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Comparison of Anterior and Posterior Approaches in Cervical Spinal Cord Injuries

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Summary: This study reports the results of 52 patients with unstable cervical spine injuries and associated spinal cord injuries randomized to either anterior or posterior stabilization and fusion. All patients had achieved reduction and had unstable injuries that were thought to require surgical stabilization. Patients requiring a specific approach for either reduction or decompression were not included. Frankel grades and ASIA motor index scores were followed in each patient as well as fusion status, changes in alignment, and pain at final follow-up. Neurologic improvement was noted in each group with no significant differences. In the anterior group, 70% improved at least 1 Frankel grade and 57% improved 1 Frankel grade in the posterior group. There were two nonunions in the anterior group (90% fusion) and none in the posterior group (100% fusion), although this was not statistically different. Seven patients in each group complained of pain at the final follow-up. There were no significant differences in fusion rates, alignment, neurologic recovery, or long-term complaints of pain in patients treated with either anterior or posterior fusion and instrumentation. **Key Words:** Cervical spine injuries—Fusion—Instrumentation—Spinal cord injury.

INTRODUCTION

Trauma to the cervical spine with associated spinal cord injury (whether complete or incomplete) is a devastating injury. Patients with this injury generally have two interrelated problems that need to be addressed immediately: that of ongoing neurologic injury by continued compression and that of instability that prevents mobilization and rehabilitation and may interfere with the management of coexisting problems.

Initial management includes decompression of the neural elements. This is best accomplished by traction, generally using tongs, and may aid in neurologic recovery (1–3). Those cases in which fracture reduction is not achieved and ongoing compression exists may be considered for emergent surgical reduction by whatever approach is required. If adequate decompression is achieved by closed means, surgery is indicated to restore segmental stability and allow early mobilization of the patient. This will aid in the recovery of other injuries and speed rehabilitation (4,5).

Operative treatment of the patient with an unstable cervical spine has undergone many advances, including the use of instrumentation to impart immediate stability and maintain alignment to promote fusion. Anterior cervical plating is now common. Posterior lateral mass screw and plate or rod constructs have gained significant popularity and are shown in *in vitro* studies to be biomechanically superior to other techniques (6,7).

The prime objective, no matter what instrumentation system is chosen, is to gain stability ultimately through fusion.

There is no clear evidence that favors the anterior or

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posterior approach in treating patients with cervical spinal cord injuries and unstable cervical spines. There is appeal, though for different reasons, to both the anterior and posterior approaches to gain stability and perform a fusion. Anteriorly there is less muscle splitting and an easier dissection. Some say it is therefore better tolerated by the patient postoperatively. The anterior column can be reconstructed directly. Also, the approach and anatomy are well known to most cervical spine surgeons. Biomechanical strength, in the laboratory, favors the posterior approach and ensures anatomic reduction of the facet joints.

Often the decision to approach from anteriorly or posteriorly is clear-cut and based on the pathology present. The authors' approach to this decision is based on the location of neurologic compression. If there is a disc herniation, in general, an anterior approach is required to adequately decompress the spinal cord. Dislocated facets, which cannot be reduced by closed means, may require a posterior approach for open reduction. Burst fractures often require anterior decompression. Ligamentous instability can be treated by either approach.

Occasionally, unstable cervical spine injuries do not require a specific approach, such as dislocated facets reduced by closed means or burst fractures, which do not require operative decompression. It then becomes the surgeon's choice as to which approach to use. There is little in the literature, to date, to guide the surgeon in making this decision. This study tests the null hypothesis that there is no difference in outcomes in patients who have reduced unstable cervical spine fractures treated by posterior lateral mass plating or anterior plate fixation.

MATERIALS AND METHODS

Fifty-two consecutive patients with spinal cord injuries and cervical spine instability were randomized to either anterior or posterior stabilization and fusion. All patients were cared for by both the Neurosurgical team and the Orthopaedic spine team and were randomized by the day of admission and, therefore, the neurosurgeon on call. The same Orthopaedic service took care of all patients in both groups. Inclusion criteria included unstable cervical injuries between C3 and C7, complete or incomplete spinal cord injuries, and minimum 6-month postoperative follow-up. Exclusion criteria included patients requiring a specific approach for reduction or decompression and patients with radiculopathies only or neurologically intact patients. All patients that met the inclusion criteria and did not meet the exclusion criteria were included in this study.

