Tissue classification during surgical drilling using impedance spectroscopy

EIT 2019, London, UK
3 July 2019

Yves Jegge\textsuperscript{1}, Andy Adler\textsuperscript{2,3}, Mareike Apelt\textsuperscript{1}, Gürkan Yilmaz\textsuperscript{2}, Damien Ferario\textsuperscript{2}, Kathleen Seidel\textsuperscript{4}, Juan Ansó\textsuperscript{1}

\textsuperscript{1}ARTORG, Bern, Switzerland, \textsuperscript{2}CSEM, Neuchâtel, Switzerland, \textsuperscript{3}Carleton University, Ottawa, Canada, \textsuperscript{4}Inselspital, Bern, Switzerland
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


Tissue classification during surgical drilling using impedance Spectroscopy . . . Jegge et al
Experimental Configuration

Tissue classification during surgical drilling using impedance Spectroscopy... Jegge et al
Example results – Frontal

![Image of post-operative µCT slice showing drill trajectory and probe points]

**Figure:** Post-operative µCT slice (left) of the drill trajectory where red dots indicate the probe tip at points `p1 . . . p4`.
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 $\mu$CT 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.
Figure: Post-operative $\mu$CT 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 identify 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.

Tissue classification during surgical drilling using impedance Spectroscopy . . . Jegge et al
Modelling Sensitivity – Electrode shape vs $d$

$A$

$B$

$C$

$D$

Tissue classification during surgical drilling using impedance Spectroscopy . . . Jegge et al

13 / 15
Figure: Relative change in impedance ($\Delta Z\%$) as a function of $d$ (mm), for the electrode shapes on the previous page.
Tissue classification during surgical drilling using impedance spectroscopy

EIT 2019, London, UK
3 July 2019

Yves Jegge¹, Andy Adler²,³, Mareike Apelt¹, Gürkan Yilmaz², Damien Ferario², Kathleen Seidel⁴, Juan Ansó¹

¹ARTORG, Bern, Switzerland, ²CSEM, Neuchâtel, Switzerland, ³Carleton University, Ottawa, Canada, ⁴Inselspital, Bern, Switzerland