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# EVALUATION OF POSSIBLE FAILURE MECHANISMS OF SHORT SEGMENT FIXATION IN UNSTABLE BURST FRACTURES OF THORACOLUMBAR SPINE IN ANIMAL MODEL

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**Abstract :** Background - Burst fractures are common cause of disability among the affected young population and instrumented surgical stabilisation remains the treatment of choice for unstable burst fractures of the vertebra. Circumferential fixation and short segment posterior fixation with intermediate screws inserted into the fractured level are the commonly performed surgical stabilisation procedures. But, decreasing the instrumented level in order to preserve the number of motion levels may adversely affect the stability of the construct and can ultimately result in implant failure. Aim - To evaluate the possible mechanisms of failure of the short segment fixation methods in experimentally induced unstable burst fractures of the thoracolumbar spine in calf spine model. Materials and Methods - Eight fresh frozen calf spines specimens were prepared and grouped into two Group A and Group B. After creating an unstable burst fracture by drop weight method at the first lumbar vertebra level, Group A specimens were instrumented using short segment posterior fixation with screws inserted to the fractured level while the specimens in Group B were instrumented using circumferential fixation. The specimens were then subjected to biomechanical testing in a universal testing device (Tinius, Oslon) for failure in axial load and axial rotation. Results - All four specimens in the circumferential fixation group (Group B) failed in axial torque by screw pull out. No failure was observed during axial loading. None of the specimens in the Group A failed in either axial torque or loading. Conclusions - Our findings show that circumferential stabilization constructs can fail in axial torque, and therefore may require additional protection in the form of bracing in the immediate postoperative period. The use of the intermediate screw technique may provide superior stability in axial torque that the circumferential technique.

**Keyword :**Circumferential Fixation, Short Segment Fixation, Intermediate Screws, Burst Fracture

**Introduction**

Burst fracture of the thoracolumbar spine is a common cause of disability in young population following spinal trauma1,2. In the developing world, a fall from height is the most common mechanism of injury while in the developed countries road traffic accidents account for most of the injuries 3–5. Instrumented surgical stabilisation is the treatment of choice for unstable burst fractures of the thoracolumbar spine6,7. There is a trend to decrease the number of instrumented levels in order to preserve the motion levels8–11. Circumferential fixation using a cage anteriorly and pedicle screws posteriorly spanning the level as well as posterior short segment spanning fixation with screw inserted to the fractured level are the commonly used short segment fixation methods in unstable burst fractures of the vertebra (Fig-1)2. Decreasing the instrumentation level might affect the stability of the construct and may result in implant failure. The aim of our study is to evaluate the possible mechanisms of failure of the short segment fixation methods in experimentally induced unstable burst fractures of the thoracolumbar spine in calf spine model.


**Fig-1: Photograph showing posterior short segment spanning fixation with screw inserted to the fractured level (A) and circumferential fixation (B).**

**Materials and Methods**

IRB, Ethics Committee and Institutional Animal Ethics Committee approval were obtained for the study. Eight calf spine specimens including last two thoracic and first three lumbar vertebrae were freshly prepared from diary calves of 4 to 6 months of age, carefully removing the muscles and retaining the discoligamentous structures. The specimens were weighed; DEXA scan was obtained and were grouped into two groups – A and B with 4 specimens in each group such that the corresponding specimens in each group were similar (Table-1).

Table-1

| Specimen | Weight (g) | BMD |
|---|---|---|
| A1 | 430 | 0.707 |
| B1 | 440 | 0.757 |
| A2 | 380 | 0.603 |
| B2 | 400 | 0.636 |
| A3 | 390 | 0.666 |
| B3 | 380 | 0.646 |
| A4 | 360 | 0.606 |
| B4 | 350 | 0.537 |

Plain radiographs of the specimens were obtained to rule out any gross abnormality. An unstable burst fracture was produced in each specimen at the first lumbar vertebra using drop weight method 12; which involves dropping a weight of 4.5 kg of weight guided through a rail after destabilising the index vertebra using drill holes (Fig-2) and CT scan of the specimens was obtained (Fig-3). The specimens in Group A were instrumented using short segment posterior fixation with screws inserted to the fractured level while the specimens in Group B were instrumented using circumferential fixation (Fig-4). All specimens were instrumented with titanium monoaxial pedicle screws (Jayon , India) of 5mm diameter.

