Comparison of the Ferno Scoop Stretcher with the Long Backboard for Spinal Immobilization

Julie M. Krell, MD, Matthew S. McCoy, MD, Patrick J. Sparto, PhD, PT,
Gretchen L. Fisher, NEMT-P, Walt A. Stoy, PhD, David P. Hostler, PhD

ABSTRACT

Objectives. Spinal immobilization is essential in reducing risk of further spinal injuries in trauma patients. The authors compared the traditional long backboard (LBB) with the Ferno Scoop Stretcher (FSS) (Model 65-EXL). They hypothesized no difference in movement during application and immobilization between the FSS and the LBB. Methods. Thirty-one adult subjects had electromagnetic sensors secured over the nasion (forehead) and the C3 and T12 spinous processes and were placed in a rigid cervical collar, with movement recorded by a goniometer (a motion analysis system). Subjects were tested on both the FSS and the LBB. The sagittal flexion, lateral flexion, and axial rotation were recorded during each of four phases: 1) baseline, 2) application (logroll onto the LBB or placement of the FSS around the patient), 3) secured logroll, and 4) lifting. Comfort and perceived security also were assessed on a visual analog scale. Results. There was approximately 6–8 degrees greater motion in the sagittal, lateral, and axial planes during the application of the LBB compared with the FSS (both p < 0.001). No difference was found during a secured logroll maneuver. The FSS induced more sagittal flexion during the lift than the LBB (p < 0.001). The FSS demonstrated superior comfort and perceived security. Conclusion. The FSS caused significantly less movement on application and increased comfort levels. Decreased movement using the FSS may reduce the risk of further spinal cord injury. Key words: spinal immobilization; scoop; backboard; prehospital; goniometer; stretcher.

PREHOSPITAL EMERGENCY CARE 2006;10:46–51

Spinal immobilization, an integral part of prehospital management of trauma patients, is traditionally accomplished by using a cervical collar and long backboard (LBB). Its widespread use makes the LBB the de facto standard of care. However, the acceptable amount of movement associated with patient immobilization on an LBB remains unknown. In spite of this gap in knowledge, immobilization devices developed since the LBB have been compared with the LBB as the "gold standard."[1-16]

The traditional scoop stretcher consists of two interlocking aluminum pieces and is used to transfer minimally injured patients and to move patients out of restricted areas. The inherent flexibility of the traditional scoop stretcher is assumed to allow more movement of the spine than the LBB and it is not used for spinal immobilization. Newer designs of the scoop stretcher use a more rigid design and construction, theoretically decreasing spinal motion.[17] These devices may offer an alternative means for transfer and transport of the trauma patient, with the advantage of more practical use in enclosed spaces and possibly increased comfort.

We examined potential differences in spinal movement while subjects were being placed onto and being moved while secured to the LBB and a commercially available scoop stretcher. We hypothesized that the scoop stretcher would be as effective in spinal immobilization as the LBB.

METHODS

In this study, we evaluated the movement the of spine during immobilization and lifting between the Ferno Scoop Stretcher Model 65-EXL (FSS) (Ferno-Washington, Inc., Wilmington, OH) and the LBB (Millennia, Ferno-Washington, Inc.). We also evaluated each device for comfort and sense of security.

Selection of Participants

We recruited participants from the prehospital and residency training programs. The participants all were well trained in the standard of care of application of patients to backboards and logrolling maneuvers and use these skills in their daily jobs. Thirty-one subjects (seven female) volunteered for the study after providing informed consent. All subjects were sober and had no prior spine disorders or arthritis. The subject demographics are listed in Table 1. This study was approved by the institutional review board at the University of Pittsburgh, Pittsburgh, Pennsylvania.

TABLE 1. Subject Demographic Information

	Mean	SD	Range
Age (years)	26	7	18–47
Height (cm)	175	10	155–196
Mass (kg)	79	18	48–121

SD = standard deviation.

