Intracochlear Pressure Impulses During Tip Fold-Over Events in Cochlear Implantation

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Background

Inappropriate positioning of cochlear implant electrode arrays is associated with impaired speech perception, vertigo, and facial nerve stimulation. Tip fold-over is a subset of mal-positioned electrodes that seems to occur more often with perimodiolar devices, but there are limited studies describing the damage this event can cause. The aim of this study was to characterize pressure profiles for tip fold-over events, as we hypothesized that pressure transients could be used to identify tip fold-over events.

Methods

Cadaveric human heads were surgically prepared with a mastoidectomy and extended facial recess. Fiberoptic pressure sensors were inserted into the scala vestibuli and scala tympani near the oval and round windows to measure intracochlear pressures. Perimodiolar CI electrodes were inserted via a round window approach under fluoroscopy.

Results

The incidence of pressure transients was greatest before and during cochlear implantation electrode tip fold-over. We observed three types of tip fold-over events: anterior-posterior C-shaped roll-over, medial-lateral C-shaped roll-over, and S-shaped roll-over. The largest transient events occurred with the Anterior-posterior C-type and S-type roll-over, and these events were associated with rotation or twisting of the electrode position inside the cochlea.

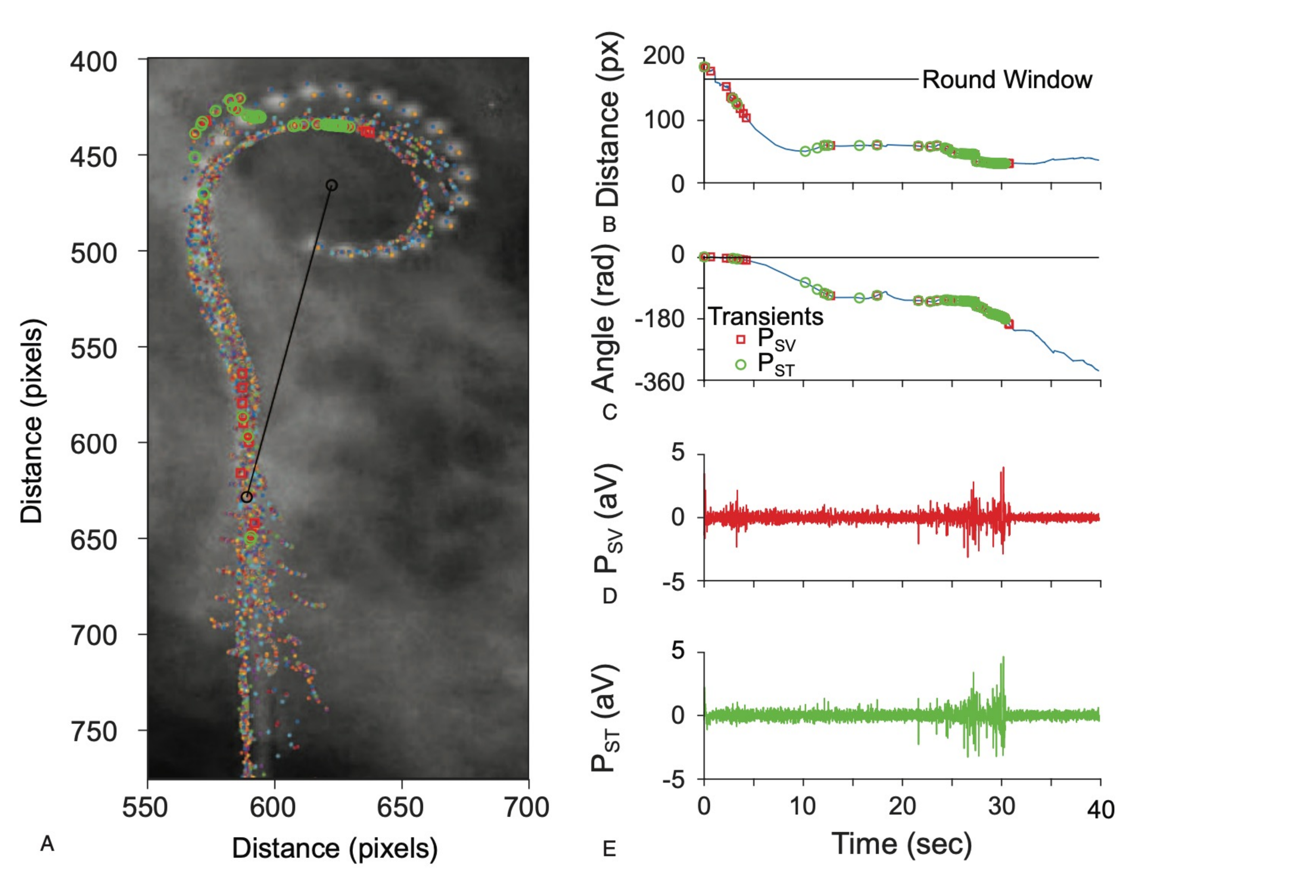

Figure 1: Normal insertion of pre-curved electrodes where no foldover event occurs. Intracochlear pressures were measured in the scala vestibuli (P_{SV}) and scala tympani (P_{ST}). Intracochlear pressure transients were identified, and their times marked in the Distance and Angle plots with red squares and green circles, indicating transients in P_{SV} and P_{ST} respectively. Vertical grey lines indicate times at which the electrode orientation transitioned.

