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History of the Management of Hearing Loss in Children

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Deaf Children: Historical Perspective

Permanent bilateral hearing loss, if undetected, can lead to significant delays in the development of speech, language and literacy, which in turn can limit educational and occupational options. The consequences of hearing loss have been known for centuries although not clearly understood. Misconceptions abounded particularly in relation to individuals with severe to profound hearing loss. One such misconception concerning "the deaf" was that these individuals could not speak because they had no vocal folds (Davis & Silverman, 1970). This inaccurate information led to the unfortunate term of "deaf mute" suggesting that deafness and muteness depended on some common organic abnormality. In addition, it was acknowledged even at that time that speech was the vehicle to transmit thought and was essential for education. The term "deaf and dumb" reflected the belief that the deaf could not be educated because they could not hear or speak. This implied that the deaf had limited mental capacity that in turn influenced their legal and civil status. Roman law (Silverman, 1970) classified individuals who were deaf with those who were considered mentally incompetent.

Deafness was clearly seen as an educational barrier since hearing was the normal channel through which speech is perceived and was considered essential for learning. Although information on the education of the deaf is relatively sparse prior to the 15th century, it is clear that during this period, some thought was given to providing the deaf with other means so that they could express their thoughts. Agricola wrote a book that was not published until the 16th century in which he proposed that the deaf could express themselves by putting their thoughts down in writing (Silverman, 1970). Little information is available on the method that was used to achieve this goal. In the 16th century as well, Cardano, an Italian physician and father of a deaf child became interested in Agricola's work and promoted the notion that the deaf could be taught to comprehend written symbols by using pictures (Silverman, 1970). At this time, the belief that the deaf could learn to express themselves using words or gestures was introduced. This was a turning point as it was realized that deafness was a barrier to communication and not an intellectual deficit. The key therefore was to find ways to help the deaf communicate and learn.

In 1555, the first school for the deaf was established in Spain by Pedro Ponce de Leon, a Catholic monk. The goal of this school was to teach "deaf mutes" to speak. The first book exclusively on the deaf was produced by Juan Pablo Bonet in 1620 (Silverman, 1970) and promoted the teaching of language and articulation supplemented by sign language and a manual alphabet. Several other books followed and it is clear that, in this period, there was recognition that the deaf could be educated and that they were equal to normal hearing individuals. In the latter part of the 17th century, two individuals in particular developed different methods to educate deaf children and both made significant contributions to this field. In France, the Abbe de l'Epee founded the first public school for the deaf in Paris, and students were educated using sign language. In Germany, Heinicke founded a public school for the deaf and advocated for the use of speech and speech reading. De l'Epee and Heinicke disagreed about the merits of sign language and oralism as methods of instruction, a controversy that was repeated in

many countries and still persists today. Regardless of the methods used, by the end of the 17th century, it was clear that the deaf were capable of instruction and it was also recognized that this was a legal and moral obligation. In the United States, the first permanent school for the deaf was founded in 1817 in Hartford Connecticut, by Thomas Hopkins Gallaudet who had travelled to France and learned the methods of de l'Epee. The school at Hartford was known as the American Asylum for the Education and Instruction of the Deaf and Dumb, which later became the American School for the Deaf. In 1872, a Canadian educator of the deaf and inventor, Alexander Graham Bell opened a training school for teachers of the deaf in Boston. Bell was a strong believer of lipreading and speech in the education of deaf children.

Technologic developments were taking place at this time that eventually had a great impact on the management of hearing loss in children. This was also the era of the advent of electricity and Bell started experimenting with ways to make speech visible and audible to the deaf. This led to the invention of the telephone that laid the firm foundation for the electrical transmission of sound. The development of devices that had the potential to increase the audibility of sound for the deaf was a critical milestone in the management of deaf children. Bell founded the Volta Bureau in 1887 to disseminate information about deafness. In 1897, Max Goldstein, an otologist who was also a strong advocate for the importance of residual hearing founded the St. Joseph's School for the Deaf in St. Louis Missouri. Instruction included a series of exercises to give children practice with sound stimulation. In 1924, Goldstein established the Central Institute for the Deaf in St. Louis. In the late 19th century and at the beginning of the 20th century, deafness was viewed as a problem that belonged to the field of education. Many schools for the deaf developed programs predominantly for school age children. Over the years, with the advent of electricity and the development of technology, a better understanding of deafness took place.

