Tissue classification during surgical drilling using impedance spectroscopy

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Motivation: tissue classification during surgical drilling

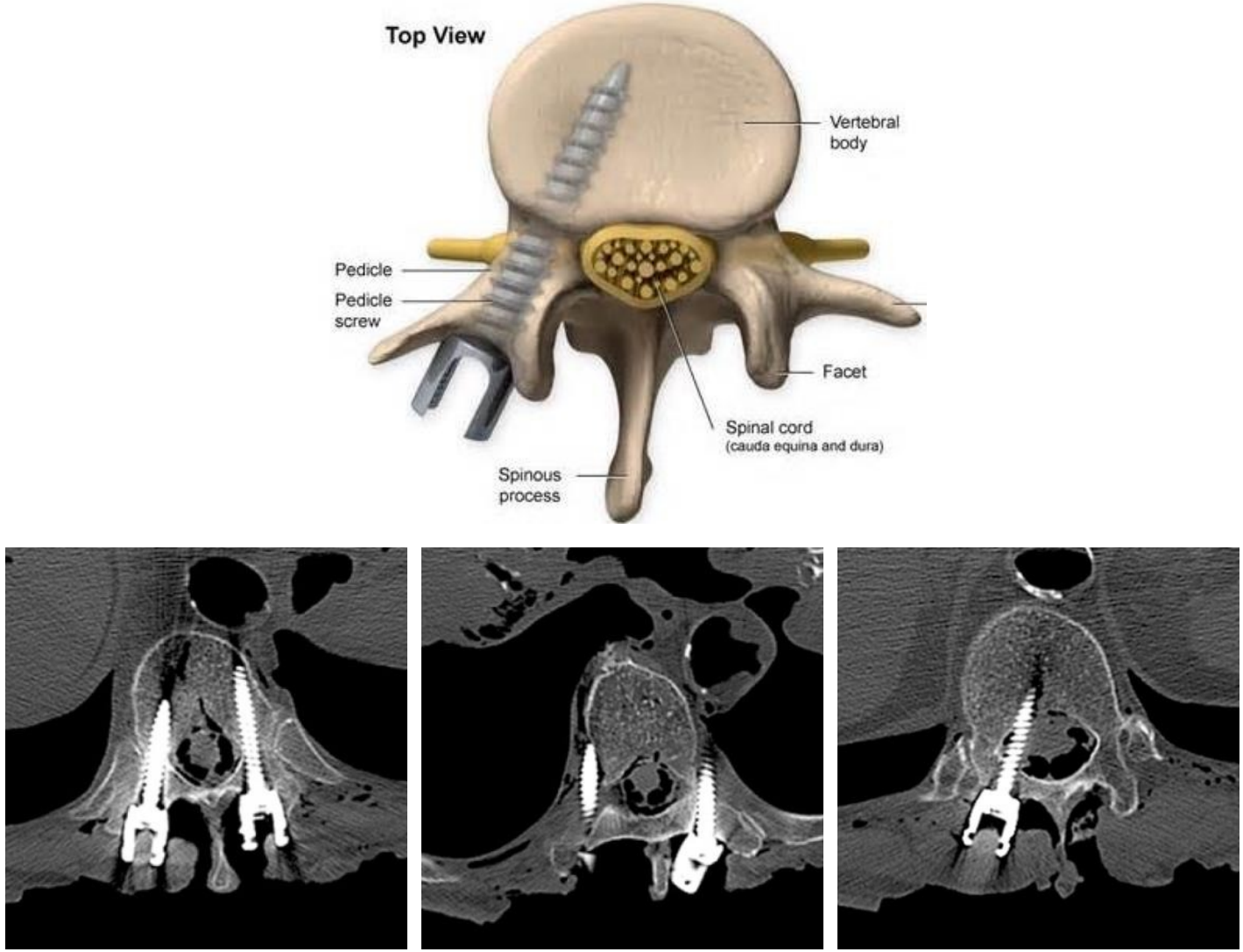
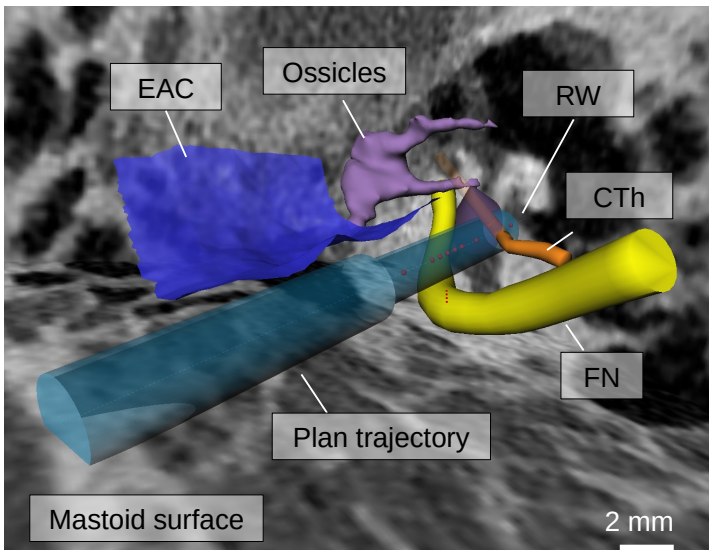
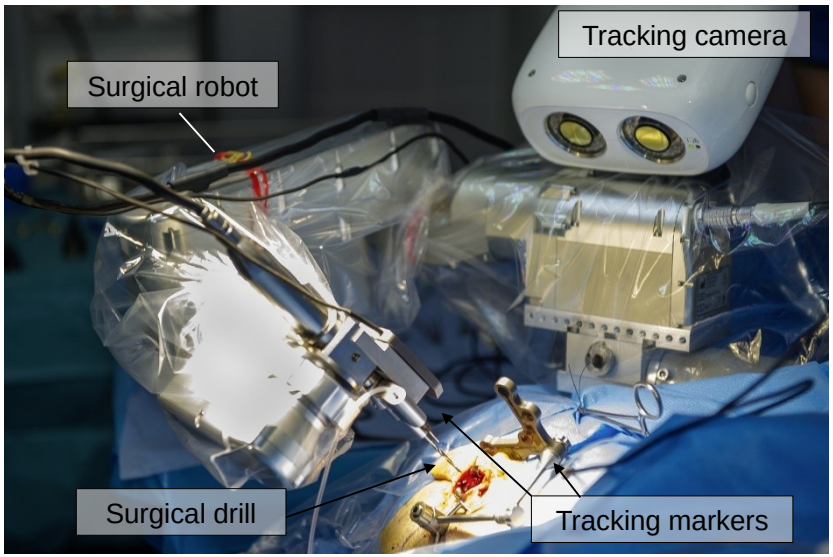