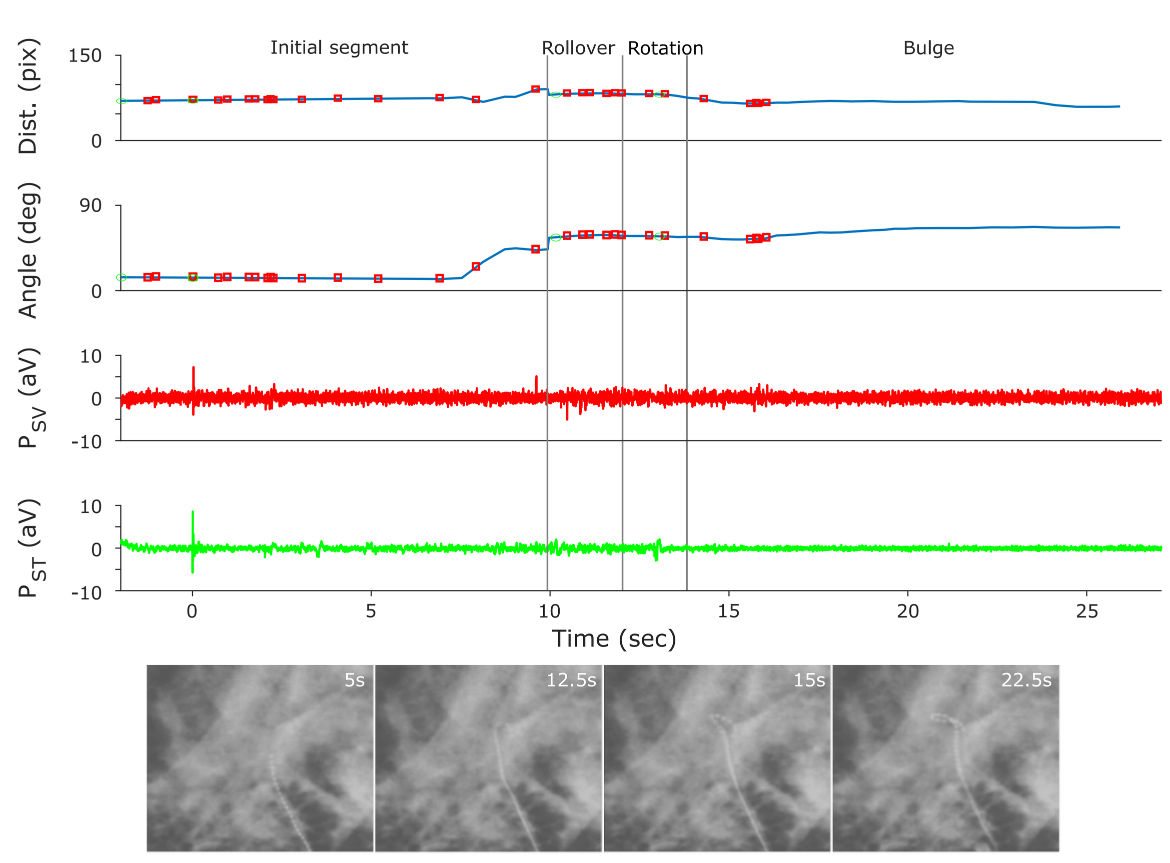

Figure 2: C-shaped cochlear implant rollover. Screenshots of the fluoroscopic video at several timepoints (indicated