Study Design and Setting

The subjects participated in a human motion analysis laboratory. We used electromagnetic-based motion sensors (Motion Monitor, Innovative Sports Training, Chicago, IL) to measure the movement of the spine and a subjective survey to evaluate the comfort and sense of security of the patients on each device. The subjects participated both as "patients" and as "providers." In order to decrease variability, the principal investigators secured the participants to the devices with quick straps. A primary investigator was present for all testing phases. The participants were not informed of our hypothesis; however, true blinding of the study objectives was impossible.

Funding

This study was funded by a grant from Ferno-Washington, Inc., who supplied the LBB, the FSS, and the rigid Wiz Loc cervical collar. We agreed, prior to initiation of the study, that the results would be submitted for publication, regardless of the findings. To reduce bias in the visual analog scale (VAS) scores, the participants did not know that their honoraria for the study came from Ferno.

Methods of Measurement

Prior to testing, we secured the electromagnetic sensors over the following body landmarks using adhesive tape and elastic straps: the nasion (forehead) and the C3 and T12 spinous processes. In addition, we secured a rigid cervical collar to the subjects. The cervical collar did not touch the sensor at C3. We attempted to place another sensor over the L3 spinous process but observed too much extraneous movement during application of the FSS and LBB, as well as during subsequent maneuvers; therefore, we did not examine these data further. For each method, there were four phases of measurement testing: 1) a 10-second baseline in which subjects lay still while supine on the ground, off of the device 2) application of the immobilization device while subjects lay supine; 3) a 90-degree logroll while subjects were secured to the device; and 4) lifting the secured subjects to a height of 1 meter. We applied the LBB by logrolling the subject 90 degrees, placing the LBB underneath the subject, logrolling back to supine, and performing a "Z-maneuver" (see Figure 1) to center the subject on

Application of Long Backboard
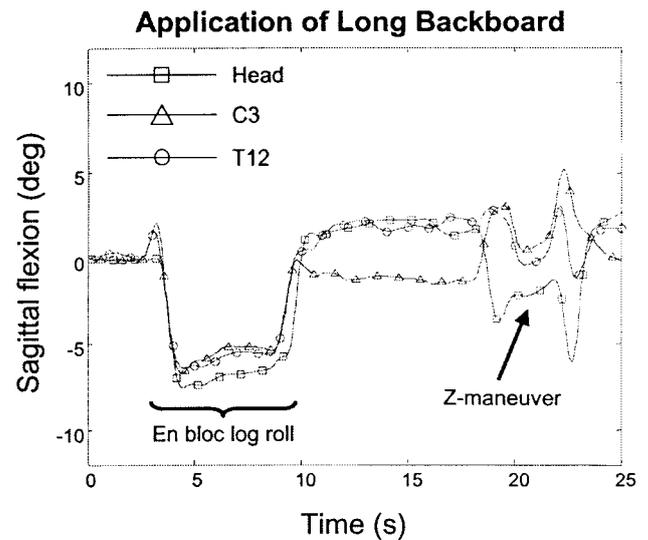
FIGURE 1. Sagittal flexion range of motion during application of the long backboard for one representative subject. Movements are displayed for all three sensors. During the initial 10 seconds, the logroll was performed. At the same time, the entire upper body was pitched forward, indicated by en bloc movement. After 10 seconds, sensors moved individually during the Z-maneuver. _Z-maneuver:_ Patients are logrolled onto a long backboard (LBB) with the assistance of four people: one at the head, two rolling the body, maintaining alignment, and one pushing the LBB under the patient while he or she is logrolled at 90 degrees. The patient is then rolled back supine with the board under him or her but off-center. Two people then stand over the patient straddling the board, while a third holds the head of the patient. The patient is moved in a caudal direction on the board, maintaining alignment. The patient is then moved cranially and diagonally, continuously maintaining spinal alignment, until the patient is aligned in the center of the board. s = seconds; deg = degrees of movement; Head = sensor over the nasion; C3 = sensor over the third cervical vertebra posteriorly; T12 = sensor over the 12th thoracic vertebra posteriorly.

the LBB while maintaining spinal alignment. We applied the FSS by sliding the two longitudinal halves underneath the subjects as they lay supine, and locking the halves at the head and foot of the stretcher. Between phases 2 and 3, we secured the subjects to the devices by using a head immobilizer and three quick straps. The four phases were performed consecutively for each device, and the order of presentation of the devices was randomly assigned. Although not measured directly, all operators involved in the study were proficient with the FSS use after one or two tries. This involved the participants' latching and unlatching the FSS prior to having a subject on it. The latching device is similar to that of other devices with which the participants were familiar.