Figure: (Above) Pedicle screw concept. (Below) CT showing correct placement (left) and two examples of wall breaches

Model of Cochlear implantation





Bell et al. In Vitro Accuracy Evaluation of Image-Guided Robot System for Direct Cochlear Access Otol. Neurotol. 2013
Caversaccio et al. Robotic cochlear implantation: surgical procedure and first clinical experience., Acta Otolaryngol., 2017

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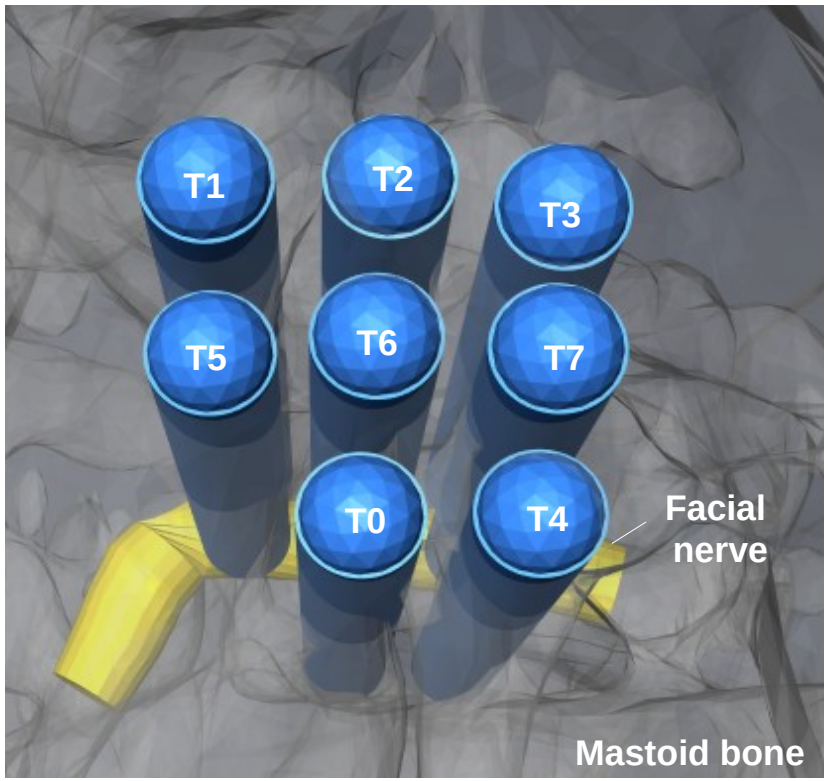
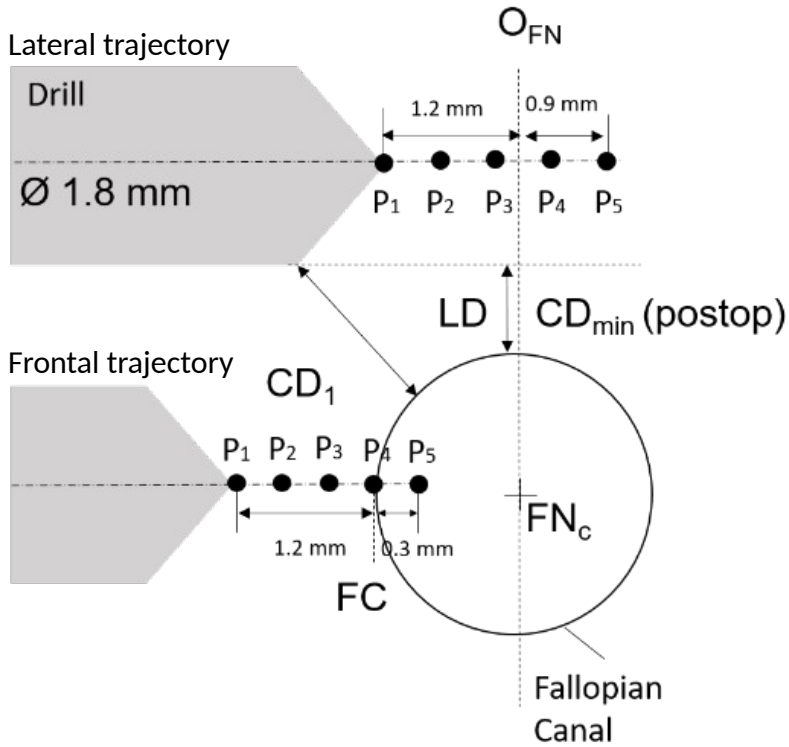
Experimental Configuration





