Music Perception of Pediatric CI users with Conventional Long Electrodes Compared With Those Using Hybrid L24

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Topic: Audiology

Keywords: Music and Cochlear Implantation

Introduction: An increasing body of literature indicates that adult recipients of the hybrid cochlear implant have more accurate perception of speech in background noise and salient structures of music (e.g., pitch, timbre) than recipients of conventional long electrodes (LE). Improved perception of pitch and melody is a function of preserved low-frequency hearing. Children and adolescents who have a high-frequency hearing loss, but who have considerable low-frequency hearing are participating in an FDA trial to evaluate the outcomes of a hybrid device (L24) with a younger population. To date, little is known regarding the efficacy of hybrid devices in an adolescent population, especially with regard to music perception.

Methods: Five adolescents with stable, high-frequency hearing loss and cut-off frequencies of 313 Hz to 1063 Hz (lowest frequency programmed), using the L24Hybrid as part of an FDA investigational device exemption (IDE), were compared with 73 children and adolescents using traditional cochlear implant systems. All subjects were compared on measures of complex pitch ranking and familiar melody recognition as a function of structural cues (pitch, rhythm, lyrics, speech reading, MRIL). A subset of 33 children and adolescent LE recipients were also compared on melodic error detection (MED) at three base frequencies (131, 262, and 523 Hz). The listener hears a melody presented twice, one presentation altered by a semitone in part of the melody, and must determine which presentation was the correct, unaltered melody.

Results: Adolescents who used the L24 device performed significantly better on MRIL than those children and adolescents using LE when provided with only pitch (p=.04) and rhythm (p=.04) cues. No significant difference was found between the LE children and LE adolescents (p=.49). The L24 and LE groups had similar MRIL accuracy when lyrics (p=.30) and visual cues (p=.35) were available. Although quite variable, the average scores for the L24 adolescents tended to be more accurate (though not significantly different) than those of the LE users on MED, specifically in the lower frequency ranges of 131 Hz and 262 Hz. Variability on complex pitch ranking by the L24 adolescents was similar to the range of scores seen in traditional implant users, ranging from 1 semitone to 19 semitones in the hybrid listening condition (p=.09). This may be due to the large variation within a small sample.

Conclusion: Residual, low-frequency information, which is preserved for many hybrid patients, is advantageous for melody recognition and melodic error detection; there remains considerable variability with regard to pitch ranking. This preservation assists hybrid users in performing more accurately in difficult listening situations where low-frequency information provides the missing components needed. It may also provide a somewhat more ‘normal’ representation of music than that of children who have grown up with the traditional implant.
Differences in Perception of Musical Stimuli Among Acoustic, Electric and Combined Modality Listeners

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Topic: Audiology

Keywords: Music and Cochlear Implantation

Introduction: Cochlear implants have shown vast improvements in speech understanding to those with severe to profound hearing loss; however, music perception remains one of the greatest challenges of electric hearing. It is unclear whether the difficulty arises from limitations of sound processing or the nature of a damaged auditory system. Objective: The purpose of this study was to examine music perception performance with different acoustic and electric hearing configurations.

Methods: Chord discrimination and timbre perception were tested in subjects representing four daily-use listening configurations: unilateral cochlear implant (CI), contralateral bimodal (CIHA), bilateral hearing aids (HAHA) and normal hearing (NH) listeners. Fourteen adults were included in each group, none of whom were professional musicians. A same-different task was used for discrimination of two chords played on piano. Timbre perception was assessed using a 10-instrument forced-choice identification task.

Results: Chord discrimination showed a more narrow range of performance across groups, with mean scores ranging between 72.5% (CI) and 88.9% (NH). Significant differences were seen between the NH and all hearing-impaired groups, but not among hearing-impaired groups. Timbre perception was significantly poorer for the hearing-impaired groups (mean scores ranged from 50.3% to 73.9%) than the NH (95.2%). Significantly better performance was observed in the HAHA group as compared to both groups with electric hearing (CI and CIHA). There was no significant difference in performance between the CIHA and CI groups.

Conclusion: Having impaired hearing decreases performance compared to NH across both chord discrimination and timbre perception tasks. For chord discrimination, electric or acoustic stimulation of the damaged auditory system provided comparable performance. In contrast, timbre perception distinguished those with acoustic hearing from those with electric hearing. Those with bilateral acoustic hearing, even if damaged, performed significantly better on this task than those requiring electrical stimulation, which may indicate that CI sound processing fails to capture and deliver the necessary acoustic cues for timbre perception. Further analysis of timbre characteristics in electric hearing may contribute to advancements in programming strategies to obtain optimal hearing outcomes.

COI: Med-El Corp
Validating the Discriminatory Properties and Test-Retest Reliability of a Diagnostic Music Battery for CI Users: MusicEAR.

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Topic: Rehabilitation/Educational Aspects

Keywords: Music Therapy

Introduction: Today’s CI users can generally understand speech quite well in quiet, as only limited spectral resolution is necessary for speech perception. However, a wealth of literature has shown that the enjoyment and perception of music among CI users is quite poor, mostly due to the lack of sufficient spectral resolution, dynamic range, and poor pitch and timbre differentiation in current CI processors. We have developed a novel self-administered diagnostic music test to help elucidate how CI users perceive music, and to better understand the potential impact that musical rehabilitation may have on cochlear implant users. MusicEAR is an attention-based software designed to assess both music enjoyment and music perception, including pitch, timbre, and simple and complex melodies. Objective: Our objectives are twofold: first, to validate the MusicEAR diagnostic test as a reliable instrument that is able to discriminate between a range of musical perceptual abilities. Second, to confirm the test-retest reliability and internal consistency of the MusicEAR diagnostic software.

Methods: In the first study, 36 subjects (M age = 38.9 years) were recruited to test the discriminatory ability of MusicEAR software; 12 non-musicians with normal hearing (NHnM), 12 musicians with normal hearing (NHM), and 12 CI users. All 24 participants in the normal hearing groups had auditory thresholds within normal limits bilaterally (<20 dB HL) across frequencies of 250 to 8000 Hz. The 12 CI users were all post-lingually deafened, and received their CI not less than 12 months prior to participation. In the second study, 40 CI users (M age = 47 years) participated in test-retest sessions (within 8 weeks) using the MusicEAR software.

Results: For the first study, comparisons between the three groups of subjects (NHnM, NHM, CI) revealed that CI users performed significantly more poorly on both simple and complex melody perception tasks. The second study validated the test-retest reliability of the MusicEAR software by revealing no statistically significant changes in scores between the first and second test sessions.

Conclusion: These results confirm that: The diagnostic MusicEAR test is sufficiently robust to distinguish musicians from non-musicians, normal-hearing non-musicians from CI users, and musicians from CI users. Any observed change in CI users’ performance on the MusicEAR diagnostic test over time cannot be attributed to test-retest variability. Taken together, these results have led us to our next step; the expansion of MusicEAR into a structured rehabilitative software for CI users.
Introduction: For young children with congenital/prelingual deafness, music therapy strategies and interventions can be effective both before and after receiving assistive hearing devices. There are many other resources available in the literature with studies and information on music for children and young adults with cochlear implants; however, professionals working with young children using cochlear implants need practical strategies and interventions that they can incorporate into assessment and treatment. This abstract will focus on specific music therapy strategies, interventions and tools to support young children with hearing loss in their overall development. Objectives: Understanding music development in early childhood provides another perspective on the development of the whole child. For children receiving cochlear implants in early childhood, music exposure and training increases the experience of pleasure in listening to music and improves pitch perception. Music therapists use all of the elements of music along with a variety of songs and strategies to engage young children in music-making activities that support development. This presentation will provide professionals with a framework for music and development and specific music experiences that can be implemented by a wide variety of professionals.