Data Collection and Processing

During each testing phase, we sampled position and direction-cosines orientation data for each sensor at 20 Hz and stored the data on a computer. Using these time series, we computed the amount of sagittal flexion, lateral flexion, and axial rotation (Table 2) using the tilt/twist method of Crawford et al.referenced to

TABLE 2. Mean (Standard Deviation) Sagittal Flexion, Lateral Flexion, and Axial Rotation Range of Motion (Degrees) Measured during Movement of the Subjects on the Long Backboard (LBB) and the Ferno Scoop Stretcher (FSS)

	Nasion			C3 Spinous Process			T12 Spinous Process		
	LBB		FSS	LBB		FSS	LBB		FSS
Sagittal flexion									
Apply	9.5 (4.9)	*	1.8 (1.1)	10.4 (5.1)	*	3.0 (1.4)	12.0 (6.4)	*	4.0 (3.0)
Roll	4.2 (2.1)		4.0 (1.7)	3.5 (1.9)		4.4 (2.2)	5.8 (3.6)		5.7 (3.4)
Lift	3.5 (1.5)	*	4.7 (1.5)	3.3 (1.2)		4.0 (1.3)	2.9 (1.3)	*	5.6 (3.5)
Lateral flexion									
Apply	7.5 (3.7)	*	1.9 (1.3)	9.0 (4.6)	*	2.7 (1.7)	9.3 (4.5)	*	2.2 (1.1)
Roll	3.8 (1.3)		2.9 (1.4)	4.8 (1.6)		4.3 (2.1)	7.8 (3.9)		6.4 (3.3)
Lift	2.1 (0.7)		2.1 (0.9)	2.2 (0.9)		2.4 (1.2)	2.2 (1.2)		3.1 (1.4)
Axial rotation									
Apply	8.8 (4.8)	*	2.0 (1.5)	10.9 (5.4)	*	3.0 (2.0)	11.8 (7.8)		6.4 (4.7)
Lift	5.5 (3.4)		6.0 (3.5)	7.9 (4.7)		6.3 (3.4)	8.8 (4.9)		8.3 (5.0)

*Indicates significant effect with a $p < 0.002$.

the baseline position.[18] We calculated the range of motion for each sensor in each of the planes, taking care not to include periods of "en bloc" movement, i.e., movement of all the sensors as a rigid body. For example, Figure 1 shows the sagittal movement of the markers during the application of the LBB to one subject. During the initial 10 seconds, the subject was logrolled 90 degrees onto one side. During the logroll, the whole upper body was also pitched forward, indicated by the en bloc sagittal flexion of about 7 degrees. Data consisting of en bloc movement, indicating whole-body movement rather than segmental movement, were not included in the analysis. Continuing with the example in Figure 1, after about 15 seconds, the sensors moved individually, and the range during this time was computed.

The subjects completed two surveys on security and comfort using a 100-mm VAS. This scale has been used in similar studies to evaluate comfort. We collected the responses for sense of security immediately after we completed the movements of logrolling and lifting the subjects.

We administered the comfort surveys separately from the motion analysis testing. As patients spend much more time secured to the device during transport than briefly being placed onto the device, we separated the evaluations of these measurements. We randomly assigned the subjects to start on either the LBB or the FSS. We secured the subjects to each device, and placed them on a carpeted floor. They maintained this position for 20 minutes on each device to simulate time spent while on an ambulance gurney during transport. There was at least a one-hour delay between evaluations of devices in order to reduce bias. The subjective evaluation of comfort of each device was recorded on a 100-mm VAS immediately after the subject was removed from the device. Each subject served as his or her own control. The subjective comfort scale included overall comfort as well as specific comfort points of the occiput, thoracic spine, sacrum, and heels. Partici-

pants were asked to choose which device they preferred overall.