Example results – Frontal

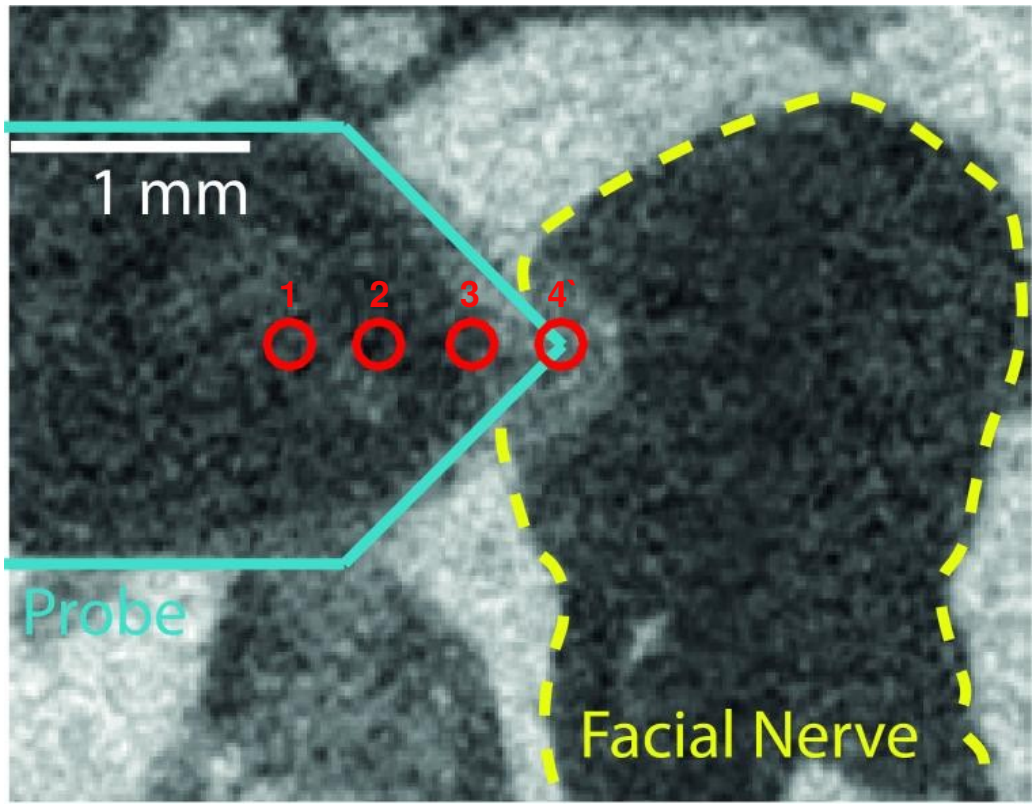


Figure: Post-operative μCT slice (left) of the drill trajectory where red dots indicate the probe tip at points p1 . . . p4.

