

Controlled Laboratory Comparison Study of Motion With Football Equipment in a Destabilized Cervical Spine

Three Spine-Board Transfer Techniques

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Background: Numerous studies have shown that there are better alternatives to log rolling patients with unstable spinal injuries, although this method is still commonly used for placing patients onto a spine board. No previous studies have examined transfer maneuvers involving an injured football player with equipment in place onto a spine board.

Purpose: To test 3 different transfer maneuvers of an injured football player onto a spine board to determine which method most effectively minimizes spinal motion in an injured cervical spine model.

Study Design: Controlled laboratory study.

Methods: Five whole, lightly embalmed cadavers were fitted with shoulder pads and helmets and tested both before and after global instability was surgically created at C5-C6. An electromagnetic motion analysis device was used to assess the amount of angular and linear motion with sensors placed above and below the injured segment during transfer. Spine-boarding techniques evaluated were the log roll, the lift and slide, and the 8-person lift.

Results: The 8-person lift technique resulted in the least amount of angular and linear motion for all planes tested as compared with the lift-and-slide and log-roll techniques. This reached statistical significance for lateral bending ($P = .031$) and medial-lateral translation ($P = .030$) when compared with the log-roll maneuver. The lift-and-slide technique was significantly more effective at reducing motion than the log roll for axial rotation ($P = .029$) and lateral bending ($P = .006$).

Conclusion: The log roll resulted in the most motion at an unstable cervical injury as compared with the other 2 spine-boarding techniques examined. The 8-person lift and lift-and-slide techniques may both be more effective than the log roll at reducing unwanted cervical spine motion when spine boarding an injured football player. Reduction of such motion is critical in the prevention of iatrogenic injury.

Keywords: football; spine board; lift and slide; 8-person lift; log roll; cervical spine

The annual incidence of spinal cord injury in the United States is approximately 11,000 cases.²⁷ Sports accidents account for approximately 7.4% of these and are the second most common cause in those younger than 30 years.²⁷ American football results in the largest number of these injuries in the United States. There are an average of 6 catastrophic spinal cord injuries each year from football.¹ Over an 11-year period, there were 14 spinal cord injuries in the National Football League alone.¹⁷

When a football player sustains a spinal cord injury, there exists a real risk of progressive neurologic deterioration after the initial injury. Once the patient comes under the care of medical personnel, this risk has been estimated to range from 1.8% to 10% in the hospital, and up to 25% at the scene of injury.^{13,20} Excessive spinal motion may lead to secondary neurologic deterioration and may be generated during management and transport. The ideal method of handling and immobilizing a player with football equipment in place continues to be debated.

To our knowledge, there has been no published study that investigates the effectiveness of different spine-boarding techniques in the football player in uniform with an unstable cervical spine. We sought to evaluate spinal

The Orthopaedic Journal of Sports Medicine, 3(9), 2325967115601853
DOI: 10.1177/2325967115601853
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motion generated during 3 spine-board transfer techniques in a cadaveric model with an unstable cervical spine injury and with the model wearing shoulder pads and a helmet. The null hypothesis was that there would be no difference between these 3 techniques.

METHODS

Five whole cadavers were lightly embalmed to maintain similar soft tissue characteristics to live subjects. There was no previous history of spine pathology. The mean (\pm SD) age of the specimens was 86.2 ± 11.4 years, mean height was 175.9 ± 10.2 cm, and mean weight was 84.7 ± 28.0 kg.

Cadavers were fitted for appropriately sized shoulder pads and helmets by an athletic trainer. Two fellowship-trained orthopaedic spine surgeons created and confirmed the unstable C5-C6 injuries. Transection of the supraspinous and interspinous ligaments, the ligamentum flavum, and the facet capsules was performed posteriorly. An anterior approach was then performed and the anterior longitudinal ligament, the intervertebral disc, and the posterior longitudinal ligament were transected to create global instability. Great care was taken to preserve anatomy and not disrupt any unnecessary tissue planes. Prior to creation of the injury, specimens were tested in the intact state and after injury creation to confirm the presence of an unstable injury. This testing was performed by applying Gardner-Wells tongs to the cranium and taking the cervical spine through a range of motion in all planes tested both before and after the creation of the instability.

Sensors were rigidly fixed to the C5 and C6 lamina using custom-made fiberglass mounting brackets and screws through the posterior incision. The relative angular (flexion-extension, lateral bending, and axial rotation) and linear motion (anterior posterior, axial, and medial-lateral translation) that occurred was measured as the cadavers were taken through range of motion using cranial tongs, as well as during testing. An electromagnetic motion analysis device (Liberty; Polhemus Inc) was used to assess the amount of motion occurring at the level of injury. The Liberty device uses electromagnetic fields to establish the 3-dimensional position and orientation of its sensors. The Liberty device detects angular motions with a precision of 0.3° within its optimal operating range of 10 to 70 cm. This technology has been used extensively in previous studies.^{2,3,5-11,14-16,21-26}

A group of medical staff consisting of orthopaedic spine surgeons, orthopaedic surgery residents, and certified



Figure 1. Log-roll technique.

athletic trainers performed each of the transfer methods. The same personnel and techniques were used throughout the study for consistency, and all participants were previously trained and proficient with the techniques. Appropriately sized shoulder pads and helmets were in place during all trials. Three different spine-boarding techniques were evaluated: the log roll (LR), the lift and slide (LS), and the 8-person lift (EPL). All techniques required 1 person at the head to provide in-line manual stabilization of the cervical spine by holding the football helmet.