Primary Data Analysis

We tested whether the magnitude of the range of motion was influenced by immobilization device (LBB and FSS), phase of testing (application, logroll, and lift), and body segment (nasion, C3, and T12) using repeated-measures analysis of variance (ANOVA) A separate ANOVA model was considered for sagittal flexion, lateral flexion, and axial rotation. In the axial rotation case, the logroll phase was not examined because it was not possible to distinguish segmental axial rotation from whole-body axial rotation. The primary goal of the study was to examine whather there was a difference in the amount of movement induced by the LBB and FSS for each segment and phase of testing; consequently, we performed individual comparisons between the FSS and LBB for post-hoc testing. Using an experimentwise $\alpha = 0.05$ with a Bonferroni correction for multiple comparisons, the individual significance level was set at $\alpha = 0.002$.

We tested the effect of each device on the security scores during the logroll and lift maneuvers using paired t-tests. In addition, we tested the effect of each device on the comfort scores rated at the occiput, thoracic spine, sacrum, and heels using paired t-tests.

RESULTS

During baseline conditions, i.e., while the subjects lay quietly on the ground, range of motion was generally less than 1 degree. Application of the LBB and FSS to the subjects, and logrolling and lifting the subjects, resulted in greater motion in all planes. An example of movement in the sagittal and lateral planes during the application of the LBB and FSS is shown in Figure 2. This example demonstrates that there was greater movement in both planes during application of the LBB compared with application of the FSS.