Example results – Frontal

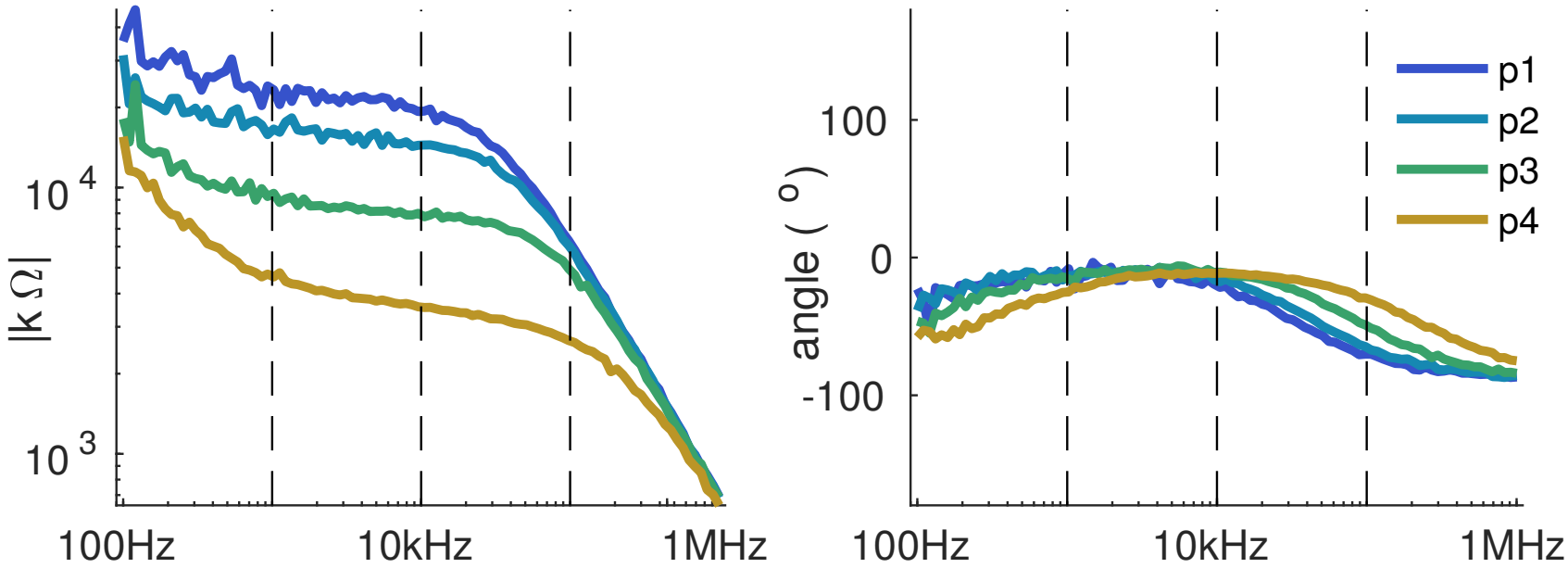


Figure: Impedance magnitude (left) and phase (right) for a representative trajectory. Points indicate the approach of the probe to the nerve, entering it at p4.

Example results – Frontal

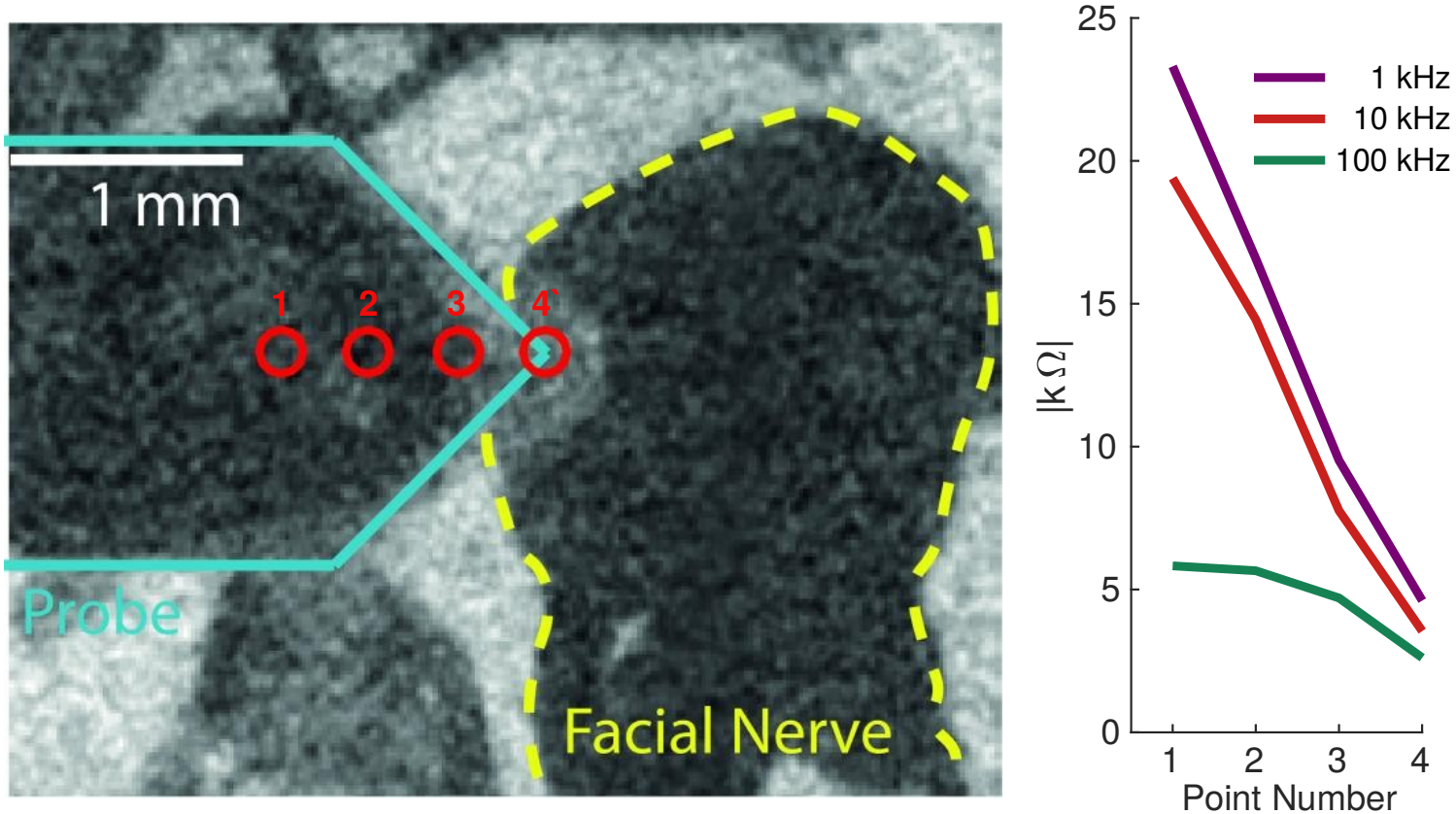


Figure: Post-operative μCT slice (left) of the drill trajectory where red dots indicate the probe tip at points p1 . . . p4. $|Z|$ (right) at three frequencies as a function of point number.