Methods: In understanding early childhood development and music, it is helpful to use the framework developed by Elizabeth K. Schwartz and defined in the book, Music, Therapy and Early Childhood: A Developmental Approach (2008). Early childhood developmental levels presented include awareness, trust, independence, control and responsibility. Music therapy strategies appropriate for early childhood work include therapeutic instrument play, therapeutic singing, musical word fill-in, improvisation, structured musical activities, and musical memory training.

Results: In music experiences, the development of young children can be observed in responses to auditory stimulation, vocal and tonal production, and rhythmic recognition and can involve all skill areas. By providing consistent and repeated opportunities for responding to music, professionals working with children using cochlear implants will be able to provide a more varied repertoire of post-implantation rehabilitative service options.

Conclusion: For cochlear implant recipients, the influence of music and music therapy strategies can have a lasting impact on the interpretation of sound and the pleasure associated with music. Through hands on music-making experiences, teachers and therapists working with young children will strengthen their skills and encourage participation in active listening and sound production. Participants will leave this session with a greater knowledge of musical tools and specific tips that they can implement in their work.
ACI2014
Timbre and Pitch Perception of Children Listening to Cochlear Implant Simulations and Relations with Talker Identification, Speech Recognition and Age
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Topic: Rehabilitation/Educational Aspects

Keywords: Music Therapy, Speech and Language Development with CI

Introduction: Present-day cochlear implant (CI) processing strategies remove temporal fine-structure information in the stimulus waveforms, preserve temporal envelopes extracted from 6 to 22 frequency bands, and convey the envelope via a small number of wide bandpass filters. This processing results in coarse spectral cues poorly suited for presenting spectrally complex sounds in music or speech, such as timbre, pitch, talker identification, and speech in noise. At present, few studies with pediatric CI users have examined perception of timbre or pitch, or investigated how timbre and pitch relate to spectrally complex elements of speech. This study examined children’s timbre recognition, talker discrimination, and speech recognition (in quiet and noise) as a function of spectrally coarse auditory input (vocoder simulations); (b) investigated the relations among these variables; and (c) examined performance in relation to age at time of testing, musical training prior to testing, and pitch perception.

Methods: 35 normal hearing (NH) children ages 8-14 (M=10.43; SD=1.66) were tested on music measures of timbre recognition of 6 musical instruments representing different production principles and frequency ranges (MIDI files representing normal hearing and vocoder simulations) and complex pitch ranking. Two speech tests were administered using vocoder simulations: talker discrimination and the Multimodal Lexical Sentence Test for Children (in quiet; in noise). Questionnaire data were gathered on musical background. T-tests were used to compare timbre recognition in normal hearing and simulation conditions. Regression analyses were used to determine those factors most predictive of timbre recognition, talker discrimination, and speech recognition in spectrally degraded conditions.

Results: Participants had significantly poorer timbre recognition accuracy (p <.0001, difference of 33.1%) in the simulation compared with normal hearing condition. Age at time of testing was the strongest predictor for the simulation conditions of timbre recognition, talker discrimination, and speech recognition in quiet. Pitch was a significant predictor for simulated speech recognition in background noise. Interestingly, timbre recognition was not predictive of talker discrimination.

Conclusion: Consistent with prior studies with adult CI users, the degraded spectral features conveyed via CI simulation (vocoder) resulted in poorer accuracy by children for timbre recognition; pitch perception was predictive of accuracy on vocoded speech recognition in background noise. Chronological age appears to be an important predictor for all of the outcomes, which may be related in part to test-taking capabilities, or maturation of executive functioning and other central processing functions. The extent to which these outcomes can be generalized to pediatric CI users, whose auditory development differs substantially from NH listeners, requires further research.

COI: G.N.Otometric ¹
Developing the Musical Brain to Boost Early Pre-Verbal Communication and Listening Skills Through an Early Intervention Approach and Resource for Babies and Very Young Children with Hearing Loss

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Keywords: Rehabilitation for Children, Music Therapy, Speech and Language Development with CI

Introduction: Developing early communication and listening skills in hearing impaired babies and infants with hearing aids (HAs) and cochlear implants (CIs) through home based interventions focused on empowering parents supports the goals of early intervention best practices. Providing age appropriate support for newly diagnosed babies and infants with HAs, waiting for their CI, under the age of 12 months, can be challenging. The age of implantation has decreased; therefore, family centered resources need to fully support the pre-verbal stage. Research indicates that Musical activities can naturally develop the areas of attachment, listening and boost early development of communication skills. For parents and young children, the home provides a natural environment to develop these skills.

Methods: The study objective was to determine the effects of a musical, multi-sensory resource and monitoring tool for babies aged 3 – 24 months that promotes music, listening and early communication. This resource aims to support the natural development of attachment, supporting babies and toddlers to build early developmental skills that are essential for later language development. It aims to bridge the gap between having a HA, and waiting for a CI. The pilot consisted of 20 families (n=14 aided babies waiting for a CI, n=6 babies with CI) participated in a demonstration group, working with the resource at home for 6 months and a summary session.

Results: Parental feedback was positive. Parent and child centered ideas from the resource were carried over into the families everyday routines with a focus on the use of Infant Directed Speech. Monitored evidence illustrated that parents observed in their babies increased vocalization, attention and anticipation of the activities. Parents also reported their increasing confidence in singing, moving and playing with their baby during this program. Discussion The finding that early intervention is essential to maximize outcomes, led to the development of the Baby Beats. It will help parents to actively engage their child using movement to music and will, with a focus on music, help develop early communication, listening and language skills. Furthermore, it will support the child’s social and emotional development.

Conclusion: The resource has been shown to be age appropriate, practical and flexible for use in the home environment. It reflected how music can captivate babies and allows them to explore and demonstrate their awareness of sound in an easier, more developmental appropriate way – through whole body movements, facial expressions, vocalisations and playing on instruments. Babies listen for predictable melodies, harmonies as found in lullabies. This resource aims to support the natural development of attachment, supporting babies and toddlers to build early developmental skills that are essential for later language development. It aims to bridge the gap between having a HA, and waiting for a CI.
Development of Instrument Identification Abilities in Children with Cochlear Implants and Normal Hearing

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Topic: Audiology

Keywords: Music and Cochlear Implantation

Introduction: Investigations of music perception have shown that adult cochlear implant (CI) users perform more poorly than normal-hearing (NH) listeners. The post-lingually implanted adult population typically develops years of music experience with acoustic hearing, and subsequently needs to adapt music perceptions to electric hearing post-implantation. It is unknown whether music perception would be better if musical experiences were developed though exclusive use of electrical hearing, such as for implanted children. The objective this study was to measure development of instrument identification skills in children with normal hearing (NH) and with cochlear implants (CI).

Methods: Subjects were children ranging from 5 to 17 years of age with NH (n=67) or CI (n=39). Octave scales for each of 6 instruments (flute, clarinet, organ, trumpet, alto saxophone, and violin) were presented using the M.u.S.I.C. Test software presented in the sound field at 65 dBA. After each scale was played subjects were asked to identify the instrument from pictures of the 6 possible instruments on a computer screen. There were a total of 35 randomized instrument presentations, and performance was measured in percent correct identification. It was hypothesized that CI children would be able to identify instruments as well as NH children.

