Quarterly Abstract Update

April – June 2007

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1. **"Design for a simplified cochlear implant system".** An, S. K.; Park, S. I.; Jun, S. B.; Lee, C. J.; Byun, K. M.; Sung, J. H.; Wilson, B. S.; Rebscher, S. J.; Oh, S. H.; Kim, S. J.; (2007); IEEE Trans Biomed Eng. 54(6 Pt 1):973-982

A simplified cochlear implant (CI) system would be appropriate for widespread use in developing countries. Here, we describe a CI that we have designed to realize such a concept. The system implements 8 channels of processing and stimulation using the continuous interleaved sampling (CIS) strategy. A generic digital signal processing (DSP) chip is used for the processing, and the filtering functions are performed with a fast Fourier transform (FFT) of a microphone or other input. Data derived from the processing are transmitted through an inductive link using pulse width modulation (PWM) encoding and amplitude shift keying (ASK) modulation. The same link is used in the reverse direction for backward telemetry of electrode and system information. A custom receiver-stimulator chip has been developed that demodulates incoming data using pulse counting and produces charge balanced biphasic pulses at 1000 pulses/s/electrode. This chip is encased in a titanium package that is hermetically sealed using a simple but effective method. A low cost metal-silicon hybrid mold has been developed for fabricating an intracochlear electrode array with 16 ball-shaped stimulating contacts.

2. **"A preliminary study looking at parental emotions following cochlear implantation".** Anagnostou, F.; Graham, J.; Crocker, S.; (2007); Cochlear Implants Int. 8(2):68-86

This preliminary research investigated the emotions of parents with cochlear implanted children. The object for the research was first to compare four emotions engendered in parents of deaf children before and after cochlear implantation. Second, to monitor changes in these emotions during a period of up to four years after implantation. Third, to see whether any of the emotions studied was significantly more prominent than the others, and fifth to identify any differences in emotions that were related to the gender of parents.A self-report questionnaire was given to 112 participants of whom 53 replied. There were equal groups of parents in two categories, those with children up to two years after implantation, and those two to four years after implantation. The responses were interpreted using parametric statistics. The results highlight that grief is the strongest emotional condition that parents experience before and up to two years after implantation, alongside family adjustments. Parents of the up to two years after implantation group generally have stronger feelings and are less satisfied than parents in the over two years implanted group. Finally, fathers use denial more than mothers. Considerations for future research and implications for paediatric cochlear implant teams will be discussed.

3. **"Ensuring the long-term use of cochlear implants in children: the importance of engaging local resources and expertise".** Archbold, S. & O'Donoghue, G. M.; (2007); Ear Hear. 28(2 Suppl):3S-6S

Cochlear implantation for children is now a mature service, recognized as being safe and effective. Early identification is enabling implantation to be undertaken in the first years of life, with the likelihood of better outcomes. Traditional models of service delivery provided excellent clinic-based services, with intensive early habilitation. However, the current challenges extend beyond this time frame, and clinic-based services are overstretched with the growing numbers of children with implants. Needs analyses of parents and teachers in Europe provide evidence that they are keen to have regular links between implant center and home and school and that for both parents and teachers a major concern is the long-term management of the technology. There are major challenges, not in the implant clinic, but at home and school where implant systems are used. Implementing complex technology in the child's community in the long term is only possible by engaging parents and the local professionals, particularly teachers, from the outset, and using their expertise. This calls for a critical appraisal of the traditional approach to service delivery. Such engagement of local professionals does not happen automatically but can be achieved by educational programs for parents and local professionals that are adapted to local needs and cultures. Communication between implant center and home and school is essential, ensuring that the technology of implantation is used effectively at all times and is accessible to all wherever they live. This article recommends ways in which parents, teachers, and local professionals can play a central role in the management of children with implants to ensure the successful long-term use of their implant systems. Engaging and using the skills and expertise of those who know the child best, parents and teachers, will not only ensure that implantation is sustainable in the long term in diverse cultures, but is also cost-effective.

4. **"Cochlear implant channel separation and its influence on speech perception - implications for a new electrode design".** Arnoldner, C.; Riss, D.; Baumgartner, W. D.; Kaider, A.; Hamzavi, J. S.; (2007); Audiol Neurootol. 12(5):37-48

There are a variety of factors which can influence cochlear implantation outcome. Channel interaction is one of the variables responsible for audiological performance deterioration in multichannel implants. Electrode design is - among others - one way to decrease the incidence of channel interaction. At present, electrodes differ in overall length, diameter, contact design and distribution, but none of the electrodes available have a distinct variability in the amount of space between contacts across the length of the electrode. The aim of this study was to investigate whether a new electrode design featuring larger contact spacing in the apical part of deeply inserted electrodes would lead to an increase in speech perception. Eighteen postlingually deafened patients fitted with MedEl Combi 40+ or MedEl Pulsar cochlear implants using the MedEl implementation of continuous

interleaved sampling participated in this study. Patients were tested in 6 conditions, in which the channel spacing and distribution of electrode contacts in each patient were artificially varied by activating or deactivating different channels. Performance was tested immediately after each change in setup with a monosyllable and sentence test (Hochmaier, Schultz and Moser). Our results showed that the condition with the highest distance between contacts in the apical part (up to 6.4 mm instead of 2.4 mm) is the most effective for the matched map condition: the results improved statistically significantly for the sentence test from 72% in the standard 12-channel condition to 83.2% and from 40.8 to 50% for the monosyllable test. Based on these findings, we present a new electrode design which can help achieve further increases in speech perception with cochlear implants.

5. **"Quality control after insertion of the nucleus contour and contour advance electrode in adults".** Aschendorff, A.; Kromeier, J.; Klenzner, T.; Laszig, R.; (2007); Ear Hear. 28(2 Suppl):75S-79S

OBJECTIVE: To evaluate the quality of insertion of the Nucleus Contour and the newly developed Contour Advance electrode in adult cochlear implant recipients and to compare results of speech performance tests with regard to electrode position. DESIGN: A total of 43 adult patients with a history of progressive hearing loss having received a Nucleus cochlear implant, 21 of which had received a Contour electrode and 22 a Contour Advance electrode, were evaluated by rotational tomography after surgery. Electrode position was determined to be in scala tympani, scala vestibuli, or with a dislocation from one scala to the other. Speech test results were collected for Freiburg numbers, Freiburg monosyllables, and Oldenburg sentence tests 1 yr after surgery. RESULTS: The Contour array presented with a high rate of scala vestibuli insertions and a high rate of dislocations from scala tympani to scala vestibuli, whereas the Contour Advance array showed a high rate of scala tympani insertions with very few dislocations and few scala vestibuli insertions. Speech tests results varied with respect to the location of the intracochlear electrode position, with insertions into the scala tympani being significantly superior to the scala vestibuli. CONCLUSIONS: Results of studying the Contour array influenced the surgical procedure that improved surgical ability to perform insertions into the scala tympani by using the Contour Advance array. In addition, a comparison between Contour and Contour Advance electrode demonstrated an improved mechanical behavior of the Contour Advance electrode with a decrease of dislocation rate. The use of the Contour Advance electrode allows a more atraumatic electrode insertion, which is of interest with extending indications and the use of further advanced coding strategies. The intracochlear electrode position with regard to speech performance results demonstrated advantages of scala tympani insertions.

6. **"Transient deafness in young candidates for cochlear implants".** Attias, J. & Raveh, E.; (2007); Audiol Neurootol. 12(5):49-57

This study describes 5 infants who were diagnosed with auditory neuropathy (AN) associated with severe to profound neural hearing loss shortly after birth. However, on repetition of the tests 7-12 months later, all infants showed full or partial recovery. The follow-up electrophysiological patterns were characterized by the appearance of wave I, followed by wave III and V, reflecting synchronization of auditory pathways and improvement in auditory nerve function. Suspected causative or contributory factors were neonatal hyperbilirubinemia, hypoxia, ischemia, and central nervous system immaturity, alone or in combination. These findings indicate that lack of an auditory brain stem response does not necessarily mean no hearing and that the situation where AN exists can improve. Thus, clinicians should be made aware that although cochlear implants may yield better auditory performance when applied early, they should be considered a therapeutic option only after repeated measures have proved persistent AN, and no child should be considered for an implant until a behavioral measure of hearing has been obtained.

7. **"Standardization of reliability reporting for cochlear implants: An interim report".** Backous, D. D. & Watson, S. D.; (2007); Ear Hear. 28(2 Suppl):91S-94S

OBJECTIVE: To propose a standard definition of "out of specification" for cochlear implants and a paradigm for inclusion of category C of the ISO standard 5841-2:2000 for reporting in cumulative survival statistics.Hypothesis: A standard definition of "out of specification" and consistent reporting by manufacturers of cochlear implants will create a fair and consistent representation of cumulative survival. This will allow discernment of differences between manufacturers for reliability and for detection of trends in reliability between model types from the same manufacturer. DESIGN: Three separate meetings with representatives of the three manufacturers of cochlear implants marketed in the United States were staged over a 13-mo period. Standard questions, created by the authors, were addressed by each representative to determine the current state of device reliability reporting. Results were presented to clinicians at the William House Cochlear Implant study Group and the Implantable devices sub-committee of the American Academy of Otolaryngology (2004, 2005) and at the 8th International Cochlear Implant Conference (2004) for feedback. After assimilation of feedback by all parties, the standard was written and reviewed by representatives from each manufacturer for accuracy of data. RESULTS: A complaint-driven standard was developed. A "cochlear implant" as an internal device placed and skin closed in surgery. An internal device is "out of specification" when one or more technical characteristics is outside the limits of normal function and results in explantation or non-use by the patient." Children will be reported separately from adults, each model of device will be reported on annually, a minimum of 200 devices must be in each model group for Cumulative Survival Reporting (CSR). Confidence limits are

set at 95%. Explants will be determined to be "biological" or "technical." Technical explants are included in CSR reports. Devices failing to meet specifications set by the manufacturer, not in use but still in situ due to patient choice not to be re-implanted are considered category C and included in CSR reports. Implants that cannot be classified at explant are placed in an "under investigation" category while evaluation is completed. If no classification is made by 6 months, these devices will be included in the CSR report. Notification to the implant center regarding "in" or "out of specification" will be made within 60 d of the explant arriving at the manufacturer with final root cause of failure reported to centers when complete. Information will be passed on to patients by members of the implant team. A standardized form will be created to provide the manufacturers with necessary patient information to guide reliability analysis, including performance after re-implant. CONCLUSIONS: The standard for reliability reporting described in this paper improves patient care by presenting data which are understandable to clinicians delivering cochlear implant services. It fosters fair and accurate reporting without discriminating or granting perceived advantage to any manufacturer. This standard provides a basis for reporting research related to or including device reliability in the medical literature.

8. **"Nucleus Freedom North American clinical trial".** Balkany, T.; Hodges, A.; Menapace, C.; Hazard, L.; Driscoll, C.; Gantz, B.; Kelsall, D.; Luxford, W.; McMenomy, S.; Neely, J. G.; Peters, B.; Pillsbury, H.; Roberson, J.; Schramm, D.; Telian, S.; Waltzman, S.; Westerberg, B.; Payne, S.; (2007); Otolaryngol Head Neck Surg. 136(5):757-762

OBJECTIVE: To evaluate hearing outcomes and effects of stimulation rate on performance with the Nucleus Freedom cochlear implant (Cochlear Americas, Denver, CO). STUDY DESIGN AND SETTING: Randomized, controlled, prospective, single-blind clinical study using single-subject repeated measures (A-B-A-B) design at 14 academic centers in the United States and Canada and comparison with outcomes of a prior device by the same manufacturer. PATIENTS: Seventy-one severely/profoundly hearing impaired adults. RESULTS: Seventy-one adult recipients were randomly programmed in two different sets of rate: ACE or higher rate ACE RE. Mean scores for Consonant Nucleus Consonant words is 57%, Hearing in Noise Test (HINT) sentences in quiet 78%, and HINT sentences in noise 64%. Sixty-seven percent of subjects preferred slower rates of stimulation, and performance did not improve with higher rates of stimulation using this device. CONCLUSIONS: Subjects performed well, and there was no advantage to higher stimulation rates with this device. SIGNIFICANCE: Higher stimulation rates do not necessarily result in improved performance.