Technologic Developments That Have Influenced the Management of Hearing Loss in Children

The Profession of Audiology

Prior to the advent of electricity and the development of the audiometer, it was very difficult to obtain precise information on the degree, configuration, and nature of hearing loss. The importance of obtaining information about a child's hearing loss was recognized and methods using various environmental sounds and speech were used. Itard in the 19th century (Silverman & Lane, 1970) developed a classification based on children's responses to bells, drums, and flutes. Urbantschitsch (Silverman & Lane, 1970) used a harmonica with specific frequency ranges and known intensities for the same purpose. These efforts led to classifications of types of hearing loss based on children's responses that were not unlike those used a half century later.

In 1929, the National Research Council in the United States sponsored a conference to address the problems of the deaf and hard of hearing (Hirsh, 1952). The need to accurately measure the degree and type of hearing loss was identified as an important priority together with the standardization of methods.

During World War II, audiology became the recognized profession with expertise in the science of hearing. Audiology was best defined by its multidisciplinary origins as it included knowledge from physics, psychology, education, and otolaryngology. This new specialty was created because of the numerous war casualties who suffered from hearing loss and deafness. Audiology provided a much needed professional service that had not been available. Since the work of Hirsh (1952), considerable information has been collected about sound and hearing measurement. The developments of the electric audiometer and audiometric standards have made it possible to measure auditory thresholds at frequencies important for speech perception. In addition, the medical field of otology contributed to the identification of the site of lesion and to the medical management of hearing loss in children. Hearing aids were developed and could provide some deaf children with access to sound. In these early days of technologic developments, the professions of audiology, otology, and education worked together to develop the most appropriate rehabilitation and educational programs for children with hearing loss.

The ability to measure hearing led to some interesting classifications of hearing loss in children. The terms deaf and hard-of-hearing were based predominantly on the degree of hearing loss and age of onset, and were used to guide the educational process and also, indirectly, to set expectations. It also was recognized that some children who had developed speech and language prior to the onset of severe to profound deafness had very different needs and therefore fell into the hard-of-hearing category. The deaf child was defined as one who did not have sufficient residual hearing to enable him or her to understand and develop speech even with a hearing aid, without special

instruction. The sense of hearing for the deaf child was thought to be nonfunctional for everyday functioning. Systematic and laborious procedures were necessary in order for the deaf child to learn to communicate (Silverman & Lane, 1970). As in North America, a similar trend took place in England under the School Health Regulations, whereby children were described as deaf and partially deaf (Ewing & Ewing, 1954). The deaf had no "naturally" acquired speech when they were admitted to school, whereas the hard-of-hearing had begun to talk naturally although with some imperfections. The hard-of-hearing child was thought to have a sense of hearing which, although defective, was also functional with or without a hearing aid. Deaf children were described as having pure-tone average hearing losses of 91 dB or greater, and as not being able to rely on the auditory channel as a primary avenue of communication. It was believed that hearing losses of such severity could not be overcome. Although the terms "deaf" and "hard of hearing" were used extensively at that time, the need to define children with hearing loss in terms of their educational and psychological potential was also identified. In fact, it came to be recognized that some "totally deaf" individuals could benefit from the use of appropriate amplification (Silverman & Lane, 1970).

Early Identification

Although the technologic developments of the 1940s to the 1960s clearly contributed to enhancing the management of children with hearing loss, many challenges still needed to be addressed. One such challenge was the late identification of hearing loss in children. The importance of early education of children with hearing loss had been identified and it was recognized that infants needed to be exposed to sound. The period from birth to the age of 5 years was identified as being particularly critical to learning. At the same time, however, it was acknowledged that it was difficult to evaluate a young child's hearing reliably and there was a lack of awareness by physicians of hearing loss in children. The average age of identification for hearing impairment in children was reported as 3 to 4 years (Bess, 2000; Wong & Shah, 1979) and there were significant delays between identification of hearing loss and hearing aid fitting. In addition, there was a difference of opinion on when a child was ready to wear a hearing aid and whether hearing aids could damage hearing.