The LR technique required 1 person to hold the head, 1 person each to assist in rolling the upper torso, pelvis, and lower extremities, and a fifth person to position the spine board beneath the patient. After the board was in place, the cadaver was rolled back into the supine position onto the spine board and centered (Figure 1). The LS technique employed a head-holder and 3 more people to straddle and lift the patient (at the upper torso, pelvic, and lower extremities). The fifth member of the LS team slid the spine board under the cadaver, and the cadaver was carefully lowered onto the board (Figure 2). The EPL technique involved 3 pairs of people on each side of the upper torso, pelvis, and lower extremities lifting in unison. The same head-holder provided manual in-line stabilization of the head and C-spine. The seventh person stabilized the cervical spine as the eighth person slid the board under the cadaver, and the team then lowered it onto the board in unison (Figure 3).⁸

A repeated-measures analysis of variance statistical analysis was performed to evaluate instability at the injured level during the 3 spine-boarding techniques

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One or more of the authors has declared the following potential conflict of interest or source of funding: The study was funded in part by the Southwest Foundation and the National Operating Committee on Standards for Athletic Equipment (NOCSAE).



Figure 2. Lift-and-slide technique.



Figure 3. Eight-person lift technique.

using SPSS software (SPSS Inc). Three repetitions were performed using each of the 3 techniques according to randomization with each of the 5 cadavers. The recorded displacements were then compared.

RESULTS

There was more motion in all planes at C5-C6 after creation of the injury as compared with the intact state (Figures 4 and 5). The EPL resulted in less angular and linear motion as compared with both other techniques in all planes. With the numbers available, this was statistically significant compared with the LR for lateral bending motion ($P = .031$) and medial-lateral translation ($P = .030$). The LS maneuver, when compared with the LR, was significantly more effective at stabilizing angular motion in axial rotation ($P = .029$) and lateral bending ($P = .006$) (Figures 6 and 7).

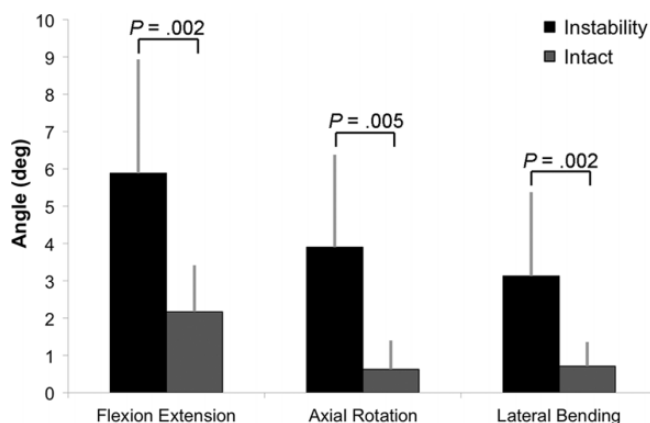


Figure 4. Angular motion at C5-C6 before and after the creation of instability.

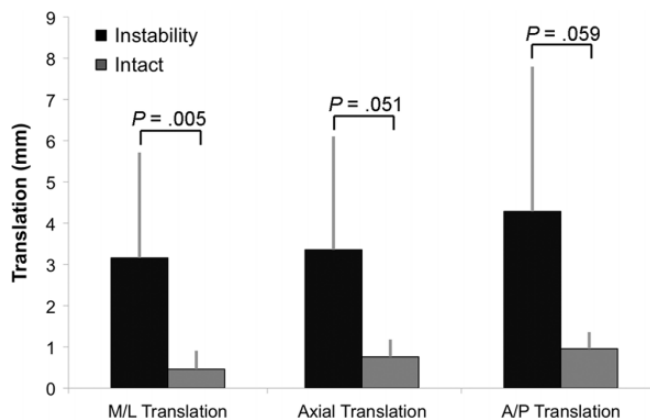


Figure 5. Translation at C5-C6 before and after the creation of instability. A/P, anterior-posterior; M/L, medial-lateral.