The patients were first seen and treated in the emergency department. Standard resuscitation techniques were followed according to ACLS guidelines. The standard methylprednisolone bolus and drip were given per protocol (NASIS II) (8). Gardner-Wells tong traction was started at 10 pounds, increasing as required under radiographic control. Following adequate reduction, with decompression of the neurologic elements, the patients were then randomized to anterior or posterior surgery based on the day of admission and the neurosurgical attending on call. The anterior procedure was performed under tong traction. A standard left-sided transverse incision was used. A discectomy or corpectomy was performed, as required, and an autologous tricortical iliac crest graft harvested for fusion. An anterior cervical locking plate (Synthes, Paoli, PA) was then placed (Fig. 1). The posterior procedure was performed with the patient prone on a turning frame under tong traction. A standard midline posterior incision was made, and a posterior fusion was performed with iliac crest cancellous autograft and lateral mass screws and plates (Synthes) as described by Anderson et al. (7) (Fig. 2).

Postoperatively, patients in both groups were placed in Minerva braces or Miami J collars for 8–10 weeks. Patients were mobilized as soon as tolerated and transferred for spinal cord injury rehabilitation as their other medical conditions allowed.

The two treatment groups, group A (anterior approach) and group B (posterior approach), were independently reviewed (D.S.B.) and statistically compared using the Student *t* test and χ^2 analysis. The patients were assessed by changes in ASIA motor score and Frankel level and presence or absence of cervical pain (9–11). Preoperative, immediate postoperative and follow-up radiographs were assessed for kyphotic angulation across the injury site using the Cobb technique and anterior–posterior displacement of the vertebral body. Radiographic fusion was determined by confirmation of crossing trabecular bone seen on radiographs, no lucencies noted, and no motion seen on flexion–extension films. This was evaluated by measuring the distance between spinous process tips on flexion–extension radiographs as described by Bohlman et al. (12). Greater than 1 mm spread indicated nonunion.

RESULTS

There were 52 patients included in the study: 22 were treated with anterior surgery and 30 with posterior surgery. Two patients in the anterior group died of other injuries in the early postoperative period, and three patients in the posterior group had <6 months of follow-up. These patients were not included in the analysis.

Forty-seven patients were included in the final analysis: 20 in the anterior group and 27 in the posterior group (Table 1). There were no statistically significant differences between the two groups in age, sex, mechanism of injury, or time to surgery. Of these 47 patients, the diag-