Long Backboard
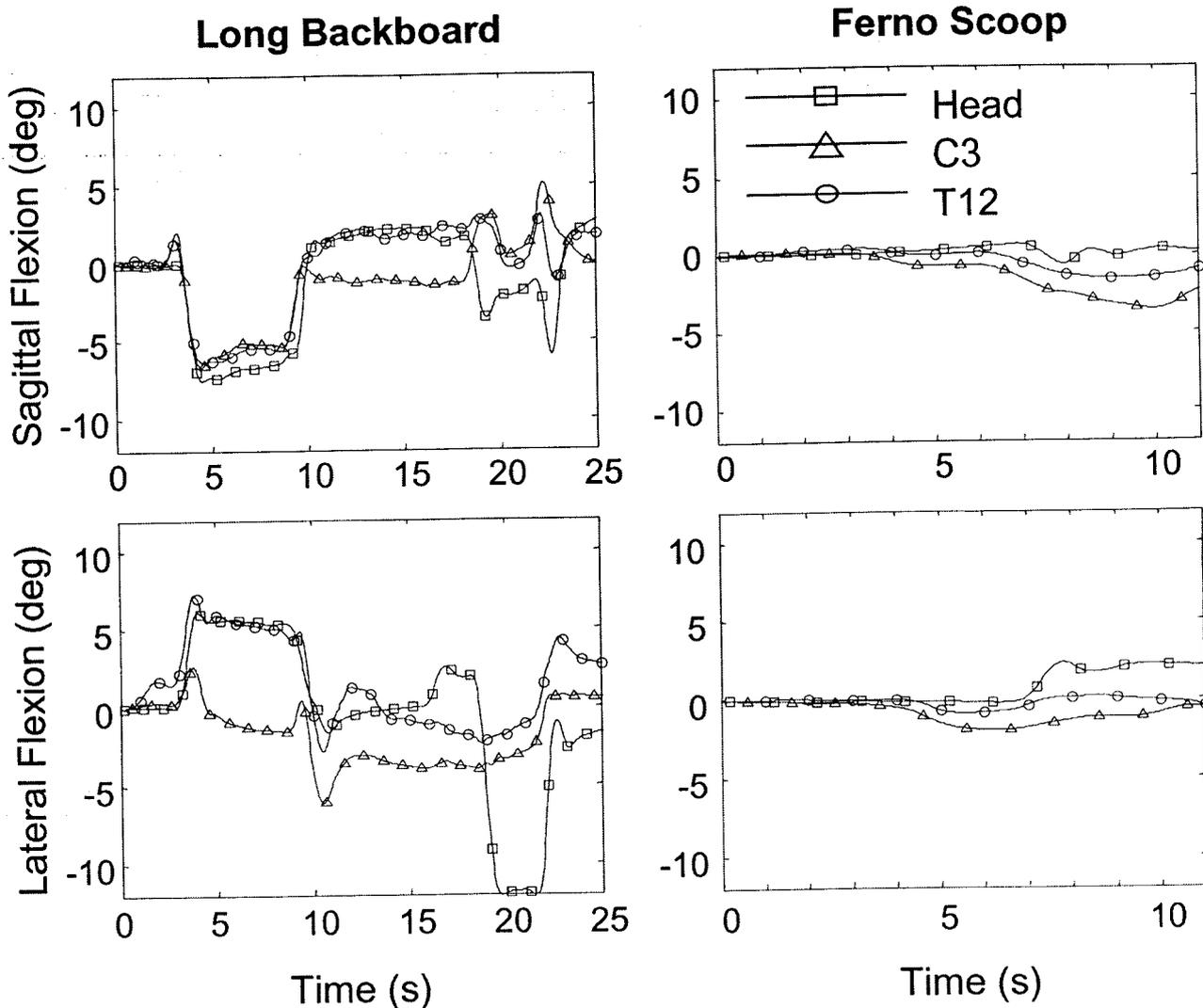
Ferno Scoop

FIGURE 2. Sagittal and lateral flexion of markers placed at the head, the third cervical vertebra, and the 12th thoracic vertebra during application of the long backboard (LBB) and the Ferno Scoop Stretcher (FSS) for one subject. In this example, application of the LBB and the FSS required approximately 25 seconds and 10 seconds, respectively.

We performed a repeated-measures ANOVA for each movement plane (sagittal flexion, lateral flexion, and axial rotation). All of the main effects (device, phase, and body segment) and the device-by-phase interaction were significant for all three planes of movement ($p < 0.001$). Considering the device-by-phase interaction, we found that the use of the LBB induced three to five times as much movement as with use of the FSS, primarily because of movement induced during application of the devices. There was approximately 6–8 degrees greater motion in the sagittal, lateral, and axial planes during the application of the LBB compared with the FSS. However, no differences were found between the LBB and FSS during the logrolling maneuver once the subjects were secured to the devices. Finally, lifting the subjects on the FSS resulted in greater sagittal flexion at the nasion and T12 (up to 2.7 degrees) than on the LBB. Another consistent finding was that the range of motion was significantly greater at T12 and C3 compared with the nasion, and at T12 compared with C3.

The security and comfort ratings are summarized in Table 3. We found that subjects felt more secure during the logroll maneuver while attached to the FSS. In addition, the comfort ratings at each of the body segments

TABLE 3. Mean (Standard Deviation) Security and Comfort Ratings* on the Long Backboard (LBB) and the Ferno Scoop Stretcher (FSS)

	LBB	FSS	p-value
Security			
Logroll	59 (21)	74 (13)	0.003[†]
Lift	79 (13)	79 (17)	1.000
Comfort			
Occiput	58 (27)	61 (31)	0.596
Thoracic spine	64 (18)	78 (17)	0.001[†]
Sacrum	40 (27)	72 (16)	< 0.001[†]
Heels	64 (29)	81 (15)	0.002[†]
Overall	58 (16)	75 (13)	< 0.001[†]

*Subjects rated scores on a 100-mm visual analog scale with 100 = "most secure" and "most comfortable."
[†] Statistically significant.

except the occiput were also greater after the subjects lay on the FSS compared with the LBB. The FSS was found to be more comfortable for 24 of 30 subjects.