Several individuals and events influenced the developments of early identification initiatives. In the United Kingdom, the Ewings (Ewing, 1957), who stressed the importance of early identification, parental involvement, and early amplification had an enormous impact on the management of hearing loss in children. In 1964, an international conference, "The Deaf Child" took place in Toronto, Canada, bringing together more than 30 experts from North America, Great Britain, Scandinavia and the Netherlands (Davis, 1965). Participants at this workshop were already sensitized to the importance of the early identification and early management of hearing loss in children. The purpose of the meeting was to find ways to alleviate the handicap to auditory communication imposed by early hearing loss. Considerable discussion took place on definitive tests of hearing for the very young, which were not available at that time. Systematic reviews of available tests were presented at the meeting and these included new electrical techniques that detected cortical evoked responses to sound in young children. This was seen as a breakthrough that might make it possible to eventually identify hearing loss in newborns and infants. Neonatal tests of hearing and the age at which reliable, reasonably valid, and definite tests of hearing could be performed were seen as crucial but the technology was not yet available. For this reason, the screening of high-risk groups of infants was recommended although the concept of universal neonatal screening in fact, was also discussed. Participants felt that it was too early to form an opinion about auditory evoked cortical responses as a test, and some were sceptical that an inexpensive, uncomplicated instrument could be developed to satisfy the requirements for clinical applications. All felt that more research was needed to determine the validity and reliability of tests to identify hearing loss early. Interestingly, at this conference, consensus was not reached on the age at which the use of amplified sound should be initiated and opinions ranged from two weeks to two months. The majority agreed, however, that two years was the maximum acceptable delay. Generally, participants felt that it would be ideal if hearing impairment were detected and confirmed by six months of age.

In 1969, in the United States, the Joint Committee on Infant Hearing (JCIH) was established and included representatives from audiology, otolaryngology, pediatrics, and nursing. The committee was mandated to make recommendations with regard to early identification of hearing loss. Over the years, several statements were issued by the Joint Committee on newborn screening (JCNS, 1970) and the JCIH (1982, 1990, 1994, 2000, 2007) and addressed the populations to be screened and the methods to be used for screening. In the first statement (JCNS, 1970), after reviewing the data from a small number of controlled studies on the screening of infants for hearing loss, the committee did not recommend the routine screening of newborns because of

a lack of accurate screening methods. At that time, screening methods were limited to behavioral responses to the presentation of relatively loud broadband stimuli (Mencher, 1976). This kind of testing had evolved from the behavioral responses obtained to auditory stimuli by Ewing and Ewing (1944) and Wedenberg (1956) to name a few. At the same time, and similar to the recommendations made by the 1964 Conference on the Deaf Child, the JCIH started to identify certain children who were at significant risk of developing hearing loss. This gave rise to the use of the high risk register, which was introduced as a supplement to the 1970 JCNS statement (Joint Committee on Infant Screening, 1976). Between 1982 and 1994, the high risk register was further refined to include additional factors (JCIH, 1982, 1990, 1994). The approach was therefore to screen children who fell on the high risk register since it was felt this would lead to the identification of the majority of children with a permanent hearing loss. At the same time, it became more and more evident that behavioral screening, even in its most sophisticated and automated form such as the Crib-O-Gram (Simmons & Russ, 1974), was not reliable nor valid (Durieux-Smith, Picton, MacMurray, & Goodman, 1987; Wright & Rybak, 1983).

In the last 30 years, considerable technologic developments have taken place, making it possible to accurately identify abnormal auditory function in newborns and infants. Two physiological measures, the auditory brainstem response (ABR) and otoacoustic emissions (OAEs) have clearly revolutionized early hearing detection and have led to the early identification and intervention of children with permanent hearing loss. In the late 1970s, Schulman-Galambos and Galambos (1979) recommended the ABR for newborn hearing assessment. Subsequently, several studies continued to investigate the usefulness of the ABR, particularly with high risk infants (Durieux-Smith, Picton, Edwards, Goodman, & MacMurray, 1985; Galambos, Hicks, & Wilson, 1982, 1984; Hyde, Riko, & Malizia, 1990; Kileny, 1987). Follow up studies of infants screened by this technique also showed good validity (Durieux-Smith et al., 1987; Hyde et al., 1990). The 1982 Position Statement of the JCIH recommended that the initial screening include the observation of behavioral or electrophysiological responses to sound, although the committee did not recommend any specific testing method. In the 1990 Position Statement, the JCIH recommended the use of ABR using clicks as the screening method for high-risk neonates. One of the problems at the time was that the equipment used to assess the ABR was costly, required considerable expertise to operate, and was not readily portable and therefore not really appropriate for screening. In the late 1980s and early 1990s, another technique, OAEs, was introduced as a promising method to assess cochlear function in newborns and infants. In 1978, Kemp in England was the first to show that OAEs could be detected in the human external ear in response to stimulation with clicks. The recording of these OAEs was viewed as evidence of normal cochlear function and more specifically of outer hair cell integrity (Kemp, 1980). Kemp's discovery and the development of equipment to record OAEs gave rise to an entire new approach to newborn and infant screening (Bonfils, Uziel, & Pujol, 1988; Kennedy et al., 1991; Stevens et al., 1989, 1990; White & Behrens, 1993). Studies that followed infants screened with this technique reported that OAEs could identify infants with hearing loss of approximately 30 dB HL and greater (Kennedy et al., 1991).