**Fig-2: The drop weight method**

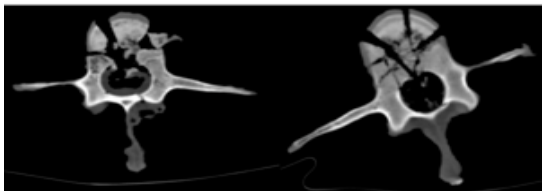

**Fig-3: CT axial cut images of the specimens A2 and B3 showing complete burst fracture with laminar fracture**

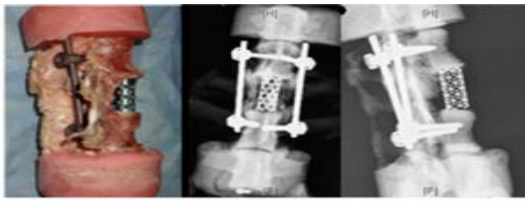

**Fig-4: The photograph and radiographs of specimen B2**

The specimens were then subjected to biomechanical testing in a universal testing device (Tinius, Oslon). A three dimensional stereophotogrammetric measurement of the special orientation of the vertebrae in space was measured using 6 *df* electromagnetic sensors (Polhemus, Inc., Colchester, VT) attached to the last thoracic and second lumbar vertebra. The constructs were tested for failure in axial load and axial rotation. A failure is defined as the breakage of the pedicle or the screw or pull out of the screw. An axial load of 1200N were applied to each specimen for three loading cycles and assessed for failure. Then the specimens were subjected to axial torsion of 15 Nm for three cycles using a system of cables and pulleys and again assessed for failure. The loading was alternated between axial load and torsion in the specimens so as to avoid bias.

**Results**

All four specimens in the circumferential fixation group (Group B) failed in axial torque by screw pull out in the second or third loading cycle (Fig-5). No failure was observed during axial loading. None of the specimens in the Group A failed in either axial torque or loading, although a mean increase in the kyphotic angle of 5 degrees was observed in axial loading which was measured stereophotogrammetrically.

**Fig-5: Screw pull out in axial rotation**

**Discussion**

A stable fixation is essential for immediate post op rehabilitation following unstable thoracolumbar burst fractures. Bust fractures are considered to be unstable if the loss of vertebral body height is >50 or the angulation at the thoracolumbar junction is >20 degrees13,14. The incidence of neurologic deficit in unstable burst fractures is approximately 50% and is associated with retropulsion of the fragments into the spinal canal; but is not correlated to the amount of retropulsion or canal compromise15–17. Both posterior-only as well as circumferential (anterior-posterior) constructs have been advocated for stable fixation, however the relative stability afforded by these constructs is unknown. The effect of the body weight and musculature acting on the spine termed as follower load has a stabilising effect on instrumented spine during flexion and extension, but its effect on torque is not significant18. McLain *et al* reviewed the failure of pedicle screw constructs and concluded that failure of short segment pedicle screw constructs occur distal to the screw hub within the pedicle due to cantilever bending effect on axial loading14. But the failure mechanism in axial rotation has not been described.

The biomechanical advantages of an 'intermediate screw' added to the fractured level have been well established19,20. Calf spine is a validated model to test pedicle screw constructs in the thoracolumbar region because of its similarity in motion kinetics to that of human spine in this region21,22. Moreover, easy availability, expendabilty and low interspecies variability makes it a good testing model to gain a preliminary idea of the pedicle screw constructs21. Although similar in motion kinetics, there are anatomic differences between calf spine and human spine23. Bovine spine has longer transverse and spinous processes and greater intertransverse length. Bovine species have 6 lumbar vertebrae. The pedicle diameter of the calf spine at 4 to 6 months of age corresponds best to that of the human 23,24,25. Because of the variablity in the number of thoracic vertebrae in bovine species, we harvested the specimen so as to include the last two thoracic vertebrae looking at the rib attachment; and from the last thoracic vetebra we counted the lumbar vertebrae. Our findings show that circumferential stabilization constructs can fail in axial torque, and therefore may require additional protection in the form of bracing in the immediate postoperative period. The use of the 'intermediate screw' technique may provide superior stability in axial torque that the circumferential technique.

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