Results: The ability to identify instruments increased with age for both groups. However, improvement in scores for NH children increased much more rapidly and to a larger extent than for CI subjects (regression slopes: 5.3 NH, 1.2 CI). Across age there was a significant difference in median scores between NH and CI groups (NH 60%, CI 34%; p<0.001). For all subjects, scores stabilized at approximately 12 years of age and resembled similar performance to adult subjects. The mean score for the CI children at and above 12 years was 41% (SD 15), which was similar to a group of 24 CI adults with 39% (SD 15) from a previous study.

Conclusion: Children with cochlear implants, despite developing their auditory systems almost exclusively with electrical stimulation, do not obtain recognition of instrument stimuli at normal rates. These data suggest that significant improvement is needed in the representation of some musical qualities by cochlear implants.

MED-EL Corp¹, MED-EL Corp²
Can the Binaural Interaction Component of the Cortical Auditory Event-Related Potential be Used to Optimize Interaural Electrode Matching for Bilateral Cochlear Implant Users?

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Introduction: Binaural processing is more effective when neural response channels from the two ears are appropriately matched. Interaural electrode pairing may be an important factor to consider in the programming process of bilateral cochlear implantation. While behavioral measures have been used to match interaural electrode pairs in adult CI users, doing so in children can be a challenge. The long-term goal of this study is to develop objective tools that can be used to assist with device programming in young bilateral CI users. As the initial step, this study investigated the effect of electrode spacing on the BIC of the eERP and the association between BIC amplitude and sensitivity to interaural time difference (ITD) in adult bilateral CI users.

Objective: This study aimed to evaluate the utility of the binaural interaction component (BIC) of the electrically evoked cortical auditory event-related potential (eERP) to optimize interaural electrode matching for bilateral cochlear implant (CI) users.

Methods: Five postlingually deafened adult bilateral Med-EL CI users participated in this study. For each subject, electrode 6 in the right ear was paired with each of ten electrodes space across the electrode array in the left ear. Each of five subjects participated in four psychophysical test procedures: loudness estimation, loudness balancing, interaural pitch comparison and ITD sensitivity evaluation. Initially, loudness estimates were obtained in order to define the subject’s dynamic range (DR). Next, a psychophysical loudness balancing procedure was performed for each interaural electrode pair. The stimulation levels judged by the subjects to be equally loud were used to measure ITD sensitivity and record the eERP. Each subject also completed an interaural pitch-comparison task using a two-interval, two-alternative forced-choice procedure and an ITD sensitivity evaluation using a three-interval, two-alternative forced-choice procedure. eERPs were measured using loudness balanced, biphasic current pulses presented in the left monaural, right monaural and bilateral stimulation conditions. BICs were computed based on measures of the eERP obtained for each subject and each interaural electrode pair.

Results: Our preliminary data showed that interaural electrode spacing could affect both the BIC of the eERP and interaural ITD sensitivity. However, the magnitude of this effect varied across subjects.

Conclusion: The association between BIC amplitudes and ITD sensitivities in these subjects will be discussed.
ACI2014
A Novel Electrically Evoked Compound Action Potential Recording Paradigm to Acquire
Fine-grain Growth Functions
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Topic: Audiology

Keywords: Objective Measures, Fitting

Introduction: Electrically evoked compound action potentials (ECAPs) have become an important tool for fitting in children. In a standard clinical setup, recordings of ECAPs are averaged over 25 to 100 repetitions to allow the detection of an ECAP within the noise floor. To obtain an amplitude growth function (AGF), these measurements are normally performed for 5 to 10 different stimulation levels. The stimulation level resulting in a maximal acceptable loudness percept is normally unknown and needs to be obtained behaviorally during the measurement. We want to extend the recording paradigm routinely performed to acquire ECAP AGFs to allow for an improved assessment of the status of the electrode-nerve interface. Furthermore we want to reduce the clinically relevant total recording time and in parallel improve the possibility of the CI user to behaviorally feedback when a maximal acceptable loudness is reached.

Methods: We present a recording paradigm where the stimulation intensity is increased in quasi-continuous steps and instead of averaging repeated recordings with identical stimulation parameters, running averages over small intervals of stimulation levels are computed. The first visible ECAP within an AGF was manually identified by an expert and a sigmoidal model was fitted to the measured AGF.

Results: AGFs were recorded within 30 CI users using the new proposed ECAP recording paradigm as well as the above described standard clinical procedure. The intra-subject difference between the first visible ECAP response and the ECAP threshold derived from the fitted sigmoidal AGF model were evaluated for the two paradigms, as well as the total recording time needed to obtain an ECAP threshold. All subjects could reliable indicate when the maximal acceptable loudness was reached. Furthermore the fine-structure of the AGF is analyzed in single cases applying an extended sigmoidal model of the AGF.

Conclusion: Beside a more robust determination of the eCAP threshold, the proposed quasi-continuous stimulation paradigm results in a more robust behavioral feedback of the CI user upon the maximal acceptable loudness percept. Furthermore this paradigm can also reveal the fine-structure in the amplitude growth function.
Validation of a High-Speed Protocol for the Measurement of the Electrically Evoked Auditory Brainstem Response During Cochlear Implant Surgery

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Topic: Audiology

Keywords: Objective Measures, Auditory Neuropathy

Introduction: The electrically evoked auditory brainstem response (eABR) is a powerful tool for the evaluation of neural processing through the level of the brainstem. Though current research often focuses on the eABR as an objective means of fitting cochlear implants, the eABR, measured intraoperatively, provides information pertaining to the state of brainstem maturation, as well as to the effects of auditory deprivation on the auditory nerve and brainstem pathways. When obtained using optimal stimulation parameters, the utility of the eABR extends far beyond that of the more commonly measured electrical compound action potential (eCAP), which mirrors functionality of the auditory nerve. Despite the wealth of information it provides, a significant drawback of the eABR in comparison to the eCAP is the practical issue of increased measurement time. In comparing the two potentials, it is quickly recognized that the longer time window needed to fully capture the eABR response, when combined with the greater number of averages needed to successfully resolve the waveform, creates a possible deterrent to eABR usage in the modern, hyper-efficient operating room. One technique to reduce test time would be to stimulate at increased rates. While the effects of increased stimulation rate on peak amplitudes and latencies for acoustically-stimulated ABRs are well-known, effects on electrically-stimulated ABRs are less established. Objective: The purpose of this study was to systematically investigate the effect of stimulation rate on peak amplitudes and latencies of the eABR.

Methods: eABRs were obtained in both adult and pediatric patients during cochlear implant surgery. Measurements were conducted contralateral to the implanted ear with needle electrodes inserted at vertex and mastoid. Stimulus intensity was fixed based on clinical experience to a level which on average corresponds to a subjective loudness rating of "loud" or "very loud". Stimulation rates were varied from 13-99 stimulations/sec. All responses were band-pass filtered between .1 and 5000 Hz.

Results: Time required to obtain high-quality eABR waveforms was reduced by approximately 80%, when stimulation rate was increased from the more traditional rate of 20/second to high-speed rates approaching 100/sec. An insignificant (p>.05) effect of high stimulation rate was observed for both peak amplitude (a reduction) and peak latency (a prolongation); however, these changes were clinically insignificant and also much smaller than what would be expected using acoustic stimulation.