In 1993, the National Institute of Deafness and other Communication Disorders (one of the National Institutes of Health [NIH]) held a consensus development conference, "Early Identification of Hearing Impairment in Infants and Young Children," in the United States (NIH, 1993). The objective of this conference was to develop an improved approach to identifying hearing loss in infants. The 1993 Consensus Statement recommended that all infants be screened for hearing loss by 3 months of age. This recommendation was made after reviewing compelling evidence that clearly demonstrated that screening infants on a high risk register missed 50% of children who had a permanent hearing loss (Jacobson & Jacobson, 1990; Mauk, White, Mortensen, & Behrens, 1991; Watkin, Baldwin, & McEnery, 1991); this was subsequently confirmed by other studies (Durieux-Smith & Whittingham, 2000; Korres et al., 2005; Uus & Bamford, 2006). This was the first recommendation for universal newborn hearing screening. In addition, a screening protocol was proposed that included a two-stage screening process, namely, OAEs followed by ABRs for children who were referred by the OAE screen. In 1994, the JCIH gave careful consideration to the recommendations of the NIH conference and endorsed universal hearing screening while recommending additional research on the evaluation of the electrophysiological techniques that were now established to assess auditory function in newborns and infants. Since 1994, several investigators (Finitzo, Albright, & O'Neal, 1998; Mason & Herrmann, 1998; Prieve & Stevens, 2000; Vohr, Carty, Moore, & Letourneau, 1998) have documented the validity, reliability and effectiveness of both electrophysiological measures for universal newborn hearing screening. In 2000, the JCIH issued a new position statement describing the principles underlying effective Early

Hearing Detection and Intervention (EHDI) programs and providing guidelines for their successful implementation. In 2007, the JCIH reiterated its support for universal hearing screening, recommending that all infants be screened by one month of age, have a complete audiological evaluation by 3 months of age and receive appropriate intervention no later than six months of age. The definition of the target disorder was refined together with protocols for screening, diagnostic audiologic evaluation and medical evaluation.

In addition to technologic advances in screening for auditory function in newborns and infants, considerable progress has also taken place in methods for audiologic diagnosis (Ackley & Decker, 2006). Tone pip ABRs have supplemented click ABR and can now yield clinically acceptable estimates of pure tone thresholds by air conduction (Stapells, 2000). Bone conduction (BC) frequency-specific ABR threshold estimates can be obtained although the dynamic range of BC stimulation is limited and the possibility of error still exists (Campbell, Harris, Hendricks, & Sirimanna, 2004; Stapells & Oates, 1997). An assessment of infant middle ear systems using high frequency probe tones also can contribute to differential diagnosis (Alaerts, Lutz, & Woulters, 2007; Meyer, Jardine, & Deverson, 1997). Technologic developments in the last 30 to 40 years now make it possible to accurately identify hearing loss in infants and proceed with management for those with a permanent hearing loss.

Amplification

One of the preoccupations in the management of permanent hearing loss in children has been to expose the deaf child to sound stimulation through the use of amplification. Before the advent of electricity, mechanical hearing devices were developed. The ear trumpet dating from the seventeenth century was initially used by sailors to communicate with each other over long distances. Only in the 19th century did this device become an option for the deaf together with smaller versions known as cornets and auricles (Niemoller, Silverman, & Davis, 1970). The first electric hearing aid was designed in the late 1800s and it is thought that this invention was related to Alexander Graham Bell's work on the development of the telephone. This first prototype amplified sounds by mechanically funnelling sound to the ear by electronic magnification. The first amplification device contained a battery operated carbon transmitter and earphones, and subsequently a carbon transmitter model hearing aid became commercially available. In the 1920s, the carbon transmitter was replaced by the vacuum tube. The device now consisted of a microphone, an ear receiver, amplifier, and two batteries. Batteries only lasted for one day. One of the main challenges of the early hearing aids was to deliver sufficient energy. Over the next several decades, improvements were made with batteries becoming smaller, and in 1947 a major breakthrough came with the development of the transistor (Northern & Downs, 1991). Silicon transistors allowed hearing aids to shrink in size so that they could become "body aids." Even with these developments, early hearing aids were still very large, unattractive, provided limited bandwidth, and produced high levels of harmonic distortion (Killion, 1997). During that time, hearing aids primarily were designed for adults and not children. Binaural fittings were impossible with these cumbersome instruments and monaural fittings became an established practice. Because hearing aids were so large, a single Y-cord was often used to provide "binaural" amplification.