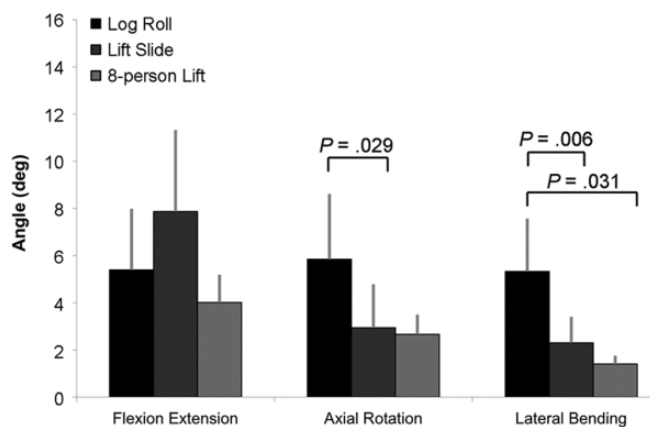


Figure 6. Comparison of angular motion at C5-C6 with the 3 spine-boarding techniques.

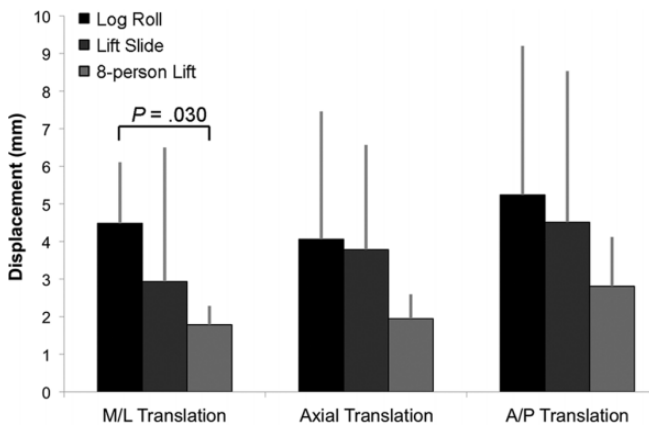


Figure 7. Comparison of translation at C5-C6 with the 3 spine-boarding techniques. A/P, anterior-posterior; M/L, medial-lateral.

DISCUSSION

We sought to determine the safest method of spine boarding the cervical spine in an injured football player with protective equipment in place. Shoulder pads and football helmets complicate early care of such a patient by altering spinal alignment, impeding access, and making transfers more difficult. As per the National Athletic Trainers' Association position statement, football equipment should be left in place, other than face mask removal for access to the airway, until arrival at the emergency room.²⁸

In the present study, the EPL technique proved superior to the LR technique at immobilizing the unstable cervical spine when performing spine boarding with protective football equipment in place. There was less angular and linear displacement in all planes with the EPL versus the LR, and this reached statistical significance for lateral bending and medial-lateral translation. The LS tended to result in less motion than the LR as well, but it was not as effective as the EPL. This was statistically significant for axial rotation and lateral bending when comparing the LS with the LR.

Our group has previously evaluated various spine-boarding transfer techniques.^{6-9,14,23,24} Results of these studies support our current findings and suggest that the lifting techniques may be a better alternative to the LR. Del Rossi et al⁷ specifically looked at these 3 methods of spine boarding and found less motion with the use of lifting techniques as compared with the LR. In a later study examining typical movements and transfers of a trauma patient, in addition to spine boarding, it was again shown that the LR results in additional motion at an unstable cervical spine injury.²³ These studies did not evaluate the maneuvers with protective football equipment in place. Dealing with such a situation requires proper training and possibly alternative techniques.²⁸

Other studies and groups have called into question the use of the LR maneuver.^{4,18,19,29} McGuire et al¹⁹ radiographically evaluated the LR transfer maneuver in a normal human subject, in a cadaver with an unstable thoracolumbar injury, and in an acutely injured patient

with a T12-L1 fracture dislocation. They demonstrated angular motion of up to 10° and translational movement of up to 7 mm in the unstable segment during this transfer technique. Additionally, a case report and cadaver study by the same group indicated that the LR maneuver resulted in significant anteroposterior and rotational displacement in a cadaver with an unstable L1-L2 spinal segment.¹⁸

Several limitations of the study must be acknowledged. The use of cadavers and in vitro testing is an obvious weakness. The use of a single level of injury can be considered a further weakness of the model, although it has been shown that C5-C6 is the most common site of an unstable injury in the cervical spine.¹² Finally, the current study is neither able to demonstrate the amount of spinal motion necessary to invoke secondary neurological injury nor determine what plane of motion is most detrimental. Even so, it is a well-accepted tenet that spinal motion must be minimized as much as possible in the setting of a cervical spine injury.

Facing the potential for permanent injury to the young patient, the cost to the family and society, and an aggressive medicolegal environment, it is essential that we adhere to strict principles of spinal immobilization when dealing with players who may have cervical spine injuries. Based on the results of the current study, we advocate the use of the EPL technique when spine boarding an injured football player. In addition, there may be benefit of using the LS over the LR technique if there are not an adequate number of trained personnel on the field to perform an EPL. It is important that sports medicine staff be educated and proficient with all techniques, as various clinical scenarios may arise.

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