DISCUSSION

Spinal immobilization is an integral part of the treatment of trauma patients in reducing the risk of worsening spinal injuries; however, the maximum allowable number of degrees of spinal movement needed to prevent spinal cord injury is unknown. The LBB is the gold standard against which all other devices are measured. Many studies evaluate different immobilization devices and their efficacy in immobilizing cervical spine injury, yet few look at complete spinal immobilization.[2-16,19-22] Because up to 10% of people with one vertebral fracture will have at least one other vertebral fracture,[23] we chose to evaluate movement in the entire spine. The LBB has been shown to minimize cervical spinal movement once the patient is secured to the device, but the logroll maneuver that is used to place patients onto the device may be detrimental.[5,8-10] A study by McGuire et al. showed 2.1 cm of lateral movement in the cadaveric lumbar spine during a logroll on an unstable spinal injury that completely occluded the spinal canal.[22] Although few immobilized patients actually sustain severe injuries, they would benefit most from reduced movement.

The FSS, a stretcher made with two interlocking pieces, has been used for movement of minimally injured and medical patients.[17] More recently developed scoop stretchers have a much more rigid design than the older metal scoop stretchers, potentially providing more stability and less flexibility. Patients are secured to the FSS without being logrolled; the device is placed around the patient rather than rolling the patient onto the device. We hypothesized that the FSS would be no different in immobilizing patients than the LBB. A secondary goal was to determine on which device the subjects would feel more comfortable and secure.

We demonstrated that the FSS is as effective in stabilizing the spine once attached to the board as is the gold standard of the LBB but, more importantly, demonstrated 6–8 degrees less movement in all planes of motion during the application of the FSS vs. the LBB. Five degrees of movement has been used in other studies as a safe amount of movement. During the logroll, the two devices performed equally well. There was less than 5 degrees of movement during the secured logroll and lift on both the LBB and the FSS. The FSS induced 1.2–2.7 degrees of extra sagittal flexion during the lift, indicating that the FSS may bow during this maneuver. It is not certain whether this amount is clinically significant. Future outcome studies would be needed to evaluate this further. The FSS was found to be more comfortable that the LBB, and the subjects felt equally secure on the two devices.

All operators involved in the study were proficient with the FSS use after one or two tries. Proficiency of a prehospital service can be easily accomplished in a short training session. The FSS is curved slightly, so it may not be as easy to use for extrication of patients from vehicles, but this needs to be investigated further.

The benefit of the FSS was exemplified in the elimination of two logroll maneuvers, during application to and removal from the board. Increased comfort can increase the safety of patients because they are less likely to move around on the board to find a more comfortable position. The FSS can offer additional benefit to patients in confined areas. Often patients are moved out of a confined area without adequate immobilization to a place where they can be placed on an LBB. The FSS design allows for separation of the pieces to be placed around the patient in the position in which he or she is found, decreasing excess movement while unsecured. Although the FSS costs about three times as much as a longboard, the benefits may outweigh the price difference.

LIMITATIONS

Limitations of our study included the use of sober, young, healthy adult volunteers with no prior back problems or significant arthritis in a controlled setting. The subjects were asked to lie still for this study and were cooperative. Frightened or intoxicated trauma patients may try to move about while secured. Another limitation is that the sensors may have moved slightly on the skin during some of the maneuvers. However, the use of the goniometer has been compared with and found to be as accurate as spinal movement evaluation with x-rays, and it eliminates the radiation exposure required with x-ray evaluation.[3]

An additional limitation is that the comfort phase of the FSS evaluation was done on the ground instead of on a mattress or gurney, which would have been more realistic. Therefore, the comfort scores might have been higher with cushioning under the spine. There was some pinching of the skin and hair when applying the FSS, but the FSS was still rated as more comfortable than the LBB (75 vs. 58 on a VAS with 100 as "most comfortable").

These findings need to be tested on a larger scale to evaluate clinical significance. A randomized study needs to be done that randomizes LBB and FSS in the field on actual patients with spinal injuries and follows their outcomes.

