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## PRELIMINARY REPORT

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### CHRONIC ELECTRICAL STIMULATION OF THE AUDITORY NERVE AT HIGH STIMULUS RATES : PRELIMINARY RESULTS

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The present preliminary report describes the electrophysiological response of the cochlea during long-term stimulation. The data indicate that electrical stimulation at a rate of 1000 pulses per second does not appear to adversely affect the implanted cochlea.

Multichannel cochlear implants selectively stimulate discrete populations of residual auditory nerve fibres in order to provide patients with important pitch and timing cues for speech discrimination. An important condition for the success of these devices is that the residual auditory nerve fibres must survive long-term electrical stimulation. Previous research has shown that chronic electrical stimulation of the auditory nerve at stimulus rates of less than 500 pulses per second (pps) does not adversely affect the adjacent spiral ganglion cell population. Recently, however, a number of clinical trials have suggested that speech processing strategies using high pulse rates (e.g. 1000 pps) can further improve speech perception (Wilson et al 1991). It is therefore important to evaluate the long-term safety of such stimulation regimes, especially considering that a number of acute studies have shown that high rate electrical stimulation can result in a significant reduction in the excitability of the auditory nerve (Tykocinski et al 1994).

#### Report

Thirteen normal hearing adult cats were *bilaterally* implanted with scala tympani electrode arrays and *unilaterally* stimulated using either two bipolar or three monopolar electrodes. The unstimulated, implanted cochleas were used as controls. Stimuli consisted of short duration (25-50  $\mu$ s/phase) biphasic current pulses presented at 1000 pps for each electrode, and were generated by a carefully designed charge balanced stimulator. The stimulus waveform was presented in a duty cycle (500 ms on/500 ms off) at an intensity within 6 dB above threshold. The animals were stimulated for approximately 15 hrs/day for a total stimulation period ranging from 700-2100 hours. Stimulus current and electrode voltage levels were recorded twice daily to ensure that each stimulator was operating at the correct level. In addition, auditory brainstem responses to both acoustic (ABRs) and electrical (EABRs) stimuli were periodically recorded to monitor the animals' hearing and the status of the auditory nerve.

All animals exhibited an increase in acoustic thresholds during the first two weeks following implant surgery. Click-evoked ABRs returned to near pre-surgical levels by three to four weeks in approximately half the animals. Moreover, the incidence of hearing loss appeared no greater in chronically stimulated cochleas compared with unstimulated controls. The use of frequency specific stimuli indicated that the most extensive hearing loss occurred in the high frequency basal region of the cochleas, with the majority of animals exhibiting a moderate to severe loss in the 12-24 kHz region in both unstimulated and stimulated cochleas. Significantly, lower frequency thresholds (2, 4 and 8 kHz) appeared at normal or near normal levels despite both long term cochlear implantation and electrical stimulation. These findings suggest that hair cells apical to both an implanted and a chronically stimulated electrode array can not only survive but apparently function at near normal levels.

EABRs are used to monitor the status of the electrically stimulated auditory nerve. Large reductions in auditory nerve fibres as a result of adverse pathology will result in increases in threshold and a reduction in the amplitude of the evoked responses. Our results showed that the majority of cochleas exhibited a slight increase in threshold. However, response amplitudes remained very stable throughout the course of the chronic stimulation. One of the animals in this study exhibited a systematic reduction in EABR amplitudes with stimulation time and this may have been due to labyrinthitis.

#### Conclusion

The present preliminary findings indicate that long term intracochlear electrical stimulation at high pulse rates, using a carefully designed charge balanced stimulator, does not appear to adversely affect the implanted cochlea.

#### References

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