in the upper right corner of each image) are shown at the bottom.

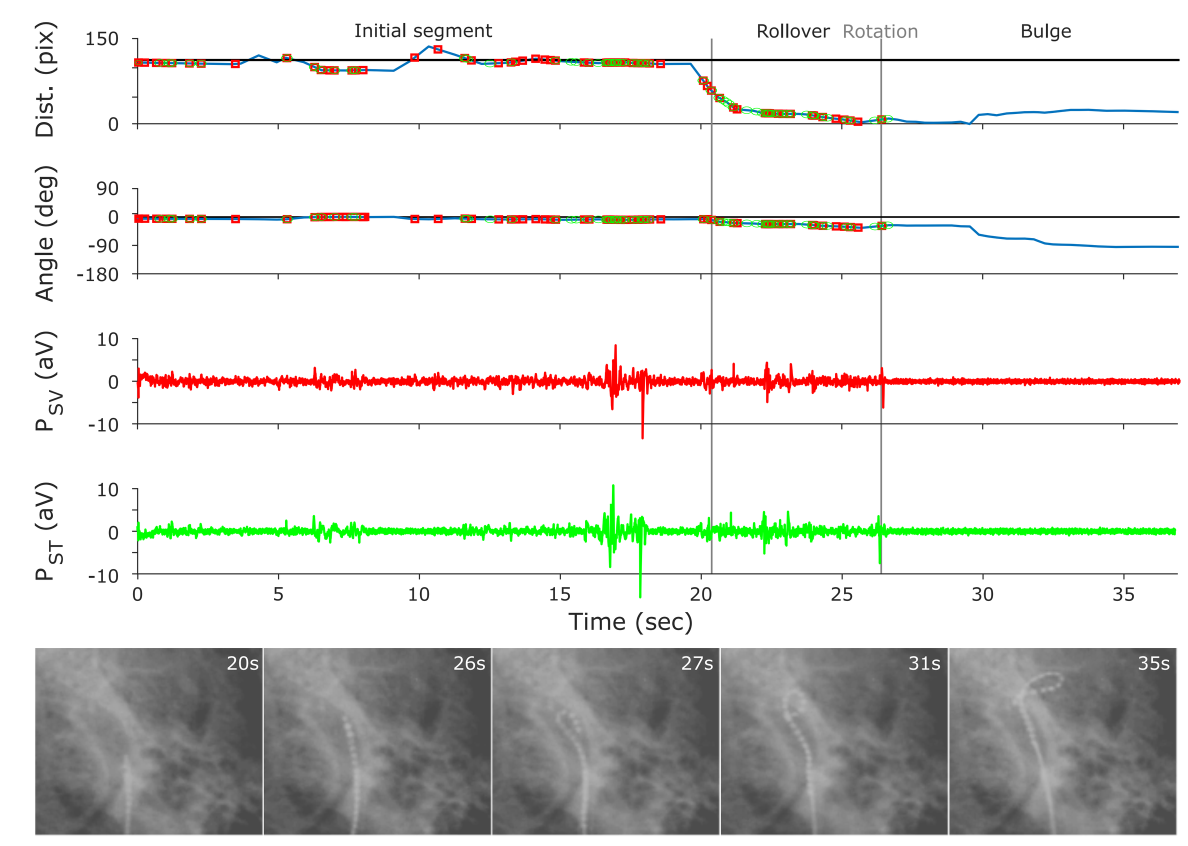

Figure 3: Medial-lateral cochlear implant rollover.

