Proceedings of the annual conference of the American cochlear implant alliance

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The American Cochlear Implant Alliance (ACI Alliance) is a not-for-profit membership organization organized in 2012 by a group of professionals in the field with the purpose of eliminating barriers to cochlear implantation. Despite important quality of life benefits for children and adults with moderate to profound hearing loss, cochlear implants remain a greatly underutilized health intervention.

The organization's membership spans scientists and clinicians from across the cochlear implant continuum of care including otolaryngologists, audiologists, speech pathologists, educators, psychologists and others on CI teams. Parents of children with hearing loss, adult recipients, and other advocates for access are also active members. It's diverse membership and focus on CI access makes ACI Alliance a unique entity. The mission has remained unchanged since its founding – to advance access to the gift of hearing provided by cochlear implantation through research, advocacy and awareness. Extensive resources are provided for those in and outside of the cochlear field on the website www.acialliance.org

During the 2017-2018 timeframe, the organization undertook an aggressive program to achieve its mission. Some of the organization's major accomplishments included:

**Research**
- Awarded a three-year grant to conduct a study to develop and validate Quality of Life instruments specifically targeted to cochlear implant recipients.
- Funded a planning grant designed to lead to a comprehensive assessment of the cost effectiveness of cochlear implants in children, a project designed to update the seminal Project Hope study published in 2000.
- Continued a multi-center study for the Centers of Medicare and Medicaid Services with the aim of expanding candidacy under Medicare.
- Collected data on Medicaid utilization across 30+ states demonstrating widespread dependence on Medicaid coverage for pediatric CI.
- Initiated a program to support survey research activities undertaken by ACI Alliance members with bi-annual push-outs of approved survey instruments to the membership.

**Awareness**
- Carried out programs in collaboration with consumer organization Hearing Loss Association of America (HLAA) to improve consumer understanding of CI candidacy, residual hearing, hearing aid use, insurance and outcomes associated with cochlear implantation in adults.
- Initiated outreach to the national organizations of family physicians, internists and pediatricians seeking to organize presentations at national and state conferences. Conducted state talks and presented at the October 2018 Family Medical Experience (FMX) annual meeting of the American Academy of Family Physicians.
- Developed a new resource for primary care physicians and nurses, Adult Candidacy for Cochlear Implantation: Clinical Guidance, being used for primary care physician and nurse outreach.
- Initiated a focused effort to expand website visibility and reach the general public and primary care physicians/nurses on key cochlear implant topics.
- Collaborated with Stanford University and University of California San Francisco on a cooperative pediatric CI symposium held July 26-29, 2017 in San Francisco with over 1300 attendees. Conducted a consumer workshop on Saturday afternoon for parents and adults with 130+ attendees.
- Expanded consumer blog resources for adults covering wide ranging rehabilitation topics.
- Initiated a PR outreach campaign in preparation for the March 2018 launch of a powerful documentary by filmmakers Jane Madell and Irene Taylor Brodsky profiling the journeys of 15 young adults, deaf from childhood, who benefitted from advanced hearing technology.

**Advocacy**
- Continued expansion of ACI Alliance State Champion program, which now includes over 100 Champs representing 42 states.
Collaborated with other organizations to advance reauthorization of the Early Hearing Detection and Intervention Act, which passed through Congress and was signed into law in 2017. Language suggested by ACI Alliance on the need for accurate, comprehensive, up-to-date information for families on options was included in the final bill.

Conducted research and highlighted problems of access to appropriate cochlear implant care at the Veterans Health Administration.

Worked with other organizations to support the retention of Essential Health Benefits (EHBs) in any healthcare reforms.

Actively participate in coalitions in the hearing loss and general disability field to address access and awareness. Assumed leadership for coordinating Friends of the Congressional Hearing Health Caucus.

Initiated a new coalition to protect Parent Choice in decision-making for children with hearing loss and address efforts to interrupt parental decision-making on technology and options for their own children. Published a strong Parent Choice Position Paper.

**Build an Effective Organization**

- Grew the number of active members to 1450 with 90 Organizational members.
- Continued expansion of social media with website visibility Twitter and Facebook.
- Expanded interactions with healthcare organizations and disciplines outside of hearing care to increase cochlear implant visibility in the larger healthcare communities.

**Annual Clinical Research Symposium**

American Cochlear Implant Alliance has conducted an annual clinical research symposium bringing together clinicians, educators, and scientists since 2013. Attendees address cochlear implants in a range of settings – universities, hospitals, private clinics, non-profit organizations, schools, and governmental agencies. CI 2018 Emerging Issues in Cochlear Implantation was the third conference that used this particular format. It was held in Washington, DC March 7-10, 2018. The symposium provided attendees with the opportunity to explore in depth four topics that have significant potential for improving outcomes across the age span. These included:

- Quality of Life and Cochlear Implantation
- CI Candidacy in 2018
- Parental Engagement in Pediatric CI Outcomes
- Cochlear Implant Practice Management

The annual Dr. John K. Niparko Memorial Lecture, given by William G. Kronenberger PhD, addressed ‘Executive Functioning and Language Development in Children with Cochlear Implants.’

We are grateful to the individuals who shared their knowledge and experiences as presenters, panelists and audience participants.

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**Executive functioning and language development in children with cochlear implants**

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Hearing loss is primarily a brain issue, not an ear issue (Flexer, 2011)

… deaf children are not simply hearing children who cannot hear (Marschark and Knoors, 2012)

The benefits of cochlear implants (CIs) are well-established for restoring some attributes of hearing and allowing for spoken language development in prelingually-deaf children. However, effects of hearing loss may extend beyond spoken language skills alone to include other domains of neurocognitive functioning. Because the brain is an integrated organ that develops based on experience, changes in exposure to hearing, language, and other experience-related factors have downstream influences on neurocognitive functioning.