Conclusion: As predicted by modern theories of hyper-synchronicity in response to electrical stimulation, no significant degradation of waveform quality was observed in response to dramatic increases in stimulation rate, even in several patients with auditory neuropathy. Therefore, high stimulus rates (>60/second) are recommended as a time-saving measure for incorporation into intraoperative eABR protocols.
Recordings of Acoustic Evoked Potentials Directly from the Different Places of Cochlea Via Intracochlear Electrodes in Cochlear Implantees.

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Keywords: Objective Measures , Residual Hearing

Introduction: The latest developments in cochlear implants, electrodes and surgical techniques allowed for expansion of indication criteria in cochlear implants. Currently, it is possible to implant patients with Partial Deafness (PD), with normal hearing up to 1.5kHz and with high frequency severe to profound sensorineural hearing loss with certain degree of hearing preservation after the cochlear implantation. Using appropriate tools allows us to perform measurements that have never been obtained in human and further to improve our understanding of inner ear and hearing. For instance, to this date it was not possible to record acoustically evoked or acoustically and electrically evoked response directly from the cochlea. Currently, there are available only studies recording the acoustic potentials via far field recordings (i.e. using a clinical ABR technique) or intraoperatively via an electrode placed in the vicinity of the round window. However, none of these approaches allows us to get better understanding of pattern of excitation within the cochlea. Specifically, using such measurement set-ups it is not possible to obtain frequency specific information.

Methods: The acoustical stimuli were presented via inserts placed in the ear canal of the subject in implanted ear. The personal computer with Synergy system was used for controlling and providing acoustical stimulation. Near field responses were recorded from multichannel intracochlear electrode using Research Interface Box (RIB) II system.

Results: Our pioneering work showed that recordings of acoustic evoked potentials directly from the different places of cochlea are possible using implant electrode.

Conclusion: Our method, if confirmed, would be very helpful as an objective tool for assessing possibility of utilization of remained acoustic hearing after CI implantation. Especially for Partial Deafness children it would help to fit acoustic part of hearing prostheses in implanted ear in the most accurate way. The work was supported by Polish National Science Centre, decision no. DEC-2013/09/B/ST7/04213.

COI: Med-El¹
Study to Demonstrate Objectiveness and Effectiveness of Cochlear Implant Audio Processor Programs for Young Children Generated from Electrically Elicited Stapedius Reflex Thresholds

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Topic: Audiology

Keywords: Fitting, Objective Measures, Young and Very Young Children

Introduction: Objective fitting methods are preferred particularly for young children who are unable to provide satisfactory feedback on loudness or perform to stimuli. Objective methods tend to be faster and more reliable than subjective methods. Collection of definitive data means fewer follow up fitting sessions are required. This is important for CI clinics with busy schedules. Maximum comfort level (MCL) can be set on each electrode at electrically elicited stapedius reflex threshold (ESRT) level and threshold (THR) can be set at 10% of MCL. ESRT’s can be elicited to live voice once a program is activated to check ‘loudness’ of the generated program, small global MCL changes may ensue. Objectives: 1. Identify correlations between MCL set by 2 different audiologists based on eSRT measures. 2. Outline the time required to measure eSRT’s on each active electrode. 3. Describe the auditory performance of new CI users with eSRT based AP programs using cortical assessment.

Method: 10 children implanted with a MEDEL CI before the age of 36 months, with 2-3 months of CI experience were provided with an eSRT based program by a first audiologist. Processing strategy, frequency range and automatic sound management were left on default and a volume of 100 % was used on activation. A second audiologist with no prior knowledge of the child’s 1st. program then provided the CI user with a second eSRT based program. Electrodes included in the program and the MCL’s set on each electrode by the two audiologists were compared. Time to measure eSRT’s on each electrode and perform a ‘live’ eSR test was recorded. The second program was downloaded to the AP and aided cortical assessment using automated equipment was carried out. P1 responses to speech stimuli /M/, /G/, /T/, presented at 55 dBSPL were checked. Cortical responses were scored, 1 point awarded for a P1 and a further point awarded if the latency fell within the reference range.

Results: There was a high correlation between MCL’s set for each child by the first and then the second audiologist. Both audiologists activated the same electrodes. Time taken to measure eSRT’s on each active electrode and perform a ‘live’ eSR check varied from 8-12 minutes. These CI users with eSRT generated programs tended to score 5-6 points on cortical testing at 55 dBSPL demonstrating they had P1 responses mostly in the reference latency range by 8-12 weeks post switch on.

Conclusion: The high correlation between MCL’s set by 2 different audiologists reflects the objectivity and reliability of eSRT measures. The short amount of time required to measure eSRT’s makes this a viable measure for use in busy CI clinics and finally the fact that eSRT based AP programs access users to sufficient sound to promote auditory maturity within just 2-3 months of switch on highlights the accuracy of these programs.
Incorporating Cortical Evoked Potentials Into the Diagnostic Assessment of Infants with Hearing Loss as a Standard of Care
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Topic: Audiology

Keywords: Objective Measures, Young and Very Young Children, Auditory Neuropathy

Introduction: The recent FDA approval of cortical evoked potentials creates a new opportunity to improve the care and management of children and infants with moderate to profound sensorineural hearing loss and auditory neuropathy spectrum disorder. Current standard of practice includes the use of auditory brainstem response evoked potentials for diagnostic testing, but cannot help to assess cortical function and benefit with amplification. The opportunity to incorporate testing may have a profound effect on how quickly these children can be accurately assessed and determine if they should be referred for cochlear implantation.

Methods: With the review of currently proposed protocols for cortical evoked potentials, we will assess the ease and feasibility of incorporating these protocols into standard of care for children and infants with moderate to profound sensorineural hearing loss and auditory neuropathy spectrum disorder. We will begin with a current review of protocols, equipment availability and ease of use, clinic time necessary, and billing procedures. After review we will make a determination of the reality of implementation for incorporating this testing for all infants diagnosed with moderate to profound sensorineural hearing loss and auditory neuropathy spectrum into the standard of care.

Results: Current protocols exist and can be easily implemented into the standard of care of infants diagnosed with moderate to profound sensorineural hearing loss and auditory neuropathy spectrum. The equipment can be easily incorporated into clinic schedules and minimal changes to billing procedures are necessary. The information obtained was felt to have high diagnostic value allowing for earlier referral to cochlear implant evaluation and implantation for children who are difficult to test behaviorally.

Conclusion: The incorporation of cortical evoked potentials is a feasible and valuable assessment tool for the care and management of infants diagnosed with moderate to profound sensorineural hearing loss and auditory neuropathy spectrum. This tool has important diagnostic value for the timely referral of children who may be cochlear implant candidates and should be incorporated as a standard of care.
Changes in Hearing Perception with Electrical Stimulation in Users with Meniere’s Disease: A Case Series

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Topic: Audiology

Keywords: Outcomes, Fitting

Introduction: Meniere’s disease (MD) causes fluctuating, progressive hearing loss that can lead to severe to profound hearing loss. Some patients with MD will have hearing loss that progresses to cochlear implant candidacy and subsequent implantation of unilateral or bilateral cochlear implants. New tests and less stringent criteria mean that patients with MD may be implanted while still in active stages of the disease. Clinical observation has revealed that some MD patients with cochlear implants report changes in their hearing perception, sometimes related to vertigo attacks associated with their MD. Objective: To describe the effects of active MD on patients with cochlear implants and to help guide clinical management of these patients if this subset of patients if different than the general cochlear implant population.

