Relationship between Electrical Stapedial Reflex Thresholds and HiRes™ Program Settings: Potential Tool for Pediatric Cochlear-Implant Fitting

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INTRODUCTION

As the age at implantation becomes increasingly younger, it has become more important to develop objective methods for programming cochlear implants in very young children who cannot provide a behavioral response. One objective measure that may provide usable information is the electrical compound action potential (ECAP), which can be measured with the telemetry capabilities of the Nucleus and HiResolution™ Bionic Ear System (e.g., Hughes et al. 2000, Overstreet et al. 2003). Another objective measure that may prove useful is the electrical stapedial reflex threshold (ESRT). Previous studies have indicated that there may be some relationship between ESRTs and behavioral responses for stimulation on single electrodes (e.g., Battmer et al. 1990, Hodges et al. 1997, Shallop and Ash 1995, Spivak and Chute 1994). This preliminary study examined the relationship between ESRTs and program parameters in adults and children who use the HiResolution™ Bionic Ear System. The aim was to determine if a systematic relationship exists between ESRTs and behaviorally measured comfort levels for electrical stimulation using speech-like stimuli delivered to several electrodes at one time.

METHODS

Subjects

ESRTs and psychophysical comfort levels were measured in six adults and two children who used the HiResolution™ Bionic Ear System with HiResolution™ Sound (HiRes™) processing.

ESRT Measurement

In normal ears, a reflex contraction of the middle-ear stapedius muscle will occur when sound is of sufficient intensity. The stapedius muscle is attached by a tendon from the posterior wall of the middle ear to the head of the stapes. When the stapedius contracts, the tendon produces tension on the stapes and the middle-ear ossicles stiffen, thereby reducing the transmission of low-frequency energy through the middle ear. This change in immittance can be detected by clinical immittance meters. Importantly, stapedius muscles on both sides contract in response to sound delivered to either ear. Therefore, one can present the stimulus in one ear while recording the reflex in the other ear (see Stach 1998). For this study, electrical stimuli were presented via the cochlear implant in the implanted ear and reflexes were measured using standard immittance equipment in the contralateral ear.

The stimuli consisted of "Speech Bursts" generated by the SoundWave™ programming software. Speech bursts consist of white noise that is passed through the same processing filters and envelope detectors that are used when processing sound during everyday HiRes™ use. The 16 processing filters correspond to each of the 16 electrode contacts. The stimulation rate for these patients was approximately 3000 pulses per second per contact. The spectral and temporal characteristics of these speech-burst stimuli are more representative of real sounds, unlike the slow pulse trains conventionally used for setting threshold and comfort levels.

Speech bursts were delivered to four groups of four adjacent electrodes. For each group, the stimulus amplitude was increased until a reflex was observed.

Behavioral Measures

Each patient's program was activated using the ESRT levels obtained. The volume was adjusted until the patient reported a most comfortable level for speech. These final M values were then compared with the ESRT levels that were obtained during the same test session.

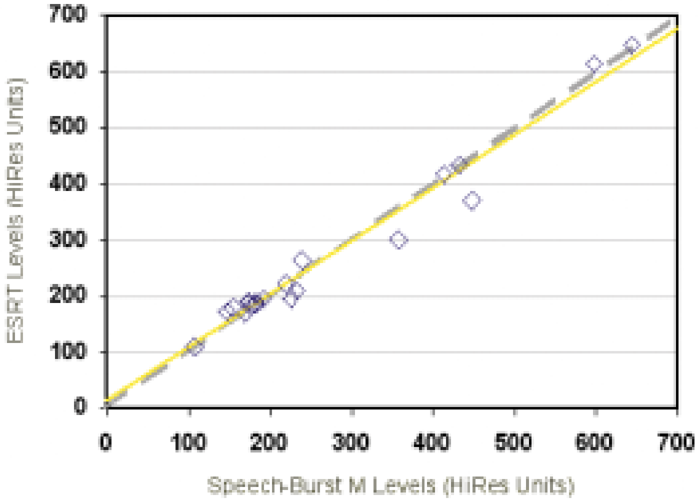

Figure 1. ESRTs vs. M levels for six adults who use HiResolution sound processing. Stimuli were speech bursts delivered to four groups of four adjacent electrode contacts.

