The "pull-back" technique for Nucleus 24 perimodiolar electrode insertion

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OBJECTIVE: **To observe the influence of electrode pull-back after cochlear implant insertion of Nucleus 24 perimodiolar electrodes.**
STUDY DESIGN: **In a prospective intraoperative study, we analyzed the impedances, neural response telemetry responses, and the spread of excitation after cochlear implant electrode insertion and compared these data to those obtained after a subsequent, controlled pull-back of the electrode. Postoperative depth of electrode insertion was controlled by x-ray.**
SETTING: **Tertiary referral center.**
SUBJECTS: **Six patients (4 male, 2 female; 18 to 69 years) were implanted with a Nucleus 24 (RCA) cochlear implant with a perimodiolar electrode.**
RESULTS: **After a controlled pull-back, a significant decrease of the spread of excitation at the stimuli electrodes 5, 10, 15, and a nonsignificant decrease at stimuli electrode 20 compared to the recordings after the primary normal insertion procedure was found. The mean electric compound action potential amplitude was increased with an apical-to-basal tendency. Impedances remained unchanged by the pull-back. Mean insertion depth at the postoperative x-ray control was 372 degrees (± 10.2).**
CONCLUSION: **Controlled cochlear implant electrode pull-back is a novel technique that optimizes objective intraoperative electrophysiological recordings in patients implanted with a Nucleus 24 perimodiolar cochlear implant by a greater approximation of the electrode to the modiolus.**
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The development of cochlear implant (CI) electrodes over the last few years has changed their shape remarkably. Straight electrodes that were guided by the lateral wall to the apical cochlear parts[1] were replaced by perimodiolar electrodes. Their location closer to the modiolar spiral ganglion cells is more favorable for several reasons. The proximity to the modiolus is assumed to be responsible for reduced electrical stimulation threshold and comfort levels that increase with the distance from the modiolus.[2] Moreover, the dynamic range is impaired with increasing distance from the modiolus.[2] Modiolar proximity and, thus, current spread seem to be of central importance for channel interactions and speech understanding.[3] In turn, this has a major impact on the selected speech strategies and the clinical outcome.[4] Therefore modiolus proximity is one of the major goals of electrode positioning in all CI systems, but insertion depth also seems to play a role.[5]

Surgical insertion techniques have also been modified in parallel with these new electrodes.[6] The CI manufacturers have suggested insertion tools (Advanced Bionics Corp, Sylmar, CA) or stylet systems (eg, Cochlear Corp, Melbourne, Australia) to facilitate the insertion. An additional reduction of the known surgical intracochlear trauma[7,8] have led to the development of the AOS (Advanced of stylett) system, even though perimodiolar electrodes have a better but not uniform modiolar proximitiy.[3]

It was therefore the aim of the present study to investigate the influence of an electrode "pull-back" technique to reach a closer perimodiolar position by perioperative, electrophysiologic recordings.

MATERIALS AND METHODS

In a prospective study, 6 patients (18 to 69 years of age) were included from 2003 to 2004. The patients gave their informed consent to participate in the study. The patients were deaf and were implanted with a Nucleus 24 RCA CI (Cochlear Corp). The surgical procedure was modified after inserting the electrode, ie, the so-called "pull-back" technique combined a deep insertion of the Nucleus 24 RCA electrode (maximum possible electrode insertion without mechanical resistance) with a subsequent electroding pulling back until the first silicon ring of the electrode becomes microscopically visible within the cochleostomy opening. Two electrophysiologic recordings were done after deep insertion and after pull-back. They included NRT recordings[9] and measurement of the spread-of-excitation.[10] The latter was done by using the masker-probe

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paradigm with a fixed probe and an alternating masker position.[10] The subtraction method (response probe alone-[response probe after masker-response masker alone]) was applied for the elimination of the stimulus artifact.[9] The alternating masker position leads to a decrease of the resulting potential if the probe response after the masker or the masker response increases. However, the probe response after the masker can only increase if the channel interaction between the alternating masker and the fixed probe decrease. The measurements were carried out with a fixed stimulus strength for the electrodes (probe) 5, 10, 15, 20 (recording electrodes 7, 12, 17, 18), and an alternating masker on all otherelectrodes before and after the "pull-back." The precise intracochlear electrode position was calculated by means of x-ray as described elsewhere.[11]

Data are given as mean ± SDM. Statistical evaluation was done by paired *t* test ($P < 0.01$). The study protocol was approved by our Institutional Review Board (IRB).