Methods: A retrospective case series looking at documented patient reports and clinical data, including cochlear implant settings, speech recognition testing, and vestibular testing, of cochlear implant patients also diagnosed with MD. Three of the case studies with the clearest patient reports will be featured in descriptive analysis, with pertinent highlights of other cases described as well.

Results: Eight cochlear implant patients at the center were identified as also having MD. A chart review revealed three of these patients to have clear reports of changes in their hearing perception with their cochlear implant(s) when experiencing MD attacks. These changes were often reported to improve after the MD attack, though not always back to their perceived baseline prior to the attack. The reports were often accompanied by requests of programming changes to address the perceived change in hearing. The chart review also revealed additional patients in this population that had mentions of changes in sound quality or speech perception and often subsequent programming changes, though these changes were not necessarily reported to be directly linked to significant MD attacks.

Conclusion: Cochlear implant patients with active MD may experience changes in their electrically stimulated hearing during attacks. Care must be taken if making large programming changes based on these reports during or right after the MD attack, as our experience reveals that when the attacks resolve, more minimal changes sufficiently address the remaining concerns. Some patients may need or desire additional programs or larger volume range due to these fluctuating hearing changes. These case studies suggest that further research is needed to help us better understand the changes in electrical hearing that can occur during a MD attack.
Session 3: Music and Speech Understanding in Adults and Adolescents

ACI2014
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Keywords: Music Therapy

Introduction: Despite significant advances in speech performance for cochlear implant users, music perception and enjoyment remain challenging for most, as implants lack the spectral resolution necessary to fully capture a musical piece. Little progress has been made to address the rehabilitative aspect of music perception. Objective: In this study, a self-administered music rehabilitative software - MusicEAR - was designed to help improve the perception of musical patterns of increasing complexity, as well as pitch and timbre perception, premised on focused and divided attention.

Methods: 21 adult CI users (14 Female, 7 Male) were recruited, ranging in age from 32 to 82 years (M=57 years). Time since hook-up varied from 3 months to 153 months (M = 14 months). Participants had varying musical backgrounds. Participants were tested with a validated “diagnostic” version of the MusicEAR program before and after 4 weeks of training; including tests of pitch perception, timbre perception, and pattern identification with increasing levels of difficulty and complexity. Participants completed a number of subjective tests including one of music appreciation, an assessment of past musical experience, and a (post-training) questionnaire pertaining to the training process and software program. Speech data in quiet and noise was also collected both pre- and post-training. Participants trained with the “rehabilitative” version of MusicEAR on their home computer for a minimum of 3.5 hours a week, for 4 weeks. Training was monitored while results were captured and transferred into an online database, including information such as time spent on task, reaction times, percentage scores, etc.

Results: Post-training diagnostic MusicEAR test scores, as compared to pre-training scores, indicated significant improvements in musical pattern perception. Those with little musical training significantly improved on tests of pitch, 3- and 4-note pattern perception, and complex patterns in melodies, whereas participants with more extensive musical backgrounds only improved on the most complex levels of the diagnostic test. Speech Perception scores in quiet and in noise improved significantly pre-to-post training in the low musical ability group. All of the training participants felt that the training helped to improve their recognition skills, and found the program to be beneficial.

Conclusion: Results of this study suggest that even with the limitations of current CI speech processors, auditory training can improve speech in noise and music perception abilities, lending further support to rehabilitation being an integral part of the post-implantation paradigm. The intensity required for focused and divided attention resulted in significant benefits for those patients with little-to-no musical backgrounds, as compared to patients with greater degrees of musical training. A high degree of patient compliance and motivation is necessary to achieve the desired outcomes.
Introduction: Most cochlear implant (CI) recipients struggle to reliably sing in tune. Singing in tune is dependent upon frequency resolution and accompanying pitch perception, which are known to be poor for CI users. A singer also must use vocal feedback (i.e. hearing one's own voice), which is limited by the spectral resolution afforded by the CI. This project is the first step in evaluating how CI signal processing can affect vocal reproduction. The hypotheses driving the study were that subjects would be better able to reproduce pitch for unprocessed signals and that musicians would be more accurate at vocal reproduction for both processed and unprocessed stimuli.

Methods: Musicians and non-musicians were recruited to sing along with music stimuli that had been processed through a 15-channel vocoder (e.g., Litvak et al., 2007). Ability to match pitch and sing in tune was compared to performance with unprocessed stimuli. The test stimuli fell into a spectrum of increasing musical complexity and context including single notes, 5-tone patterns, nursery rhyme melodies, and pop songs with which the subjects were most familiar.

Results: As expected, performance was significantly better for unprocessed stimuli as compared to vocoded stimuli for both listener groups. Musicians were significantly more accurate singing single tones for the unprocessed stimuli. When listening to the vocoded stimuli, however, there was no difference across the participant groups for single tones such that both groups were equally poor in vocal accuracy. For more complex musical stimuli, musicians significantly outperformed the non-musicians for the vocoded stimuli, but not for the unprocessed stimuli. Specifically, musicians were better able to match key to vocoded pop songs, though this may have more to do with auditory and muscle memory than the musicians' abilities to extract fine spectral detail from the vocoded stimulus. There was no difference across the participant groups for 5-tone patterns nor for simple nursery rhymes.

Conclusion: Even in an acute listening experiment, both musicians and non-musicians showed poor vocal reproduction abilities which was presumably due to the poor frequency selectivity associated with the spectral smearing of the musical stimuli. Individuals with musical training were significantly better able to sing on key with familiar pop music; however, these listeners had access to unrestricted vocal feedback as well as auditory and muscle memory. It is likely that for musicians with CIs, the vocal feedback loop is significantly limited by the spectral resolution of the CIs. Future investigations will include comparing CI recipients' performance to the results found in this study, to estimate the contribution of vocal feedback as well as to investigate the influence that duration of CI experience may have on outcomes.
Consonant Recognition and Error Patterns in Voiceless Fricatives in Postlingually Deafened Adult Cochlear Implant Users, Prelingually Deafened Adolescent Cochlear Implant Users, and Normal Hearing Listeners with Cochlear Implant Simulation

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Topic: Audiology

Keywords: Outcomes, Pre-/Perilingual Adolescents

Introduction: Cochlear implantation has facilitated high performance levels for understanding speech in quiet situations via access to high frequency consonants in people with severe to profound hearing loss. We compared consonant recognition and error patterns of voiceless fricatives in well-performing postlingually deafened adult cochlear implant (CI) users to those of normal hearing (NH) listeners with varying number of CI simulated channels, and to those of well-performing prelingually deafened adolescent CI users.

Methods: Nine adult NH listeners, 12 adult CI users (7 with conventional CIs and 5 with Hybrid CIs), and 5 teenage CI users (between 16 and 18 years old with CIs received before 3 years old) have participated so far. A consonant recognition test was administered using 16 consonants in an /a/-consonant-/a/ context (Turner et al., 1995). Consonant and phonetic feature recognition, specifically error patterns in voiceless fricatives (/f/, /θ/, /s/, and /?/), which was the most common errors, were analyzed.

