CROATIAN MEDICAL JOURNAL

42(1):49-53,2001

CLINICAL SCIENCES

Anterior Decompression and Fixation versus Posterior Reposition and Semirigid Fixation in the Treatment of Unstable Burst Thoracolumbar Fracture: Prospective Clinical Trial

Marin F. Stančić, Egidio Gregorović[1], Etica Nožica[2], Ljubomir Penezić[3]

Division of Neurosurgery and Departments of [1]Neurology, [2]Anesthesiology, and [3]Radiology, Pula General Hospital, Pula, Croatia

Aim. To compare the anterior and posterior surgical approach in the emergency treatment of unstable burst thoracolumbar fracture.

Methods. Twenty-five patients with unstable thoracolumbar fracture underwent either anterior neurodecompression and fixation (n=13) or posterior reposition and semirigid fixation by hook-rod with pedicle screw fixation (n=12), depending on the type of implants available at the time of operation. Neurologically injured patients were operated on within the first 8 hours and neurologically intact patients within the first 2 days after the fracture. Neurological improvement was assessed according to the American Spinal Injury Association grading scale and the Prolo economic/function outcome scale. We also recorded operation time, blood loss, cosmetic outcome, hospital stay and cost, complications, and donor site pain.

Results. There were no significant differences between the two groups in either neurological improvement (p=0.86) or favorable economic or function outcome (p=0.54 and p=0.53, respectively). The operation time was shorter in the posterior approach group than in the anterior approach group (median 174 min, range 130-215, vs median 250 min, range 200-295, respectively, p<0.001). The blood loss was smaller in the posterior approach group (median 750 mL, range 500-1,100, vs median 1,362 mL, range 1,150-1,500, in the anterior approach group; p<0.001). The posterior approach group also had better esthetic outcome, lower hospital cost, lower complication rate, and no donor site pain.

Conclusion. Both surgical techniques were equally effective in neurological improvement and functional outcome. Posterior surgery can be recommended in emergency neurodecompression and fixation of unstable thoracolumbar fractures because of the shorter operation time and smaller blood loss.

Key words: *emergency treatment; fracture fixation; laminectomy; lumbar vertebrae; paraparesis; spinal injuries; decompression, surgical; thoracic vertebrae*

Fracture is the most common pathological event at the thoracolumbar junction (1). These fractures often result in a significant instability of the spine and lead to acute or delayed neurological deficits. Most authors agree that unstable thoracolumbar fractures require surgical treatment, but which specific approach should be used for the treatment is still controversial (2-4). Posterior approach surgery has the most acceptable perioperative parameters, which presents a great advantage if a surgical decompression is planed within first 8 hours after the fracture. However, anterior and combined front/back surgical approach are still commonly employed (2-13). Two major disadvantages make the posterior approach surgery less popular. The first one is the usually insufficient indirect spinal canal clearance obtained by annulotaxis (6,14). Partial or complete laminectomy can improve decompressions of the spinal canal but may destabilize the spine by increasing the spinal deformity (15). The second disadvantage is a frequent failure of pedicle screw fixation techniques, which happens even in cases in which a laminectomy has not been performed (16). Previously, we proposed hook/rod operative technique with pedicle screw fixation for anatomic reduction of fractured vertebra and sufficient decompression of the dural sac, followed by semirigid posterior fixation of the spine (17,18).

Although we emphasized that a posterior approach has better perioperative parameters, our starting hypothesis was that the selection of either anterior or posterior approach for neurodecompression cannot influence neurological or functional outcome. Therefore, the aim of the study was to compare the results of anterior approach decompression and fixation with posterior reposition and semirigid fixation utilizing hook/rod with pedicle screw fixation in emergency circumstances.

