IMPROVING REPEATABILITY OF VERTEBRAL KINEMATICS IN A RAT DISLOCATION SPINAL CORD INJURY MODEL

Stephen Mattucci (1,2), Jie Liu (2), Paul Fijal (1,2), Wolfram Tetzlaff (2), Thomas Oxland (1,2)

1. Departments of Orthopaedics and Mechanical Engineering, University of British Columbia, Canada
2. International Collaboration on Repair Discoveries (ICORD), University of British Columbia, Canada

Introduction

Dislocation is the most common clinically observed spinal cord injury (SCI) mechanism, occurring in 45% of SCI cases [1], however, there are few pre-clinical models [2, 3]. Despite demonstrating different patterns of injury compared to more common contusion injury models [4], the dislocation models that do exist have issues with repeatability. Since dislocation involves clamps which grip and displace the spine, a potential cause of variability may be slipping at this interface. The objectives were to: i) design new injury clamps, ii) measure intervertebral kinematics during a high-speed dislocation injury in an in vivo rat model; and iii) quantify relative motion at the vertebrae-clamp interface to determine which clamps provide the most rigid connection.

Methods

The existing clamps [2] act as two parallel ridges gripping two adjacent vertebrae; however, if one vertebra is smaller, it may not be held securely. The design criterion was to enable new clamps to grip both vertebrae independently for both the rostral and caudal pair. New clamps were designed to pivot, and self-align (PSA) when tightened via a custom saddle washer resting against a rounded outer surface, ensuring each clamp holds both intended vertebrae. The dislocation injury was performed using both the existing and redesigned clamps, where 400 μm radiopaque tantalum beads were fixed to C3-C6 and the clamps to track relative motion (Fig. 1).

![Figure 1: Schematic of the location of the fiducial markers on the vertebrae and injury clamps, with a corresponding high-speed x-ray image.](image)

The injury was performed at C4/C5 on anesthetized Sprague-Dawley rats (n = 17 per group), to a displacement of 2.3 mm at a velocity of 700 mm/s. A high-speed x-ray system recorded the tests at 8000 frames per second, a 512 x 512 image resolution, and a spatial resolution of 0.12 mm/pixel. The motion of the clamps and vertebrae were tracked using TEMA motion analysis. The cases of motion analyzed were: C5 relative to the caudal clamp in translation and rotation, C4 relative to the rostral clamp in translation and rotation.

Results

The relative motion of C5 with respect to the caudal clamp was significantly less for both translation (Fig. 2) and rotation for the PSA clamps (p < 0.05), and the maximum observed motion was four times less for the PSA clamps. The motion of C4 with respect to the rostral clamp was not statistically different between the different clamps.

![Figure 2. Relative motion of C5 with respect to the caudal clamp compared between the existing and redesigned PSA clamps in y-translation.](image)

Discussion

This was the first time the motion of the vertebrae with respect to the clamps has been measured in a dislocation model. This study clearly demonstrated that relative motion was occasionally present between the existing dislocation injury clamps and the vertebrae. By redesigning the clamps, relative motion has been reduced, and thus produced more repeatable spine kinematics during injury. These improvements will serve to address a potential source of variability in the injury model and progress toward a more repeatable rat dislocation model, better suited for investigating SCI interventions, and further shed light on the importance of injury mechanism.

References


Acknowledgements

The authors wish to acknowledge the Canadian Institutes for Health Research (CIHR) and the Blussom Integrated Cures Partnership (BICP) for financial support.