Example results – Lateral

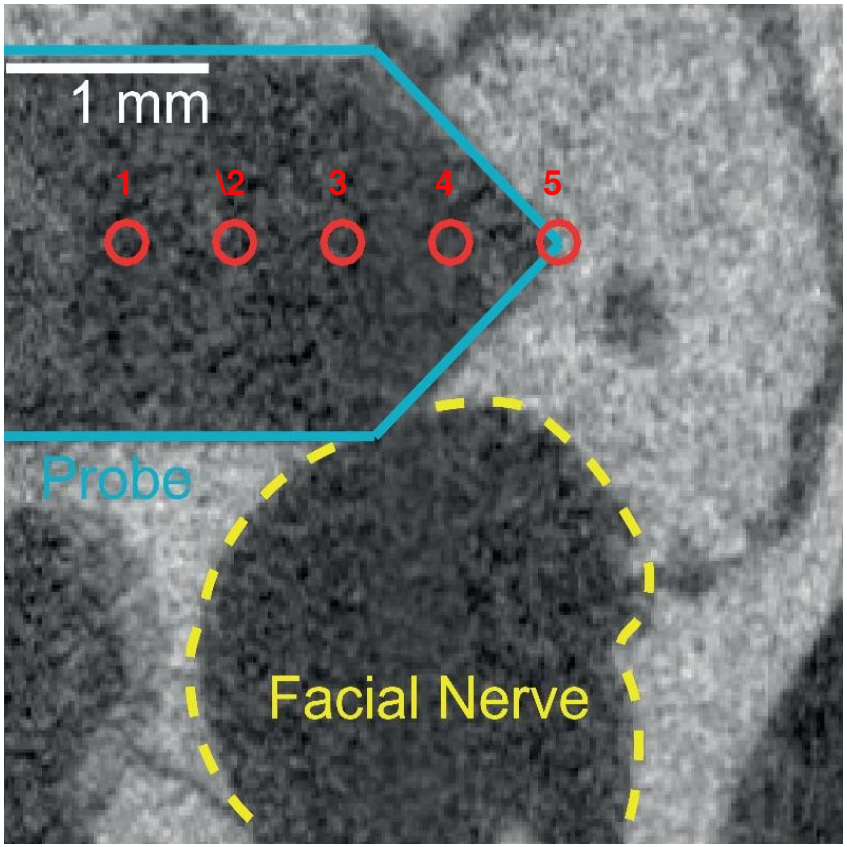


Figure: Post-operative μCT slice (left) of the drill trajectory where red dots indicate the probe tip at points p1 . . . p5.

Example results – Lateral

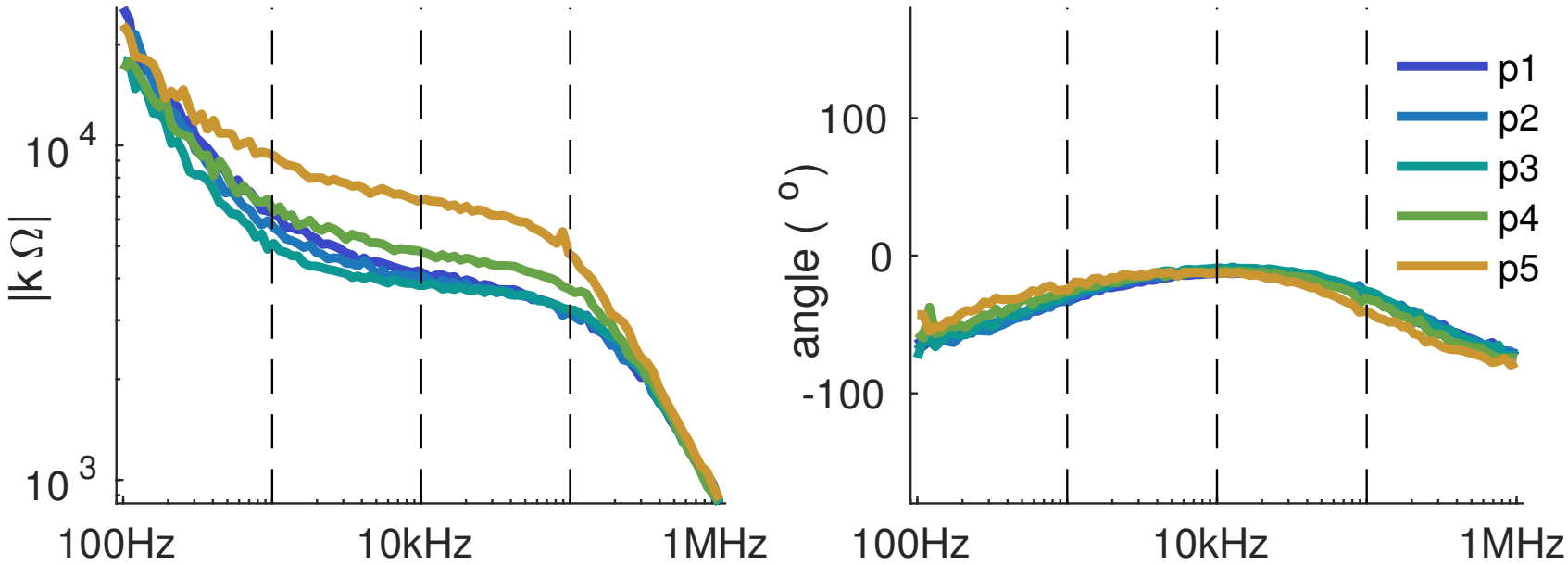
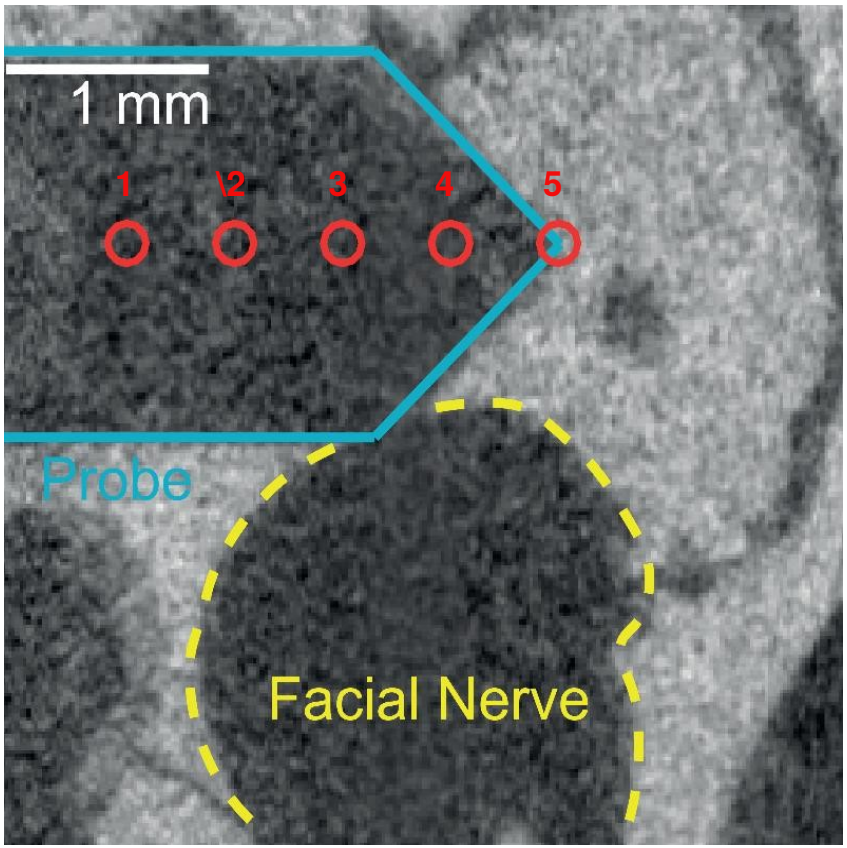