Patients and Methods

Patients

The study comprised 25 patients, aged 16-60 years, who were admitted to the hospital because of unstable thoracolumbar fracture. Criteria for the inclusion in the study were incomplete neurological injury, with thoracolumbar burst fractures and mechanical instability associated with burst fracture and without a neurological deficit. Radiographic evidence of instability comprised one or more of the following (2): 1) vertebral height loss greater than 50% on lateral radiography; 2) kyphosis over 20 degrees; and 3) spinal canal encroachment greater than 40% on axial computed tomography (CT).

Patients classified as grade A according to the American Spinal Injury Association/International Medical Society of Paraplegia (ASIA/IMSOP) (19), with no motor or sensory function preserved in the S4 and S5 sacral segment, were excluded from the study. Late admittance to the hospital that consequently prevented operative treatment within a time window of 8 hours was the second exclusion criterion.

Following admission to the hospital, the degree of the neurological deficit according to the ASIA/IMSOP impairment scale was assessed for each patient (19). Antero-posterior and lateral radiographs of the thoracolumbar spine were obtained, fractures were categorized according to the Denis classification system (20), and kyphotic deformity was measured by the Cobb method (21). CT scans of the appropriate vertebral levels were used to determine the extent of the spinal canal encroachment. All patients included in the study gave their informed consent.

Patients were divided in two trial groups according to the implants available in the operating theater at the time of a patient's admission to the hospital. Patients undergoing anterior decompression/fixation formed the anterior approach group and the posterior approach group comprised those who underwent posterior reposition/ semirigid fixation with hook/rod with pedicle screw fixation (Fig. 1). Neurologically injured patients were operated on within the first 8 h, and patients without neurological deficit in the first two days after the fracture.

Surgical Treatment

In the anterior approach group, a left-sided 11th or 12th rib extrapleural-retroperitoneal approach was used to expose fractured vertebrae (8,11). A subtotal corpectomy was performed and the spinal canal was fully decompressed. The dura was visualized through the craniocaudal retraction of the fractured vertebrae and mediolateral retraction from one pedicle to the other. After neurodecompression, a tricortical iliac crest autograft was set into the vertebra body defect. Screw-plate instrumentation (Instrumentarija, Zagreb, Croatia) was used in 8 patients, and screws with rods (Moss Miami, DePuy, Warsaw, IL, USA) in 5 patients (Fig. 2A).

The posterior approach group underwent fracture reposition, indirect spinal decompression by annulotaxis, and semirigid fixation achieved by a combination of hook-rod and pedicle screw fixation (Moss-Miami) (17,18). Partial or complete laminectomy was performed to increase spinal canal decompression when preoperative spinal canal encroachment was greater than 50%. Intertransverse autogenous cancellous bone strips were packed prior to wound closing (Fig. 2B).

Primary Endpoints

Postoperative coronal and sagittal plane alignment and hardware position were evaluated with anteroposterior and lateral spine radiographs. Postoperative kyphosis of less than 5 degrees was considered an anatomical reposition.

Neurological improvement was calculated as the difference between ASIA/IMSOP grade on admission and ASIA/IMSOP grade a 12-month follow-up examination. Employment/activity and pain rating grades according to the Prolo scale (22) as well as lateral flexion and extension radiographs for evaluation of the mechanical stability of the patients' spines, were obtained on 12-month follow-up examination. We determined Cobb's angle from lateral radiographs, and if the loss of correction was greater than 5 degrees, it was considered a recurrent kyphosis. CT scans of the matching vertebral levels were used to determine the size the spinal canal.

Secondary Endpoints

Operative time, blood loss, complications, hospital stay and hospital cost were recorded. Operative incision length was measured and a cosmetic result of postoperative scars was assessed on a 5-point scale from 1 (poor) to 5 (excellent). Donor site pain, if present, was also noted.