*Dr. John K. Niparko Memorial Lecture.*

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Furthermore, because language is supported by multiple neurocognitive functions such as attention, reasoning, and memory, a reciprocal relationship exists between language and other domains of neurocognitive functioning, with each influencing and supporting the other. Therefore, understanding and explaining neurocognitive functioning in children with CIs is critical for improving language functioning and quality of life.

A subdomain of neurocognitive functioning that is dependent in part on auditory and language experiences is executive functioning (EF). EF is an umbrella set of neurocognitive functions responsible for the active regulation of cognitive, behavioral, and emotional processes in the service of planned, organized, controlled, goal-driven thinking and behavior (Diamond, 2013). Multiple subdomains of EF exist, including working memory (WM), inhibition, flexibility-shifting, planning, organization, and controlled attention for efficient/fast processing (Barkley, 2012; Kronenberger and Pisoni, 2018). Hearing provides valuable stimulation and practice with EF to the developing child through experiences such as selective attention (focusing on a specific auditory stimulus), resisting distraction (screening out competing auditory stimuli that are not the focus of attention), sequential processing/tracking (sustaining attention and processing effort on a sequence of auditory stimuli), and sensory integration (integrating auditory stimuli with visual, tactile, olfactory, and other stimuli) (Kral et al., 2016; Kronenberger and Pisoni, 2018). Evidence from studies of music exposure (Bialystok and DePape, 2009; Slevc et al., 2016), sequential processing (Conway et al., 2011), and early deafness (Kral et al., 2016) support the beneficial role of auditory experience for development of EF. Spoken language, which is facilitated by auditory experience, also enhances the development and use of EF by serving as a tool to control focus and behavior (self-talk), to maintain goals and sequential steps in mind (by representing goals and steps using language), to assist WM (actively holding information in mind using language), and to organize complex information (representing ideas with language) (Byrd et al., 2004; Fatzer and Roebers, 2012; Petersen et al., 2015; Zelazo et al., 2003). Thus, deprivation of early auditory experience from deafness, and restoration of some components of hearing (and spoken language) with a CI, may influence EF outcomes in prelingually deaf children who receive CIs.

EF is also a significant factor supporting the development and deployment of language skills by providing concentration and mental effort to enhance language learning and processing. Research supports the important role of domains of EF such as WM in the acquisition of language skills and fund of verbal information in normal hearing (NH) children (Gathercole and Baddeley, 1993; Gathercole et al., 2003). Furthermore, several models (such as the Ease of Language Understanding [ELU] (Rönnberg et al., 2013) and Framework for Understanding Effortful Learning [FUEL] (Pichora-Fuller et al., 2016) models) have been developed to explain the important role that controlled mental effort and working memory have during complex, challenging speech-language processing. According to these models, simple language processing, such as speech perception under ideal conditions by NH children or rapid access to well-specified vocabulary in the mental lexicon, occurs through a fast, automatic processing channel that requires little concentration or mental effort. However, challenging, complex processing, including speech perception under challenging conditions, requires active, controlled processing that places more demands on EF components such as controlled effort and WM. For children with CIs, speech perception and access to the mental lexicon is more demanding and challenging than for NH children, making the use of EF more important for language processing for children with CIs (Kronenberger and Pisoni, 2018).

In order to explain the relationship between hearing, spoken language, and EF in children with CIs in the context of many other biological, psychological, and social influences on language and EF, we have proposed an Auditory Neurocognitive Model (ANM; Figure 1) (Kronenberger and Pisoni, 2018). This model recognizes the influences of auditory experience on language and EF, as well as the influence of EF on language, which occur within a broader context of biopsychosocial influences on the neurocognitive development of the child. By identifying the network of influences on the reciprocal relationship between language and EF, the ANM specifies important domains of neurocognitive functioning that may explain outcomes and serve as targets for intervention.

Empirical research has supported the basic tenets of the ANM. Children with CIs are at elevated risk for EF delays relative to NH children, although the majority of children with CIs develop EF skills in the average range (Kronenberger et al., 2013b, 2014a, 2014b). Approximately 1/3 of children with CIs have been found to have clinically significant EF delays, a rate 2–5 times that of NH peers (Kronenberger et al., 2013b, 2014a). Cross-sectional and longitudinal studies have consistently found associations between some components of EF – especially verbal working memory, controlled fluency-speed, inhibition, and concentration – and language outcomes, and associations between EF and language are stronger in children with CIs than in NH children (Harris et al., 2013; Kronenberger et al., 2013a, 2014b; Pisoni et al.,
Recently, a pilot experimental study has found that reducing access to EF adversely affects real-time speech-language processing of children with CIs more than NH peers (Kronenberger et al., 2018). Reviews of research in this area have found overwhelming and consistent evidence of the reciprocal/bidirectional hearing-language-EF relationship, and have identified significant limitations in research studies that contradict this relationship (Kronenberger and Pisoni, 2018).

Models linking hearing, language, and EF in prelingually deaf children with CIs have important clinical and translational implications: Routine assessment of neurocognitive functioning, especially EF, should be integrated into outcome evaluations for children who receive CIs. Children who are at-risk for EF delays should be targeted for EF interventions, guided by tenets of models such as the ANM as well as existing evidence-based EF treatments (Diamond and Lee, 2011). Because speech-language skills and EF skills are closely intertwined, improvement in EF may be a target or a by-product of speech-language interventions, and, conversely, treatment components that improve EF may be effective in producing better spoken language performance in challenging settings. Families may benefit from education about EF and language outcomes in order to embed children with CIs in family environments that model, encourage, and teach EF. Finally, new research should evolve beyond comparisons of CI and NH samples to investigate factors explaining the wide variability in EF outcomes within the population of CI users and to test novel interventions to improve EF.

