Does overloading of flexed ovine lumbar segments containing two intervertebral discs induce endplate fracture or herniation? A preliminary study

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Summary

Overloading flexed ovine lumbar segments containing one intervertebral disc (IVD) *ex vivo* at 40 mm/min more likely result in herniations [1]. This new study investigated the most frequent occurring mode of failure when overloading flexed ovine double-segments containing two IVDs. The results showed that the flexed double-segments compressed at 40 mm/min *ex vivo* fail via endplate fracture. The kinematic measurements showed changes in flexion angles for both IVDs during compression and suggest that an increase in flexion makes the corresponding IVD more at risk to fail.

Introduction

Ex vivo IVD structural failure studies typically utilise segments containing one IVD. One such study compressed flexed healthy ovine lumbar segments to failure at 40 mm/min and reported that most samples failed by herniation [1]. However, utilising segments containing one IVD does not provide information about the complex behaviour of the multi segment spinal system, such as the 3D motion of the vertebrae and the related changes in flexion angles. Therefore, this novel study aims to investigate the effect of compressive overloading at 40 mm/min on the structural failure of flexed ovine double-segments containing two IVDs.

Methods

Five fully hydrated L3-L4-L5 ovine double-segments with two IVDs and intact facet joints (Figure 1) were creep-loaded at 300 N for 15 minutes. A 7° wedge was mounted at each sample end and 9 reflective markers were attached to the wedges and sample to measure the segment's kinematics during compressive overloading with optical motion capture. Each sample was flexed, fixed in the flexion posture and then compressed to failure at 40 mm/min. All samples were externally inspected for herniations and then sagittally bisected to assess the segment's internal structure with a microscope.

Results and Discussion

No herniation was visible on the 5 samples and sagittal bisection indicated that all had failed via endplate fractures (Figure 1 & Table 1). The 14° initial flexion applied to the samples resulted in an average of 15.9° measured with the kinematic system indicating its usage to study trends. The segment kinematic measurements (Table 1) revealed that the flexion angle of one IVD increased during compression to failure while the angle of the other IVD decreased. Only sample 2 (Table 1) also showed failure in the IVD that had experienced a decrease in flexion. The double-segments failed at an average load of 8.75 kN (7.30-11.07) and these loads are within the range of the loads at failure of flexed segments containing one IVD that were compressed at the same rate of 40 mm/min and failed via endplate fracture [1].

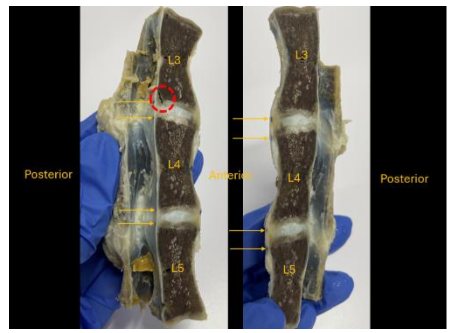

Figure 1: Images of sample 1, arrows showing landmark point used for motion capture registration. Red circle showing endplate failure.

Table 1: Angle change during compressive overloading to failure. Positive angle is flexion and EPF indicates endplate fracture

Sample	1	2	3	4	5
L3L4	1.9 (EPF)	-3.0 (EPF)	-1.3	-5.7	-2.6
L4L5	-2.0	2.9 (EPF)	1.3 (EPF)	5.7 (EPF)	2.6 (EPF)

Conclusions

This study shows that flexed double-segments containing two IVDs compressed at 40 mm/min *ex vivo* fail by endplate fracture and suggests that the IVD experiencing an increase in flexion during overloading is more at risk of failure. Interestingly, segments containing one IVD, when compressed at the same rate, are more likely to herniate [1]. Additional data is being collected to investigate a possible explanation for the differences in observations.

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References

[1] Wade KR et al. (2014). *Spine*, **13:** 1018-1028.