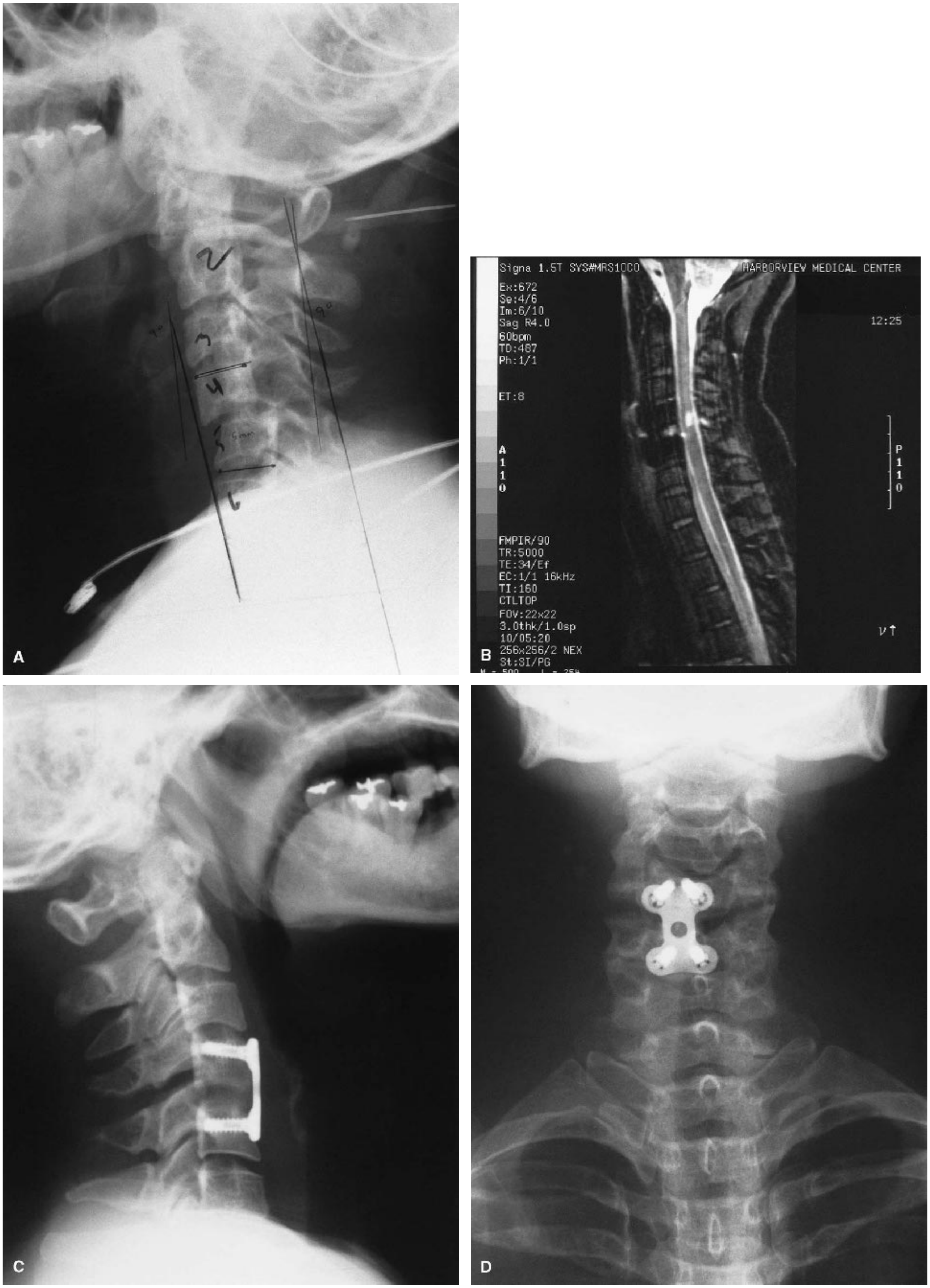

FIG. 1. Lateral radiograph (**A**) and postoperative MRI (**B**) of a 45-year-old woman with a C4–C5 bilateral facet dislocation and complete spinal cord injury. Following reduction, she was treated with an anterior fusion and instrumentation (**C** and **D**).

FIG. 2. Lateral radiograph (**A**) and axial CT (**B**) of a 38-year-old man in a motor vehicle accident with a C5 burst fracture and incomplete paraplegia. Following reduction by traction, he was treated by posterior fusion with lateral mass instrumentation (**C** and **D**).

TABLE 1. *Demographics*

	Anterior group	Posterior group
Number	20	27
Age (yr)	38	33
Gender		
Male	15	22
Female	5	5
Mechanism of Injury		
MVA	11	21
Fall	6	5
Diving	3	0
Assault	0	1
Diagnosis		
Burst fracture	4	3
Facet dislocation	6	18
Burst + facet dislocation	8	4
Flexion/compression + facet dislocation	1	2
Extension/distraction	1	0
Neurologic status		
Frankel Score preoperative	2.2	2.3
ASIA Motor Index preoperative	43	40
% complete spinal cord injury	50	59

MVA, motor vehicle accident.

nosis in 24 patients was bilateral facet fracture and/or dislocation (6 anterior, 18 posterior). Twelve patients had a burst fracture with bilateral facet disruption (8 anterior, 4 posterior). Seven patients had only burst fractures (4 anterior, 3 posterior). Three patients had flexion injuries with facet disruption (1 anterior, 2 posterior). One patient had an unstable extension injury, randomized to the anterior group. There were no differences between the groups in the initial neurologic state as measured by Frankel grade, percent of complete patients, and ASIA motor score. Similarly, there was no difference in the number of fused levels, with 1.7 average levels fused in the anterior group and 1.8 levels in posterior group. No difference was present in length of follow-up.