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References


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Cejas et al., 2014; Hoffman et al., 2015; Niparko et al., 2010; Quittner et al., 2007). Studies of cochlear implantation (CI) typically focus on clinical measures of efficacy related to communication (e.g. auditory skills, speech), which does not represent the overall CI benefit. HRQoL measures provide a crucial assessment of the impact of CI’s on everyday functioning (physical, emotional, social; Lin and Niparko, 2006). Condition-specific HRQoL measures have shown greater sensitivity and responsivity to interventions than generic measures because they include items that are more relevant and deemed as important by patients/parents (Quittner et al., 2013).

The Quality of Life-CI is the first HRQoL measure for pediatric patients using cochlear implants (Hoffman et al., in press). These measures were developed using the recommended FDA guidance, including stakeholder focus groups and open-ended interviews with parents and children. Data obtained showed that the most frequent areas of concern reported by families were: parental acceptance (e.g. allowing children to wear short hair/colored processors and magnets), device management (e.g. pieces breaking), receptive and expressive language skills (e.g. hearing in the cafeteria), processing fatigue (e.g. exhaustion at the end of the school day from listening), academic difficulties (e.g. reading, writing), and emotional functioning (e.g. feeling ‘different’ from peers). Ratings of frequency and severity indicated that both health care providers and parents considered expressive and receptive language, academic performance, peer relationships, and self-esteem as the primary domains impacted by hearing loss/use of CI(s).

The QOL-CI can be used to generate a profile of the strengths and weaknesses of the ‘whole child’. It is recommended that CI centers administer these tools annually to identify those at-risk, target interventions and track patient outcomes. As noted in our study, despite age-appropriate language skills, children reported challenges in other areas, including social functioning and fatigue. These tools could also be used to compare CI outcomes across centers, changes in HRQoL over time, predictors of better quality of life (e.g. age at implantation, socioeconomic status) and the effects of medical comorbidities on daily functioning.

To request a copy of the QoL-CI or to obtain further information, please contact Dr. Ivette Cejas at icejas@med.miami.edu.

References

Development of new cochlear implant quality of life instruments for adults
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Based on expanding cochlear implant (CI) indications and an increased number of adults with hearing loss due to an aging population, the number of adult cochlear implantations performed annually continues to increase. Health-related quality of life (QOL) instruments have become increasingly important in understanding the impact of a medical intervention on a patient’s life. This is especially true for low-risk procedures where outcomes such as mortality are not the primary end-point. Patient-reported outcome measures (PROMs) are instruments devised to capture a patient’s perspective about their overall health or treatment. The use of PROMs to assess

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QOL allows the affected population to provide direct input about how disease processes and interventions impact patients’ lives. The increased importance of PROMs is perhaps best highlighted by the Center for Medicaid and Medicare Services (CMS) targeting QOL improvement as a primary outcome measure in the Quality Strategy Report and the FDA requirement that PROMs be included in all clinical trials where an intervention seeks FDA approval.

Cochlear implant outcomes have been traditionally assessed using word and sentence recognition, which, although important, do not capture the diverse listening and communication experiences of CI users. Clinical protocols remain limited to the same metrics (speech understanding) that have been used for the past 30 years. Importantly, whether using words in quiet, sentences in quiet, or sentences in noise, speech recognition poorly correlates with CI user self-report of real-world communication ability (Capretta and Moberly 2016; McRackan et al., 2018; McRackan et al., 2018). This is likely related to the controlled manner in which speech recognition testing is done and the known reliance of most CI users on audio and visual cues and other information for communication that are not represented in traditional speech testing (Stevenson et al., 2017).

The positive effects of CI on QOL have been demonstrated using a wide variety of health-related and hearing-related QOL instruments (McRackan et al., 2018, McRackan et al., 2018), but there is no universally accepted QOL instrument for CI patients. This gap may partially explain the results of a poll taken at the American Cochlear Implant Alliance conference in 2018, which showed only a quarter of CI centers were including QOL as a CI outcome measure (Fig. 1).

The NIH established the Patient-Reported Outcomes Measurement Information System (PROMIS) in 2004 to develop, evaluate, and disseminate PROMs that assess well-being from a patient perspective. Since that time, PROMIS has established a multiple-step process for developing and validating PROMs (PROMIS). Following the PROMIS guidelines, our team at MUSC has made significant progress in developing a suite of new CI-specific QOL instruments for adults, including systematic literature search (McRackan et al., 2018; McRackan et al., 2018), patient focus groups (McRackan et al., 2017), and psychometric evaluation of our item (question) bank (McRackan et al., 2018). To enroll the large number of research subjects required, the Cochlear Implant Quality of Life Development Consortium was established in 2017 to help recruit a diverse, nationwide sample of subjects. The Consortium consists of 29 CI centers that represent all regions of the United States.

We now have a psychometrically valid item bank with 81 question representing 6 domains (communication, emotion, entertainment, environment, listening effort, and social). Using this item bank, we have developed a 35-item profile CIQOL instrument (CIQOL-35 Profile) and a 10-item global CIQOL instrument (CIQOL-10 Global) with strong face, content, and construct validity. The next step will be to psychometrically evaluate the profile instrument against legacy QOL outcome measures.

**References**


PROMIS Instrument Development and Validation Scientific Standards.
Exploring psychosocial determinants of CI outcome in older adults

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ABSTRACT: Evidence of strong associations between hearing loss and several health outcomes in older adults suggests that cochlear implantation has significant potential to positively impact health. At the same time variability in the psychosocial and cognitive consequences of hearing loss in older adults can pose significant challenges to realizing full benefit from this intervention. This paper summarizes efforts to characterize predictors of cochlear implant outcome and patient participation using a conceptual model that takes into consideration individual, environmental and intervention variables. Preliminary findings suggest psychosocial, socioeconomic and cognitive factors that may be used to triage candidates according to their need for supplemental rehabilitation or logistical support to maximize benefit.