The main difficulty with these early electrical instruments continued to be the high power requirements and the size. Nevertheless, these early electronic aids revolutionized opportunities for deaf children as they provided sound stimulation. Due to their large size, the earliest electric models were not portable and were used exclusively in classrooms. The portable or desk type hearing aid was used as it had more power and provided a better quality signal (Niemoller et al., 1970). The teacher spoke into a free-standing microphone and the hearing-impaired listener received the amplified sound through headphones. This type of system required that the child remain in one place. The microphone and headphones were connected to an amplifier by means of cables and the child's movements were restricted by the radius of the cord connecting the amplifier and the headphones. This system was used for individual speech training. Systems were capable of reproducing a wider range of frequencies than individual hearing aids, few of which could provide significant amplification beyond 3500 Hz (Ling & Ling, 1978). For some children, hard wire systems helped to provide acoustic cues not available through personal hearing aids.

Another type of system was the group hearing aid with one or more microphones, an amplifier and as many as 10 pairs of over-the-ear or insert receivers. The use of electromagnetic transmission eliminated the need for connecting wires from amplifier to the listeners. Because the speaker wore the microphone, a better signal to noise ratio (S/N) was achieved. Another method used an induction loop around the classroom that received electric energy from the amplifier of the

group hearing aid. The magnetic field created by the loop current was sensed by a telephone pick up. This allowed the child to receive speech at the same level anywhere within the loop. In addition, the movements of the child were not restricted and loops could be used in settings outside of the classroom such as the child's home. One of the disadvantages was that loops could not be used in adjacent classrooms because of overspill whereby the electromagnetic field would extend outside the loop area. Group hearing aids were used in schools for the deaf and the technology at that time required that the management of children with permanent hearing loss take place predominantly in an educational setting. Today, special amplification systems such as radio frequency modulated systems (FM) make it possible for children to wear their personal hearing aids with an FM system. This ensures teacher/child mobility, and consistent favorable signal levels and has facilitated the inclusion of children with a permanent hearing loss in the regular school system (Sanders, 1993). Furthermore, the use of such systems is not restricted to the classroom setting.

With the advent of transistor circuitry and resulting miniaturization of hearing aids, it became recognized that the greatest advantage of personal hearing aids was that the child could have access to amplification at all times. It was acknowledged that the management of hearing loss should not only take place in the classroom setting but that children should benefit from auditory experience in everyday life. In the early 1950s, it became possible to wear two body aids and by 1955 hearing aids were worn in a harness around the body worn over clothing. The superiority of true binaural fittings was recognized as providing an increased directional sense and better perception of speech in noise (Carhart, 1958; Harris, 1965; Jordan, Greisen, & Bentzen, 1967; Ross, 1969). Furthermore, it became recognized that in most instances binaural hearing aids should be the standard treatment in every case of bilateral hearing loss. It also was acknowledged that it was more natural to receive sound at ear level and since the early 1960s ear level hearing aids have become more widely used (Northern & Downs, 1974). Because behind-the-ear aids were not as powerful as body hearing aids, it was recommended that behind–the-ear aids be fitted on all hearing losses less than below 80 dB HL and that two body aids be used for children with hearing losses greater than 80 dB HL (Jordan et al., 1967). The other advantage of body hearing aids was the separation of microphone and receiver that diminished the probability of acoustic feedback.

Tremendous technologic advances have been made with regard to hearing aids in the past four decades. Digital technology developments have led to signal processing that allows the provision of a uniform and high quality signal, but is beyond the scope of this chapter to review all of these in detail. Furthermore, there have been advances in hearing aid selection and verification methods. Much research and discussion have taken place addressing the appropriate selection of frequency responses, gain and output characteristics of hearing aids for children (Stelmachowicz, 2005). In the 1970s and early 1980s, systematic hearing aid fitting algorithms began to emerge although these were based solely on average adult data. One major development has been the use of clinical probe-microphone systems in the 1980s which facilitated the fitting of hearing aids to children. Through the use of these systems, Seewald and colleagues (Moodie, Seewald, & Sinclair, 1994) developed the innovative real ear to coupler difference (RECD) procedure that facilitates real-ear measures in infants as young as a few weeks of age (see Chapter 25 of this volume).