Results: Consonant recognition scores of well-performing postlingually deafened CI users, both conventional and Hybrid CI users, resembled those of NH listeners with 8-channel CI simulation (> 80% correct). Also, phonetic feature recognition scores of adult CI users was comparable to those of NH listeners with 8-channel simulation for voicing and manner (> 90% correct) and place of articulation (> 80% correct). The /?/ sound was the easiest (> 90% correct) and /θ/ was the most difficult (< 55% correct) voiceless fricative to recognize in adult CI groups and NH listeners with 8-channel simulation. Most interestingly, consistent confusion patterns were found in these adult groups; /?/ was almost always confused with /?/, both /f/ and /s/ were commonly confused with /θ/, and /θ/ was commonly confused with /f/. Well-performing teenage CI users obtained comparable consonant recognition scores to adult CI scores; however, the phonetic feature recognition and error patterns were slightly different from the adult groups. Unlike postlingually deafened CI adults, prelingually deafened CI adolescents showed more difficulties in recognizing voicing than the place of articulation. While the data of adult CI users showed that /θ/ (40-50% correct) was the most difficult sound to recognize and was most confused with /f/, prelingually deafened teenage CI users encountered most difficulty with /θ/ (7% correct), which was most confused with /f/.

Conclusion: Preliminary results showed that well-performing CI users, regardless of the electrode type, performed similar to NH listeners with 8-channel simulation in consonant recognition. Phonetic feature recognition and error patterns in voiceless fricatives were similar in all adult groups. However, well-performing teenage CI users showed struggles with voicing information compared to the adult CI group, even though their overall consonant recognition was similar.
Self-reported Outcomes for Adolescents and Young Adults >3 years Post Sequential Bilateral Implantation

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Topic: Rehabilitation/Educational Aspects

Keywords: Rehabilitation for Children

Introduction: Unilateral implantation was the standard of care for children with profound hearing loss for around 20 years. Despite increased rates of simultaneous implantation in some countries, children worldwide also continue to be unilaterally implanted due to limitations of access or cost, family choice, or clinical recommendation. Many of these children may later consider bilateral implantation as an older child or young adult. To provide future candidates with evidence-based preoperative counselling and appropriate postoperative support it is important to document the experiences and outcomes of this group. Objective: To obtain self-reports of attitude and device preference change, adaptation, and device use from adolescents and young adults who were more than 3 years post sequential bilateral implantation.

Methods: Participants were 26 adolescents and young adults (>11 yrs old) who were >3 years post sequential bilateral implantation. The second implant was received between 5 and 21 years of age, with an inter-implant delay of up to 17 years. A questionnaire was administered in a face-to-face or phone interview. Participants were asked to reflect on their experiences in the first two years postoperative, specifically to report on the situation in the first few months, at 6 to 12 months, and at 12 to 24 months, and also to report on their situation at the time of interview.

Results: The proportion of participants who reported that their attitude towards the second implant had been positive increased for each postoperative time point, and was highest for the time of interview (88%). The proportion who reported that they preferred to use bilateral implants over a unilateral implant also increased over time, reaching 81% for the time of interview. 69% reported that it had been easy or only a bit difficult to adapt to using two implants, and that they were happily using both together most of the time within 6 months. At the time of interview, 54% reported using bilateral implants full time, and 23% reported using them 60 to 90% of the time. When costs, risks, and benefits were balanced, 88% considered obtaining the second implant had been worthwhile.

Conclusion: The proportion of respondents with a positive attitude towards the second implant and a preference for bilateral implants increased with time. Adaptation to bilateral implants was most often, but not always, easy and relatively quick. At interview, the majority preferred to use bilateral implants, and used them most of the time. Nearly all reported that the second implant was worthwhile obtaining. Older children and young adults should be encouraged to make an informed choice about sequential bilateral implantation, irrespective of age or inter-implant delay. It can be a challenging process and self-motivation is vital. Changing attitudes and preferences over time, and information about adaptation, have implications for postoperative management of this group.
Auditory Brainstem Development In Children Receiving Different Devices In A Simultaneous Bilateral Implant Procedure.

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Topic: Audiology

Keywords: Objective Measures

Introduction: Simultaneous bilateral cochlear implantation has been shown to support symmetric development of the auditory brainstem when the same device is used bilaterally. Objective: In the present study, we asked whether auditory brainstem development would be affected by implantation of two different electrode arrays: a pre-curved array and a straight array with the same receiver stimulator.

Methods: Twenty-eight children were implanted with a pre-curved array in one ear and a straight array from the same manufacturer in the other in the same surgery. Electrically evoked auditory brainstem responses (EABRs) were collected at three time-points: the first week post-activation, 3 to 6 months post-activation, and 9 to 12 months post-activation. EABRs were evoked by biphasic single pulses delivered at 11Hz from the apical electrode (#20) and measured at a midline cephalic location (Cz) referenced to each earlobe in separate recording channels. Stimuli were provided at levels which were comfortably loud and evoked equal amplitude wave eV amplitudes (peak to trough) from each side. Wave eV latencies and amplitudes were marked and analyzed using repeated measures ANOVAs for time, device and ear effects.

Results: Stimulus protocols resulted in consistent EABR wave eV amplitudes which did not significantly differ between devices (p<0.05) or change over time (p<0.05). EABR eV latency, on the other hand, significantly decreased between initial measures (p<0.05) and follow up measures with no effects of device or which ear was implanted with the straight array (p>0.05).

Conclusion: Despite the use of two different devices, children receiving bilateral cochlear implants simultaneously show symmetric auditory brainstem development during initial stages of implant use. Further analysis of this group will determine whether brainstem development varies with residual hearing and surgical approach.
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Cochlear Implantation in Neurofibromatosis Type 2
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Topic: Surgery/Medical

Keywords: New Indications, Medical/Surgical Issues

Introduction: Traditionally, auditory brainstem implantation was the only method of hearing rehabilitation for profoundly deaf patients with neurofibromatosis type 2 (NF2). The first documented case of cochlear implantation (CI) in a patient with NF2 was in 1992. Since that time, less than 50 unique accounts have been published. The primary objective of the current study is to investigate cochlear implant performance outcomes among 15 patients with NF2.

Methods: Retrospective case series at a tertiary academic referral center including all patients with NF2 who underwent CI between 2004 and 2013.

Results: Fifteen patients met study criteria. The median duration of follow-up after CI was 34 months. Six patients received previous microsurgical resection of their ipsilateral vestibular schwannoma, 8 underwent prior stereotactic radiosurgery, and 1 patient had no tumor treatment before CI. Of the 14 patients with adequate audiometric follow-up, 9 (64%) attained open-set speech recognition. Associations between patient variables and cochlear implant performance will be discussed.

Conclusion: Cochlear implantation is an attractive alternative to auditory brainstem implantation for hearing rehabilitation in patients with NF2. CI should be strongly considered in patients with non-serviceable hearing who have an anatomically intact cochlear nerve, whereas auditory brainstem implantation should be reserved for patients with evidence of cochlear nerve loss.
Introduction: By further developing the coding strategies of cochlear implant systems, the performance in speech understanding of cochlear implant users could be constantly improved over the years. The basis for many CI coding strategies still forms the classic CIS (Continuous Interleaved Sampler) strategy. Based on this basic principle, MED-EL has developed the fine structure coding strategies, which aim at delivering better low-frequency coding by dynamically adapting the stimulation rate on the most apical channels depending on the actual acoustic signal. The first of these fine structure strategies FSP (Fine Structure Processing) offered rate pitch information on up to 4 apical channels with an average of 2 channels only, depending on the map parameters. This was followed by a more advanced version, FS4 with four guaranteed fine structure channels. The newest iteration of the fine structure processing is called FS4 HR. HR stands for High Rate and offers an increased stimulation rate in the non-fine structure, CIS-type channels. Objective: The aim was to compare speech perception outcomes with the different fine structure implementations. Results from two studies will be presented. In the first, FS4 LR (Low Rate) has been compared with the original FSP strategy, while in the second, FS4 LR has been compared with FS4 HR.