There is growing evidence that unmitigated hearing loss is associated with impaired function and a degraded aging experience with significant financial implications (Huddle et al., 2017). As cochlear implantation (CI) professionals, we should consider how this apparent interaction between auditory deprivation and the aging experience impact the quality of engagement in the CI intervention process as well as functional and QoL outcomes. Increasing social isolation, impaired self-efficacy, and other mechanisms have been proposed to mediate the cascade of downstream effects that may accelerate dependence, morbidity, and mortality (Genther et al., 2015). If so, our interventions ought to take these mechanisms into account as they are also likely to impact the quality of participation and outcome. Contrera et al. (2017) has demonstrated higher loneliness scores among patients who are CI candidates compared to those who use hearing aids (HA) and are not CI candidates. It is also encouraging to see that isolation improves following CI.

Older patients therefore appear to be experiencing the interactive effects of aging and auditory deprivation, which increase over time and with greater degrees of hearing loss. Patients enter the CI intervention process with these cumulative effects, some of which may be reversed with improvements in speech perception (SP) and communication. The quality of engagement in the intervention process and the magnitude of communication benefit, however, are likely influenced by a number of psychosocial factors, some of which are in turn influenced by the cumulative downstream effects of hearing loss. In order to decipher which clinical and psychosocial determinants are important and worthy of action in the CI intervention process, we have found it useful to adopt a conceptual model proposed by Wilson and Cleary (Clark et al., 2012), which prompts us to consider potentially important individual, environmental, biological, and technological determinants of functional and quality of life outcome with a cochlear prosthesis.

We tested hypotheses related to this conceptual model by retrospectively collecting as much information as was available for 219 consecutive adult patients, age 60 years or older (Francis et al., 2015). The primary outcome of interest was change in open-set SP scores at 3, 6, and 12 months after activation compared to 1 month pre-operative scores (CNC word, phonemes, and HINT sentences in quiet). Independent variables explored the impact of age, and extent of auditory deprivation measured as proportion of life using a HA. We also examined the impact of socioeconomic status captured by education level, as well as access to social interaction and support as reflected by living arrangement and cohabitation status. A history of depression and health status as reflected by the Charlson index was also studied. It was important to record the rate at which SP data were missing (missingness), as a potential real-world indication of level of participation, and to identify potential analysis bias associated with missing outcome data. A step-wise approach was used to establish multivariate models that evaluated the relationships between these patient characteristics and SP gains. The criteria for a factor’s inclusion in the final model was a P-value for entry of ≤0.1 and a P-value for removal of ≥0.2.

In our step-wise multivariate analysis, we found that early SP gains at 3 m were consistently associated with the proportion of life using a HA – a presumed correlate of the extent of hearing deprivation (Fig. 1). There was an inverse relationship to baseline SP scores, presumably due to ceiling effects. Chronological age was not found to influence SP gain. Later SP gains between 6 and 12 months after activation were positively correlated to higher education level relative to high school or non-HS graduates. Relative to residence in assisted-living facilities other residential categories were associated with larger SP gains in the second half of the first post-operative year. Whereas lower health status was inversely proportional to later SP benefit, the diagnosis of depression was actually associated with higher gains.
There was no effect of chronological age. Education level, residential status and co-morbidities were also associated with overall 12 m gains, and there was an inverse relationship with missing data. Patients with missing data at 3 months on average had more extensive periods of hearing deprivation, and at 12 months had less family support, more co-morbidities, and were more likely to be female and reside in assisted-living facilities.

We conducted a follow-up prospective study of 76 patients who received their CIs at age 65 years and older in 2013 and 2014 (Tang et al., 2017). Higher 1-year AzBio scores were associated with higher education level and cohabitation. There was also higher SP performance in patients who were active users of tablet devices possibly indicating greater comfort and competence in using technology. Patients who engaged with aural rehabilitation scored significantly larger improvements in quality of life at 1 year after CI as measured using the Glasgow Benefit Inventory (GBI). There was no effect of age. Missing data was associated with mild cognitive impairment and lower social engagement scores on the GBI, which supports the practice of keeping track of missing data in convenience clinical cohorts to reduce bias and to provide a window into how marginal performers could be identified and possibly helped earlier. An updated conceptual model shows the feedback effect of functional status, and the places where post-operative rehabilitation presumably exerted benefit leading to better QoL outcomes in this subgroup of patients (Fig. 2).

Our findings suggest that delays in intervention and associated increase in the cumulative effects of auditory deprivation may lead to deficits in SP benefit with a CI. Furthermore sustained growth of SP is influenced by psychosocial, socioeconomic and general health factors. There is evidence that early declines in cognition and frail health are associated with reduced access or ability to engage in on-going CI services. Risk assessment and appropriate adjunct

![Figure 1](image_url) Positive and negative (in parentheses) correlations between SP gain and psychosocial and health-related variables. C1 3-month interval, C2 6-month interval, C3 12-month interval; SP speech perception.

![Figure 2](image_url) Findings by Tang et al. (2017) placed within a conceptual model for cochlear implant outcomes in older adults (Clark et al., 2012) showing the influence of individual and environmental characteristics as well as functional consequences of hearing loss (A) on SP results (B) and ultimately, quality of life outcome.
measures may mitigate these sources of variability and enhance benefits in social functioning and quality of life. The presented studies support a growing effort to identify the impact of reimbursement policy, community-based intervention models, and practice guidelines that promote more consistent restoration of communication health and successful aging (Lin et al., 2012; Nieman and Lin, 2017).

