Investigation on Relationship between the Subjective and Objective Response of Auditory Pathway in Children with Cochlear Implant

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Abstract

The aim of the study was to determine the relationship between the electrically evoked whole nerve compound action potential (ECAP) and psychoacoustic stimulation threshold for children using the Nucleus 24 cochlear implant. ECAP thresholds was measured postoperatively, using the Neural Response Telemetry system of the Nucleus 24 device and were compared with the behavioural measured stimulation threshold. The novelty in this approach: the measurements of neural responses were performed using as stimulating electrodes, which reproduced signals used in tonal audiometry. ECAP threshold were seen fall between the stimulation thresholds. On average, the VIII-nerve response thresholds fell approximately at 50- 60 % of the map dynamic range. The ECAP threshold was found to be more strictly correlated to the C-level than the T-level.

Keywords: cochlear implant, neural response telemetry, T- minimal audible level, C- comfort level, 
T – NRT – threshold of neural response

Introduction

The task of the implant, placed near the ending of the auditory nerve, is to provide a direct electric stimulation. The biggest group of implanted patients is composed of children diagnosed with prelingual deafness of diverse etiology. Because of both age and low level of auditory competence of the children, it is quite difficult to establish contact with them. One of the problems encountered is fitting of a speech processor: a small child, for whom so far inactive channel of perception has just been opened, is hard to cooperate with. That is why when fitting speech processors it is necessary to take into account not only objective measuring methods but also psychophysical tests. To overcome those difficulties, the present study aims at optimization of the procedure of implant system fitting in small children. The system of cochlear implant in the Nucleus 24 series is designed to allow for a two-directional communications with the inner part of the implant [1]. Neural Response Telemetry (NRT) serves to measure action potential generated as a response to electric stimulation. NTR is a quick and non-invasive measurement of peripheral neural function up to 22 intracochlear sites and provides useful information to supplement or confirm behavioral measurement.

Experimental procedures

In an intraoperative tests optimum parameters of registration were determined. Optimum parameters of the measurement were identified. The measurements of neural responses were performed using as stimulating intra-cochlear electrodes which reproduced signals used in tonal audiometry [2]. For patients from the sample the detection threshold perceived by the implant within the frequency range 0.5-6 [kHz] (the course of the threshold on audiogram) was always found within 35-40 dB [SPL]. The
study sample comprised 60 patients with cochlear implant Nucleus 24: 5 adults - control group, and 55 children – main group. The implanted children with prelingual deafness at age 1.5- 14 years (mean: 4 years 8 months) took part in this study. Measurements were taken directly through the implant system. The neural response within the limit of programmed stimulation threshold was measured [3]. In clinical tests optimum parameters of postoperative measurements were determined [4]. The tests were designed to detect:

1. Detection threshold in the implant in a sound-insulated room;
2. Electric stimulation thresholds T, C;
3. Acceptance of stimulation signal;
4. Recording the response of auditory nerve.

The test was taken for each patient by successive stimulating each at 6 electrodes. The parameters of currently used program were read from the speech processor for each patient. Frequency bands were correlated with electrodes and these bands include frequencies applied in pure-tone audiometry (0.5-6 kHz). Acceptation of signal was measured in adult patients (control group). First, a scale of subjective category sensation used for loudness evaluation was explained to patients. Next, it was made sure that each patient understands the task of identifying the perceived loudness of a signal by pointing to one of the categories. On the basis of the measurements taken in adults, appropriate parameters were optimized [1]. For the control group a possible level of discomfort on exposure to the measuring signal was established. In the individually

![Graph](image1.png)

**Fig. 1.** The examples results for: implant CI 24M (a); implant CI 24RS Contour (b) The abscissa – comfort level C [CL]; The ordinate – neural response threshold T-NRT [CL]
identified stimulation thresholds, verified in an every day use for 3 months, no sensation of discomfort was reported. The measuring signal was heavily affected by the masker current level above 10 CL stimulation level, and a by significantly longer period of stimulation time of an individual electrode. By determining optimal conditions for adults it was possible to significantly decrease the time and number of measurement conducted in children.

Results

Neural response was recorded in all patients. The ECAP threshold was found to be more strictly correlated to the implant CI 24 Contour with perimodiolar electrode array (Fig. 1b) than the implant CI 24M with straight electrode array (Fig. 1a). Amplitude of the pulses was specified in “current level” units (CL) from 1 to 255. These units are approximately proportional to the logarithm of stimulus current and typically range from a current output of 10 μA to 1.75 mA. For the implant CI 24M the correlation coefficient r value: T-NRT/T (r=0.64, p<0.05); T-NRT/C (r=0.84, p<0.05) and for the implant CI 24 Contour: T-NRT/T (r=0.83, p<0.05) T-NRT/C (r=0.94, p<0.05).

1. In all subjects tested a neural response triggered by an electrical stimulus was recorded;
2. Stimulation with measuring signal within the given range – for the detected stimulation parameters – does not cause any discomfort;
3. The lowest threshold for recorded neural response was measured for the band-to-frequency electrodes including the frequencies 0.5; 1; 6 [kHz] – in electrodes placed beneath the base and apex of the cochlea.

Conclusions

An objective test, such as NRT, can be conducted on the awakening patients during the session of speech processor programming. Availability of an NRT system allows an easy and rapid electrophysiological estimate to made of auditory sensitivity. The ECAP threshold can provide an indication of safe levels of stimulation. Such test may be helpful in adjusting the thresholds of electric stimulation in non-cooperated children.

References