Masking and Follow-up

After neurological examination, the neurosurgeon (MFS) divided the patients into two trial groups according to the implants available in the operating theater. The neurologist (EG) examined, assessed, and graded patient's sensibility and motor functions using ASIA/IMSOP impairment scale. Preoperative neurological findings were forwarded to the neurosurgeon, who entered the data in the database under the coding patient's number. The anesthesiologist (EN) recorded operative time, blood loss, complications, hospital stay, and cost after a patient's discharge from our division. The investigators were working independently. On 6-month and 12-month follow-up examinations, the neurologist examined the patients who had their torso covered to mask which operative group they belonged to. Neurological findings according to ASIA/IMSOP neurological impairment scale and Prolo activity/pain outcome results were recorded and entered in the database. A medical student (see Acknowledgment) measured the operative incision length, assessed aesthetic appearance, and noted the presence of the donor site pain. The radiologist (LP) evaluated X-ray and CT parameters. The neurosurgeon, not involved in the patient assessment, analyzed all the data.

Statistical Analysis

Fisher exact probability test was used to compare categorical data, and Mann-Whitney U-test to analyze numerical data.

Results

Between September 1, 1997, and January 1, 2000, 28 patients were recruited for the study, but 3 of them had to be excluded – 2 with no motor or sensory function below the lesion and one admitted 24 h after injury (Fig. 1). According to X-ray and CT scans, the remaining 25 patients had positive inclusion criteria. They were divided into two trial groups: 13 patients undergoing anterior and 12 undergoing posterior approach surgery. There were no withdrawals from the trial, which ended on August 31, 2000. Postoperative X-rays in all patients included in the study showed good hardware position and anatomical reposition. There were 3 patients in each trial group who were operated on later than August 31, 1999 and had follow-up shorter than 12 months. CT scans and X-rays after a 12-month follow-up examination showed re-canalization of the spinal canal in all patients. There was no evidence of instability, hardware breakage or disconnec-

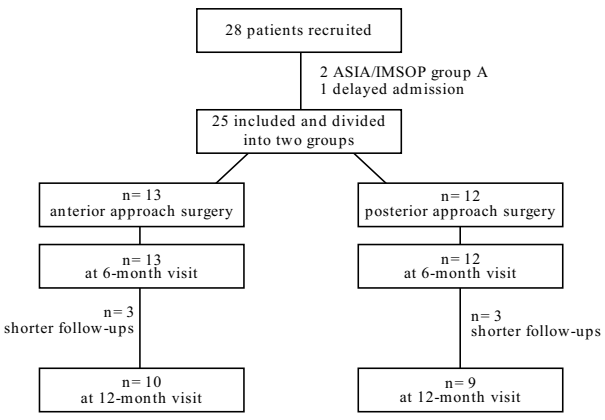

Figure 1. Trial profile.