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References


Current state of knowledge: Quality of life in adolescents with hearing loss using cochlear implants
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Speech perception, speech production, and language outcomes dominate the pediatric cochlear implant (CI) literature, but good communication skills do not guarantee positive ratings of life satisfaction, or quality of life (QoL). QoL refers to a uniquely personal perception of life satisfaction across multiple dimensions in diverse situations. This paper reviews three realms of QoL – physical, mental, and social well-being – in adolescents with CIs.

Physical well-being includes physical health, pain, and fatigue. Adolescents with CIs show no difference in overall physical well-being compared to peers with typical hearing (TH) (Loy et al., 2010). However, parent proxy and self-report measures reveal significantly higher levels of fatigue in children and adolescents using hearing aids or CIs versus TH age-mates (Bess and Hornsby, 2014; Werfel and Hendricks, 2015). This documented fatigue echoes anecdotal reports of lower energy and higher listening effort in individuals with hearing loss of all ages. Fatigue particularly may affect adolescents, who experience increased academic and social listening demands in difficult sound environments (Stoff et al., 1989). Greater fatigue in children could have cascading effects such as higher absenteeism and lower attention, concentration, and school achievement. In sum, auditory status does not affect overall physical health, but does influence levels of fatigue and listening effort.

Communication and social-emotional deficits related to hearing loss can affect mental well-being, including internalizing symptoms (e.g. anxiety, depression), externalizing symptoms (e.g. aggression), and self-esteem. Compared to TH peers, children with hearing loss experience higher rates of depression (26% vs. 15–20%) and aggression (15–23% vs. 5%), but not anxiety (Brown and Cornes, 2015; Theunissen et al., 2012, 2014). Participation in mainstream education and use of oral speech corresponds to lower levels of depression (Theunissen et al., 2014). Adolescents with hearing loss report slightly but significantly higher ratings of global self-esteem versus TH peers (Warner-Czyz et al., 2015). Affiliation, attention, and fewer depressive symptoms were associated with higher self-esteem (Warner-Czyz et al., 2015). In summary, adolescents with CI show higher rates of depression, but similar levels of anxiety and self-esteem to hearing peers.

Social well-being reflects the integration of communication skills and theory of mind into real-world interactions. Historically, adolescents with hearing loss feel lonelier and have more difficulty making and maintaining friendships than hearing age-mates (Huber et al., 2015; Kouwenberg et al., 2012; Moeller, 2007; Nicholas and Geers, 2003; Wiefkerink et al., 2012). Preliminary data in our laboratory show no effect of auditory status on friendship quantity. However, adolescent CI users appraise friendship quality less positively than hearing peers, particularly for conflict and betrayal, and more similarly to chronologically younger children (Evans and Warner-Czyz, 2018). Auditory status also affects peer victimization (i.e. bullying) rates. Adolescents with hearing loss using auditory technology report significantly higher rates of bullying versus the general population (50% vs. 28%), especially for social exclusion (26% vs. 5%), mimicking patterns in children with exceptionalities (Warner-Czyz et al., 2018) (Fig. 1). Thus, adolescents with hearing loss report similar quantity but different quality of friendships, which may underscore higher rates of peer victimization and social exclusion.

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Clinicians and researchers should think beyond speech, language, and hearing performance to consider how hearing loss and/or the impoverished CI signal influences fatigue levels, mental health, and social interactions. Asking questions about experiences outside the clinic will inform the need to refer patients to other health professionals to improve QoL in adolescents with CI.

References


CI 2018 emerging issue: CI candidacy in 2018

Co-Chairs: Craig Buchman (Washington University), Teresa Zwolan (University of Michigan)

Presenters: Maura Cosetti (Ear Institute of the New York Eye and Ear Infirmary of Mount Sinai), Sandra Prentiss (University of Miami), Oliver Adunka (Ohio State University), Jill Firstz (Washington University)

When cochlear implants were first introduced, candidacy determination was a straightforward process: patients were expected to have bilateral profound deafness and demonstrate no benefit from hearing aids, which often meant 0% speech recognition. As technology has improved, CI candidacy has expanded to include patients with greater amounts of residual hearing and greater speech recognition skills. This session will review recent changes in CI Candidacy, including the use of contemporary measures to evaluate traditional candidates, medical/surgical considerations when determining CI Candidacy, the role that age and cognition play in candidacy considerations, and expansion of candidacy to include patients with SSD and asymmetric hearing losses.

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**Figure 1** Effect of auditory status on type of peer victimization experienced by adolescents.

Made fun, teased, insulted you
Spread rumors about you
Threatened you with harm
Physically hurt you
Coerced you
Excluded you from activities
Destroyed your property on purpose

□ Adolescents in the general population (n = 4,326) ■ Adolescents with hearing loss (n = 56)
Cochlear implantation candidacy: Elderly and cognition ‘Of sound mind, the role of advanced age and cognition in cochlear implant candidacy’

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Keywords: cochlear implant, cognition, cognitive testing, elderly

Changes in US and global demographics have brought age-related health issues to the forefront of healthcare across many specialties. Hearing loss and cognitive decline, or dementia, are two of the most prominent age-related diseases and recent data suggests that these may be closely related.

Hearing loss in older adults is prevalent and growing affecting 2/3 of individuals over age 70. Recent data has led to a greater recognition of the impact of hearing loss on health and function in aging, and specifically on cognitive decline. In large scale, longitudinal population-based studies of community dwelling elderly individuals, Lin and colleagues found hearing loss was independently associated with a 40% rate of accelerated cognitive decline (Lin et al. 2013).

Compared with their normal-hearing peers, individuals with mild moderate and severe hearing loss had 2, 3, and 5-fold (respectively) increased risk of all-cause dementia over 10 years of follow-up. This was supported by additional epidemiologic data in which the degree of hearing loss was found to be an independent risk factor for faster cognitive decline (Deal et al. 2017; Gurgel et al. 2014).