Methods: In both studies, speech intelligibility tests were performed. These were the Oldenburg sentence test in noise, the HSM sentence test in noise and the Freiburg monosyllabic test. The first study (FSP vs. FS4 LR) went over 12 months and actually 7 subjects have finished the study. The second study (FS4 LR vs. FS4 HR) is still ongoing with 15 subjects to be included (currently 9).

Results: On average, the comparison of FSP and FS4 LR shows equal results in the speech performance tests. However, there are remarkable individual differences with the one or the other strategy among the study group. The preliminary data of the FS4 LR and FS4 HR comparison shows significantly better results for the FS4 HR strategy in the Freiburg monosyllables and in the Oldenburg sentence test for the nine study subjects.

Conclusion: On the basis of the current study results, it seems viable to give a careful recommendation for the use of FS4 HR in the daily clinical routine. More conclusive data will be presented at the conference.
Introduction: When cochlear implant candidates have been identified and then introduced to the cochlear implant manufacturers, it is commonplace for the prospective recipient to ask their provider which manufacturer they would select for themselves. The market for cochlear implants is unique in that no other medical field predominantly requires candidates to choose the manufacturer of their implantable device.

Methods: The purpose of this research was (1) to identify the practices of providers in the United States related to device recommendation and (2) to learn if the current practice of not making a device recommendation meets the needs of recipients. This study used a cross-sectional survey design. One survey was sent to cochlear implant providers in the United States and a second was sent to cochlear implant recipients implanted within the last year throughout the United States.

Results: A sample of 150 audiologists across the United States indicate that providers in the United States typically do not make recommendations to the average candidate and feel that they do not try to influence candidates to choose a specific manufacturer. Their rationale is that they want candidates to be responsible for their own healthcare, to make them more committed to the cochlear implant process, and to encourage responsible ownership of their device after surgery. A pilot study in Utah that included 36 people implanted within the last year indicates that while the majority of the candidates want to choose the manufacturer themselves, most of them want a specific recommendation. While none of the respondents felt that their provider should choose the device for them, only 8% of respondents felt like they should choose their device with no guidance from providers, which is the current practice in the United States. Other data associated with choosing the device include the level of anxiety associated with choosing a device, which factors people considered when choosing their device, which influenced their decision, and how choosing their implant affected their commitment to their device and follow-up. Data collection of a national sample of recipients is currently in progress and will be available for review at the time of this presentation.

Conclusion: While the current practice of requiring people to choose their implant does meet the desires of recipients to be involved in the device selection process; recipients indicate that they want more guidance from experienced professionals to help them choose their device.
Supporting Access to New Indications for Cochlear Implants: Health Technology Assessment
Challenges and Insights
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Topic: Economics and Public Policy
Keywords: Health Economics, Disability-adjusted Measures, Public Policy Concerns

Introduction: Health care payers – insurance companies and health authorities – continually examine evidence for providing effective care to their beneficiaries while simultaneously managing costs. Payers across the globe have relied on Health Technology Assessments (HTAs) to discern which treatments are clinically and cost effective in order to make coverage decisions. Cochlear implantation has been the subject of several HTAs in recent years, and additional HTAs are likely to be conducted as new indications are proposed. This session will explain the HTA process, and its implications for patient access to new indications for cochlear implants.

Methods: This talk will review experience with cochlear implant HTAs to date and discuss their outcomes as evidenced by the HTA final reports.

Results: The presentation will identify specific HTA challenges faced when expanding indications for cochlear implantation, and will discuss potential actions to address those challenges.

Conclusion: Manufacturers, clinicians, and researchers have the opportunity to develop and conduct prospective clinical studies that provide the type of evidence needed for the HTA process that, in turn, will support access to new cochlear implant indications for an expanding population of individuals with hearing loss. COI: Advanced Bionics
Introduction: The Patient Protection and Affordable Care Act (ACA) is a federal statute intended to decrease the number of Americans who are uninsured by providing affordable and qualified health benefit plans to individuals and small businesses. The American Cochlear Implant Alliance appointed a network of individuals known as State Champions to monitor the rollout of the new law and serve as advocates to address any coverage concerns related to cochlear implantation.

Objective: The objective of the initiative was to review each state's coverage language and where appropriate, initiate efforts to address needed changes with state officials to provide appropriate access to the continuum of cochlear implant care.

Methods: State Champions were trained in how to obtain and review the Essential Health Benefits Plan for their state. In instances in which the language was unclear or cochlear implants were not specifically mentioned, the State Champions met with appropriate state insurance officials to assess coverage. The State Champions looked for mention of cochlear implant coverage, bilateral coverage, and aftercare including mapping, therapy and hardware replacement (durable medical equipment or DME).

Results: As of June 25, 2014, there have been no instances found of exclusions in cochlear implant coverage. Bilateral coverage is unknown as we have seen no instances of exclusions but also no specific stated instances of coverage. Most State Champions are finding that state plans offered on the ACA Exchanges have annual visit limits on therapy post cochlear implantation and further that these limits are insufficient for the care needed for a prelingually deafened child who has received a cochlear implant. Additionally, early on in the rollout we have found that some Marketplace insurance plans offered are not currently accepted by cochlear implant clinics. These shortcomings will need to be explored further and aggressively addressed to ensure that the Exchanges provide appropriate access and not have a negative impact on patient access.

Conclusion: The Affordable Care Act is not a panacea for hearing health though it may provide an opportunity for those who do not currently have health insurance coverage to access cochlear implantation. The law addresses some issues that have been difficult in the past such as precluding coverage for cochlear implantation due to deafness being defined as a non-covered “pre-existing” condition. Limits on the number of therapy sessions that may be covered in a calendar year is emerging as a potential issue that will need to be proactively addressed to ensure that the entire continuum of cochlear implant care is appropriately covered by the new health care law.
Introduction: Healthcare reform has imposed rigid procedural and administrative requirements and restrictions on healthcare providers which, when coupled with increased patient expectations and decreased reimbursement, has necessitated an examination of procedures used in cochlear implant centers. The purpose of this project was to identify areas to address in order to improve efficiency and increase profitability for a large cochlear implant center, without negatively affecting delivery of services, patient care or staff satisfaction.

Methods: Lean Six Sigma (LSS) is the application of knowledge and capability to improve performance of processes within a business. Utilizing LSS methodologies, the center focused on reducing non-value added activities which included non-billable time and reduction of cancellation/no show rates, and increasing billable time. The staff developed policies to address all issues. The center also increased productivity by implementing improved administrative reporting to monitor and control scheduling and delineate responsibilities to maximize staff efficiency.

Results: Improved efficiency resulted in increased profitability by reducing overhead and increasing billable encounters. Modification of management techniques, heightened productivity and schedule adjustments resulted in more rapid patient access and increased revenue. Since the changes were driven and agreed upon by the professional and administrative staff, no interpersonal conflicts arose.