9. **"Cochlear implantation in psoriasis patients".** Basavaraj, S.; Wardrop, P.; Sivaji, N.; Shanks, M.; Allen, A. A.; (2007); Auris Nasus Larynx. 34(2):221-223

Cochlear implantation has become a safe and effective method for the auditory rehabilitation of severe to profound sensorineural hearing loss. Flap problems are

the commonest of the surgical complications [Axon PR, Mawman DJ, Upile T, Ramsden RT. Cochlear implantation in the presence of chronic suppurative otitis media. J Laryngol Otology 1997;111:228-32] and the risk increases further when associated with medical conditions predisposing to infection. We present two patients with psoriasis who underwent cochlear implant surgery, discussing the risk of surgical site infection and treatment options to minimise infection.

10. **"Using genetic algorithms with subjective input from human subjects: Implications for fitting hearing aids and cochlear implants".** Baskent, D.; Eiler, C. L.; Edwards, B.; (2007); Ear Hear. 28(3):370-380

OBJECTIVE: To present a comprehensive analysis of the feasibility of genetic algorithms (GA) for finding the best fit of hearing aids or cochlear implants for individual users in clinical or research settings, where the algorithm is solely driven by subjective human input. DESIGN: Due to varying pathology, the best settings of an auditory device differ for each user. It is also likely that listening preferences vary at the same time. The settings of a device customized for a particular user can only be evaluated by the user. When optimization algorithms are used for fitting purposes, this situation poses a difficulty for a systematic and quantitative evaluation of the suitability of the fitting parameters produced by the algorithm. In the present study, an artificial listening environment was generated by distorting speech using a noiseband vocoder. The settings produced by the GA for this listening problem could objectively be evaluated by measuring speech recognition and comparing the performance to the best vocoder condition where speech was least distorted. Nine normal-hearing subjects participated in the study. The parameters to be optimized were the number of vocoder channels, the shift between the input frequency range and the synthesis frequency range, and the compression-expansion of the input frequency range over the synthesis frequency range. The subjects listened to pairs of sentences processed with the vocoder, and entered a preference for the sentence with better intelligibility. The GA modified the solutions iteratively according to the subject preferences. The program converged when the user ranked the same set of parameters as the best in three consecutive steps. The results produced by the GA were analyzed for quality by measuring speech intelligibility, for test-retest reliability by running the GA three times with each subject, and for convergence properties. RESULTS: Speech recognition scores averaged across subjects were similar for the best vocoder solution and for the solutions produced by the GA. The average number of iterations was 8 and the average convergence time was 25.5 minutes. The settings produced by different GA runs for the same subject were slightly different; however, speech recognition scores measured with these settings were similar. Individual data from subjects showed that in each run, a small number of GA solutions produced poorer speech intelligibility than for the best setting. This was probably a result of the combination of the inherent randomness of the GA, the convergence criterion used in the present study, and possible errors that the users might have made during the paired comparisons. On the other hand, the effect of these errors was probably small compared to the other two factors, as a

comparison between subjective preferences and objective measures showed that for many subjects the two were in good agreement. CONCLUSIONS: The results showed that the GA was able to produce good solutions by using listener preferences in a relatively short time. For practical applications, the program can be made more robust by running the GA twice or by not using an automatic stopping criterion, and it can be made faster by optimizing the number of the paired comparisons completed in each iteration.

11. **"Simulating listener errors in using genetic algorithms for perceptual optimization".** Baskent, D. & Edwards, B.; (2007); J Acoust Soc Am. 121(6):EL238-EL243

The genetic algorithm (GA) was previously suggested for fitting hearing aid or cochlear implant features by using listener's subjective judgment. In the present study, two human factors that might affect the outcome of the GA when used for perceptual optimization were explored with simulations. Listeners with varying sensitivity in discriminating sentences of different intelligibility and with varying error rates in entering their judgment to the GA were simulated. A comparison of the simulation results with the results from human subjects reported by Baskent et al. Ear Hear. 28(3) 277-289 (2007) showed that these factors could reduce the performance of the GA considerably.

12. **"Combined effects of frequency compression-expansion and shift on speech recognition".** Baskent, D. & Shannon, R. V.; (2007); Ear Hear. 28(3):277-289

OBJECTIVE: To explore combined acute effects of frequency shift and compression-expansion on speech recognition, using noiseband vocoder processing. DESIGN: Recognition of vowels and consonants, processed with a noiseband vocoder, was measured with five normal-hearing subjects, between the ages of 27 and 35 yr. The speech signal was filtered into 8 or 16 analysis bands and the envelopes were extracted from each band. The carrier noise bands were modulated by the envelopes and resynthesized to produce the processed speech. In the baseline matched condition, the frequency ranges of the corresponding analysis and carrier bands were the same. In the shift only condition, the frequency ranges of the carrier bands were shifted up or down relative to the analysis bands. In the compression and expansion only conditions, the analysis band range was made larger or smaller, respectively, than the carrier band range. By applying the shift to carrier bands and compression or expansion to analysis bands simultaneously, the combined effects of the two spectral distortions on speech recognition were explored. RESULTS: When the spectral distortions of compression-expansion or shift were applied separately, the performance was reduced from the baseline matched condition. However, when the two spectral degradations were applied simultaneously, a compensatory effect was observed; the reduction in performance was smaller for some combinations compared to the reduction observed for each distortion individually. CONCLUSIONS: The results of

the present study are consistent with previous vocoder studies with normal-hearing subjects that showed a negative effect of spectral mismatch between analysis and carrier bands on speech recognition. The present results further show that matching the frequency ranges of 1 to 2 kHz, which contain important speech information, can be more beneficial for speech recognition than matching the overall frequency ranges, in certain conditions.

13. **"A multicenter study of device failure in European cochlear implant centers".** Battmer, R. D.; O'Donoghue, G. M.; Lenarz, T.; (2007); Ear Hear. 28(2 Suppl):95S-99S

OBJECTIVE: To evaluate the failure rate of cochlear implant systems across a range of European implant centers. STUDY DESIGN: Retrospective review. SETTING: Tertiary care cochlear implant centers in Europe. MATERIAL AND METHODS: A postal questionnaire was designed to assess the incidence and mode of total device failure and was sent to 34 European clinics. RESULTS: Twenty seven (79%) centers replied providing data on 12,856 devices of which 488 (3.79%) had undergone total device failure. Of 8,581 Nucleus devices (Cochlear, Sydney, Australia), 169 had failed; of 1,761 Advanced Bionics systems (Advanced Bionics, Sylmar, USA), 123 had failed; of 1987 Med El devices (Med-El, Innsbruck, Austria), 179 had failed; and of 527 MXM devices (Laboratoires MXM, Vallauris, France), 17 had failed. Six (22%) centers never reported failures to competent authorities. CONCLUSIONS: The study suggests that the overall reliability of cochlear implant systems is satisfactory but that reliability varies considerably between individual systems. There is a compelling need for agreed international definitions of failure and for the adoption of uniform reporting protocols. A common database, independent of the industry, would offer greater transparency to users and clinics.

14. **"Outcomes in adults implanted with the FLEX(soft) electrode".** Baumgartner, W. D.; Jappel, A.; Morera, C.; Gstottner, W.; Muller, J.; Kiefer, J.; Van De Heyning, P.; Anderson, I.; Nielsen, S. B.; (2007); Acta Otolaryngol. 127(6):579-586

Conclusion. Achieving deep insertions, as well as good speech perception results, the FLEX(soft) electrode array allows for some preservation in subjects with measurable low frequency hearing, even after a period of time. This opens the door for future research in electrode design, hearing preservation research and drug delivery systems. Objectives. The FLEX(soft) electrode is designed to be atraumatic to the structures of the cochlea during deep insertion of a cochlear implant electrode. This paper reports on the surgical and functional outcomes in implantations with the FLEX(soft) electrode array. Patients and methods. Twenty-three adult subjects received a FLEX(soft) electrode array and were assessed on speech perception tests (monosyllables, sentences in quiet and in noise), a subjective questionnaire (Nijmegen Cochlear Implant Questionnaire) and a pure-tone audiogram. Results at 1, 3, 6 and 12 months post first fitting were compared

to scores from the preoperative interval. Results. Surgery was uneventful in all cases, the surgical handling was satisfactory and correct position of the electrode was achieved in all cases. Hearing could be preserved (as determined by the audiogram) in half of the subjects who had measurable audiograms preoperatively at the 1 month test interval, and in a quarter of subjects after 12 months of device use, despite deep insertion of the electrode. Speech perception scores showed significant improvement over time, as did quality of life scores, and were comparable to results with the standard electrode array as used in the COMBI 40+ and PULSARCI(100).

15. **"Sound localization ability of young children with bilateral cochlear implants".** Beijen, J. W.; Snik, A. F.; Mylanus, E. A.; (2007); Otol Neurotol. 28(4):479-485

OBJECTIVE: To evaluate the benefit of bilateral cochlear implantation in young children. STUDY DESIGN: Clinical trial comparing a group of bilaterally implanted children with a group of unilaterally implanted children. SETTING: Tertiary referral center. PATIENTS: Five bilaterally implanted children (mean age at testing, 3 yr 7 mo) were compared with 5 unilaterally implanted children (mean age at testing, 5 yr 3 mo). Meningitis was the cause of deafness in all of the children. METHODS: Children were asked to localize a prerecorded melody band limited from 500 to 4,000 Hz presented from loudspeakers placed at either -90 or 90 degrees or -30 or 30 degrees azimuth. Their parents filled in the Speech, Spatial and Qualities of Hearing Scale (SSQ) and PedsQL questionnaires on hearing and health-related quality of life of their children. RESULTS: The bilaterally implanted children had significantly better scores on the localization test than the children with unilateral cochlear implants. The scores of the children with bilateral cochlear implants were also significantly higher on the spatial domain of the SSQ, which concerns localization. No significant differences were found in the speech and quality of hearing domains and the total scores on the SSQ or the PedsQL between the two groups. CONCLUSION: Children with bilateral cochlear implantation already demonstrate an advantage over unilaterally implanted children at a young age.

16. **"Cochlear implants in young children: Informed consent as a process and current practices".** Berg, A. L.; Ip, S. C.; Hurst, M.; Herb, A.; (2007); American Journal of Audiology. 16(1):13-28

PurposeThis study examined the types of information that pediatric cochlear implant (PCI) centers and teams provide to parents of deaf children and the extent to which the informed consent process extends beyond medical issues to include social and cultural aspects. A second purpose was to determine the extent to which centers are applying selected new practices in cochlear implantation: younger age at implantation and bilateral implantation. MethodA 23-question survey was sent to 445 cochlear implant centers in the United States. Of the 445 centers contacted, 188 (42%) were excluded as ineligible (nonpediatric), 257 (58%) were determined eligible, and 121 (47%) of these completed the survey.

Survey topics included characteristics of PCI centers and teams; the role and importance of professionals/consultants; types of medical, educational, Deaf culture, and identity information and perspectives provided to parents; and current practices regarding age of implantation and bilateral implantation. ResultsAll of the PCI teams completing the survey presented medical/surgical risks, audiologic information, and variability of communication/educational options; fewer than half (45%) presented Deaf culture and emerging autonomy/identity issues to parents. Most PCI centers felt the optimal age to implant a child was 10-15 months. The majority of PCI centers, regardless of affiliation with a teaching hospital, responded that they rarely or never implanted bilaterally, and few discussed bilateral implants with parents. ConclusionsAudiologists are the only nonsurgical professionals always represented on the cochlear implant team. In order to best prepare audiologists for this role, graduate audiology programs need to address more extensively the Deaf culture and perspective, as well as genetics of hearing loss. Increased attention to educational audiology and evidence-based research regarding best age to implant and bilateral implantation needs to be included in the discussion with parents. Audiologists play a crucial role in informing parents and coordinating care, and should therefore carefully consider their role in the informed consent process.

17. **"Effects of auditory feedback deprivation length on the vowel /epsilon/ produced by pediatric cochlear-implant users".** Bharadwaj, S. V.; Graves, A. G.; Bauer, D. D.; Assmann, P. F.; (2007); J Acoust Soc Am. 121(5 Pt1):EL196-EL202

Effects of auditory deprivation on speech production by ten cochlear-implanted children were investigated by turning off the implant for durations ranging from 0.3 to 5.0 s and measuring the formant frequencies (F1 and F2) of the vowel /epsilon/. In five of the ten talkers, F1 and/or F2 shifted when auditory feedback was eliminated. Without feedback, F2 frequency lowered consistently, suggesting vowel centralization. Phonetic transcription indicated that some of these acoustic changes led to perceptible shifts in phonetic quality. The results provide evidence that brief periods of auditory deprivation can produce perceptible changes in vowels produced by some cochlear-implanted children.