Figure: Impedance magnitude (left) and phase (right) for a representative trajectory. Points indicate the approach of the probe to the nerve, entering it at p5.

Example results – Lateral



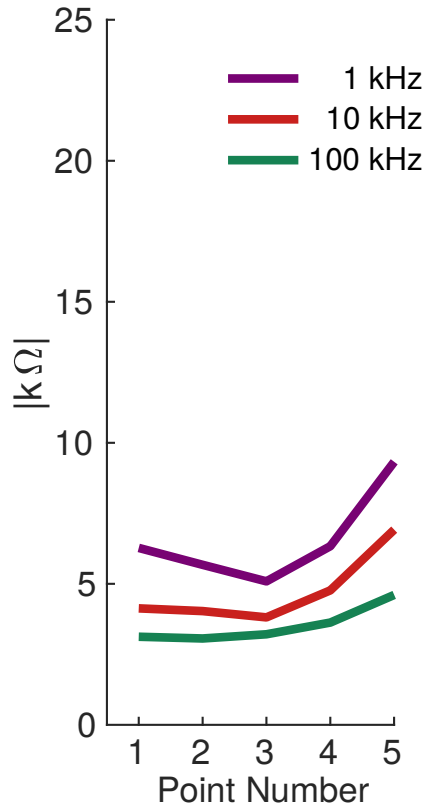


Figure: Post-operative μCT slice (left) of the drill trajectory where red dots indicate the probe tip at points p1 . . . p5. $|Z|$ (right) at three frequencies as a function of point number.

Results and Discussion

- can ability to distinguish nerve tissue from bone
- Most useful f: 1 – 10 kHz
- Question:

  Can we itentify **before** *we reach the nerve?*

- Analysis is continuing to optimizing the probe sensitivity.