Neurologic Outcome

Patients were given a Frankel score and an ASIA motor index score based on their sensory and motor examination at the time of injury and at the final follow-up. The Frankel grade (A–D) was converted to a numeric score (1–4). The average Frankel score at the time of injury in the anterior group was 2.2, increasing to 3.1 at the final follow-up (Table 2). Included as a Frankel score of 1 (Frankel A) were all patients in both treatment groups with no motor or sensory function below the level of the injury, although this may have included some patients in spinal shock that may have been incomplete cord injuries. Seventy percent improved at least 1 grade. In the posterior group, the Frankel score improved from 2.3 to 2.9, with 57% improving at least 1 grade. There was no statistically significant difference in improvement between the groups ($p = 0.63$). The ASIA motor index score increased from 43 to 64 in the anterior group and 40 to 54 in the posterior group ($p = 0.54$). Ten of the 20 patients (50%) in the anterior group had complete spinal cord injuries (Frankel A) preoperatively, dropping to 6 (30%) postoperatively (Table 3). In the posterior group, 16 of the 27 patients (59%) were complete preoperatively, dropping to 10 (37%) postoperatively (Table 4). Again, there was no statistically significant difference.

TABLE 2. *Neurologic outcome*

	Anterior group	Posterior group	Significance
Frankel Score			
Preoperative	2.2	2.3	
Follow-up	3.1	2.9	
Change	0.9	0.6	NS
	70% improved 1 level	57% improved 1 level	
ASIA Motor Index			
Preoperative	43	40	
Follow-up	64	54	
Change	21	14	NS
% complete			
Preoperative	50	59	
Follow-up	30	37	
Change	20	22	NS

NS, not significant.

Fusion Status

All 27 patients in the posterior group fused (100%), whereas 18 of 20 patients in the anterior group fused (90%) (Table 5). This was not statistically significant ($p = 0.14$). Preoperative kyphosis in the anterior group averaged 6°, improving to 2° lordosis at follow-up. Posteriorly the angular deformity improved from 7° kyphosis to 1° lordosis. Thus, both groups improved an average of 8°. Translation improved from 3-mm anterolisthesis to neutral in the anterior group and 4-mm anterolisthesis to neutral in the posterior group. There were again no significant differences in improved alignment or loss of correction between groups.

TABLE 3. *Frankel grades: anterior group*[a]

	Postoperative				
Preoperative	A	B	C	D	E
A	6	3		1	
B			1		1
C				3	
D					5
E					

[a]Change in Frankel Grade, preoperative to postoperative.

TABLE 4. *Frankel grades: posterior group*[a]

	Postoperative				
Preoperative	A	B	C	D	E
A	10	6			
B					
C					
D				2	9
E					

[a]Change in Frankel Grade, preoperative to postoperative.

Postoperative Pain and Complications

There were no significant differences in the number of complications between the anterior and posterior groups. In the anterior group, one patient developed pneumonia, one patient developed adult respiratory distress syndrome, and there was one instrumentation failure. There were also two patient deaths of unrelated causes. In the posterior group, there were two patients that developed pneumonia and one instrumentation failure, although this patient did go on to fuse. There were seven patients in each group who reported neck pain at final follow-up.

DISCUSSION

Operative stabilization of the cervical spine has evolved significantly over the last 40 years since Robinson and Smith first described their approach and procedure for an anterior discectomy and fusion (13). Anterior plates with fixed angle unicortical screws have met with great success, replacing bicortical screw plate systems because of ease of use and similar stability (6,14–16). They restore normal or supernormal stiffness in flexion, extension, rotation, and axial loading. Posterior cervical fixation with lateral mass screws and plates or rods is newer (7). In biomechanical *ex vivo* studies, they seem to provide increased stiffness in flexion, extension, and rotation as compared with anterior plates (6,15). There has been little clinical experience for correlation.