18. **"The Great Ormond Street Hospital paediatric cochlear implant programme 1992-2004. A review of surgical complications".** Black, I.; Bailey, C.; Albert, D.; Leighton, S.; Hartley, B.; Chatrath, P.; Patel, N.; (2007); Cochlear Implants Int. 8(2):53-67

The authors present a review of surgical complications following cochlear implantation at Great Ormond Street Hospital, since inception of the programme in 1992 until June 2004. Complications are defined as major (resulting in re-operation, explantation, re-implantation or which resulted in permanent serious morbidity or mortality) or minor (where the implant was not threatened). A comparison of surgical complication rates is made both with an earlier study in the

same institution and also with other cochlear implantation centres worldwide. The decrease in surgical complication rates is discussed along with the difficulties inherent in cochlear implantation in the paediatric population with coexisting medical complaints.

19. **"Adult aural rehabilitation: What is it and does it work?".** Boothroyd, A.; (2007); Trends in Amplification. 11(2):63-71

Adult aural rehabilitation is here defined holistically as the reduction of hearing-loss-induced deficits of function, activity, participation, and quality of life through a combination of sensory management, instruction, perceptual training, and counseling. There is a tendency for audiologists to focus on sensory management, aural rehabilitation being seen as something done by someone else after the provision of hearing aids or cochlear implants. Effective sensory management may, by itself, lead to improved activity, participation, and quality of life, but there is no guarantee that these outcomes will be automatic or optimal. In fact, there is often a disconnect between clinical measures of assisted auditory function and self-assessed benefit. Costs associated with a holistic approach can be minimized by bundling as many as possible into the cost of hearing devices, by taking advantage of computer-based perceptual training, and by capitalizing on the benefits of group counseling.

20. **"AutoNR: An automated system that measures ECAP thresholds with the Nucleus Freedom cochlear implant via machine intelligence".** Botros, A.; van Dijk, B.; Killian, M.; (2007); Artif Intell Med. 40(1):15-28

OBJECTIVE: AutoNRT is an automated system that measures electrically evoked compound action potential (ECAP) thresholds from the auditory nerve with the Nucleus Freedom cochlear implant. ECAP thresholds along the electrode array are useful in objectively fitting cochlear implant systems for individual use. This paper provides the first detailed description of the AutoNRT algorithm and its expert systems, and reports the clinical success of AutoNRT to date. METHODS: AutoNRT determines thresholds by visual detection, using two decision tree expert systems that automatically recognise ECAPs. The expert systems are guided by a dataset of 5393 neural response measurements. The algorithm approaches threshold from lower stimulus levels, ensuring recipient safety during postoperative measurements. Intraoperative measurements use the same algorithm but proceed faster by beginning at stimulus levels much closer to threshold. When searching for ECAPs, AutoNRT uses a highly specific expert system (specificity of 99% during training, 96% during testing; sensitivity of 91% during training, 89% during testing). Once ECAPs are established, AutoNRT uses an unbiased expert system to determine an accurate threshold. Throughout the execution of the algorithm, recording parameters (such as implant amplifier gain) are automatically optimised when needed. RESULTS: In a study that included 29 intraoperative and 29 postoperative subjects (a total of 418 electrodes), AutoNRT determined a threshold in 93% of cases where a human expert also determined a

threshold. When compared to the median threshold of multiple human observers on 77 randomly selected electrodes, AutoNRT performed as accurately as the 'average' clinician. CONCLUSIONS: AutoNRT has demonstrated a high success rate and a level of performance that is comparable with human experts. It has been used in many clinics worldwide throughout the clinical trial and commercial launch of Nucleus Custom Sound Suite, significantly streamlining the clinical procedures associated with cochlear implant use.

21. **"Comparison of musical activities of cochlear implant users with different speech-coding strategies".** Brockmeier, S. J.; Grasmeder, M.; Passow, S.; Mawmann, D.; Vischer, M.; Jappel, A.; Baumgartner, W.; Stark, T.; Muller, J.; Brill, S.; Steffens, T.; Strutz, J.; Kiefer, J.; Baumann, U.; Arnold, W.; (2007); Ear Hear. 28(2 Suppl):49S-51S

Speech coding might have an impact on music perception of cochlear implant users. This questionnaire study compares the musical activities and perception of postlingually deafened cochlear implant users with three different coding strategies (CIS, ACE, SPEAK) using the Munich Music Questionnaire. Overall, the self-reported perception of music of CIS, SPEAK, and ACE users did not differ by very much.

22. **"Nonword repetition with spectrally reduced speech: Some developmental and clinical findings from pediatric cochlear implantation".** Burkholder-Juhasz, R. A.; Levi, S. V.; Dillon, C. M.; Pisoni, D. B.; (2007); The Journal of Deaf Studies and Deaf Education 2007 12(4):472-485

Nonword repetition skills were examined in 24 pediatric cochlear implant (CI) users and 18 normal-hearing (NH) adult listeners listening through a CI simulator. Two separate groups of NH adult listeners assigned accuracy ratings to the nonword responses of the pediatric CI users and the NH adult speakers. Overall, the nonword repetitions of children using CIs were rated as more accurate than the nonword repetitions of the adults. The nonword repetition accuracy ratings from both groups of subjects were correlated with open- and closed-set word recognition scores and forward digit spans. Only the perceptual accuracy scores from pediatric CI users were correlated with measures of speech production accuracy. These results suggest that although the pediatric CI users had more experience and success in perceiving speech under degraded auditory conditions, developmental differences in their memory skills prevent them from performing as well on working memory tasks as mature listeners.

23. **"Very far-advanced otosclerosis: Stapedotomy or cochlear implantation".** Calmels, M. N.; Viana, C.; Wanna, G.; Marx, M.; James, C.; Deguine, O.; Fraysse, B.; (2007); Acta Otolaryngol. 127(6):574-578

Conclusion: Every patient with severe or profound hearing loss must have a temporal bone high-resolution computed tomography (CT) scan. Stapedotomy is a

simple, safe and low-cost procedure compared with cochlear implantation and can provide very good results. This can justify our decision to propose stapedotomy at the initial treatment in patients with very far-advanced otosclerosis. In cases of hearing failure after stapes surgery, cochlear implantation is an option. Objective: This study aimed to find the best first intention treatment of very far-advanced otosclerosis. Materials and methods: This was a retrospective study and included 14 patients with non-measurable preoperative bone and air conduction thresholds and otosclerosis on temporal bone high-resolution CT scan. Stapes surgery followed by a well fitted hearing aid was the initial treatment in 11 patients and cochlear implantation in 7 patients, including 4 patients who had poor results after stapedotomy. Objective and subjective audiometric results were studied and compared between stapedotomy and cochlear implantation groups. Results: Objective and subjective results were statistically better in the cochlear implant group than in the stapedotomy group. However, four patients in the stapedotomy group had comparable results to the patients with cochlear implants.

24. **"A model for auditory brain stem implants: Bilateral surgical deafferentation of the cochlear nuclei in the macaque monkey".** Cervera-Paz, F. J.; Saldana, E.; Manrique, M.; (2007); Ear Hear. 28(3):424-433

BACKGROUND: Patients with extensive bilateral lesions of the auditory nerve have a profound and irreversible sensorineural hearing loss (SNHL), which can only be overcome with individually-fitted auditory brain stem implants that directly stimulate the cochlear nuclei. Despite the enormous potential of this increasingly applied treatment, the auditory performance of many implanted patients is limited, and the variability between cases hinders a complete understanding of the role played by the multiple parameters related to the efficacy of the implant. OBJECTIVES: To mimic the condition of patients who have bilateral lesions of the auditory nerve, we developed an experimental model of bilateral deafferentation of the cochlear nuclei by surgical transection of the cochlear nerves of adult primates. MATERIALS AND METHODS: We performed bilateral transection of the cochlear nerves of six adult, healthy, male captive-bred macaques (Macaca fascicularis). Before surgery, brain stem auditory evoked potentials were recorded. The histological material obtained from these animals was compared with similarly processed sections from seven macaques with intact cochlear nerves. The surgical technique, similar to that used in human neuro-otology, combined a labyrinthectomy and a neurectomy of the cochlear nerves, and caused deafness. We analyzed immunocytochemically the expression in cochlear nerve fibers of neurofilaments (SMI-32), and cytosolic calcium binding proteins calretinin, parvalbumin and calbindin, and also applied a histochemical reaction for acetylcholinesterase. RESULTS: None of the primates had any major complications due to the surgical procedure. The lesions produced massive anterograde degeneration of the cochlear nerves, evidenced by marked gliosis and by loss of both type I fibers (which in this species are immunoreactive for calretinin, parvalbumin and neurofilaments) and type II fibers (which are acetylcholinesterase positive). The model of surgical transection described herein

causes extensive damage to the cochlear nerves while leaving the cochlea intact, thus mimicking the condition of patients with profound SNHL due to bilateral cochlear nerve degeneration. CONCLUSIONS: The phylogenetic proximity of primates to humans, and the paramount advantage of close anatomical and physiological similarities, allowed us to use the same surgical technique applied to human patients, and to perform a thorough evaluation of the consequences of neurectomy. Thus, bilateral surgical deafferentation of the macaque cochlear nuclei may constitute an advantageous model for study of auditory brain stem implants.

25. **"Performance of older adult cochlear implant users in Hong Kong".** Chan, V.; Tong, M.; Yue, V.; Wong, T.; Leung, E.; Yuen, K.; van Hasselt, A.; (2007); Ear Hear. 28(2 Suppl):52S-55S

OBJECTIVE: To compare the speech perception performance of older adults with that of adult cochlear implant (CI) recipients in a single center in Hong Kong. DESIGN: A retrospective study of 14 older adult CI users (age at operation, 56 to 77 yr old) and 14 adults (age at operation, 18 to 53 yr old) who received CIs and were matched for duration of profound deafness. The outcome indicator of their performance includes ratings of 0 to 7 on the speech perception category (SPC), which is based on their speech perception test scores at 6, 12, and 24 mo after implantation. Statistical analyses were used to compare SPC ratings between the two groups at the tested intervals. Results of specific speech perception tests between the two groups were also analyzed at the tested intervals, along with the rate of improvement of the specific tasks from 0 to 6 mo, 0 to 12 mo, and 0 to 24 mo postoperatively. Multiple regression analysis was used to assess which variables would independently predict the outcome performance of CIs. RESULTS: There were no significant differences ($p = 0.228$ to 0.724) between the SPC ratings of the adult group and the older adult group at the tested intervals. The adult group scored significantly better in the postoperative 0- to 6-mo improvement rate ($p = 0.047$) in open-set sentence recognition, but the improvement decelerated so that it was comparable with that of the older adult group by 12 mo after implantation. The adult group also scored significantly better ($p = 0.031$) in tone identification at 24 mo after implantation compared with the older adult group. The majority of the speech perception task scores, and rates of improvement were comparable between the older adult group and the adult group at the tested time intervals. Multiple regression analysis revealed a significant relationship ($p = 0.025$) between the outcome indicator of everyday sentence recognition at 12 mo after implantation and the outcome predictor of duration of profound deafness. However, the goodness of fit (r) of this model was 0.11, suggesting that only 11% of the variance in 12-mo postoperative everyday sentence recognition was explained by duration of profound deafness, leaving a large proportion of unexplained variance. CONCLUSION: The overall performance of the older adult CI recipients is comparable with that of the adult group. Duration of profound deafness, irrespective of age, is accountable for a small part of the

outcome. Because older adults as well as younger adults can benefit from CIs, age should not be the predominant factor for declining CIs among older adults.

26. **"Variation in consonant cluster production by pediatric cochlear implant users".** Chin, S. B.; (2007); Ear Hear. 28(2 Suppl):7S-10S

OBJECTIVE: To provide an account of variation in the production of consonant clusters by pediatric cochlear implant users. DESIGN: Productions of consonant clusters by pediatric cochlear implant users were analyzed for variation in number of segments, reduction patterns, and segmental substitutions within the framework of Optimality Theory. RESULTS: A finite set of faithfulness and markedness constraints and variable constraint ranking can account for much of the variation in the production of consonant clusters by pediatric cochlear implant users. CONCLUSION: Variation in consonant cluster production by pediatric cochlear implant users is not structurally random but subject to the same principles of phonological organization that govern other linguistic systems.