Despite these developments with hearing aids, there remained a population of profoundly deaf children who received very limited auditory information with conventional amplification. Cochlear implants were developed on the premise that in sensorineural deafness although hair cells are damaged or depleted, some cochlear neurons could be stimulated directly by the application of an externally produced electric current. Cochlear implants were developed from a single channel analog device in the 1960s and in the 1980s, multichannel implants were introduced (Owens & Kessler, 1989). Initially, the use of cochlear implants was restricted to adults who were postlingually deafened. In 1990, cochlear implants were approved by the Federal Drug and Administration (FDA) for use with children. The signal analog channel cochlear implant such as the 3M/House single channel implant provided little more than sound awareness, prosody or rhythm of speech. Improvements also were observed in speech recognition as determined on closed-set auditory only tests. Multichannel cochlear implants, with each channel uniquely programmable, provide sufficient frequency discrimination capability to facilitate speech perception and understanding (Thoutenhoofd et al., 2005). Language and literacy improvements in children with cochlear implants have been reported as being comparable to the results obtained with children who use hearing aids and who have less severe hearing loss (Moog & Geers, 2003). In fact, language scores of some children with implants have been documented as being within the range of children with normal hearing (Geers, Nicholas, & Sedley, 2003). Consequently, cochlear implants have become the standard of care for children with bilateral severe to profound hearing loss (Berg, Ip, Hurst, & Herb, 2007).

Recent advances in technology have fundamentally altered the way we think of the development of communication skills in deaf children. The early, appropriate fitting of hearing aids was probably the single most important tool in the management of the child with permanent hearing loss (Ross, 1977). Technologies for early identification and audiologic diagnosis of permanent hearing loss have made it possible to fit amplification to babies. Technologies for digital and programmable hearing aids and cochlear implants have made it possible for children with profound hearing losses to have access to sound and to spoken language. These advances have significantly altered our expectations of spoken language development for deaf children. These technologies have had a major impact on the development of different types of intervention. On their own, however, they are of little use if not followed by intervention programs.

Intervention for Children With Hearing Loss

Educational Options

Historically, there has been considerable difference of opinion about the most effective methods for developing communication. However, there is a consensus that the overall goal of (re)habilitative and educational management for children with hearing loss is to overcome or minimize the barriers to communication imposed by hearing loss in order to enable learning and participation in society. The extent to which permanent hearing loss affects typical spoken communication development and the need for specialized management will depend on characteristics of the hearing loss, such as time of onset and severity as well as characteristics specific to the child, family, and learning environment. These factors undoubtedly influence decisions related to language learning and educational approaches for facilitating communication development. However, it is clear that over the years management approaches have also been extensively influenced by technologic limitations, practitioners' experiences and philosophical views of what constitutes appropriate communication for a child with hearing loss (Beattie, 2006; Marschark & Spencer, 2006). It is perhaps these views, more than empirical data, that have contributed to the rich history of the (re)habilitation and education of children with hearing loss, one characterized by a mosaic of intervention methods.

As outlined in the previous sections of this chapter, prior to the advent of modern day hearing aids and particularly cochlear implant technology, children with hearing loss fell essentially into two broad categories based on hearing potential; those who had considerable access to acoustic speech signals and those who had limited or no access to speech despite the best available hearing technology. Two parallel (re)habilitation and educational management philosophies evolved, both with a focus on equipping the child with communication skills. One philosophy described as a manual approach supported the development of communication through a visual-based sign language system as the natural language of individuals who were deaf. In contrast, the oral philosophy adopted spoken communication and participation in the hearing community as a primary goal of intervention. Numerous variants of these two primary philosophies were developed throughout the world. A detailed review of the many approaches are beyond the scope of this chapter but a brief description of some of the most common intervention methods that fall under the manual and oral philosophies will be described briefly in the following sections. The interested reader is referred to more comprehensive historical perspectives and critical reviews in such writings as Spencer and Marschark (2006), Schick, Marschark, and Spencer (2005), and Lynas, Huntington, and Tucker (1989).

Although hearing loss begins as a health issue, the management of children with hearing loss has its roots in education and historically, service provision was viewed as the "field of education of the hearing-impaired" with teachers of the deaf responsible for educating children (Clark, 1997). This was likely due to the fact that most children were not identified with hearing loss until late and there were no or limited intervention programs in the preschool years. As audiologic services and better technology became available, earlier identification and early intervention services provided the foundations for changes in practice. Accordingly, responsibilities for the management of children expanded to include not only educators but also speech-language pathologists, audiologists, and other specialists in the management of children with hearing loss.

Traditionally, the educational system for children with hearing loss consisted primarily of special schools for the deaf that provided services in either sign language or oral communication methods. Two important notions underlie the support for manual communication. One fundamental concept is that sign language systems such as American Sign Language (ASL) or its international counterparts constitute the natural language of individuals who are deaf. Accordingly, ASL is viewed as a visual language comprised of signs with its own grammatical structure that is distinctly different

from that of spoken English grammar. Visual-manual systems such as ASL are consistent with a cultural view of deafness in which the Deaf individual is viewed as belonging to a linguistic minority with a distinct language and culture (Lynas, 2005). Essentially, ASL and other manual languages are structured for visual rather than auditory learning. The second important concept that led to support for sign language, particularly for children with profound deafness (prior to cochlear implantation), is that strong visual input is a requirement to overcome the barriers to communication imposed by reduced access to the acoustic patterns of speech.