Conclusion: Implementation of LSS can effect changes which result in improved practice management and business processes without compromising a high level of patient care or staff satisfaction.
Challenges to Transferring Kaizen Methodologies to CI Programs Functioning in Non-Lean Medical Centers

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Topic: Economics and Public Policy

Keywords: Health Economics, Public Policy Concerns

Introduction: A model line project was completed in 2008 using principles of Kaizen at a CI Center in Seattle. Gains were achieved at a hospital fully invested in a Lean management structure. This report is on the hypothesis that Kaizen methods are transferrable to CI centers based in non-lean medical centers.

Methods: A new CI program was started in January 2011 at our Institute in Seattle, WA. The physical space was designed with the principles of patient flow and throughput. Protocols for new patient evaluation, switch-on, and for routine programming sessions were implemented. Once adapted, patient satisfaction was surveyed and followed longitudinally. Two additional adult CI centers were then recruited. Teams were led through a one-week value stream mapping session. Each Center had a 1-week 5-S workshop. From their respective value stream map, each site chose three issues, which were addressed sequentially with 5-day Kaizen workshops lead by outside Lean consultants.

Results: Value stream mapping served as an introduction to Kaizen tools and forced CI teams to understand their program patient flow. 5-S weeks produced significant standardization of workspaces and protocols. Both centers reached a level 3, 5-S. This was sustained at the 90-day checkpoint. The workshops had variable sustained success. Issues leading to poor adoption included inadequate senior management buy-in to the process, lack visibility of the improved processes and inadequate time for staff members to initiate Kaizen protocols.

Conclusions: This study verified that Kaizen principles are transferrable to CI programs functioning in non-lean environments. Long-term sustainability of newly developed processes requires adequate support from senior management and visible feedback to team members. Patient satisfaction data provides significant impetus for audiology teams to accept to their daily work. Cochlear Corporation1, Cochlear Corporation2
Use Of Lean Six Sigma In Improving Best Cochlear Implant Practices And Financial Sustainability
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Keywords: Health Economics, Public Policy Concerns

Introduction: The added pressure of healthcare reform coupled with the goal of continued provision of excellent patient care challenges Cochlear Implant (CI) programs to revisit clinical practices. This includes redefining models of care to grow the CI program to increase patient access. The goal of this study was to increase the number of patients seen per day per audiologist by limiting technical and administrative functions previously performed by Audiologists through the development of best practice guidelines as well as the implementation of a Hearing Aid/Cochlear Implant (HA/CI) coordinator.

Methods: Lean Six Sigma (LSS) is the application of knowledge and capability to improve performance of processes within a business. Utilizing LSS methodologies, a plan was developed to reorganize the Audiology clinic. This included development of best practice protocols which allow the audiologist to reduce technical and administrative functions by 30%. The training of the non-clinical HA/CI coordinator was critical to provide basic non-reimbursable clinical services for patients and completion of clerical duties.

Results: Significant improvements have been made including twice as many patients being seen in a period of 1 year following the initiation of LSS principles. This has resulted in a significant increase in revenue over the prior year.

Conclusion: Use of LSS has resulted in re-organization of the clinic practice activities. This in turn has allowed for improved efficiencies and increased revenues. Use of these best practice modalities will allow for sustainable growth and improve quality of CI Audiology Practice. COI: Cochlear


ACI2014
Challenges to Implementing a Follow-Up Program to Newborn Screening in the Era of Hospital Consolidation
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Topic: Audiology

Keywords: Outcomes, Objective Measures, Young and Very Young Children

Introduction: Of the 85,000 children born each year in Washington State, 15% are delivered in one of our hospitals. Hospital consolidation and Accountable Care Organization (ACO) alignment presents challenges for the continuity of care in enlarging health systems. Here, we addressed the problem of losing our infant population not passing newborn hearing screening within our newly consolidated 5-hospital tertiary health system and ACO by creating a comprehensive audiological/otological patient care pathway. Objective: Develop a comprehensive audiological and otolaryngological newborn hearing screening follow-up program within a newly consolidated hospital system and ACO.

Methods: In 2013, we implemented a system-wide follow-up to the newborn hearing screening program by coordinating the efforts of a contracted screening service (Pediatrix®) with our internal audiology service line. The goal was to minimize the number of patient’s lost to follow-up, those leaving our system for care, and to reduce the time to intervention for hearing loss after initial screening. Those infants not passing the in-patient hearing screening are referred to audiology for assessment which is completed within 10 days. Infants diagnosed with hearing loss are then medically evaluated within 1 week and fit with appropriate amplification within 2 weeks. Referrals are made to a family resource coordinator at the state level for the presentation of manual versus spoken language options. Response to amplification is closely monitored and any infant not progressing is referred for cochlear implantation. Medical evaluation, genetic testing, neuroimaging, and the initiation of the Pneumovax series is started with the goal of having affected infants ready for CI consideration between 6-12 months of age. All patients are followed longitudinally by a program shepherd with open communication to their pediatrician.

Results: The creation of an audiological care pathway with immediate access to pediatric audiology and otology services significantly improves all aspects of pediatric hearing care. Results indicate that our model fosters rapid identification and treatment of hearing impaired infants as well as facilitating the preparation of pediatric candidates for implantation.

Conclusion: By developing an all-inclusive center for infant audiological needs within our newly consolidated health system and fostering meaningful ties with in-patient hearing screeners, we are reducing the number of children lost to audiological follow-up as well as accelerating the diagnostic/habilitative time-line. We are also tracking these metrics to evaluate program efficiency. Given the significant improvement in patient care, this program is now being rolled out to our parent health system and is open to hospitals screened by Pediatrix® in our 5-state region. COI: Cochlear Corporation®
ACI2014
Raising The Bar For Industry And Clinical Partnerships: A Call For Action And Transparency
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Topic: Economics and Public Policy

Keywords: Health Economics, Public Policy Concerns

Introduction: Midst the greatest scientific efforts behind cochlear implant technology, the vital relationship between clinical care providers and the manufacturers of the implant products remains somewhat obscure and undefined. With ever-increasing demands for transparency within the clinical care and industry relationship, it behooves all parties to identify potential pitfalls, challenges, incentives, and behaviors which may impact the relationship of sacred trust with patients. The nature of clinical objectivity and effective patient care requires complete clarity and integrity in order to earn, preserve and protect patient and professional trust.

Methods: A literature review was conducted regarding the impact of incentive-based relationships. In addition, an analysis of regulatory agencies, professional codes of ethics, statutes and guidelines was conducted and summarized relative to the relationships which rightfully and necessarily exist between industry and care providers. Real scenarios were identified which test such relationship parameters and isolate numerous potentially hidden conflicts of interest.

Results: Various events, activities and actions of both care providers and industry members were identified and described. These included industry-sponsored educational events, meals, entertainment opportunities, equipment, discount contracts, and other such offerings. The analysis also described the nature of expectations between clinicians and their industry partners. Which of these particular activities or actions is acceptable? Which is compliant or reportable? How are clinicians and industry held accountable? How is the patient relationship preserved and protected?

Conclusion: This seminar raises common issues and misperceptions about clinician relationships with industry and their “blinded” impact on patient care. “Guiding Questions” and a “Call to Action” for all partners are proposed as a method of building appropriate transparent bridges of partnership for the benefit of compliance to applicable agencies, as well as providing and preserving exemplary and objective patient care.