27. **"The totally implantable cochlear implant".** Cohen, N.; (2007); Ear Hear. 28(2 Suppl):100S-101S

The concept of a totally implantable cochlear implant (TICI) offers the following advantages over the present generation of semi-implantable cochlear implants. These advantages include (1) cosmetics: deafness can be "hidden," because there is no external hardware during use; (2) no external hardware (e.g., cables, speech processor) to fail or be damaged; and (3) hearing possible 24/7, during sleep, in the shower, and while swimming. The TICI would incorporate all of the current external hardware within the buried device itself. There would also have to be external hardware for recharging the batteries and to serve other important diagnostic and functional purposes. All of this must be accomplished safely, without sacrificing performance.

28. **"ENT challenges at the small scale".** Coulson, C. J.; Reid, A. P.; Proops, D. W.; Brett, P. N.; (2007); Int J Med Robot. 3(2):91-96

BACKGROUND: In this paper we consider two relatively frequently performed operations in the field of ear, nose and throat (ENT) surgery and consider how they could be improved by using robotic applications. We consider currently available robots and propose theoretical robotic solutions. METHODS: The application of robotic systems for both cochlear implantation and endoscopic sinus surgery was considered. Currently available robotic systems were reviewed and those with potential use in ENT surgery were identified. For aspects of operations where there is no available technology, hypotheses are presented on how robots could help. RESULTS: Three robotic systems were identified with potential usage in ENT: the Pathfinder neurosurgical robot, the Acrobot knee replacement system and the autonomous smart drill for drilling a cochleostomy. CONCLUSIONS: The challenge for the future of ENT is being able to perform tasks be yond the level of

human perception and abilities. The examples presented here demonstrate that microtechnologies could be used to reduce complications, decrease operating time and improve clinical results.

29. **"Classroom performance and language development of CI students placed in mainstream elementary school".** Damen, G. W.; Langereis, M. C.; Snik, A. F.; Chute, P. M.; Mylanus, E. A.; (2007); Otol Neurotol. 28(4):463-472

OBJECTIVE: Investigation of the relation between classroom performance and language development of cochlear implant (CI) students in mainstream education. Structural analyses of assessment of mainstream performance (AMP) and Screening Instrument For Targeting Educational Risk (SIFTER) instruments. STUDY DESIGN: Cross-sectional instrument and language development analyses. SETTING: Tertiary university medical center. PATIENTS:: Twenty-six CI children in elementary school with congenital or prelingual deafness were included. At the time of this study, mean period of multichannel CI use was 5.3 years, and children's ages ranged from 6.5 to 12.8 years. MAIN OUTCOME MEASURE: Assessment of mainstream performance and SIFTER instruments measured classroom performance and language development were measured by means of Reynell and Schlichting tests. RESULTS:: Assessment of mainstream performance and SIFTER domains showed good reliability (Cronbach alpha >0.6), but factor analyses only showed the expected instrument structure in the AMP. In both questionnaires and within all domains, individual variability is detected. Spearman's correlation analyses showed the probable explanation of individual questionnaire variability by language test results (p value mostly <0.01). The AMP and SIFTER instruments showed a predictive capacity for language development, based upon general linear model univariate and linear regression analyses. CONCLUSION: Individual classroom performance, measured by AMP and SIFTER questionnaires, of CI children in mainstream education varies. Correlation analyses showed strong significant relation between questionnaire results (classroom performance) and both expressive and receptive language test results (Schlichting and Reynell tests). Structural questionnaire analyses of the AMP and SIFTER demonstrated good reliability. The predictive value of the AMP can monitor the actual linguistic functioning of the child.

30. **"Cochlear implantation and quality of life in postlingually deaf adults: Long-term follow-up".** Damen, G. W.; Beynon, A. J.; Krabbe, P. F.; Mulder, J. J.; Mylanus, E. A.; (2007); Otolaryngol Head Neck Surg. 136(4):597-604

OBJECTIVE: To investigate long-term quality of life (QoL) in postlingually deaf adults after entering the cochlear implantation (CI) program. STUDY DESIGN AND SETTING: Follow-up study from 1998 onwards in tertiary university medical center. Long-term CI users, patients who have not received a CI, and relatively short-term CI users were re-evaluated six years after initial data collection in 1998 by using three questionnaires (NCIQ, HUI3, and SF36) and speech perception tests. RESULTS AND CONCLUSIONS: In general, the beneficial effect of CI

remained stable during long-term follow-up, though scores on the questionnaires decreased slightly. Outcomes before and after cochlear implantation were significantly different. The group without a CI demonstrated slightly decreasing trends in outcomes. Long-term speech perception performance improved in time. SIGNIFICANCE: This is the first study to investigate long-term follow-up of CI patients, in all aspects of QoL combined with speech perception performance, in comparison with postlingually deaf adults without CI.

31. **"Clinical evaluation of expanded input dynamic range in Nucleus cochlear implants".** Dawson, P. W.; Vandali, A. E.; Knight, M. R.; Heasman, J. M.; (2007); Ear Hear. 28(2):163-176

OBJECTIVE: The aim of this study was to investigate whether expanded instantaneous input dynamic ranges (IIDRs) in the Nucleus cochlear implant system benefit speech perception in the laboratory and listening in the real world. DESIGN: Until recently, Nucleus cochlear implants have used an IIDR of approximately 30 dB. In this study, an IIDR of 31 dB was compared with 46 dB and 56 dB in the SPEAR3 research processor with nine adult implant recipients. Subjects were given two, 2-wk blocks of take-home experience with each of the three IIDRs. A single IIDR setting was used in each trial period. During the take-home experience with the expanded IIDRs, subjects used two programs: a standard program (with clinically measured electrode dynamic ranges) and a program with adjusted thresholds (decreased T levels). After each block of take-home experience, speech perception testing was conducted for CNC words in quiet (at 45 dB and 55 dB SPL) and for CUNY sentences in the presence of multi-taker babble. RESULTS: On average, CNC word recognition at low presentation levels was significantly better with the 46 dB and 56 dB IIDRs, compared with the 31 dB IIDR; however, there was no significant difference between the 46 dB and 56 dB IIDR conditions. These benefits were greater for standard programs than for reduced T level programs. For CUNY sentences in babble, group results indicated no significant difference in performance across IIDR. The three IIDRs were rated similarly in real-life listening situations, and two of the subjects expressed tolerance problems with the expanded standard IIDRs. CONCLUSIONS: IIDRs of 46 and 56 dB provided benefit in accessing low-level speech without a decrement in sentence perception in babble. Most subjects accepted the standard, wider IIDR programs in everyday life. No significant differences were found between the 46 dB and 56 dB IIDR programs.

32. **"Communication development in children who receive the cochlear implant younger than 12 months: Risks versus benefits".** Dettman, S. J.; Pinder, D.; Briggs, R. J.; Dowell, R. C.; Leigh, J. R.; (2007); Ear Hear. 28(2 Suppl):11S-18S

BACKGROUND: The advent of universal neonatal hearing screening in some countries and the availability of screening programs for at-risk infants in other countries has facilitated earlier referral, diagnosis, and intervention for infants with

hearing loss. Improvements in device technology, two decades of pediatric clinical experience, a growing recognition of the efficacy of cochlear implants for young children, and the recent change in the U.S. Food and Drug Administration's age criteria to include children as young as 12 mo has led to increasing numbers of young children receiving cochlear implants. Evidence to support provision for infants younger than 12 mo is extrapolated from physiological studies, studies of children using hearing aids, and studies of children older than 12 mo of age with implants. To date, however, there are few published research findings regarding communication development in children between 6 and 12 mo of age who receive implants. The current study hypothesized that earlier implantation would lead to increased rates of language acquisition as the children were still in the critical period for their development. METHOD: A retrospective review was completed for 19 infants (mean age at implantation, 0.88 yr; range, 0.61-1.07, SD 0.15) and 87 toddlers (mean age at implantation, 1.60 yr; range, 1.13-2.00, SD 0.24) who received the multichannel implant in Melbourne, Australia. Preimplantation audiological assessments for these children included aided and unaided audiograms, auditory brain stem response, auditory steady state response (ASSR), and otoacoustic emission and indicated profound to total bilateral hearing loss in all cases. Communication assessment included completion of the Rossetti Infant-Toddler Language Scale and educational psychologists' cognitive and motor assessment. Computed tomography scan, magnetic resonance imaging, and surgical records for all cases were reviewed. Postimplantation language assessments were reported in terms of the rate of growth over time on the language comprehension and language expression subscales of the Rossetti Infant-Toddler Language Scale. RESULTS: Results demonstrated that cochlear implantation may be performed safely in very young children with excellent language outcomes. The mean rates of receptive (1.12) and expressive (1.01) language growth for children receiving implants before the age of 12 mo were significantly greater than the rates achieved by children receiving implants between 12 and 24 mo, and matched growth rates achieved by normally hearing peers. These preliminary results support the provision of cochlear implants for children younger than 12 mo of age within experienced pediatric implantation centers.

33. **"Intracranial complications of cochlear implantation".** Dodson, K. M.; Maiberger, P. G.; Sismanis, A.; (2007); Otol Neurotol. 28(4):459-462

OBJECTIVE: To describe intracranial complications after cochlear implantation in the pediatric and adult populations. STUDY DESIGN: Retrospective chart review. SETTING: Tertiary referral center. PATIENTS: A chart review of the intracranial complications and their management in 345 patients undergoing cochlear implantation was undertaken. INTERVENTIONS: Variables, including age, sex, implant manufacturer, cause of deafness, intraoperative findings, and postoperative complications, were collected and analyzed. MAIN OUTCOME MEASURE: Presence of intracranial complication of cochlear implantation. RESULTS: There were 134 Nucleus-22 (Cochlear, Englewood, CO) devices, 50

Nucleus-24 devices, 118 Med-El (Durham, NC) devices, and 43 Advanced Bionics Corporation (Sylmar, CA) devices in 151 adults and 194 children. There was a 9.3% overall complication rate, with most (59%) being related to device failure. There were three intracranial complications (<1%), two in elderly individuals and one in a child. Two minor dural defects with cerebrospinal fluid leak at the site of the receiver/stimulator recess in Med-El devices were repaired intraoperatively with temporalis fascia. One elderly patient experienced an acute extensive subdural hematoma after Nucleus-24 implantation, which was treated successfully with immediate evacuation. CONCLUSION: Intracranial complication rates associated with cochlear implantation are low, although potentially very serious. Surgeons should be aware of intracranial complications, especially in older individuals, and take immediate appropriate action.

34. **"An electric frequency-to-place map for a cochlear implant patient with hearing in the non-implanted ear".** Dorman, M. F.; Spahr, T.; Gifford, R.; Loiselle, L.; McKarns, S.; Holden, T.; Skinner, M.; Finley, C.; (2007); J Assoc Res Otolaryngol. 8(2):234-240

The aim of this study was to relate the pitch of high-rate electrical stimulation delivered to individual cochlear implant electrodes to electrode insertion depth and insertion angle. The patient (CH1) was able to provide pitch matches between electric and acoustic stimulation because he had auditory thresholds in his nonimplanted ear ranging between 30 and 60 dB HL over the range, 250 Hz to 8 kHz. Electrode depth and insertion angle were measured from high-resolution computed tomography (CT) scans of the patient's temporal bones. The scans were used to create a 3D image volume reconstruction of the cochlea, which allowed visualization of electrode position within the scala. The method of limits was used to establish pitch matches between acoustic pure tones and electric stimulation (a 1,652-pps, unmodulated, pulse train). The pitch matching data demonstrated that, for insertion angles of greater than 450 degrees or greater than approximately 20 mm insertion depth, pitch saturated at approximately 420 Hz. From 20 to 15 mm insertion depth pitch estimates were about one-half octave lower than the Greenwood function. From 13 to 3 mm insertion depth the pitch estimates were approximately one octave lower than the Greenwood function. The pitch match for an electrode only 3.4 mm into the cochlea was 3,447 Hz. These data are consistent with other reports, e.g., Boëx et al. (2006), of a frequency-to-place map for the electrically stimulated cochlea in which perceived pitches for stimulation on individual electrodes are significantly lower than those predicted by the Greenwood function for stimulation at the level of the hair cell.

