Adaptive Behavioral Scales (VABS) and found that motor score tend to be higher that other non-motor behaviour of children with cochlear implant and children with higher motor scores demonstrated significantly higher performance on other language skills (including visual attention). In another study, by administering a standardized design-copying task and by obtaining spoken language data, the development of visual and motor integration were found to be correlated with early auditory and linguistic experience, meaning duration of implantation and age at the time of implantation (Horn et al., 2005b).

To assess how perceptual motor skills contribute to the development of speech and language of children with cochlear implant, Houston et al. (2012) carried out a research based on the duration of cochlear implantation experience. They administered visual-motor task (increasingly complex two dimensional figure) and timed maze tracing task; and found that implant users with at least 2 year of implant experience were delayed compared to the published norms on both a visual-motor task that required them to copy increasingly complex two-dimensional figures and a timed maze tracing task. Houston et al. (2012) also examined the motor skill of prelingually deaf children, by applying Vineland Adaptive Behavior Scales, and found that older children were more advanced in gross motor skills than fine motor skills. In addition to duration of experience and age at the time of implantation, as reported by Horn et al. (2005b), Houston et al. (2012) study uncovered the impact of age and pre-implant motor skills experience for the development of gross and fine motor skills after the implant.

To sum up, even though the available resource in the area is very limited, from the reviewed articles age at the time of implantation, experience with cochlear implant, and pre-implant motor skills are the identified factors influencing the visual-motor integration among children with cochlear implants.

**Vocabulary spurt of children with cochlear implant**
In the literature on the acquisition of the lexicon, researchers come across the notion Vocabulary Spurt (VS). VS mean that children (typically developing or children with SLI) would go through a stage in their language acquisition process, where the vocabulary increases more rapidly than before (Dandurand and Shultz, 2011). There are several explanations given for the VS. Some authors claim a cognitive basis (e.g. based on Piaget theory of cognitive development): children know at a certain stage that object have names and that knowledge helps them to name objects more rapidly and more frequently.

The present review describes and synthesizes vocabulary spurt among children with cochlear implant. Special attention is given for the age of child at implantation, implant experience, and age of the child (with implant and without implant) at which the spurt observed, for all the variables found to have a strong relationship with diversity of words among typically developing children. Operationally, 18-30 months of age is taken as a reference point, since many research findings (e.g. Dandurand and Shultz, 2011; Nicolas and Geers, 2003; Conner, 2006; James, 2007; and Leigh, 2013) uncovered that typically developing children exhibits burst of vocabulary at this age. In one comparative study by Dimling (2010), between NH and implanted children, deaf and hard of hearing children were seriously delayed in vocabulary growth and did not experience vocabulary spurt at any age.

A study by Dandurand and Shultz (2011), among typically developing children, vocabulary spurt was observed in the second year of life, in which children were exhibited a sharp increment in vocabulary acquisition. Key outcomes for children with CIs are auditory perceptual, language and speech development, together with the related areas of literacy and phonological awareness (Pascoe et al., 2013); and hence children with cochlear implant is expected to demonstrate an increase in diversity of types of words immediately after the implant.

By administering Peabody Picture Vocabulary Test 3, Connor et al. (2006) reported that speech and vocabulary development were strongly influenced by chronological age, length of cochlear implant use, and the age at which children receive the implant. They found that children who implanted before the age of 2.5 years (29 months) showed a burst of vocabulary development. Vocabulary spurt was seen among normal hearing children between 18-30 months of age, even though such trend was not mirrored in the implanted children, even at a year or two years later (Nicolas and Geers, 2003).

The capacity for incorporating significant words into the existing vocabulary and to use these words to form sentences with more mature syntactic structures was emerged after the implantation (Ouellet et al., 2001). Even though all the study participants exhibited a progress in producing different words in speech, Ouellet and associates were unable to find a consistent development among implanted children. For such inconsistent outcome they attributed that the cause and diagnosis of deafness, the age at which deafness occurred, the duration of deafness, and the age at implantation as the underlying factors.

Children who received their cochlear implant by 12 months of age were demonstrated vocabulary growth rates equivalent to their normally hearing peers and achieved age appropriate speech production scores 3 years postimplant, while children who received their cochlear implant between 13 and 24 months demonstrated a significant vocabulary growth delay at 3 years postimplant (Leigh, 2013). This supports the provision of a cochlear implant within the first year of life to enhance the likelihood of vocabulary spurt after implantation.

By using hierarchical linear modelling, Connor (2006) examined latent-growth curves in vocabulary for 100 children who had received their implants when they were between 1 and 10 year of age and concluded that children received their implant before the age of 2.5 years (29 months) might exhibits a burst in both speech and vocabulary after implantation. The researcher also underlined that burst of growth in vocabulary diminishes systematically with an increase age at implantation and a spurt in vocabulary was not observed for children who were older than 7 years.
Generally, children who gained access to sound via a cochlear implant between 12 - 30 months of age commonly demonstrated vocabulary- growth and able to validate the existence of vocabulary spurt. Even though there is a spurt among children after the implant, the observed vocabulary burst was much delayed compared to typically developing children. The delay was attributed for the time between birth and implantation, in which vocabulary development was dormant. The impact of age at implantation on vocabulary growth was not consistent. Researchers agreed upon the advantages of early implantation for the likelihood of spurt in vocabulary, but did not come up about the time in which the spurt appears after implantation. Duration of implant use also correlated with diversity in lexicon. Age of the child at implantation, implant experience, and age of the child influenced the curve in vocabulary spurt.

**Conclusion**

Based on the review, the following synthesised conclusion could be drawn:

- It is imperative to look on how children with cochlear implants integrate the verbal and nonverbal inputs in perception and production of spoken language.
- The influence of visual information on auditory performance after cochlear implants would not be expected the same. Children with hearing loss miss a great deal of the verbal content before the cochlear implants, they rely more heavily on nonverbal cues during interaction. The rehabilitation process can be facilitated if we look on how children with cochlear implants
- It would be worth to consider the level of understanding of spoken language of children after the implant before sending them to a mainstream school.
- Implantation prior to the age of 18 months may increase the effectiveness of cochlear implantation in terms of immediate outcomes such as communication skills and reasonable to hypothesize that the acquisition of speech intonation can be challenging for prelingually deafened children with a cochlear implant.
- The duration of implantation, age at the time of implantation, and additional skill based training are identified areas to be intervened to enhance implanted children’s social competence and well-being.
- Children who gained access to sound via a cochlear implant between 1-2,5 years of age demonstrated vocabulary - growth and age of the child at implantation, implant experience, and age of the child influenced the curve in vocabulary spurt.

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