DEVELOPMENT OF IMPROVED SPINAL CANAL OCCLUSION TRANSDUCER (SCOT)

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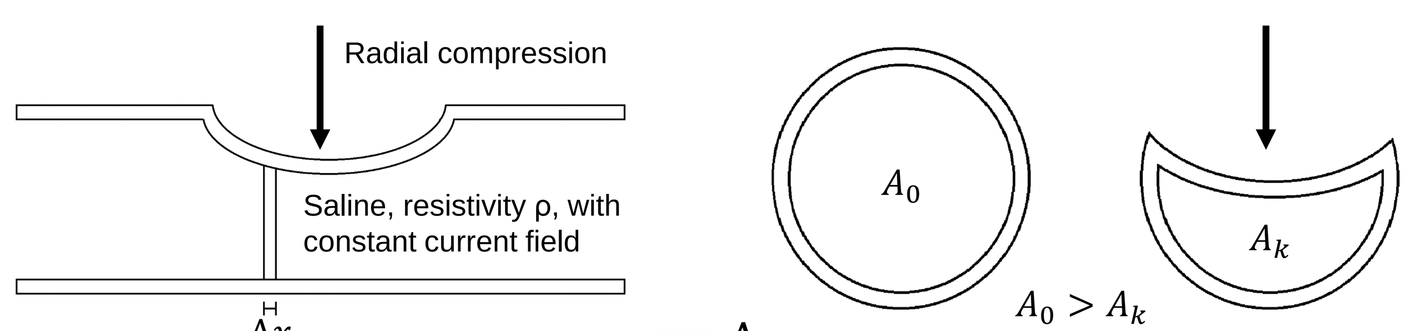
Motivation

- 13, 000 spinal cord injury (SCI) cases in North America annually, with injury at the cervical level most common[1]
- Combined *lateral bending* and *compression* loading frequently experienced during rollovers and sports impacts[2]

Study of combined loading conditions on bony incursion in the spinal canal will improve our understanding of SCI

SCOT

- Electromechanical sensor used to detect geometry changes of the spinal canal
- Highly flexible tube inserted into the specimen spinal canal
- SCOT tube filled with saline and constant current field created with a custom sensor (figure 2)
- Radial compression of SCOT tube results in change in cross-sectional area and increased resistance to constant current flow (figure 1)



$$R = \rho \sum_k \frac{\Delta x}{A_k}$$

Figure 1: Radial compression to the tube cause a change in cross sectional area, resulting in an increase in electrical resistance

- Sensing elements along length of tube used to detect resulting voltage change due to radial compression
- Two step calibration process converts measured voltage to cross-sectional area of SCOT tube

Aim

- Design, build and characterize a new sensor
- Improve upon previous iterations by increasing SCOT durability and signal stability

Methods

- Designed and built physical prototypes for testing
- Different sensing element sizes, electrical connections and casing materials considered (table 1)
- Added sponge surrounding the sensor to maintain its location in the SCOT tube
- Presently, controlling electronics remain unchanged
- Prototypes loaded in radial compression to a maximum displacement of 8 mm at a load rate of 2 mm/s

Table 1: Summary of prototypes built for testing

Sensor	Excitation / Ground element	Sensing element	Electrical connection	Casing material
SCOT Original	2 loops 31 AWG wire	2 loops 31 AWG wire	Continuous wire	Standard wire insulation
SCOT v1	Ø 3.97 mm SS ball	Ø 3.97 mm SS ball	Solder	Standard wire insulation
SCOT v2	Ø 3.97 mm SS ball	Ø 3.18 mm SS ball	Silver doped epoxy	Standard wire insulation
SCOT v3	Ø 3.97 mm SS ball	Ø 3.18 mm SS ball	Silver doped epoxy	Heat shrink
SCOT v4	Ø 3.97 mm SS ball	Ø 3.18 mm SS ball	Solder + silver doped epoxy	Heat shrink
SCOT v5	Ø 6.35 mm SS ball	Ø 3.18 mm SS ball	Solder	Heat shrink
SCOT v6	Ø 3.97 mm SS ball	Ø 3.18 mm SS ball	Solder	Heat shrink