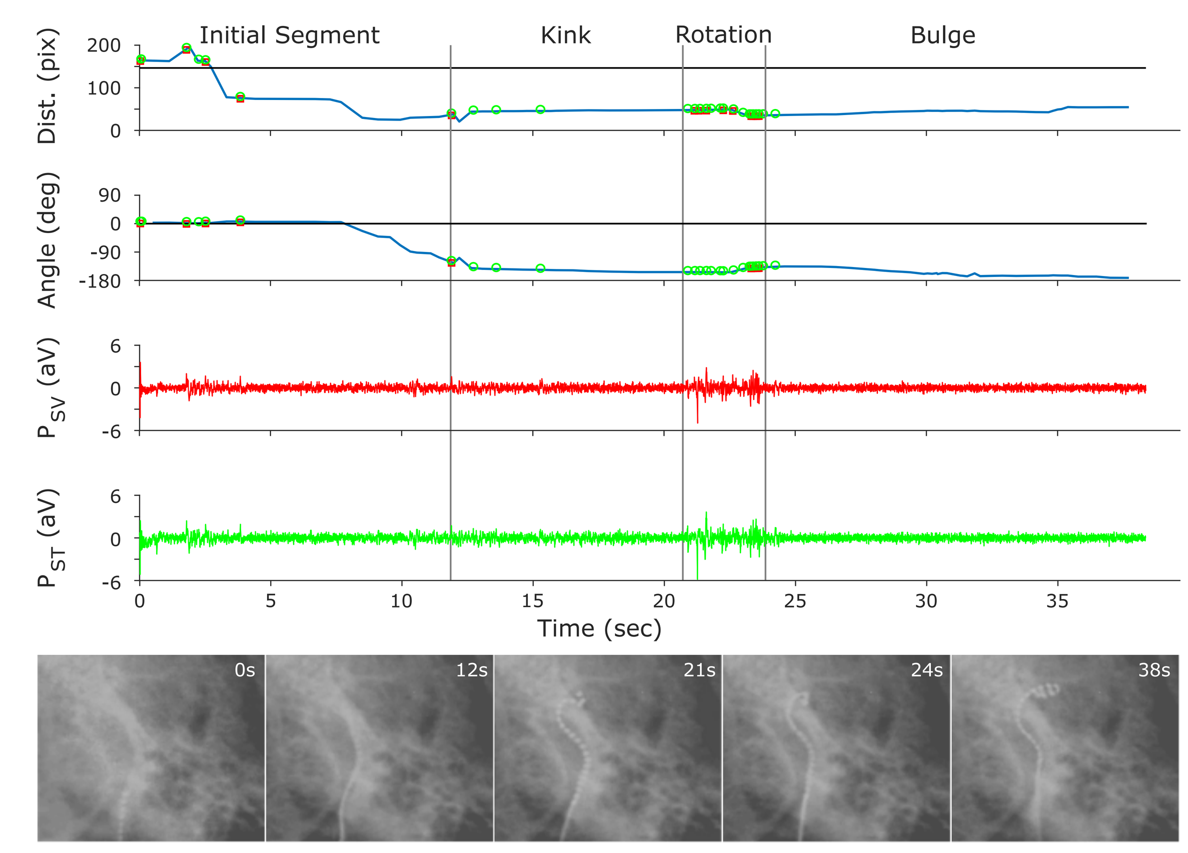

Figure 4: S-shaped cochlear implant rollover.

