PHYSIOLOGICAL AND HISTOPATHOLOGICAL EFFECTS OF CHRONIC MONOPOLAR STIMULATION ON THE AUDITORY NERVE USING VERY HIGH STIMULUS RATES.

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Speech-processing strategies using high stimulus rates are used in some cochlear implant systems. While some data suggests that electrical stimulation of the auditory nerve at rates of 2000 pps per channel is safe, there is little data concerning higher rates. The present study was designed to evaluate the safety of a rate of 5000 pps per channel. Under anaesthesia, (ketamine (20 mg/kg, i.v.) and xylazine (3.8 mg/kg, i.v.)), four normal hearing cats were bilaterally implanted with a three channel platinum (Pt) scala tympani electrode array and a return Pt-electrode placed within the temporalis muscle. Each animal was stimulated unilaterally for durations of up to 2700 h using 25μs per phase charge-balanced biphasic current pulses. The stimuli were delivered at 5000 pps per channel at mid-dynamic range intensities. Acoustically-evoked auditory brainstem responses (ABRs) were recorded during the stimulation regime to monitor the animals' residual hearing. Electrically-evoked auditory brainstem responses (EABRs) were periodically recorded to monitor the status of the auditory nerve and to ensure stimulus intensity remained above threshold. ABRs typically showed poor recovery in the stimulated ear. Longitudinal EABRs recorded from all animals remained relatively stable for the duration of stimulation. Electrode impedances were calculated from daily monitoring of current and voltage waveforms. Two animals that exhibited the highest electrode impedance throughout the duration of stimulation were found to have significant amounts of new bone growth and fibrous tissue in the basal region of the cochlea. However, as one of these animals showed a similar response in the contralateral, unstimulated, implanted cochlea, this response cannot be attributed to electrical stimulation per se. There was no statistically significant difference in spiral ganglion cell density in the stimulated cochleae when compared to corresponding regions in controls (p=.2, Mann-Whitney Rank Sum Test). These initial results indicate that chronic monopolar stimulation of the cochlea at a rate of 5000 pps per channel does not have an adverse effect on spiral ganglion cell density.

CHRONIC ELECTRICAL STIMULATION OF THE AUDITORY NERVE USING HIGH-SURFACE AREA PLATINUM ELECTRODES

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Electrical stimulation using high surface area (HiQ) platinum (Pt) electrodes exhibit a lower electrode impedance, polarisation and direct current (DC) in vitro compared with standard (ST) Pt electrodes of the same geometric size. In the present study we investigated whether HiQ electrodes maintain these advantages in vivo. This could be important for the development of new arrays with an increased number of smaller electrodes. Under general anaesthesia (Ketamine 20 mg/kg and Xylazine 4mg/kg i.p.) five normal hearing cats were implanted bilaterally with a two-channel Pt scala tympani electrode array (4 HiQ, 1 ST array). Chronic electrical stimulation using charge balanced biphasic current pulses was delivered unilaterally via a transcortaneous leadwire connected to a backpack-stimulator for periods of up to 2400 hours. DC, stimulus current and electrode voltage waveforms were monitored twice daily and access resistance (Rₐ), electrode impedance (Zₑ) and polarisation (Zₑ-Rₐ) calculated (kΩ). Mean HiQ data were compared to ST data using Students t-test (*=p<0.05, **=p<0.001). Immediately following implantation both HiQ and ST-electrodes exhibited low impedance values (Rₐ: 1.06 vs 1.00, Zₑ: 1.24 vs 2.12*, and Zₑ+Rₐ: 0.18 vs 1.08**). Subsequently impedance increased, largely due to a rise in Rₐ (5.35 vs 6.8: Zₑ: 6.96 vs 9.80, and Zₑ-Rₐ: 1.61 vs 3.00*). At the end of the experiment the array was explanted and tested in saline (Rₐ: 0.63 vs 0.74*, Zₑ: 0.73 vs 1.90**, Zₑ+Rₐ: 0.10 vs 1.16**). These initial results suggest that intracochlear tissue growth increased the access resistance of both electrode designs. However, HiQ electrodes maintained not only a significantly lower polarisation, they also showed a lower average residual DC (23 vs 130 nA**) throughout the experiment.
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