35. **"Central auditory development: Evidence from CAEP measurements in children fit with cochlear implants".** Dorman, M. F.; Sharma, A.; Gilley, P.; Martin, K.; Roland, P.; (2007); Journal of Communication Disorders. 40(4):284-294

In normal-hearing children the latency of the P1 component of the cortical evoked response to sound varies as a function of age and, thus, can be used as a

biomarker for maturation of central auditory pathways. We assessed P1 latency in 245 congenitally deaf children fit with cochlear implants following various periods of auditory deprivation. If children experience less than 3.5 years of auditory deprivation before implantation, P1 latencies fall into the range of normal following 3-6 months of electrical stimulation. Children who experience greater than 7 years of deprivation, however, generally do not develop normal P1 latencies even after years of stimulation. Moreover, the waveforms for these patients can be markedly abnormal. Cortical reorganization stimulated by deprivation is likely to be a significant factor in both variation in the latency and morphology of the cortical evoked response to so und for children fit with a cochlear implant and variation in the development of oral speech and language function. Learning outcomes: The reader will be introduced to research using cortical evoked responses (CAEPs), positron emission tomography (PET) scans and in-depth recording from the auditory cortex of congenitally deaf cats that converges on the existence of a sensitive period for the development of central auditory pathways in children. The reader will also be provided with two case studies that illustrate the use of the P1 response as biomarker for development of central auditory pathways. Finally, suggestions for future research will be provided.

36. **"Autosomal recessive postlingual hearing loss (DFNB8): Compound heterozygosity for two novel TMPRSS3 mutations in German siblings".** Elbracht, M.; Senderek, J.; Eggermann, T.; Thurmer, C.; Park, J.; Westhofen, M.; Zerres, K.; (2007); Journal of Medical Genetics. 44(6):e81

Mutations in the transmembrane protease, serine 3 (TMPRSS3) gene, encoding a transmembrane serine protease, cause autosomal recessive deafness childhood (DFNB8) or congenital onset (DFNB10). TMPRSS3 mutations have been mainly identified in patients from Asian and Mediterranean countries and seem to be a rare finding in the Northern European population so far. The identification of two novel pathogenic TMPRSS3 mutations (c.646C[->]T - R216C; c.916G[->]A - A306T) is described in four affected siblings of German origin with postlingual hearing loss, treated by bilateral cochlear implantation with good results. Although TMPRSS3 mutations are supposed to be a rare cause of autosomal recessive hearing loss, in families with postlingual disease onset TMPRSS3 is the most favourable candidate gene after exclusion of GJB2 mutations.

37. **"Profiles of vocal development in young cochlear implant recipients".** Ertmer, D. J.; Young, N. M.; Nathani, S.; (2007); Journal of Speech, Language, and Hearing Research. 50(2):393-407

PurposeThe main purpose of this investigation was to examine the effects of cochlear implant experience on prelinguistic vocal development in young deaf children. ProcedureA prospective longitudinal research design was used to document the sequence and time course of vocal development in 7 children who were implanted between 10 and 36 months of age. Speech samples were collected twice before implant activation and on a monthly basis thereafter for up

to 2 years. Children's vocalizations were classified according to the levels of the Stark Assessment of Early Vocal Development--Revised (SAEVD-R; S. Nathani, D. J Ertmer, & R. E. Stark, 2006). ResultsThe main findings were (a) 6 of 7 children made advancements in vocal development after implantation; (b) children implanted between 12 and 36 months progressed through SAEVD-R levels in the predicted sequence, whereas a child implanted at a younger age showed a different sequence; (c) milestones in vocal development were often achieved with fewer months of hearing experience than observed in typically developing infants and appeared to be influenced by age at implantation; and (d) in general, children implanted at younger ages completed vocal development at younger chronological ages than those implanted later in life. Specific indicators of benefit from implant use were also identified. ConclusionThe time course of vocal development in young cochlear implant recipients can provide clinically useful information for assessing the benefits of implant experience. Studies of postimplantation vocal development have the potential to inform theories of spoken language development.

38. **"Blocking c-Jun-N-terminal kinase signaling can prevent hearing loss induced by both electrode insertion trauma and neomycin ototoxicity".** Eshraghi, A. A.; Wang, J.; Adil, E.; He, J.; Zine, A.; Bublik, M.; Bonny, C.; Puel, J. L.; Balkany, T. J.; Van De Water, T. R.; (2007); Hear Res. 226(1-2):168-177

Neomycin ototoxicity and electrode insertion trauma both involve activation of the mitogen activated protein kinase (MAPK)/c-Jun-N-terminal kinase (JNK) cell death signal cascade. This article discusses mechanisms of cell death on a cell biology level (e.g. necrosis and apoptosis) and proposes the blocking of JNK signaling as a therapeutic approach for preventing the development of a permanent hearing loss that can be initiated by either neomycin ototoxicity or electrode insertion trauma. Blocking of JNK molecules incorporates the use of a peptide inhibitor (i.e. D-JNKI-1), which is specific for all three isoforms of JNK and has been demonstrated to prevent loss of hearing following either electrode insertion trauma or loss of both hearing and hair cells following exposure to an ototoxic level of neomycin. We present previously unpublished results that control for the effect of perfusate washout of aminoglycoside antibiotic by perfusion of the scala tympani with an inactive form of D-JNKI-1 peptide, i.e. JNKI-1(mut) peptide, which was not presented in the original J. Neurosci. article that tested locally delivered D-JNKI-1 peptide against both noise- and neomycin-induced hearing loss (i.e. Wang, J., Van De Water, T.R., Bonny, C., de Ribaupierre, F., Puel, J.L., Zine, A. 2003a. A peptide inhibitor of c-Jun N-terminal kinase protects against both aminoglycoside and acoustic trauma-induced auditory hair cell death and hearing loss. J. Neurosci. 23, 8596-8607). D-JNKI-1 is a cell permeable peptide that blocks JNK signaling at the level of the three JNK molecular isoforms, which when blocked prevents the increases in hearing thresholds and the loss of auditory hair cells. This unique therapeutic approach may have clinical application for preventing: (1) hearing loss caused by neomycin ototoxicity; and (2) the progressive component of electrode insertion trauma-induced hearing loss.

39. **"Neuropsychological correlates of vocabulary, reading, and working memory in deaf children with cochlear implants".** Fagan, M. K.; Pisoni, D. B.; Horn, D. L.; Dillon, C. M.; (2007); The Journal of Deaf Studies and Deaf Educationenm023

The performance of deaf children with cochlear implants was assessed using measures standardized on hearing children. To investigate nonverbal cognitive and sensorimotor processes associated with postimplant variability, five selected sensorimotor and visuospatial subtests from A Developmental Neuropsychological Assessment (NEPSY) were compared with standardized vocabulary, reading, and digit span measures. Participants were 26 deaf children, ages 6-14 years, who received a cochlear implant between ages 1 and 6 years; duration of implant use ranged from 3 to 11 years. Results indicated significant correlations between standard scores on the Design Copying subtest of the NEPSY and standard scores on vocabulary comprehension, reading, and digit span measures. The results contribute to our understanding of the benefits of cochlear implantation and cognitive processes that may support postimplant language and academic functioning.

40. **"Patient employment status and satisfaction following cochlear implantation".** Fazel, M. Z. & Gray, R. F.; (2007); Cochlear Implants Int. 8(2):87-91

The aim of this study was to look at the effect on employment and employee perception of career opportunities after receiving a cochlear implant. Retrospective analysis based on a patient questionnaire was conducted. Eighty patients were identified: 65 (81.3%) participated in the questionnaire. Forty-five patients (69.2%) were working prior to implant compared to 54 (83.9%) after implant. Job satisfaction rating rose from 5.56 to 6.82 following cochlear implantation. Twenty patients (30.8%) were unemployed prior to surgery while 11 (16.9%) remained unemployed post implantation. Twenty-six patients (57.7%) from the working group believed that their hearing disability had affected their career, while 18 (40%) from the same group believed that receiving the cochlear implant significantly improved their career prospects. Cochlear implantation is associated with an improved chance of being employed. It also helps with improved job satisfaction as well as improving employee perception of their career prospects.

41. **"Childhood Development after Cochlear Implantation (CDaCI) study: Design and baseline characteristics".** Fink, N. E.; Wang, N. Y.; Visaya, J.; Niparko, J. K.; Quittner, A.; Eisenberg, L. S.; Tobey, E. A.; (2007); Cochlear Implants Int. 8(2):92-116

Children with severe to profound sensorineural hearing loss face communication challenges that influence language, psychosocial and scholastic performance. Clinical studies over the past 20 years have supported wider application of cochlear implants in children. The Childhood Development after Cochlear

Implantation (CDaCI) study is the first longitudinal multicentre, national cohort study to evaluate systematically early cochlear implant (CI) outcomes in children. The objective of the study was to compare children who have undergone cochlear implantation, with similarly aged hearing peers across multiple domains, including oral language development, auditory performance, psychosocial and behavioural functioning, and quality of life. The CDaCI study is a multicentre national cohort study of CI children and normal hearing (NH) peers. Eligibility criteria include informed consent, age less than 5 years, pre- or post-lingually deaf, developmental criteria met, commitment to educate the child in English and bilateral cochlear implants. All children had a standardised baseline assessment that included demographics, hearing and medical history, communication history, language measures, cognitive tests, speech recognition, an audiological exam, psychosocial assessment including parent-child videotapes and parent reported quality of life. Follow-up visits are scheduled at six-month intervals and include a standardised assessment of the full battery of measures. Quality assurance activities were incorporated into the design of the study. A total of 188 CI children and 97 NH peers were enrolled between November 2002 and December 2004. The mean age, gender and race of the CI and NH children are comparable. With regard to parental demographics, the CI and NH children's families are statistically different. The parents of CI children are younger, and not as well educated, with 49% of CI parents reporting college graduation vs. 84% of the NH parents. The income of the CI parents is also lower than the NH parents. Assessments of cognition suggest that there may be baseline differences between the CI and NH children; however the scores were high enough to suggest language learning potential. The observed group differences identified these baseline characteristics as potential confounders which may require adjustment in analyses of outcomes.This longitudinal cohort study addresses questions related to high variability in language outcomes. Identifying sources of that variance requires research designs that: characterise potential predictors with accuracy, use samples that adequately power a study, and employ controls and approaches to analysis that limit bias and error. The CDaCI study was designed to generate a more complete picture of the interactive processes of language learning after implantation.

42. **"The effect of perimodiolar placement on speech perception and frequency discrimination by cochlear implant users".** Fitzgerald, M. B.; Shapiro, W. H.; McDonald, P. D.; Neuburger, H. S.; shburn-Reed, S.; Immerman, S.; Jethanamest, D.; Roland, J. T.; Svirsky, M. A.; (2007); Acta Otolaryngol. 127(4):378-383

CONCLUSION: Neither speech understanding nor frequency discrimination ability was better in Nucleus Contour users than in Nucleus 24 straight electrode users. Furthermore, perimodiolar electrode placement does not result in better frequency discrimination. OBJECTIVES: We addressed three questions related to perimodiolar electrode placement. First, do patients implanted with the Contour electrode understand speech better than with an otherwise identical device that

has a straight electrode? Second, do these groups have different frequency discrimination abilities? Third, is the distance of the electrode from the modiolus related to frequency discrimination ability? SUBJECTS AND METHODS: Contour and straight electrode users were matched on four important variables. We then tested these listeners on CNC word and HINT sentence identification tasks, and on a formant frequency discrimination task. We also examined X-rays and measured the distance of the electrodes from the modiolus to determine whether there is a relationship between this factor and frequency discrimination ability. RESULTS: Both speech understanding and frequency discrimination abilities were similar for listeners implanted with the Contour vs a straight electrode. Furthermore, there was no linear relationship between electrode-modiolus distance and frequency discrimination ability. However, we did note a second-order relationship between these variables, suggesting that frequency discrimination is worse when the electrodes are either too close or too far away from the modiolus.