There is great debate as to the merits of treating an unstable cervical spine from either an anterior or posterior approach. Clearly, if ventral spinal cord decompression is required due to disc protrusion or vertebral body fragments displaced into the spinal canal, the anterior approach is chosen. Likewise, if a facet dislocation with or without fracture is irreducible by closed means, many surgeons will approach from posterior unless a disc herniation is present. When neither approach is deemed necessary, that is to say, when the spine has been realigned through closed reduction and an indirect decompression of the neural elements achieved, the literature is sparse in providing guidance for this decision. Some surgeons state emphatically that the anterior approach should be chosen as patients tolerate the procedure better and neurologic outcome is improved. Others state that, based on the biomechanical studies, the posterior approach should be chosen to ensure increased stability. Finally, there are yet other surgeons that recommend anterior and posterior stabilization, not trusting either by itself. This study was designed to evaluate the differences in patient outcomes based solely on the approach chosen.

All patients in this study had spinal cord injuries and unstable cervical spines requiring surgical stabilization, but none required a specific approach for decompression or reduction. All facet dislocations were reduced by closed means with Gardner-Wells tong traction, and all burst fractures were reduced with spinal canal decompression gained by tong traction as well. Those patients that did not gain adequate reduction/decompression were not included in this study. The patients were followed for a minimum of 6 months; the anterior group averaged 17 months and the posterior group averaged 14 months. The groups were similar in age, gender, mechanism of injury, type of injury, and degree of spinal cord injury, with 50% of the anterior group and 57% of the posterior group having Frankel grade A at the time of injury. There were no differences in the number of levels fused.

One important difference in the groups, and therefore possible criticism of the study, is that the anterior group averaged 10 days from injury to surgery while the posterior group averaged 5 days. This probably did not have an effect on neurologic outcome, largely because all patients were immediately reduced in the emergency department at the time of injury; thus, only the stabilization was delayed. A separate investigation was made on the outcome of patients that were treated at $\leq$5 days from injury (50% anterior, 70% posterior) and those stabilized at >5 days from injury (50% anterior, 30% posterior). There was no difference in neurologic outcome either by Frankel score or ASIA motor index score ($p > 0.50$).

There were no differences in neurologic outcomes either by Frankel score or ASIA motor index score between those patients treated anteriorly and those patients treated posteriorly. Fusion status was not statistically different

TABLE 5. *Radiographic outcome*

	Anterior group	Posterior group	Significance
Kyphosis (°)			
Preoperative	6	7	
Follow-up	−2	−1	
Change	−8	−8	NS
Translation (mm)			
Preoperative	3	4	
Follow-up	0	0	
Change	−3	−4	NS
Nonunion (no.)	2	0	NS

either; 90% fused anteriorly and 100% fused posteriorly. Fusion assessment, by presence of crossing trabeculation and no spinous process motion on flexion and extension radiographs, was thought to be as accurate as possible within the confines of the study. All radiographs were independently reviewed by the lead author in this study (D.S.B.) who was not part of the patient care team.

Radiographic outcomes, angulation and translation, were similarly improved as well. It is clear from these similar patient groups and similar outcomes that either anterior fusion with the addition of plate fixation or posterior fusion with lateral mass plate–screw fixation can effectively stabilize the injured segment in patients with unstable fractures after successful closed reduction. The fear that anterior stabilization is not satisfactory can be largely dispelled, except in the most unstable situations such as multilevel involvement. The worry regarding pain after posterior procedures can also be discounted, as there were no differences in these patient groups.