Taken together, these and other studies broadly suggest a linear relationship between severity of hearing loss and risk for cognitive impairment and/or dementia. The implications for cochlear implantation (CI) in this at-risk group, including both candidacy evaluation and outcomes, are complex and currently unknown. CI is safe and effective in elderly patients and consistent improvement in speech understanding has been reliably shown in many studies. Early and limited studies suggest some improvement in cognitive function after CI in elderly patients, however much more data is needed (Claes et al. 2018a; Claes et al. 2018b; Cosetti et al. 2016; Mosnier et al. 2015).

At present, there are no broad standards or protocols to guide CI candidacy evaluation in this population. Cognitive testing is, in itself, fraught with bias in the hearing impaired population and issues of timing, patient fatigue and stress, cost and availability of appropriately trained personnel are just a few challenges that limit incorporation into a busy CI setting. Perhaps even more importantly is a lack of clear understanding of how results of neuropsychological testing may influence the decision to proceed with CI. Recent development and availability of cognitive testing specific to and adapted for - the hearing impaired population (such as the Hearing-Impaired Montreal Cognitive Assessment, or HI-MoCA) may assist with these challenges moving forward (Claes et al. 2018a, Claes et al. 2018b; Lin et al. 2017). On the horizon may be a better understanding of not just which tests to use, but how the test results may predict post-operative outcome, improve patient and family counseling, and direct or influence post-operative programming and auditory habilitation in this emerging candidacy group.

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References

Medical considerations for children and adults when determining cochlear implant candidacy

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Cochlear implantation continues to be the most successful treatment approach to restore hearing in both children and adults with moderate-to-profound sensorineural hearing loss (SNHL). A number of factors, however, need to be considered during pre-operative evaluation, as these groups have a significant amount of heterogeneity within them. These factors include many different etiologies, different baseline auditory perceptual abilities, variable outcomes, and other medical considerations that can complicate implantation and/or post-op rehabilitation.

With the pediatric population, a multi-disciplinary approach should be in place, and the role of the family should not be underestimated. Timing of implantation must also be heavily considered. Early diagnosis with screening programs and subsequent diagnostic testing (e.g. frequency-specific auditory brainstem response), preferably by 3 months of age or earlier, is critical to optimize outcomes (AAP, 2007). Once a permanent hearing loss has been diagnosed, other important factors include early hearing aid fitting, ongoing evaluation by Speech Language Therapists and Audiologists to ensure assessment (and treatment) of communication milestones, identification of cochlear implant candidacy if indicated, and a thorough medical work-up.

The medical work-up of pediatric hearing loss includes investigation of pre-, peri-, and post-natal factors that could lead to hearing loss, evaluation for syndromic or infectious etiologies, consideration of genetic screening, an Ophthalmologic examination, and imaging to detect malformations that could predict outcomes or preclude implantation altogether. Imaging is particularly important for the pediatric group, where routine MRI is valuable to investigate the presence of cochlear nerve deficiency, signs suggestive of congenital CMV (e.g. dilated ventricles cerebellar hyperplasia), or an EVA. In some cases, a CT of the temporal bones can add further information on middle ear and labyrinthine anatomy, such as evaluating the bony cochlear modiolus (i.e. bony cochlear nerve canal).

While the possible causes of congenital hearing loss are extensive, etiologies such as Connexin (GJB2) mutations and congenital CMV are worth further mentioning. Connexin is a gap junction protein that is required to maintain ionic balance within the cochlear duct. Its primary importance is that this etiology may account for about 40-50% of children with severe-to-profound SNHL, but these patients demonstrate a tendency to perform very well with cochlear implantation, as co-morbidities are less likely to complicate implantation and rehabilitation (Prosser et al., 2015; Vivero et al., 2010). As for congenital CMV, it is thought to be the most common cause of non-genetic hearing loss (Fowler, 2013). The clinical spectrum is variable, especially with regard to hearing loss. It may be progressive, delayed, and difficult to diagnose, especially as hearing loss may be the only manifestation of a perinatal CMV infection. Studies examining anti-viral therapy are ongoing and may be beneficial in improving hearing (Bilavsky et al., 2016; Kimberlin et al., 2015; Pasternak et al., 2018). Cochlear implantation is also a very viable option, but outcomes may be limited by other factors, such as cognitive impairment (Kraaijenga et al., 2018).

Considerations with the adult population have many similarities. A medical work-up is needed to ensure the patient is able to undergo surgery, especially in those with multiple co-morbidities. Imaging is also performed to better understand middle ear and cochlear anatomy. CT and MRI have both been successfully used, and the priority of one can change depending upon the clinical circumstances. Additionally, recent evidence has shown the importance of both peripheral auditory health and cognitive function in cochlear implant outcomes post-operatively (Holden et al., 2013). Specifically, the interplay between these two will determine most, if not all, of the large variability that is commonly seen with outcomes.

References
As a part of ongoing longitudinal studies of cochlear implantation in adults with asymmetric hearing loss (Firszt et al., 2018), the present study focused on adults with considerable hearing in the better ear (BE) and no usable hearing in the poor ear. Specifically, the participants were those with BE air-conduction thresholds less than 40 dB HL and severe to profound hearing loss (SPHL) in the poor ear that received a cochlear implant (CI). Pre- and post-implant results of 23 participants were examined: mean age at CI = 56.7 yrs (SD 10.9), mean length of SPHL in the poor ear = 8.8 yrs (SD 10.8), mean BE pure tone average (PTA, .5, 1 and 2 kHz) = 19.5 dB HL (SD 12.3), and mean poor ear PTA = 102.4 dB HL (SD 18.0). Etiology varied, however, the majority (n = 15) had sudden onset of SPHL. Prior to implantation, 15 either used or had trialed a contralateral routing device (CROS, BiCROS), 4 used a BE hearing aid (HA), 1 used bilateral HAs, and 3 had not tried or purchased any type of amplification.