RESULTS

The postoperative x-rays showed a mean angle of insertion depth of 372 degrees ± 10.2 degrees.

The comparison of the intraoperative impedances showed no relevant differences in the CG, MP1, MP2, and MP1-MP2 measurement before and after "pull back."

Measurements of the mean ECAP amplitude at a fixed stimulus level was increase after the "pull back" by 12.1% ± 8% with differences from apical (electrode 18, ie, 6.3%) to the mid (electrode 12, ie, 19.1%) and basal electrodes (electrode 7, ie, 10.5%) . The mean ECAP amplitude before and after "pull back" was for electrode 7 (294.5 μV; 324.5 μV), 12 (280 μV; 333.25 μV), 17 (375.5 μV; 423.25 μV) and 18 (396,75 μV, 421.75 μV).

The spread-of-excitation after " pull back" of the electrode showed a decrease of the response of the surrounding electrodes (Fig 1):

- Measurement around electrode 7 had a mean decrease of 61.1 % ± 14.1 standard deviation of the mean (SDM), which was statistically significant (mean μV pre–pull-back, 245.5; mean μV post–pull-back, 100.9).
- Measurement around electrode 12 had a mean decrease of 51.4 % ± 9.4 SDM, which was statistically significant after pull-back (mean μV pre–pull-back. 256.6; mean μV post–pull-back, 124.9).
- Measurement around electrode 17 had a mean decrease of 39.7% ± 21.8 SDM and a statistically significant decrease after pull back (mean μV pre–pull-back, 395.8; mean μV post–pull-back, 223.6).
- Measurement around electrode 18 had a mean decrease of 31.7 % ± 28.1 SDM and a nonstatistically significant decrease (mean μV pre–pull-back, 341.8; mean μV post–pull-back, 199.3).

DISCUSSION

It was the aim of the present series to improve surgically CI electrode insertion in favor of a highly perimodiolar position and to verify this possibly optimized approach by electrophysiological testing. An electrode with a close proximity to the modiolus leads to reduced stimulation thresholds[2] and therefore a broader spectrum of speech strategy alternatives that become available to clinically improve speech understanding by less channel interactions.[4]

Our results could demonstrate an apical-to-basal increase of the ECAP amplitude by the "pull-back" of the electrode. These regional intracochlear differences are supposedly the effect of different lumen diameters so that a spatial gradient of neural response amplitudes occurs.

In our opinion the increase of ECAP amplitude is caused by a decrease of distance between the responding electrode and the region of neural response at constant stimuli (see Methods section) assumption is supported by the finding that perimodiolar positioning of the electrode increases EABR amplitudes.[12]

The same holds true for the spread of excitation (SOE) as reported above. This SOE is highly focused at the response electrode due to its close perimodiolar proximity. In turn, the SOE levels recorded at neighboring electrodes are significantly reduced. In a comparison of straight electrodes and perimodiolar electrodes, a significant decrease of SOE has already been shown.[10] Additionally, the width of the ECAP measure is significantly correlated with the distance of the electrode band from the modiolus.[10] Our data evidence a significant decrease of the SOE except at the most apical electrode.

The pull-back seems to cause a better perimodiolar position of the electrode. The apical parts seemingly benefit from their lumen vicinity already before the pull-back because the CI electrode is already in a favorable position upon the initial (deep) insertion.[13]

This is confirmed by our x-ray data. The mean insertion angle after the pull-back of 372 degrees evidence this initial deep insertion compared with those data without a pull-back (357.7 degrees).[5] Deep insertion can only be successfully performed with a stylet electrode (due to the flexibility of the material) and the pull-back could only be standardized insofar it was always done until the first of the 3 silicon rings of the electrode became microscopically visible. This surgical