One shortcoming of this study is the potential bias introduced by our randomization process. The patients were randomized by the day of admission, and therefore the attending neurosurgeon, one assigned to the anterior patient group (D.W.N.), the other to the posterior patient group (M.S.G.). The Orthopaedic service (P.A.A. and J.R.C.) was the same for both groups and represented the continuity for the study. No patients were switched between groups, and all patients sequentially that met the inclusion criteria and did not meet the exclusion criteria were included in the study. The authors do not think this biased the results.

An additional criticism of this study is the small number of patients with particular injury types in each group. There were no consistent complications or outcome differences related to specific injuries, although there is inadequate study power to report this as a true result. Subgroup analysis for evaluation of the approach for a specific fracture type or ligamentous injury should be undertaken with caution.

CONCLUSION

Either the anterior or posterior approach can be chosen for stabilization of the unstable cervical spine following successful closed reduction. This decision may be based on surgeon preference and specific indications and conditions of the patient.

REFERENCES

1. Breig A. The therapeutic possibilities of surgical bio-engineering in incomplete spinal cord lesions. *Paraplegia* 1972;9:173–82.
2. Delamarter RB, Sherman J, Carr JB. *Spinal Cord Injury: The Pathophysiology of Spinal Cord Damage and Subsequent Recovery Following Immediate or Delayed Decompression*. Twenty-first Annual Meeting, Cervical Spine Research Society, New York, NY, December 1, 1993.
3. Ducker TB, Saleman M, Daniell BB. Experimental spinal cord trauma: III. Therapeutic effects of immobilization and pharmacologic agents. *Surg Neurol* 1978;10:71–6.
4. Mirza SK, Krengel WF 3rd, Chapman JR, et al. Early vs. delayed surgery for acute cervical spinal cord injury. *Clin Orthop* 1999;359: 104–14.
5. Oakes DD, Wilmot CB, Hall KM, et al. Benefits of early admission to a comprehensive trauma center for patients with spinal cord injury. *Arch Phys Med Rehabil* 1990;71:637–43.
6. Abitbol JJ, Zdeblisk TA, Kunz D, et al. A biochemical analysis of modern anterior and posterior cervical stabilization techniques. *Proc Am Acad Orthop Surgeons* 1994;10–11.
7. Anderson PA, Henley NB, Grady MS, et al. Posterior cervical arthrodesis with AO reconstruction plates and bone graft. *Spine* 1991; 16(suppl):72–9.
8. Bracken MB, Shepard MJ, Collins, WF, et al. A randomized, controlled trial of methylprednisolone or naloxone in the treatment of acute spinal-cord injury: results of the Second National Acute Spinal Cord Injury Study. *N Engl J Med* 1990;322:1405–11.
9. American Spinal Cord Injury Association and International Medical Society of Paraplegia. *Standards for Neurologic and Functional Classification of Spinal Cord Injury*. Chicago, IL, American Spinal Injury Association, 1992.
10. Frankel HL, Hancock DO, Hyslop G, et al. The value of postural reduction in the initial management of closed injury of the spine with paraplegia and tetraplegia. *Paraplegia* 1969;7:179–92.
11. Lucas JT, Ducker TB. Motor classification of spinal cord injuries with mobility, morbidity, and recovery indices. *Am Surg* 1979;45: 151–8.
12. Bohlman HH, Emery SE, Goodfellow DB, et al. Robinson anterior cervical discectomy and arthrodesis for cervical radiculopathy. *J Bone Joint Surg Am* 1993;75:1298–307.
13. Robinson RA, Smith GW. Anterolateral cervical disc removal and interbody fusion for cervical disc syndrome. *Bull Johns Hopkins Hosp* 1955:96:223–4.
14. Kotani Y, Cunningham BW, Abund K, et al. Biomechanical analysis of cervical stabilization systems. *Spine* 1994;22:2529–39.
15. Richman JD, Daniel TE, Anderson DD, et al. Biomechanical evaluation of cervical spine stabilization methods using a porcine model. *Spine* 1995;20:2192–7.
16. Traynelis VC, Donaher PA, Roach RM, et al. Biomechanical comparison of anterior Caspar plate and three-level posterior fixation techniques in a human cadaveric model. *J Neurosurg* 1993;79:96–103.