Post-implant, the poor ear alone (CI) demonstrated significant improvement compared to pre-implant performance. Group mean consonant-vowel-nucleus-consonant (CNC, Peterson and Lehiste, 1962) word recognition scores improved from 2.5 to 56% and AzBio Sentence (Spahr and Dorman, 2005) understanding improved from 1.6 to 65% (ps < 0.001). As with traditional CI recipients, performance varied with ranges from 14 to 89% for CNC words and from 30 to 93% for AzBio sentences. The primary interest for participants was the ‘everyday listening condition’ post-implant compared to pre-implant. Post-implant this was a CI + BE; 7 wore a HA on the BE and 16 had hearing levels that did not require a HA. Cochlear implantation resulted in significant 6-month post-implant improvement (everyday listening condition) for localization, understanding speech in noise whether noise was surrounding the listener or on either side of the participant, and perceived ability in everyday listening environments.

Group data identified significant benefit for speech recognition and localization, however there was substantial individual variability which remains unexplained. Because of this, it is important to counsel patients that improvements may be realized in some but not all listening environments. Pre-implant evaluation of individual performance for speech recognition in noise and localization is needed to assess abilities when listening with one ear and to address possible benefits from bilateral listening when a CI is used in the poor ear combined with contralateral acoustic hearing. Continued research is needed to understand performance variability, predict individual outcomes, refine clinical protocols, and ensure appropriate candidacy selection of individuals who have substantial hearing in the better ear.

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**References**


**CI 2018 emerging issue: Parent engagement in pediatric CI outcomes**

**Moderators:** Karen Johnson (Keck School of Medicine of USC), Dana Suskind (University of Chicago), Sally Tannenbaum Katsaggelos (University of Chicago)

**Speakers:** Roberta Golinkoff (University of Delaware), Dana Suskind, Jean DesJardins (Moravian College), Karen Johnson

Parents and the home routines they create play central roles in a child’s development. Research in pediatric CI outcomes has identified specific ways in which significant caregivers can promote acquisition and growth in spoken language and literacy skills in children with hearing loss. This research also highlights the effectiveness of providing parents and caregivers with specific knowledge and strategies that can be woven into family life to support their child’s communication and literacy development.

**Empowering parents through TMW interventions**

Dana Suskind

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The TMW Center for Early Learning + Public Health works to empower parents and caregivers with tools and supports they need to support the healthy development of their children’s brains, beginning at birth. The TMW Center develop and test evidence-based...
interventions and use the scientific process to learn constantly about what works and what doesn’t. Our ‘public health approach’ focuses on prevention rather than remediation, places parents and caregivers at the center of their children’s education and development and embeds proven practices that support parents’ and caregivers’ behavior change in existing early learning and public health systems. Research shows that as early as nine months of age, infants born into poverty score lower on cognitive development tests than their more affluent peers. This disparity triples by the age of two. By age five, less than half of children growing up in low-income families are ready for school compared to 75% of children raised in high-income families. There is a critical connection between parent and child interactions and the development of language, literacy, math, and executive functioning, regardless if a child has normal hearing or a hearing loss. Children’s parents are the most important source of language input to children and, as such, are also a primary source of variation in input. Despite substantial evidence that early parent language input is critical to children’s academic and life outcomes, parents remain an untapped resource, lacking the knowledge and tools to provide language rich environments to their children.

TMW’s evidence-based interventions reach parents at multiple touchpoints; TMW-Newborn (maternity ward), TMW-Well Baby (Pediatrician offices) and TMW-Home Visiting. Deployed through a web-based platform, TMW’s behavioral interventions translate emerging brain science into strategies (3Ts) caregivers can use in everyday settings. To date, interventions developed by TMW have been tested through 11 studies, 7 of which were randomized control trials or quasi-experimental trials, and have reached more than 3000 families in the Chicagoland area. Early results from these trials indicate the TMW interventions are effective in increasing caregivers’ knowledge and encouraging behaviors that support young children’s brain development by enriching their language environments.

Summer literacy intervention for children who are deaf and hard of hearing from bilingual homes: parents as partners
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Despite advances in the early identification and sensory intervention in children with hearing loss, many children who are deaf and hard of hearing (D/HH) continue to lag behind their typical hearing peers in the development of reading and writing. These delays are further compounded for children for whom English is not the home language and whose families may lack resources that support literacy engagement.

We have developed and implemented an intensive 3-week summer literacy intervention program in response to a need we observed among the children who are deaf and hard-of-hearing (D/HH) and their families in our center. The program is offered to young, school-aged children from bilingual (Spanish-English) or monolingual Spanish-speaking homes, who are developing spoken language with the assistance of cochlear implants or hearing aids. Children receive twelve 3-hour sessions (36 h) of small group instruction, centered around phonological awareness, print awareness, word knowledge, shared reading and writing, storybook conversations, and oral language. These skills have been identified as foundational in supporting literacy for typically hearing children (Shanahan and Lonigan, 2010) and areas of specific need for children who are D/HH (e.g. Ambrose et al., 2012; Desjardin et al., 2009, 2014; Geers and Hayes, 2011; Werfel et al., 2016). They are also skills for which parents can acquire strategies (e.g. Justice and Ezell, 2000; Lonigan and Whitehurst, 1998) that can be applied in the primary language of the home.