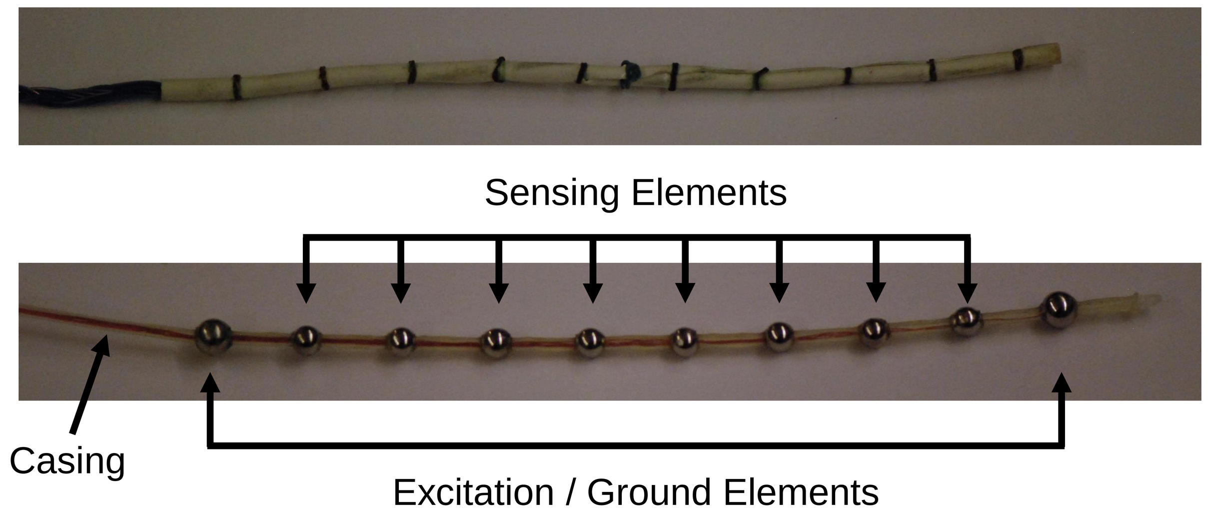


Figure 2: SCOT original (top); and SCOTv6 prototype

Analysis

- Converted output AC voltages to root mean square voltages (V_{RMS})
- Compared change in resting signal before and after loading, signal to noise ratio and durability were considered in comparison to previous SCOT iterations

Results

- Change in resting signal before and after loading reduced by 39% for SCOTv6 when compared to previous SCOT iterations (table 2)
- Effects of oxidation to sensing elements observed with original SCOT should be mitigated through use of stainless steel in new design
- Extensive water proofing was completed on new design to minimize the possibility of wire corrosion

Table 2: Summary of change in resting signal before and after loading, and signal to noise ratio for prototypes tested

Sensor	dV_{RMS} (mV) Mean ± SD	SNR (dB) Mean ± SD
SCOT Original	2.32 ± 1.51	74.42 ± 3.26
SCOT v2	2.15 ± 2.50	61.25 ± 2.50
SCOT v4	0.787 ± 0.611	72.32 ± 1.90
SCOT v5	2.35 ± 1.63	70.88 ± 1.96
SCOT v6	1.41 ± 2.00	72.39 ± 1.95

Future Work

- Complete calibration and characterization of new design
- Use finished SCOT in flexibility study of cadaveric cervical spine segments to determine extent of canal occlusion during physiologic loading (1.5 Nm applied in flexion-extension, lateral bending and axial rotation)
- Use SCOT in cadaveric studies of dynamic combined compression and lateral bending of cervical spine

References: 1. Dryden et al., 2003, *Can. J. Neurol. Sci.*, **30**(2), pp. 113-121; 2. Broglio et al., 2011, *New Eng. J. Med. Rhabil.*, **88**(3 Suppl. 1), pp. S84-88

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