More recently, programs referred to as bilingual-bicultural or sign-bilingualism (Lynas, 2005) have also emerged. The premise of these educational methods is that from the time of diagnosis of hearing loss, children should be exposed to a language such as ASL as their first language in an educational model that meets not only their linguistic but also their cultural needs as a participant in the Deaf community. Subsequently, written English is taught as a second language. These programs may also teach spoken English as a second language to enable the child to participate in everyday situations as a bilingual child (Lynas, 2005).

In contrast to visual-based approaches, the oral communication philosophy has been supported on the basis that more than 90% (Marschark, Lang, & Albertini, 2002) of children with permanent hearing loss have normal hearing parents who participate in a hearing society where spoken communication is central to the child's development, education, and employment opportunities. Central to this philosophy is the notion that despite reduced auditory access to the natural acquisition of spoken language, children can learn verbal communication through systematic teaching methods.

As noted previously, prior to the widespread availability of hearing instruments, access to hearing through vacuum tube hearing aids and group amplification systems was necessarily limited to classroom settings. Oral educational options therefore consisted primarily of special schools with special classroom programs for children with hearing loss. Unquestionably, a major breakthrough occurred with the availability of small transistorized hearing aids in the 1950s to 1960s. Wearable hearing instruments dramatically affected the variety of educational environments that became available for children with hearing loss (Clark, 1997), ranging from special schools to special classrooms in schools for normal-hearing children and eventually to integration into typical classrooms with normal hearing peers (Clark, 1997; Northcott, 1990).

The limited and part-time access to the sounds of spoken communication dictated the methods that evolved for teaching children spoken communication. Until the 1960s, oral communication methods consisted primarily of oral-visual methods with a strong focus on speech-reading and a related spoken language curriculum that concentrated on didactic methods of teaching through the teaching of words and sentence patterns (Clark, 1997). Speech skill teaching developed as a separate activity aimed at improving the quality of the child's articulation. Certain practitioners also believed that the written text was an effective method for teaching children spoken language, thus structured writing approaches as a visual means to teaching spoken communication supplemented traditional oral methods to provide the learner with increased access to communication (Clark, 1997; Marschark & Spencer, 2006).

As hearing technology and early identification services progressed and as new knowledge was acquired about speech and language development, traditional oral communication methods were modified. Several variants of the oral communication philosophy were developed to capitalize on these new opportunities. Overall, the ultimate goal of oral education of children with hearing loss remained the development of speech and language as similar to hearing models as possible. The oral approaches are based on the premise that despite reduced input, the overwhelming majority of children have residual hearing and essentially acquire language along the same developmental trajectory as children with normal hearing, although they may reach milestones at a slower pace. Improved access to hearing led to the development of models of rehabilitation that differed in their focus on audition, and natural language acquisition, inclusion with hearing peers, and parental involvement. Known under terms such as auditory-oral or aural-oral and auditory-verbal therapy, the defining difference between these variants of the oral philosophy to rehabilitation appears to relate primarily to the emphasis on the use of residual hearing.

As noted above, traditional oral methods involved significant emphasis on speech-reading. At the other end of the spectrum, lies auditory-verbal therapy, an approach that gained momentum in the 1980s and continued to grow as hearing technologies improved. The approach, which is fundamentally based on the premise that even small amounts of hearing can be tuned to acquire spoken language, has grown in popularity with the increased access to hearing provided by cochlear implants for children with severe to profound hearing loss. The approach relies heavily on language learning through the development of residual hearing. Characteristics of auditory-verbal practice include individual teaching of language via a primary caregiver and the early inclusion of children with hear-

ing loss with their normal hearing peers. However, until the advent of cochlear implants, a significant proportion of children with profound hearing loss who required specialized care had minimal access to acoustic speech signals (Boothroyd, 2008). Therefore, support continued for auditory-oral methods that also use speech-reading in teaching spoken language. The primary differences between auditory-verbal and other oral-based approaches are related to the emphasis placed on audition as the primary learning channel for speech reception and on the view that optimal development of communication and social functioning requires that children with hearing loss interact in group learning situations with children with normal hearing.