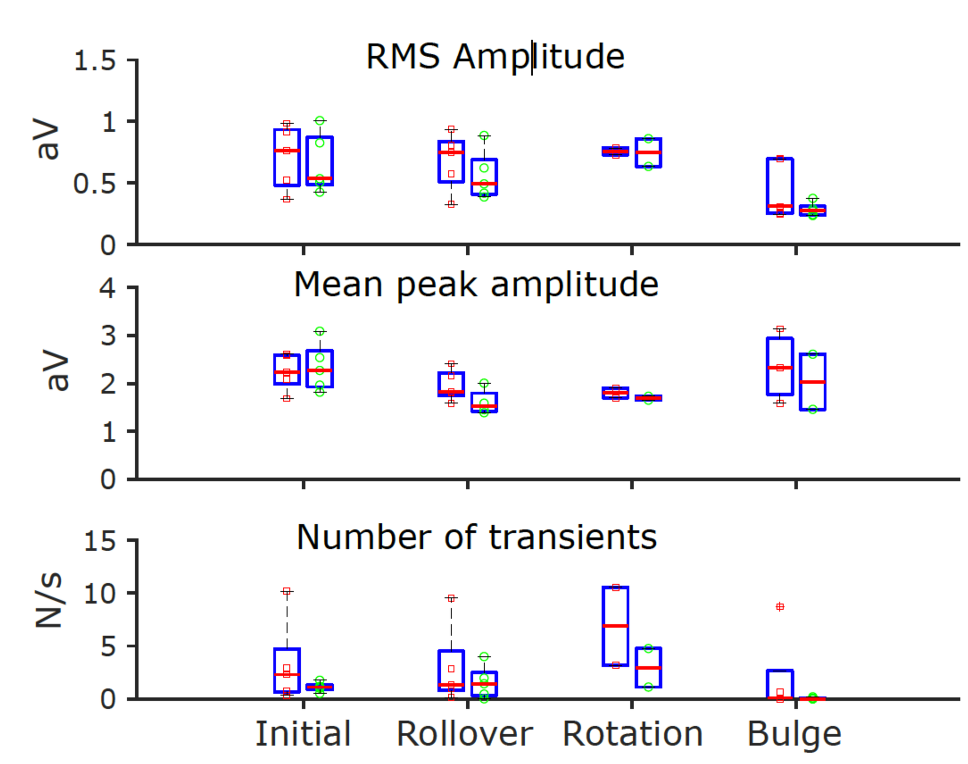

Figure 5: Summary of insertion pressures observed during implant rollovers, comparing insertion epochs. Responses are shown for mean peak amplitudes of all pressure transients, RMS amplitude, and the number of transients identified. Mean values for each insertion are shown as colored markers (P_{SV}: red, P_{ST}: green, P_{Diff}: blue).

Conclusions

With increasingly smaller cochlear implant electrode arrays and desire for perimodiolar placement, the potential for electrode array tip fold-over is growing. To optimize postoperative speech performance outcomes, early and immediate identification of these events is crucial.

While we were not able to identify any obvious difference in pressure transients recorded during tip fold-over and correct insertions, our data has demonstrated the varied nature of tip fold-over events and similarly varied intracochlear pressure transients that are associated with these events. In this limited dataset, we have characterized patterns of fold-over and the relative pressure changes.

Given the varied nature of intracochlear electrode movement and associated fluid pressure changes, we propose that electrode tip fold-over represents a heterogeneous group of events that are potentially correlated with varying findings on post-insertional imaging, electrophysiologic measures, and implant verification metrics.

While additional study is needed to confirm the clinical significance of the changes and further investigate the possible patterns of intracochlear electrode movement, this study identifies several distinct tip fold-over events that may occur, and thereby highlights the importance of early identification of tip fold-over, as well as the need for soft surgical techniques and atraumatic CI electrode insertion.

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