RESULTS

ESRTs and M levels are plotted for the six adults in Figure 1. There are four data points for each subject corresponding to the four groups of stimulated electrodes. The dotted line represents a perfect correlation (r = 1.0) between ESRTs and M levels. Data above that line indicate an ESRT higher than the M level, whereas data below that line indicate an ESRT below M level. The yellow line is the best-fit line to the patient data. The correlation coefficient r for that line is 0.94, indicating an almost perfect relationship between ESRTs and M levels in these adults.

Data from the two children are plotted in Figure 2. The r value for these data is 1.07. Notably, the data points are above the dotted line (r = 1.0) for these children, indicating that the ESRT was elicited by a level higher that the M levels used in their HiRes programs. In other words, the M levels set for the children are more conservative than for the adults, based upon the ESRT levels.

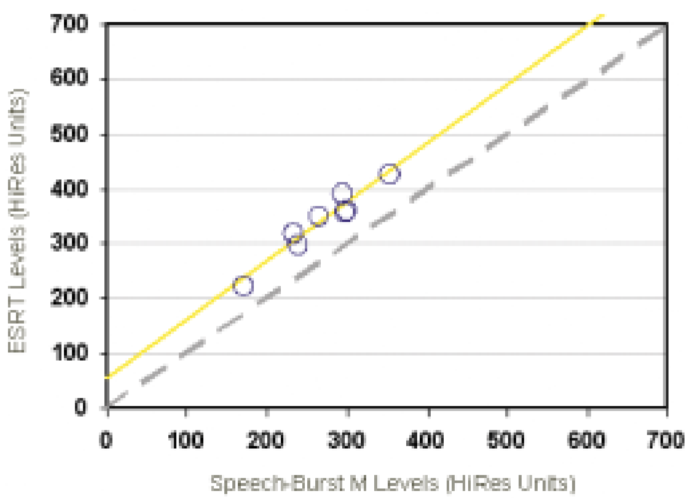

Figure 2. ESRTs vs. M levels for two children who use HiResolution sound processing. Stimuli were speech bursts delivered to four groups of four adjacent electrode contacts.

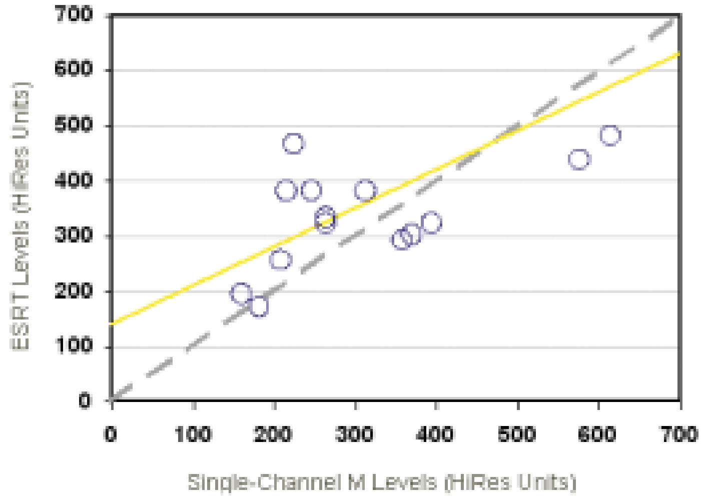

Figure 3. Results of a previous study comparing ESRTs and M levels in five adult patients who used the CI implant and HiFocus electrode. Stimuli were pulse trains delivered to each electrode contact separately.

DISCUSSION

These preliminary results suggest that speech-burst ESRTs may be an excellent objective measure for predicting M levels for HiRes programs. There is almost a one-to-one correlation between the levels that elicit a threshold reflex response and the M levels obtained behaviorally. That relationship is much closer for speech-burst stimuli than for conventional pulse-train stimuli. Figure 3 shows results from a previous study in five adults in which ESRTs and M levels were measured using pulse trains (877 pulses per second) delivered to single electrode contacts. For these stimuli, the correlation is much poorer than for speech bursts (r = 0.7) and the ESRT levels tend to be higher than the final M levels.

CONCLUSIONS

Speech-burst ESRTs are highly correlated with speech-burst M levels in patients who use HiRes sound processing. Thus, ESRTs may be useful for setting M levels in hard-to-fit adults and children. Further studies will clarify these relationships for speech-burst stimuli, and examine the relationship between single-channel ESRTs and M levels using the SoundWave™ programming software. ESRTs and M levels also will be compared to ECAP measures.

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June 2003