The assumption of all these oral language approaches is that exposure of the child to visual-based systems will delay or prevent the acquisition of spoken communication skills. In addition to the auditory-based learning methods, other teaching approaches have evolved that can be viewed as aligned with manual or oral communication methods depending on the ultimate communication development goals of the rehabilitation program. Cued speech is one method that is consistent with the oral philosophy but involves the addition of a systematic system of hand signals or cues to facilitate speech-reading and therefore speech reception. Cued speech involves the use of hand cues to code the phonemes of speech (Cornett, 1967).

Total communication is another teaching method that gained widespread recognition, particularly in the United States in the 1970s and 1980s. The method promotes the use of all input modalities including audition, speech-reading, and signs in order to enhance comprehension of speech. The approach essentially involves manually coded speech with visual symbols intended to compensate for reduced access to speech sounds through hearing. Other terms such as simultaneous communication and the combined approach have been used to describe manually coded speech systems. These multimodal communication approaches were promoted by some experts as a response to improve the low language and academic outcomes documented for children with hearing loss educated through oral communication approaches (Babbidge, 1965; Geers & Moog, 1989; Schildroth & Karchmer, 1986).

New Influences on (Re)Habilitation

As described above, developments in newborn hearing screening, hearing aid, and cochlear implant technology have had a significant impact on current thinking and management approaches. Cochlear implantation has had a significant impact on the quantity and quality of auditory information available to children with profound hearing loss and represents the single most important development in auditory (re)habilitation for these children in recent years. Early and appropriate hearing aid fitting or cochlear implants coupled with early identification of hearing loss resulting from universal newborn hearing screening initiatives have created a dramatic shift in the approaches and expectations for all children with hearing loss. Early identification through newborn hearing screening combined with advanced hearing technology has shifted rehabilitation from a remedial to a developmental model whether the choice of rehabilitation is sign language or oral language. Early access to spoken language patterns has created opportunities for children to acquire language in more naturalistic contexts and to participate in the educational system with hearing peers. Previous rehabilitation models such as auditory-verbal therapy emphasized spoken language acquisition following typical language developmental models, and efforts were made to develop spoken language in natural home and learning environments (Simser, 1993). However, due to late identification and limited access to auditory information, particularly for children with severe to profound hearing loss, many approaches included structured speech and language teaching that included remedial components particularly as children grew older (Ling, 2002).

The possibilities afforded by early identification, management through hearing technology and the developmental model are aligned with a model of family-centred care. The notion of family-centered care has dominated the management of children with hearing loss for many years, but is now growing due to the need to manage hearing loss in infancy and the new opportunities for enhancing language development in more natural and everyday contexts (Tattersall & Young, 2006; Young & Tattersall, 2007). Studies indicate that families want to be involved as partners in the process of language development and to make informed choices (Fitzpatrick, Angus, Durieux-Smith, Graham, & Coyle, 2008; Robinshaw & Evans, 2003).

There is a body of research documenting that children with various degrees of hearing loss who receive early intervention have the potential to develop spoken communication (Fitzpatrick, Durieux-Smith, Eriks-Brophy, Olds, & Gaines, 2007; Kennedy et al., 2006; Yoshinaga-Itano, Sedley, Coulter, & Mehl, 1998). In particular, a large body of research in cochlear implantation has documented positive outcomes in children with severe to profound hearing loss (Thoutenhoofd et al., 2005). Nevertheless, despite the many technologic

advances and improvement in communication outcomes, studies continue to show that children with hearing loss, as a group, have spoken language abilities significantly below their hearing peers (Kennedy et al., 2006; Wake, Poulakis, Hughes, Carey-Sargeant, & Rickards, 2005). These findings suggest that management through hearing technology alone is insufficient to attain age-appropriate skills. Accordingly, children with hearing loss continue to require professional management in developing communication and parents are required to make decisions about which intervention approach is best suited to their needs and desired outcomes.

In summary, there is a wide range of management approaches for children with hearing loss. Many of these constitute different routes to a common objective, that of developing competent spoken communication. Other approaches focus on the development of a strong communication system through sign language, which is viewed by supporters as the natural language of children who are deaf. The intervention approach and type of amplification selected depend partly on the severity of the hearing impairment and on the characteristics of the child and family but also largely on the families' choice of communication mode for the child. Advances in hearing technology and newborn hearing screening, combined with research documenting the benefits of these interventions, have increased the demand for spoken communication approaches for children with hearing loss. However, there is an understanding that families should have the right to make a fully informed decision based on the best available evidence and their long-term objectives and values for their child and family (Jerger, Roeser, & Tobey, 2001; Joint Committee on Infant Hearing, 2007).

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