Development of improved spinal canal occlusion transducer

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Abstract

It is estimated that the annual incidence of spinal cord injury (SCI) in North America is 13,000 [1] and represents a significant health issue due to the societal and financial impacts on people affected [2]. Injury at the cervical level of the spinal cord is the most common form observed. Combined loading, particularly axial compression superimposed with lateral bending and/or flexion and extension, are thought to be frequently experienced during vehicle rollovers and sports related impacts [3]. Study of these combined loading conditions on bony incursion in the spinal canal will improve our understanding of SCI.

The spinal canal occlusion transducer (SCOT) is a sensor that has been used to detect geometry changes of the spinal canal previously in the study of combined loading of the cervical spine [4, 5]. In the Van Toen study, the sensor was inserted into the spinal canal of a 3 vertebra cervical spine cadaveric specimen. The specimen was loaded in axial compression and lateral bending through an eccentric axial compression. A constant current field is created in saline filling the SCOT sensor casing. Radial compression of the SCOT casing results in a change in cross sectional area and an increased resistance to the constant current flow. Sensing elements along the SCOT probe are used to detect the resulting change in potential difference along the length of the probe and quantify the change in area of the SCOT casing. Though already a useful tool, a number of shortfalls of the most recent SCOT iteration [6] were identified for improvement. These included long term durability, stability of the signal and a low signal to noise ratio. Furthermore, we aimed to investigate how (if at all) the mechanics of the SCOT during impact loading experiments affected the resulting measurements, for example, by decreasing the resulting compression.

The purpose of this work was to address these shortfalls by improving the existing SCOT design. To date, the improvements have focussed on the design of the transducer probe and its sensing elements, the casing material and the input signal conditions, while the controlling electronics remain unchanged. Five physical prototypes with variations in sensing element size, electrical connection method and probe construction material were built. These prototypes underwent loading similar to calibration protocols used for previous SCOT iterations [7] with a range of input signal conditions beyond the previously employed 1 V peak to peak sine wave with 2 kHz

frequency. Metrics including stability of signal before and after loading, and signal to noise ratio were calculated and compared to data collected using previous SCOT iterations [6].

Preliminary data analysis has shown a 20-30% improvement in signal to noise ratio in the most recent probe designs and a 90-100% decrease in signal variability before and after loading (i.e. stability has increased). In the future we will determine the accuracy and repeatability of the updated SCOT. With the completion of this work, the sensor will be used in cadaveric studies of combined compression and lateral bending of the cervical spine and the potential of this combined loading to cause SCI.

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