Modelling

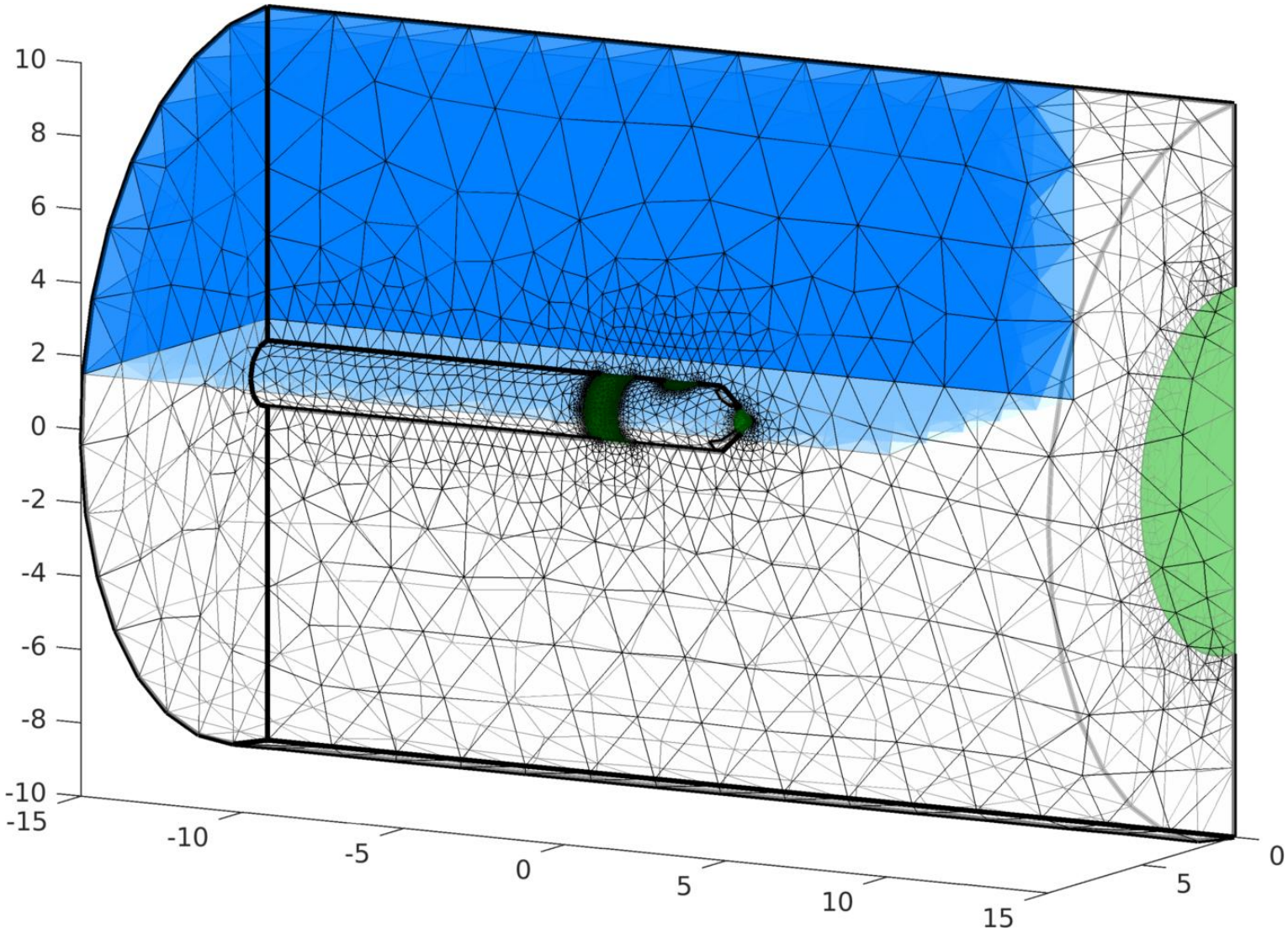
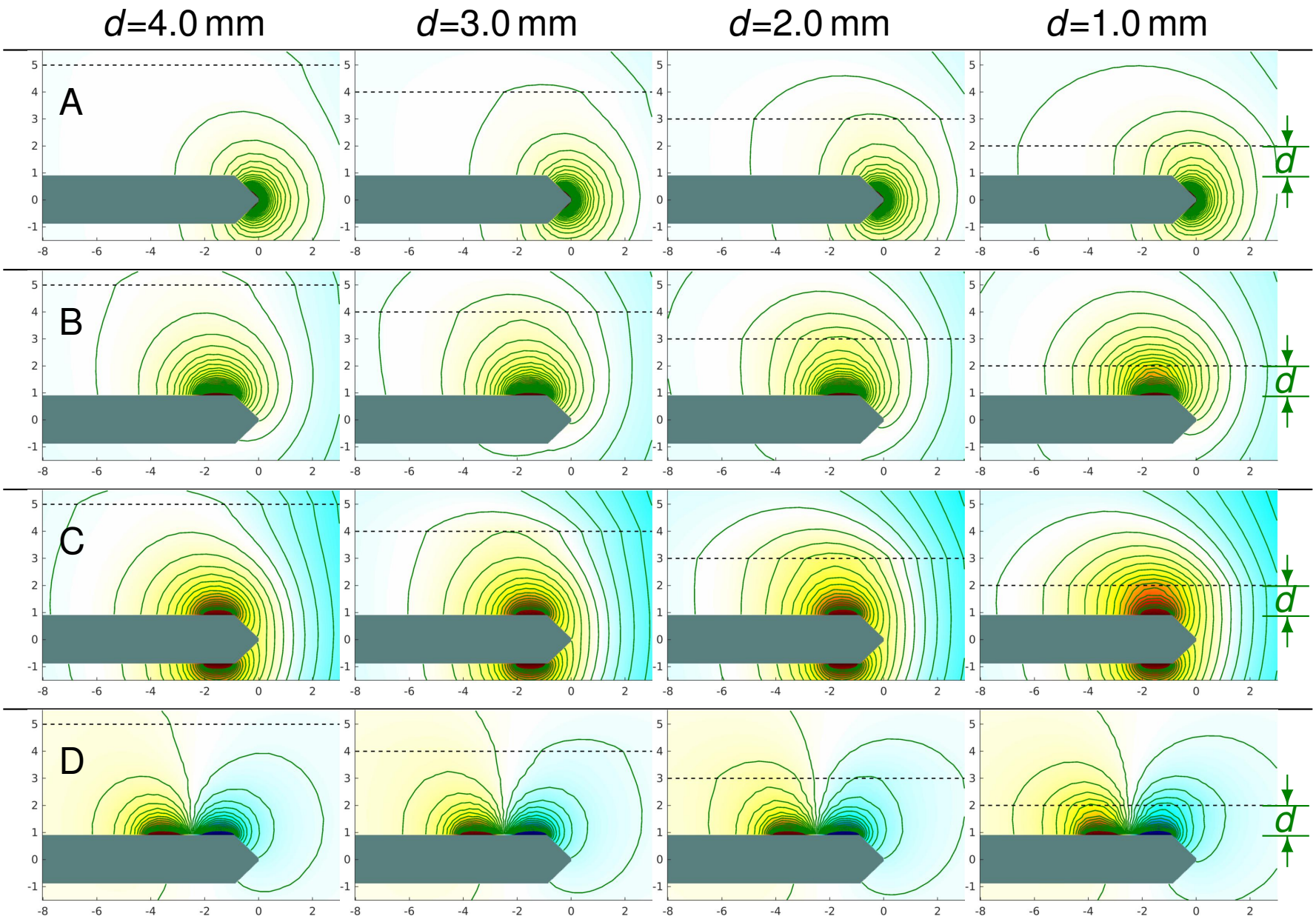