43. **"Computer-assisted speech training for cochlear implant patients: Feasibility, outcomes, and future directions".** Fu, Q.-J. & Galwin, I. J. J.; (2007); Seminars.in Hearing. 28(2):142-150

Learning electrically stimulated speech patterns can be a new and difficult experience for cochlear implant patients. Cochlear implantation alone may not fully meet the needs of many patients, and additional auditory rehabilitation may be necessary to maximize the benefits of the implanted device. A recently developed computer-assisted speech-training program provides cochlear implant patients with the means to conduct auditory rehabilitation at home. The training software targets important acoustic contrasts between speech stimuli and provides auditory and visual feedback as well as progressive training, thereby maintaining patients' interest in the auditory training exercises. Recent scientific studies have demonstrated the effectiveness of such specialized auditory training programs in improving cochlear implant patients' speech recognition performance. Provided with an inexpensive and accessible aud itory training program, cochlear implant patients may find the motivation and momentum to get the most from the implanted device.

44. **"Recurrent upper airway infections and bacterial biofilms".** Galli, J.; Ardito, F.; Calo, L.; Mancinelli, L.; Imperiali, M.; Parrilla, C.; Picciotti, P. M.; Fadda, G.; (2007); J Laryngol Otol. 121(4):341-344

BACKGROUND: Bacterial biofilms identified in various medical devices used in otorhinolaryngology, including tympanostomy tubes, voice prostheses, and cochlear implants, can directly colonise mucosal tissues. The upper airways seem to be at high risk for this type of colonisation. Chronic and/or recurrent upper airway infections may be related to the complex structural and biochemical (quorum sensing) organisation of the biofilm which interferes with the activity of antibiotics (including those with proven in vitro efficacy), thus promoting the

establishment of a chronic infection eradicable only by surgical treatment. Biofilm formation plays a role in upper respiratory infections: it not only explains the resistance of these infections to antibiotic therapy but it also represents an important element that contributes to the maintenance of a chronic inflammatory reaction. OBJECTIVES: To document the presence of biofilms in surgical tissue specimens from patients with recurrent infection diseases, and identify their possible role in the chronicity of these infectious processes. METHOD: We examined 32 surgical specimens from the upper respiratory tract (tonsils, adenoids, mucosa from the ethmoid and maxillary sinuses) of 28 patients (20 adults, eight children) with upper airway infections that had persisted despite repeated treatment with anti-inflammatory agents and antibiotics with demonstrated in vitro efficacy. Tissues were cultured using conventional methods and subjected to scanning electron microscopy for detection of biofilm formation. RESULTS: Over 80 per cent (26/32; 81.3 per cent) of the tissue specimens were culture-positive. Bacterial biofilms (associated in most cases with coccoid bacteria) were observed in 65.6 per cent of the tissue samples.

45. **"Melodic contour identification by cochlear implant listeners".** Galvin, J. J.; Fu, Q. J.; Nogaki, G.; (2007); Ear Hear. 28(3):302-319

OBJECTIVE: While the cochlear implant provides many deaf patients with good speech understanding in quiet, music perception and appreciation with the cochlear implant remains a major challenge for most cochlear implant users. The present study investigated whether a closed-set melodic contour identification (MCI) task could be used to quantify cochlear implant users' ability to recognize musical melodies and whether MCI performance could be improved with moderate auditory training. The present study also compared MCI performance with familiar melody identification (FMI) performance, with and without MCI training. METHODS: For the MCI task, test stimuli were melodic contours composed of 5 notes of equal duration whose frequencies corresponded to musical intervals. The interval between successive notes in each contour was varied between 1 and 5 semitones; the "root note" of the contours was also varied (A3, A4, and A5). Nine distinct musical patterns were generated for each interval and root note condition, resulting in a total of 135 musical contours. The identification of these melodic contours was measured in 11 cochlear implant users. FMI was also evaluated in the same subjects; recognition of 12 familiar melodies was tested with and without rhythm cues. MCI was also trained in 6 subjects, using custom software and melodic contours presented in a different frequency range from that used for testing. RESULTS: Results showed that MCI recognition performance was highly variable among cochlear implant users, ranging from 14% to 91% correct. For most subjects, MCI performance improved as the number of semitones between successive notes was increased; performance was slightly lower for the A3 root note condition. Mean FMI performance was 58% correct when rhythm cues were preserved and 29% correct when rhythm cues were removed. Statistical analyses revealed no significant correlation between MCI performance and FMI performance (with or without rhythmic cues). However, MCI performance was

significantly correlated with vowel recognition performance; FMI performance was not correlated with cochlear implant subjects' phoneme recognition performance. Preliminary results also showed that the MCI training improved all subjects' MCI performance; the improved MCI performance also generalized to improved FMI performance. CONCLUSIONS: Preliminary data indicate that the closed-set MCI task is a viable approach toward quantifying an important component of cochlear implant users' music perception. The improvement in MCI performance and generalization to FMI performance with training suggests that MCI training may be useful for improving cochlear implant users' music perception and appreciation; such training may be necessary to properly evaluate patient performance, as acute measures may underestimate the amount of musical information transmitted by the cochlear implant device and received by cochlear implant listeners.

46. **"12-month post-operative results for older children using sequential bilateral implants".** Galvin, K. L.; Mok, M.; Dowell, R. C.; Briggs, R. J.; (2007); Ear Hear. 28(2 Suppl):19S-21S

Within a long-term project investigating the perceptual benefits of bilateral implants, six children aged 5 to 15 yr received a second implant. Parent reports of functional performance were collected, and localization and spondee discrimination in noise was assessed. Outcomes varied from no benefit to significant benefit, although no improvement in localization was demonstrated. A major proportion of the benefit was likely due to headshadow effect. Success did not correlate with hearing aid use, age, time between implants, or second implant experience.

47. **"Accuracy of cochlear implant recipients on pitch perception, melody recognition, and speech reception in noise".** Gfeller, K.; Turner, C.; Oleson, J.; Zhang, X.; Gantz, B.; Froman, R.; Olszewski, C.; (2007); Ear Hear. 28(3):412-423

OBJECTIVE: The purposes of this study were to (a) examine the accuracy of cochlear implant recipients who use different types of devices and signal processing strategies on pitch ranking as a function of size of interval and frequency range and (b) to examine the relations between this pitch perception measure and demographic variables, melody recognition, and speech reception in background noise. DESIGN: One hundred fourteen cochlear implant users and 21 normal-hearing adults were tested on a pitch discrimination task (pitch ranking) that required them to determine direction of pitch change as a function of base frequency and interval size. Three groups were tested: (a) long electrode cochlear implant users (N = 101); (b) short electrode users that received acoustic plus electrical stimulation (A+E) (N = 13); and (c) a normal-hearing (NH) comparison group (N = 21). Pitch ranking was tested at standard frequencies of 131 to 1048 Hz, and the size of the pitch-change intervals ranged from 1 to 4 semitones. A generalized linear mixed model (GLMM) was fit to predict pitch ranking and to determine if group differences exist as a function of base frequency and interval size. Overall significance effects were measured with Chi-square tests and

individual effects were measured with t-tests. Pitch ranking accuracy was correlated with demographic measures (age at time of testing, length of profound deafness, months of implant use), frequency difference limens, familiar melody recognition, and two measures of speech reception in noise. RESULTS: The long electrode recipients performed significantly poorer on pitch discrimination than the NH and A+E group. The A+E users performed similarly to the NH listeners as a function of interval size in the lower base frequency range, but their pitch discrimination scores deteriorated slightly in the higher frequency range. The long electrode recipients, although less accurate than participants in the NH and A+E groups, tended to perform with greater accuracy within the higher frequency range. There were statistically significant correlations between pitch ranking and familiar melody recognition as well as with pure-tone frequency difference limens at 200 and 400 Hz. CONCLUSIONS: Low-frequency acoustic hearing improves pitch discrimination as compared with traditional, electric-only cochlear implants. These findings have implications for musical tasks such as familiar melody recognition.

48. **"Auditory neuropathy: An update".** Gibson, W. P. & Sanli, H.; (2007); Ear Hear. 28(2 Suppl):102S-106S

OBJECTIVES: To describe the round window electrocochleography (RWECochG) and electric auditory brainstem responses (EABR) in ears affected by auditory neuropathy (AN), and to determine if these electrophysiological tests can predict the outcome following cochlear implant surgery. METHODS: A longitudinal study of all pediatric cochlear implant patients between 1994 and 2005 was undertaken. Speech perception outcomes after cochlear implantation and electrophysiological data were collected prospectively and analyzed. Some otoacoustic emissions (OAE) data were collected retrospectively during the neonatal period. All subjects were tested using round window electrocochleography (RWEcochG), auditory brainstem responses (ABR), and implant-evoked electric auditory brainstem responses (EABR). The auditory neuropathy (AN) group consisted of 39 children (78 ears) which had present OAE and absent or grossly abnormal ABR (a broad N1 component only). RESULTS: All 78 ears from the 39 AN children showed large cochlear microphonics (CM) and an abnormal positive potential (APP) using RW ECochG. A further 21 children showed large CM and APP but had not been tested for OAE. In total, 60 children were discovered to have APP among 435 pediatric patients who received a cochlear implant. Electrically evoked ABR (EABR) from the implanted ear were normal in 45 and abnormal in 15. 46 age matched patients without large CM and APP were used as a control group. Two year postimplant scores (Melbourne categories) were: 6.27 (APP and normal EABR), 2.25 (APP and abnormal EABR) and 5.37 (control group). Mann-Whitney U Test for nonparametric data was used to test for significant difference at significance level $p < 0.005$ (two tailed). The APP ears which provided normal EABR had significantly better outcomes after cochlear implantation than APP ears which had abnormal EABR. Furthermore, the APP ears which provided normal EABR performed significantly better after cochlear implant surgery than the control group

of patients with no OAE, appropriate ABR results and normal EABR. CONCLUSIONS: Ears affected by AN provide large CM and APP on RW ECochG. The presence of normal EABR may indicate a significantly better outcome after cochlear implant surgery than for those APP ears which had abnormal or absent EABR. Based on these findings it is suggested that the presence of APP and/ or OAE in 75% of the ears which have absent or abnormal ABR may not indicate a pathological condition affecting the auditory nerve or synapse but only survival of outer hair cells despite extensive loss of inner hair cells.

49. **"Auditory function and speech understanding in listeners who qualify for EAS surgery".** Gifford, R. H.; Dorman, M. F.; Spahr, A. J.; Bacon, S. P.; (2007); Ear Hear. 28(2 Suppl):114S-118S

OBJECTIVE: For patients with relatively good low-frequency hearing and relatively poor high-frequency hearing, who met the pre-implant criteria for combined electric and acoustic stimulation (EAS), our aims were to i) assess deficits in low-frequency auditory function, ii) to identify measures which might be sensitive to changes resulting from the insertion of an intracochlear electrode array, and iii) to quantify the relationship between measures of auditory function and performance on tasks of speech and melody recognition. DESIGN: Measures of frequency selectivity, temporal resolution, and nonlinear cochlear function, along with measures of word, sentence, consonant, vowel, and melody recognition, were obtained from 5 normal-hearing and 17 hearing-impaired listeners. The hearing-impaired listeners had auditory thresholds at 500 Hz, ranging from 20 to 60 dB HL, and thresholds at 1 kHz, ranging from 60 to 100 dB HL. RESULTS: Nonlinear cochlear function was either reduced or absent. Frequency selectivity at 500 Hz was significantly reduced but still present in most patients. Temporal resolution, when measured at low modulation frequencies, was normal. Speech recognition in a modulated background revealed significantly poorer performance than normal. Speech and melody recognition varied over a large range. No measure of auditory function was correlated significantly with speech recognition. However, frequency selectivity was related to melody recognition. CONCLUSIONS: (1) Patients who qualify for EAS surgery have a wide range of speech and melody recognition abilities. (2) A number of the psychophysical measures tested may prove more sensitive than the audiogram in determining the degree of damage inflicted by the intracochlear electrode array. (3) Speech recognition was not correlated with any of the measures of auditory function.

50. **"Binaural processing in children using bilateral cochlear implants".** Gordon, K. A.; Valero, J.; Papsin, B. C.; (2007); Neuroreport. 18(6):613-617

Binaural auditory brainstem processing was examined using evoked potential measures in 40 children who were implanted early and received a second implant simultaneously or after long or short periods of unilateral implant use. Wave latencies were shorter when evoked by the experienced versus naïve implanted

ear at initial bilateral activation. Binaural difference waves were detected in most children in response to apical but not basal electrode stimulation and were prolonged in latency in children implanted after long or short delays between implants. Timing differences between the implanted ears in children receiving sequential but not simultaneous bilateral implants reflect a relative immaturity of pathways innervating the second ear and results in abnormal timing of binaural processing at this initial implant stage.

