INTERVERTEBRAL NEURAL FORAMINA DEFORMATION DUE TO TWO TYPES OF REPETITIVE COMBINED LOADING

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INTRODUCTION

The effects of posture and load combinations on the nerve roots have only been addressed for the cervical spine region, but it has been shown that the size of the neural spaces are dependent on posture (Harrison et al., 1999). In addition, pressure on neural tissue has been shown to elicit pain responses in rats (Hubbard et al., 2007). Altered mechanics of the spine have been observed in in-vitro experiments that exposed functional spinal units to a repetitive combined loading paradigm (Callaghan & McGill, 2001; Drake et al., 2005). This loading paradigm may also modify neural space size. Recently, it has been demonstrated that larger twist angles can be achieved when coupled with forward flexion in-vivo (Drake & Callaghan, 2008). These findings suggest a postural mechanism may be responsible for modulating the load distribution between the facets and the disc. The contribution of intervertebral disc (IVD) damage to the development of constricted neural spaces has not been explored. The objectives of this study were two-fold, to measure the occlusion of the intervertebral foramina (IVF) due to two types of repetitive loading, and to investigate whether repetitive combined axial twist loading can generate IVD injury. The outcome measures were compared to known levels of mechanical neural compression, which have been shown to cause pain, to assess viable pain generating mechanisms associated with IVD injury.

METHODS AND PROCEDURES

Sixteen porcine cervical spine motion segments (C5/6) were subjected to 1500N of compression combined with either passive range repetitive flexion/extension motions (15.5±1.4° flexion, -4.75±1.6° extension) or static flexion (16.4±2.1°) combined with repetitive left axial twist motion (5.2°). A custom 3-axis servo-hydraulic system was used to apply the loads. Pressure was measured in the IVF of both the left and right side of the specimens using 5mm diameter flexible plastic tubing and a custom pressure monitoring system. The tubes, which were the same size as the nerve roots, were inserted anterior-laterally through the IVF and terminated in the spinal canal (Figure 1) after the nerve roots and spinal cord had been removed.

Figure 1. The nerve roots in the IVF were removed and were replaced with plastic tubing bilaterally (A). The tubes ran through the IVF to the spinal canal (B).

Prior to loading and following blocks of 1000 loading cycles the specimens were subjected
to flexion-extension range of motion testing and planar radiography to document the IVD condition. The range of motion tests flexed and extended the specimens to the limits of the neutral zone five times at a rate of 0.5°/s. Resultant structural failure of the disc and vertebrae were compared to the measured pressure changes, flexion-extension stiffness, and specimen height. Testing was terminated when herniation was determined radiographically or after 10,000 loading cycles had been applied.

RESULTS

There was significantly different bilateral pressure (pre-post difference) in the IVF of specimens that were repetitively flexed-extended (P=0.028) compared to those that were repetitively twisted (Figure 2).

![Figure 2](image)

**Figure 2.** Pre-post pressure changes measured in the intervertebral foramina under two types of repetitive loading: flexion-extension motions, and left axial twist motion combined with static flexion were different(*).

The failure of the specimens was different between the repetitively loaded groups. All of the flexed-extended specimens herniated after an average of 5750 ±1065 cycles of loading. The repetitively axial twisted group sustained 9750 ±463 cycles of loading, with two specimens having no observable damage, one having a facet fracture with no IVD damage, and five having incomplete herniations. There was no significant difference of the vertical height loss or percent difference flexion-extension stiffness between the groups (P>0.199). The height loss was 3.50±0.88mm, and the pre-post percent difference stiffness (normalized to endplate area) was 54.9±23.4%.

DISCUSSION

The average pressure for the repetitive flexion-extension and axial twist loading respectively were approximately 46% and 21% of the pressure threshold reported to elicit pain behaviours in rats (Hubbard et al., 2007). These values ranged as high as 97% and 34% respectively. Based on the injury data, if the duration of exposure to repetitive axial twist was increased, greater injury to the IVD may be sustained causing further increases in IVF pressure. This information may be useful to consider when determining treatment and rehabilitation to address nerve root compression.

SUMMARY

Repetitive loading of dynamic flexion-extension motions is a viable pain generating pathway.

REFERENCES


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