Figure: FEM of probe in a uniform tissue near a lateral transition between tissue types, with electrode designs on probe and at right.

Modelling Sensitivity – Electrode shape vs *d*



Impedance vs *d* for electrode shapes

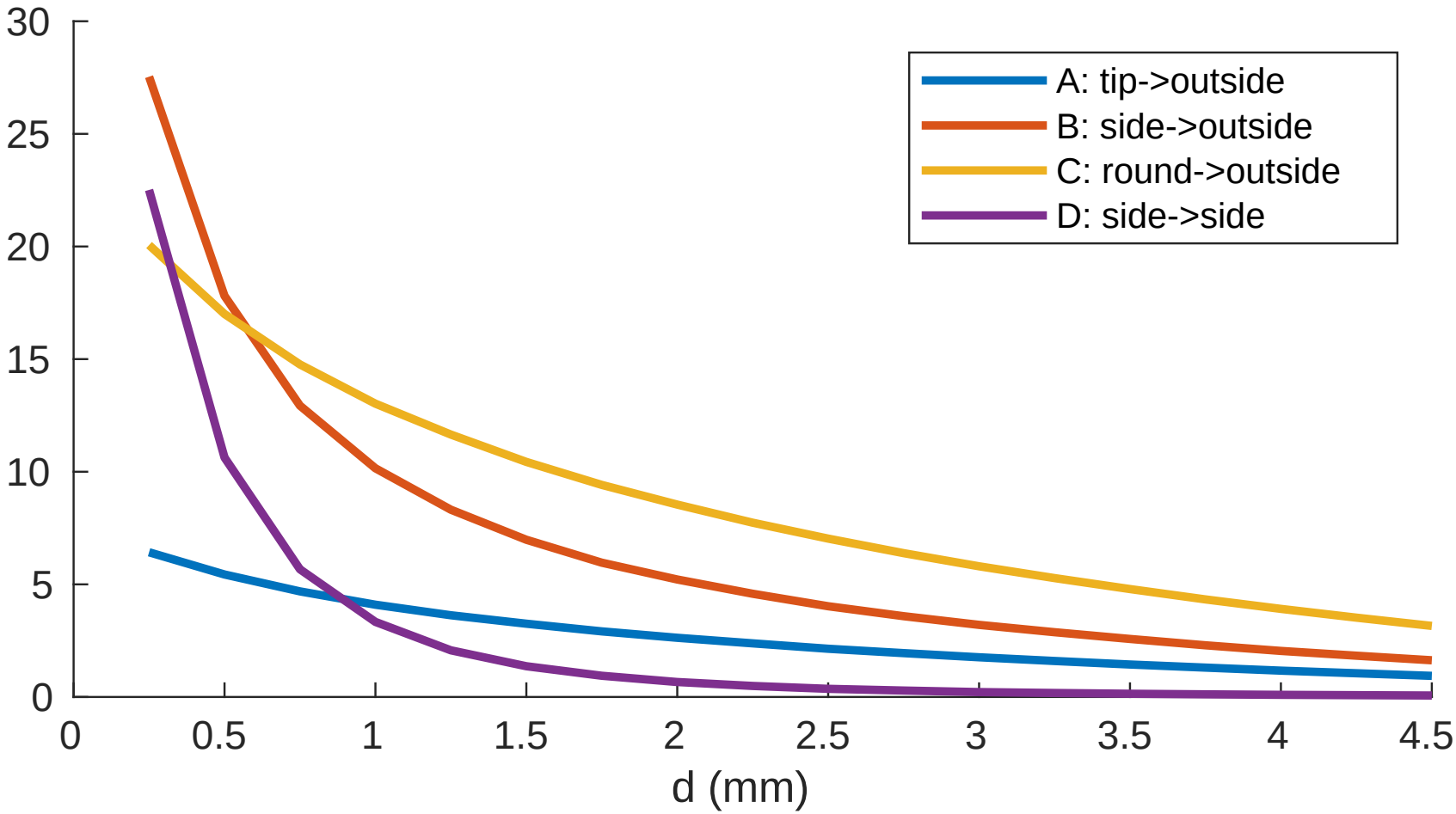


Figure: Relative change in impedance (ΔZ %) as a function of *d* (mm), for the electrode shapes on the previous page

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