51. **"Talker intelligibility differences in cochlear implant listeners".** Green, T.; Katiri, S.; Faulkner, A.; Rosen, S.; (2007); J Acoust Soc Am. 121(6):EL223-EL229

People vary in the intelligibility of their speech. This study investigated whether across-talker intelligibility differences observed in normally-hearing listeners are also found in cochlear implant (CI) users. Speech perception for male, female, and child pairs of talkers differing in intelligibility was assessed with actual and simulated CI processing and in normal hearing. While overall speech recognition was, as expected, poorer for CI users, differences in intelligibility across talkers were consistent across all listener groups. This suggests that the primary determinants of intelligibility differences are preserved in the CI-processed signal, though no single critical acoustic property could be identified.

52. **"Effects of auditory pathway anatomy and deafness characteristics? Part 2: On electrically evoked late auditory responses".** Guiraud, J.; Gallego, S.; Arnold, L.; Boyle, P.; Truy, E.; Collet, L.; (2007); Hear Res. 228(1-2):44-57

The purpose of this study was to distinguish the effects of different parameters on latencies of wave N1, wave P2, and inter-peak interval N1-P2 of electrical late auditory responses (ELARs). ELARs were recorded from four intra-cochlear electrodes in fourteen adult HiRes90K cochlear implant users who had at least three months of experience. The relationship between latencies and stimulation sites in the cochlea was characterized to assess the influence of the auditory pathway anatomy on ELARs, i.e., whether the speed of neural propagation varies according to the place that is activated in the cochlea. Audiograms before implantation, duration of deafness, and psychophysics at first fitting were used to describe the influence of deafness characteristics on latencies. The stimulation sites were found to have no effect on ELAR latency and, while there was no influence of psychophysics on latency, a strong relationship was shown with duration of deafness and the pre-implantation audiogram. Thus, ELAR latency was longer for poorer audiograms and longer durations of deafness and this relationship appeared to be independent of stimulation parameters such as stimulation site. Comparison between these findings and those from the equivalent study on EABR waves IIIe and Ve latency [Guiraud, J., Gallego, S., Arnold, L., Boyle, P., Truy, E., Collet, L., 2007. Effects of auditory pathway anatomy and deafness characteristics? (1): On electrically evoked auditory brainstem responses. Hear. Res. 223 (1-2), 48-60] shows that, while ELAR and EABR

latencies are related with parameters that reflect the integrity of the auditory pathway, ELAR latency is less dependent on stimulation parameters than EABR latency.

53. **"Use of a single channel dedicated to conveying enhanced temporal periodicity cues in cochlear implants: Effects on prosodic perception and vowel identification".** Hamilton, N.; Green, T.; Faulkner, A.; (2007); Int J Audiol. 46(5):244-253

The continuous interleaved sampling (CIS) strategy for cochlear implants has well-established limitations for the perception of pitch changes in speech. This study investigated a modification of CIS in which one channel was dedicated to the transmission of a temporal encoding of fundamental frequency (F0). Normal hearing subjects listening to noise-excited vocoders, and implantees were tested on labelling the pitch movement of diphthongal glides, on using intonation information to identify sentences as question or statement, and on vowel recognition. There were no significant differences between modified processing and CIS in vowel recognition. However, while there was limited evidence of improved pitch perception relative to CIS with simplified F0 modulation applied to the most basal channel, in general it appears that for most implant users, restricting F0-related modulation to one channel does not provide significantly enhanced pitch information.

54. **"Tone production of Mandarin Chinese speaking children with cochlear implants".** Han, D.; Zhou, N.; Li, Y.; Chen, X.; Zhao, X.; Xu, L.; (2007); Int J Pediatr Otorhinolaryngol. 71(6):875-880

OBJECTIVE: The purpose of the present study was to investigate tone production performance of native Mandarin Chinese speaking children with cochlear implants and to evaluate the effects of age at implantation and duration of implant use on tone production in those children. METHODS: Fourteen prelingually deaf children who had received cochlear implantation and 14 age-matched normal-hearing children participated in the study. Both groups were of native Mandarin Chinese speaking children. One hundred and sixty tone tokens were recorded from each of the children. The total of 4480 tokens (160x28) were then used in the tone perception tests in which seven normal-hearing native Mandarin Chinese speaking adults participated. RESULTS: The tone production of the cochlear implant children showed tremendous individual variability. The group mean performance was 48.4% correct, statistically significantly lower than the group mean performance of 78.0% correct in the normal-hearing controls. The tone confusion matrix analysis revealed that the production of Mandarin tone 2 (the rising tone) was most severely impaired in the cochlear implant children, followed by tone 3 (the low and dipping tone) and tone 4 (the falling tone). The most frequently perceived tone irrespective of the target tone was tone 1 (the high level tone). The tone production performance was negatively correlated with the age at implantation and positively correlated with the duration of implant use.

CONCLUSIONS: There is a remarkable deficit in tone production in a majority of native tone language speaking, prelingually deaf children who have received cochlear implants. While an increased duration of implant use might facilitate tone production, the age at implantation appears to have a negative effect on tone production in cochlear implant children. Therefore, early implantation might be beneficial to tone production in prelingually deaf children whose native language is a tone language.

55. **"Cognitive predictors of improvements in adults' spoken word recognition six months after cochlear implant activation".** Heydebrand, G.; Hale, S.; Potts, L.; Gotter, B.; Skinner, M.; (2007); Audiol Neurootol. 12(4):254-264

This study investigated whether cognitive measures obtained prior to cochlear implant surgery activation could predict improvements in spoken word recognition in adult cochlear implant recipients 6 months after activation. In addition to noncognitive factors identified by previous studies (i.e. younger age, shorter duration of hearing loss), the present results indicated that improvement in spoken word recognition was associated with higher verbal learning scores and better verbal working memory. Contrary to expectation, neither general cognitive ability nor processing speed was significantly correlated with outcome at 6 months. Multiple regression analyses revealed that a combination of verbal learning scores and lip-reading skill accounted for nearly 72% of the individual differences in improvement in spoken word recognition (i.e. the variance in spoken word recognition scores at 6 months that remained unexplained after controlling for baseline spoken word recognition scores). These findings have relevance for research on auditory processing with cochlear implants as well as implications for clinical interventions.

56. **"Antibiotic prophylaxis in cochlear implant surgery".** Hirsch, B. E.; Blikas, A.; Whitaker, M.; (2007); Laryngoscope. 117(5):864-867

OBJECTIVES/HYPOTHESIS: We conducted this study to determine the incidence of infection in cochlear implant surgery after using perioperative antibiotics. STUDY DESIGN: Study design was a retrospective case series. METHODS: There was a retrospective chart review of 95 patients (81 adults, 14 children) undergoing 98 cochlear implants. RESULTS: The incidence of infection following cochlear implant surgery was 1% with the use of perioperative antibiotics. CONCLUSIONS: Perioperative antibiotics, usually administered as a single dose, are sufficient for the prevention of major wound infection after cochlear implant surgery.

57. **"Hydrocodone use and sensorineural hearing loss".** Ho, T.; Vrabec, J. T.; Burton, A. W.; (2007); Pain Physician. 10(3):467-472

BACKGROUND: The hydrocodone/acetaminophen combination is one of the most commonly used analgesic preparations. Isolated incidences of suspected

association between hydrocodone abuse and rapidly progressive hearing loss have been reported. In this study, we describe the clinical characteristics of 5 patients presenting with progressive hearing loss and a history of hydrocodone use. METHODS: Patients presenting with rapidly progressive bilateral hearing loss who had a documented history of hydrocodone use were selected for the study. The presentation, audiologic findings, associated comorbidities, and treatment outcomes were reviewed. RESULTS: All patients displayed rapidly progressive sensorineural hearing loss without vestibular symptoms. Hearing loss was asymmetric in 3 patients at initial presentation, but progressed to profound loss, usually within months. Steroid treatment has no effect on the progression of the hearing loss. The admitted quantity of hydrocodone consumed ranged from 10 to 300 mg per day. Hepatitis C was the most common comorbidity, present in 60% of the patients. All patients underwent cochlear implantation with satisfactory results. CONCLUSIONS: The chronic use of hydrocodone can be associated with progressive sensorineural hearing loss. Successful auditory rehabilitation can be achieved with cochlear implantation. Genetic polymorphisms of drug metabolizing enzymes as well as associated comorbidities such as hepatitis C infection may be significant in the development of hydrocodone ototoxicity, though additional investigations are necessary.

58. **"Telephone speech perception by Mandarin-speaking cochlear implantees".** Horng, M. J.; Chen, H. C.; Hsu, C. J.; Fu, Q. J.; (2007); Ear Hear. 28(2 Suppl):66S-69S

OBJECTIVE: To evaluate Mandarin-speaking cochlear implant patients' understanding of telephone speech. DESIGN: Telephone speech was simulated by band-limiting broadband speech stimuli (300-3200 Hz) and adding Gaussian noise (35 dB signal-to-noise ratio). Recognition of multitalker vowels, consonants, voice gender, and Chinese tones was measured for both simulated telephone speech and broadband speech in fifteen Mandarin-speaking cochlear implant patients. RESULTS: Results showed no significant difference in Chinese tone recognition scores between broadband and telephone speech. However, mean recognition scores for vowels, consonants and voice gender were significantly lower with telephone speech. The effect of the limited telephone bandwidth on speech recognition was highly variable among subjects. Some subjects were more sensitive to high-frequency speech cues, resulting in a significant drop in performance with band-limited telephone speech, while other subjects were less sensitive to high-frequency speech cues, resulting in similar performance between broadband and band-limited telephone speech. CONCLUSIONS: These results suggest that the limited bandwidth negatively affects cochlear implant patients' understanding of telephone speech. Because the effect of band-limited speech was highly variable among subjects, the results also suggest that the contribution of high frequency information to speech recognition may vary significantly among cochlear implant patients. For patients who receive little benefit from high-frequency speech cues, speech processor adjustments may be necessary to access the additional cues provided in broadband speech.

59. **"Optical parameter variability in laser nerve stimulation: A study of pulse duration, repetition rate, and wavelength".** Izzo, A. D.; Walsh, J. T.; Jansen, E. D.; Bendett, M.; Webb, J.; Ralph, H.; Richter, C. P.; (2007); IEEE Trans Biomed Eng. 54(6 Pt 1):1108-1114

Pulsed lasers can evoke neural activity from motor as well as sensory neurons in vivo. Lasers allow more selective spatial resolution of stimulation than the conventional electrical stimulation. To date, few studies have examined pulsed, mid-infrared laser stimulation of nerves and very little of the available optical parameter space has been studied. In this study, a pulsed diode laser, with wavelength between 1.844-1.873 microm, was used to elicit compound action potentials (CAPs) from the auditory system of the gerbil. We found that pulse durations as short as 35 micros elicit a CAP from the cochlea. In addition, repetition rates up to 13 Hz can continually stimulate cochlear spiral ganglion cells for extended periods of time. Varying the wavelength and, therefore, the optical penetration depth, allowed different populations of neurons to be stimulated. The technology of optical stimulation could significantly improve cochlear implants, which are hampered by a lack of spatial selectivity.

60. **"Biofilm formation in cochlear implants with cochlear drug delivery channels in an in vitro model".** Johnson, T. A.; Loeffler, K. A.; Burne, R. A.; Jolly, C. N.; Antonelli, P. J.; (2007); Otolaryngol Head Neck Surg. 136(4):577-582

BACKGROUND: Cochlear implant (CI) drug delivery (DD) may improve electrophysiological outcomes, but it may also increase the risk of suppurative complications. The aim of this study was to evaluate the development of bacterial biofilms on DD ports when subjected to varying types of penetration. METHODS: Silastic models were constructed to represent CIs with a DD channel, with an intact port, a widely opened port, a noncoring needle penetrating the port, and a noncoring needle removed from the port. CIs were exposed to a culture of a biofilm-forming strain of Staphylococcus aureus for 5 days. Biofilm formation was assessed with quantitative bacterial counts (after eliminating planktonic bacteria) and scanning electron microscopy. RESULTS: Bacterial counts were significantly higher in CIs with widely fenestrated ports than all other port conditions ($P = 0.0003$). CONCLUSIONS: Biofilm formation may be minimized on CIs with DD by using fine, noncoring needles and limiting the duration of port penetration.