CONCLUSION

For immobilization of the spine, the Ferno Scoop Stretcher (FSS) was found to be as effective as, if not superior to, the standard of care, a rigid long backboard (LBB). The FSS was found to decrease movement on

application and increase comfort. Patients felt equally safe and secure on the two devices. Decreased movement of the spine in patients secured on the FSS may further reduce the risk of worsening spinal cord injury. Improving comfort while maintaining safety may augment the patient's overall experience during an otherwise traumatic event.

References

1. Baron BJ, Scalea TM. Spinal cord injuries. In: Tintinalli JE, Kelen GD, Stapezynski JS (eds). Emergency Medicine: A Comprehensive Study Guide, Fifth Ed. New York: McGraw Hill, 2000, p 1654.

2. Chandler DR, Nemejc C, Adkins RH, Waters RL. Emergency cervical spine immobilization. Ann Emerg Med. 1992;21:1185–8.

3. DeLorenzo RA. A review of spinal immobilization techniques. J Emerg Med. 1996;14:603–13.

4. DeLorenzo RA, Olson JE, Boska M, et al. Optimal positioning for cervical immobilization. Ann Emerg Med. 1996;28:301–8.

5. Hamilton RS, Pons PT. The efficacy and comfort of full-body vacuum splints for cervical-spine immobilization. J Emerg Med. 1996;14:553–9.

6. Hauswald M, Ong G, Tandberg D, Omar Z. Out-of-hospital spinal immobilization: its effect on neurologic injury. Acad Emerg Med. 1998;5:214–9.

7. Ivy ME, Cohn SM. Addressing the myths of cervical spine management. Am J Emerg Med. 1997;15:591–5.

8. Johnson DR, Hauswald M, Schokhoff C. Comparison of a vacuum splint device to a rigid backboard for spinal immobilization. Am J Emerg Med. 1996;4:369–72.

9. Lovell ME, Evans JH. A comparison of the spinal board and the vacuum stretcher, spinal stability and interface pressure. Injury. 1994;25:179–80.

10. March J, Ausband S, Brown L. How flexible are those backboards? [abstract]. Ann Emerg Med. 1997;30:405.

11. Podolsky S, Baraff LJ, Simon RR, Hoffman JR, Larmon B, Albon W. Efficacy of cervical spine immobilization methods. J Trauma. 1983;23:461–5.

12. Ralston ME, Chung K, Barnes PD, Emans JB, Schutzman SA. Role of flexion-extension radiographs in blunt pediatric cervical injury. Acad Emerg Med. 2001;8:237–45.

13. Rosen PB, McSwain NE, Arata M, Stahl S, Mercer D. Comparison of two new immobilization collars. Ann Emerg Med. 1992;21:1189–95.

14. Schriger DL. Immobilizing the cervical spine in trauma: should we seek an optimal position or an adequate one? Ann Emerg Med. 1996;28:351–3.

15. Schriger DL, Larmon B, LeGassick T, Blinman T. Spinal immobilization on a flat backboard: does it result in neutral position of the cervical spine? Ann Emerg Med. 1991;20:878–81.

16. Streger MR. Spinal immobilization. EMS. 2001;Mar:34.

17. Ferno Scoop EXL Stretcher Manual. Wilmington, OH: Ferno Washington, October 2000, Pub # 234-2125-01.

18. Crawford NR, Yamaguchi GT, Dickman CA. A new technique for determining 3-D joint angles: the tilt/twist method. Clin Biomech. 1999;14:153–63.

19. Chan D, Goldberg R, Tascone A, Harmon S, Chan L. The effect of spinal immobilization on healthy volunteers. Ann Emerg Med. 1994;23:48–51.

20. Hadley MN. Cervical spine immobilization before admission to the hospital. Neurosurgery. 2002;50(3 suppl):S7–S17.

21. Hadley MN. Transportation of patients with acute traumatic cervical spine injury. Neurosurgery. 2002;50(3 suppl):S18–S20.

22. McGuire RA, Neville S, Green BA, Watts C. Spinal instability and the log-rolling maneuver. J Trauma. 1987;27:525–31.

23. Advanced Trauma Life Support for Doctors. American College of Surgeons and Committee on Trauma, Chicago, IL, 1997, p 226.