Parents attend four 3-hour seminars (12 h), conducted in Spanish by a bilingual teacher of the deaf, who is also a certified Auditory-Verbal Educator (AVEd). The parent sessions are designed to convey the importance of joint parent–child literacy activities. Parents are also provided with strategies that support shared reading and writing activities; strategies to which the child is also exposed through interactions with his or her teacher during small group instruction.

At the conclusion of the 2017 summer program, parents were asked to complete a short-answer Parent Survey, in English or Spanish, to assess the impact of the parent training and whether the program was meeting their perceived needs. Parents’ written responses were entered into a software program (NVivo; QSR International, 2018) for qualitative analysis. Two coders unfamiliar with the summer literacy intervention used line-by-line analysis to identify meaningful units of text, which were then categorized into nodes. The coders met with a third member of our research team to review coding definitions and agreement, and to synthesize codes into corresponding themes.

Thematic analysis (Braun and Clarke, 2006) of the parental feedback demonstrated that parents were able to develop strategies that could be implemented
at home. Furthermore, parents perceived that use of these strategies were yielding positive shared literacy experiences with their child within the 3 weeks of the program. Particularly reinforcing for parents was the enthusiasm, self-motivation, and increasing independence that their children were demonstrating around reading and writing, many for the first time.

Over the past four years, a community of families has come together around the summer literacy intervention. In any given summer, approximately half of families who enroll are returning after participation the previous year. Importantly, parents report continuing to use the strategies they acquired through parent seminars in their homes throughout the year.

References


As indications for cochlear implantation continue to expand, constraints in serving patients at already busy cochlear implant centers will worsen. Some centers have instituted innovative practices to optimize efficiency in delivering clinical services. This session will examine techniques and technologies already in place as well as possible future innovations that could improve efficiency and value for CI centers and patients. Such innovations include telehealth in the evaluation, pre-operative, and post-operative elements of CI; in-center programming efficiencies; outsourced audiology services; and industry utilization. Patients may benefit from satellite centers in smaller cities or rural areas that are now poorly served.

- **Pre-Implant and Surgical Issues Panel**, Moderator: David Haynes Panelists: Loren Bartels (Tampa Bay Hearing and Balance Center), Brendan O’Connell (University of North Carolina), Charles Sym (Ear Medical Group), Mark Sym (Arizona Hearing Center)
- **Post-Implant Immediate and Long-Term Care Panel**, Moderator: Meredith Holcomb Panelists: Allison Biever (Rocky Mountain Ear Center), Camille Dunn (University of Iowa), Alejandro Ullauri (Chicago Hearing Care)
- **CI Company Solutions for Increased Clinical Efficiency Panel**, Moderator: Holly Teagle Panelists: Judy Horvath (MED-EL), Bobby Sheinin (Cochlear), Tony Spahr (Advanced Bionics)

Management options for further research and assessment

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Three sections reviewed management concerns from varying perspectives: pre-implant and surgical issues, post-implant immediate and long-term care, and company solutions for increased efficiency. The first panel was comprised of surgeons who provided widely varying perspectives, some of which were refuted by audience members. Some surgeons reported modest audiology revenue from providing cochlear implant (CI) services while others indicated their clinics operated at a deficit by providing post-operative audiological care to CI patients. Solutions that were discussed and which should be researched include decreasing CI programming appointment times, increasing the number of CI patients seen in a day, and off-loading non-billable tasks such as ordering and accessory training to others such as a CI administrative coordinator, audiology assistant or CI companies. Other solutions reviewed include moving to a
one-processor contract, negotiating for lower hospital pricing for the CI devices, and partnering with one or all of the CI companies to provide counseling, CI programming, and CI troubleshooting at an office in the CI center. A grant funded, institution initiated project was also discussed as an effective method of subsidizing costs for hearing aid, cochlear implant, and speech therapy services for children with hearing loss.

Common themes emerged from the three audiologists in the second panel. All agreed that standardization of test protocols for pre- and post-CI visits are needed. Many clinics utilize different test batteries at varying presentation levels and test conditions (noise vs. quiet). Without standardization, it is difficult for referring physicians and audiologists to understand who meets the qualification for a CI. It was recommended that hearing aid (HA) audiologists test HA patients in an aided condition with speech perception measures to more appropriately refer patients for CI evaluations. With over 11,000 hearing aid clinics in the US, screening for CI candidacy in the HA office will likely provide a more timely mechanism for referring patients to CI centers for evaluation. Other highlighted tools for further research and evaluation that could improve access to CI care include remote programming/telehealth, cochlear provider networks (CPNs), and automated patient-driven CI programming software. While several speakers discussed CPNs as viable, appropriate options for the continued growth of surgical numbers and increased access to care, others expressed concerns that simply programming a CI device is not the same as providing appropriate CI care. Care provision includes counseling, educating patients, and addressing the emotional impact of the hearing loss. When considering outsourcing programming to a satellite audiologist/CPN, CI surgical centers should thoroughly evaluate the satellite location to ensure the level of care meets patient needs.

The third panel included representatives from the three FDA approved CI companies. A common concept for clinical efficiency was simplification. Each representative discussed available online tools for patients to access information about their CI journey, their CI equipment and their post-operative aural rehabilitation. Access to information leads to more informed patients and can reduce the amount of time necessary for an audiologist to spend on pre-operative counseling. The CI companies offer streamlined ordering, programming, and equipment troubleshooting to CI centers which drastically reduces the non-billable time for the audiologist. Lastly, the CI companies stressed their commitment to improving clinical efficiency is evident by their increase in clinical and consumer specialists who assist with problem cases, patient counseling, insurance reimbursement, and completion of order forms for new surgeries and upgrades.

While many problems and advancements were discussed regarding the evaluation, pre-operative, and post-operative elements of cochlear implantation, it is clear more research is needed in the area of clinical efficiency and practice management to guide adoption and use of such innovative practices and service delivery models.