61. **"Use of S-shaped input-output functions for noise suppression in cochlear implants".** Kasturi, K. & Loizou, P. C.; (2007); Ear Hear. 28(3):402-411

OBJECTIVES: The aim of this study is to assess the influence of the shape of the acoustic-to-electric mapping function on speech recognition in noise by cochlear implant listeners. DESIGN: A new acoustic-to-electric mapping function is proposed for cochlear implant users in noisy environments. The proposed s-shaped mapping function was expansive for low input levels up to a knee point level and compressive thereafter. The knee point of the mapping functions

changed dynamically and was set proportional to the estimated noise floor level. The performance of the mapping function was evaluated on a sentence recognition task using IEEE sentences embedded in +5 to 10 dB SNR multitalker babble and in +5 dB SNR speech-shaped noise. Nine postlingually deafened cochlear implant users participated in the study. RESULTS: Results indicated that the same s-shaped mapping function did not yield significant improvements for all cochlear implant users. Significant benefits in speech intelligibility were observed, however, when the s-shaped mapping function was optimized to individual cochlear implant users. Significantly higher performance was achieved with the s-shaped mapping functions than the conventional log mapping function used by cochlear implant users in their daily strategy, in both multitalker (+5 and +10 dB SNR) and continuous speech-shaped (+5 dB SNR) conditions. CONCLUSIONS: These results clearly indicate that the shape of the nonlinear acoustic-to-electric mapping can have a significant effect on speech intelligibility in noise when it is optimized to individual cochlear implant users. The log functions currently used in most implant processors for mapping acoustic to electric amplitudes are not the best mapping functions to use in noisy environments. This is largely because compressive functions tend to amplify low-level segments of speech along with noise, thereby decreasing the spectral contrast and effective dynamic range. In contrast, the s-shaped mapping functions, which are partly compressive and partly expansive depending on the signal level, are more suitable for noisy environments and can produce significantly higher performance than the log-mapping functions.

62. **"[Long-term follow-up of oral language development in children with permanent bilateral hearing loss].** Kiese-Himmel, C. & Reeh, M.; (2007); Gesundheitswesen. 69(4):249-255

OBJECTIVE: The aim of this study was to assess the oral language development of children with permanent bilateral hearing loss without additional disabilities longitudinally (5 time points t1-t5). METHOD: The present follow-up study evaluated both receptive and expressive language developmental quotients (DQ; desired value 1.0) with standardised developmental scales and receptive and expressive vocabulary size with standardised tests (results in T-scores; m=50, SD=10). Mean follow-up duration was 38.1 (SD 4.8) months. SAMPLE: A cohort of n=18 sensorineural hearing-impaired children was recruited from the German Göttinger Hör-Sprachregister Mean diagnosis age was 21.4 (SD 16.6) months and mean age of amplification with hearing aids was 21.7 (SD 16.5) months. RESULTS: The mean DQs slowly increased from t1 to t4 (DQ receptive 0.37/0.48/0.55/0.56; DQ expressive: 0.51/0.51/0.55/0.55) and remained norm deviant. The diagnosis age of hearing loss and both the developmental quotients for receptive (-0.41/-0.42/-0.53; $p<0.05$/-0.80; $p<0.01$) and expressive language (-0.77; $p<0.01$/-0.55; $p<0.05$/-0.66; $p<0.01$/-0.79; $p<0.01$) were significantly correlated. The mean receptive vocabulary size apparently increased and came up to the lower norm range (29.6-34.2-43.8), however the mean expressive vocabulary remained far below the norm (26.8-29.8). Children with a hearing loss from 71-90 dB scored on average mostly higher than children with a loss > 90 dB

who all had received a cochlear-implant up to t3. Children who were identified as hearing-impaired before the age of 18 months exhibited on average generally greater DQs. CONCLUSION: The individual best available amplification of hearing loss did not compulsively cause an age-adequate spoken language development, at least not in case of a hearing loss > 40 dB. So a newborn hearing screening must be the first step in identification, intervention and habilitation of an infant with hearing loss. Use of a cochlear implant seemed to have a great impact on the oral language development of children with a bilateral loss > 90 dB.

63. **"Evoked potentials in the management of patients with cochlear implants: Research and clinical applications".** Kileny, P. R.; (2007); Ear Hear. 28(2 Suppl):124S-127S

Evoked potential measures are integral to the treatment of patients with cochlear implants. In particular, these techniques are useful in the management of the pediatric patient. This brief report describes three categories of evoked potentials including clinical and research examples: electrically evoked auditory brain stem responses with transtympanic stimulation, middle-latency responses with cochlear implant stimulation, and cognitive evoked potentials elicited by speech stimuli.

64. **"Selective activation of cat primary auditory cortex by way of direct intraneural auditory nerve stimulation".** Kim, S.-J.; Badi, A. N.; Normann, R. A.; (2007); Laryngoscope. 117(6):1053-1062

OBJECTIVES/HYPOTHESIS: Although cochlear implants have been successfully used by many individuals with profound hearing impairment, limitations still remain with this approach to hearing restoration, including poor stimulation selectivity because of cross-talk between electrodes and poor low-frequency percepts. These limitations may be mitigated by direct intraneural stimulation of the auditory nerve by way of an array of penetrating microelectrodes. Such an approach should provide focal stimulation and selective activation of the nerve fibers, thereby minimizing cross-talk among implanted stimulating electrodes and evoking narrow-band frequency percepts. STUDY DESIGN: We investigated the activation of primary auditory cortex evoked by such direct intraneural electrical stimulation of the auditory nerve. METHODS: We implanted 11 penetrating microelectrodes in the cat auditory nerve, simulated the nerve by way of these electrodes, and recorded the evoked neuronal activity patterns in cat primary auditory cortex. We compared these activation patterns with acoustically evoked cortical activity patterns obtained in a different animal. RESULTS: Our results showed that direct stimulation of the auditory nerve evoked localized activity patterns in primary auditory cortex similar in spatial extent to those evoked by acoustic stimulation and that the extent of cortical activation by both acoustic and electrical stimuli was graded with stimulus intensity. These results suggest that the implanted electrodes can excite independent and small populations of nerve fibers. CONCLUSION: This study demonstrates the functional feasibility of direct intraneural auditory nerve stimulation with an array of penetrating microelectrodes and that such an

approach could form the foundation for an auditory prosthesis with improved frequency coding.

65. **"Using current steering to increase spectral resolution in CII and HiRes 90K users".** Koch, D. B.; Downing, M.; Osberger, M. J.; Litvak, L.; (2007); Ear Hear. 28(2 Suppl):38S-41S

OBJECTIVES: The HiResolution Bionic Ear has the capability of creating virtual spectral channels using current steering. Through simultaneous delivery of current to pairs of adjacent electrodes, it is hypothesized that the effective locus of stimulation can be steered to sites between the contacts by varying the proportion of current delivered to each electrode of the pair. Thus, theoretically, many intermediate regions of stimulation can be created with fine control over the proportion and amplitude of current delivered to each electrode. This study investigated the number of spectral channels-or different pitches-that could be resolved by adult users of the CII and HiRes 90K cochlear implants when current steering was applied to three pairs of electrodes along the implanted array. DESIGN: Subjects were postlinguistically deafened adults recruited from the general CII and HiRes 90K user populations at 11 participating study sites. After loudness balancing and pitch ranking electrode pairs (2 and 3, 8 and 9, 13 and 14), an adaptive paradigm was used to estimate the number of intermediate pitch percepts that could be heard for each pair when current steering was implemented. Those data were used to estimate the potential number of spectral channels for each electrode pair. RESULTS: Data from 57 implanted ears indicated that the numbers of spectral channels per electrode pair ranged from one (subjects who could not tell the electrodes apart) to 52 (an individual who had 52 different pitch percepts for the midarray pair of electrodes). The average numbers of spectral channels that could be distinguished were 5.4 for the basal electrode pair, 8.7 for the midarray electrode pair, and 7.2 for the apical electrode pair. Assuming that the average numbers of spectral channels for these three electrode pairs were representative of the entire 16-contact array, the potential total numbers of spectral channels could be estimated. For the 57 ears, the number of potential channels ranged from 8 to 466, with an average of 93. CONCLUSIONS: The HiResolution Bionic Ear has the ability to steer current through simultaneous stimulation of adjacent electrode contacts. These data show that the majority of subjects perceive additional spectral channels other than those associated with stimulation of the fixed electrodes when current steering is implemented. The results suggest that the average cochlear implant user may have significantly more place-pitch capability than is exploited presently by cochlear implant systems. Current steering will be implemented in a wearable sound-processing strategy that can deliver up to 120 spectral bands to CII and HiRes 90K recipients. The new strategy takes advantage of untapped capabilities of the CII/HiRes 90K implanted electronics and will be implemented through software, with no additional surgery required. It is anticipated that the improved spectral resolution offered by current steering will lead to better speech perception in noise and improved music appreciation.

66. **"Intelligence, parental depression, and behavior adaptability in deaf children being considered for cochlear implantation".** Kushalnagar, P.; Krull, K.; Hannay, J.; Mehta, P.; Caudle, S.; Oghalai, J.; (2007); The Journal of Deaf Studies and Deaf Education 2007 12(3):335-349

Cognitive ability and behavioral adaptability are distinct, yet related, constructs that can impact childhood development. Both are often reduced in deaf children of hearing parents who do not provide sufficient language and communication access. Additionally, parental depression is commonly observed due to parent-child communication difficulties that can lead to parents' feelings of inadequacy and frustration. We sought to assess whether adaptive behavior in deaf children was associated with nonverbal intelligence and parental depression. Parents of precochlear implant patients seen for neuropsychological assessment were administered the Parenting Stress Index and Vineland Behavior Adaptive Scales to obtain measures of parental distress and child's behavioral adaptability. Precochlear implant patients' cognitive functioning was assessed via the Mullen Scales of Early Learning or the Leiter International Performance Scale-Revised, depending on the child's age at the time of testing. Regardless of age or neurological status, the deaf child's adaptive behavior consistently showed a strong relationship with intelligence. Moderate correlation between parental depression and the child's adaptive behavior was observed only in the younger group. The relationship between parental depression and communication subscale was moderated by intelligence for deaf children without neurological complications. The findings provide important implications for promoting family-centered interventions with early communication and language development.

67. **"Preoperative evaluation, surgical procedure, follow up and results of 150 cochlear implantations".** Kyriafinis, G.; Vital, V.; Psifidis, A.; Constantinidis, J.; Nikolaou, A.; Hitoglou-Antoniadou, M.; Kouloulas, A.; (2007); Hippokratia. 11(2):77-82

Background: The cochlear implantation is among the most important achievements of medicine and biotechnology in the last 20 years, because it allows individuals who had never heard or had lost their hearing to perceive sound and improve their quality of life. Selection criteria for candidates are strict and are evaluated in each individual by a scientific committee specially trained for implantations which includes Ear Nose and Throat (ENT) surgeon, audiologist, psychiatrist and speech therapist. Patients and methods: In our department, the first cochlear implantation was performed in 1995. During the last ten years more than 250 individuals have been evaluated due to profound hearing loss and 170 of them were found to be suitable candidates for cochlear implantation. One hundred and fifty (150) have already been operated and most of them are children with congenital hearing loss. No major or permanent complications were recorded in any of our 150 patients. Activation and fitting/mapping of the cochlear implant is initiated three weeks post-operatively. Regular follow-up and mapping of the implant are held, more frequently in children, along with specialized speech

therapy. Each new mapping is evaluated according to the record of the patient with regard to the acoustic perception of sounds and speech and the discrimination of individual elements of phonation based on a protocol that we have created for the needs of Greek language. Results: Speech discrimination (AHEPA Hospital protocol), before the Implantation, at the activation of the cochlear implant and till 4 years of the follow-up showed that in our patients, we obtained better and faster results in post-speech acquisition adults with recent or chronic deafness and in children with congenital deafness operated before the 5th year of age, who underwent special preoperative speech therapy programme, fact which is in agreement with current literature. Patient satisfaction evaluated by 'Sanders'; psychometrics tests, was achieved in accordance to preoperative expectations. Conclusions: In our patients, we observed better and faster results in children with congenital deafness operated before the third year of age, in post-speech acquisition adults with recent deafness and in post-speech acquisition adults with chronic deafness but with auditory memory reserve.