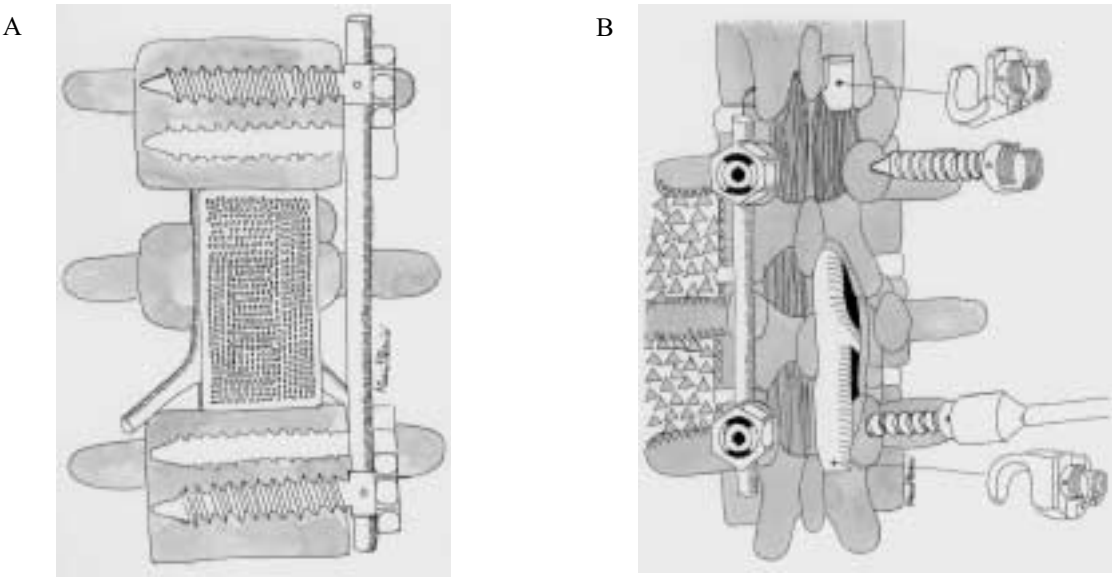

Figure 2. (A) Anterior approach operation consists of a partial corpectomy of fractured vertebra, insertion of tricortical bone graft into the defect, and fixation of adjacent vertebrae with monoaxial screws and rods**. (B)** Posterior approach operation consists of distraction with one or two rods with hooks, flexion correction with pedicle screw fixation system, and improvement of decompression by partial or total laminectomy. **Right upper quadrant**: interlaminectomy is drilled below the infralaminar surface of the second vertebra above the fracture for upper hook insertion; pedicle screw is placed for insertion in the vertebra above the fracture. **Right lower quadrant:** spinal canal decompression obtained by annulotaxis is improved with hemilaminectomy; the lower hook will be inserted above the supralaminar surface of the vertebra below the fracture, in this case, on the lower edge of hemilaminectomy; insertion of lower right pedicle screw using a screwdriver. **Left half:** pedicle screws are connected with rod and autogenous cancelous bone graft is packed between transverse processes (triangles).

tion, and recurrent kyphosis. The two groups did not differ in their age, sex, or clinical data (Table 1).

Neurological improvement, expressed as median (range) of ASIA/IMSOP grade, was similar in both groups (Table 2) as well as the number of patients with favorable economic/activity (E4 and E5) and functional/pain (F4 and F5) outcome.

Blood loss was greater and operation time longer in the anterior approach group (Table 3). On the other hand, cosmetic results were better and incisions shorter in the posterior approach group, who also had significantly shorter hospital stay and lower hospital costs. There were 2 cases of post-operative complications in the anterior approach group, and 1 in the posterior approach group. Only a single patient had a superficial wound infection, which was successfully treated with parenteral administration of antibiotics and wound care. A patient in the anterior approach group had hematothorax on the operated side and was successfully treated without thoracocentesis. Donor site pain was noticed in only 2 patients in the anterior approach group.

Discussion

Our study showed that both anterior and posterior approach surgical techniques were equally effective when the primary endpoints were compared. There were no differences in the neurological, economic activity, or functional pain outcome. According to the secondary endpoints, the posterior approach surgery can be the technique of choice, especially in emergency circumstances, because of lower blood loss and shorter operation time.

The limitations of the study were the relatively small study size and unusual allocation of the patients into groups. Patients were divided into two trial groups according to the implants available in the operating theater at the time of the patient's admission. The lack of funds was the reason why implants for posterior surgery (hook/rod with pedicle screw fixation) were rarely available. On the other hand, these circumstances prevented a

Table 1. Characteristics of patients in anterior (n=13) and posterior surgical approach trial group (n=12)

Characteristic	Surgical approach		
	anterior	p	posterior
Median age (years, range)	36 (18-53)	0.785	35 (16-60)
Sex (M/F)	7/6	0.404	8/4
Fracture level			
T12	1	0.469	2
L1	10	0.719	9
L2	2	0.735	2
Fracture type[a]			
Denis A	3	0.541	2
Denis B	7	0.418	5
Denis C	3	0.719	3
Denis D	0	-	0
Denis E	0	-	2

[a]The Denis classification of burst fractures: type A – failure of both superior and inferior end plates with bone retropulsion at both levels; type B – failure superiorly; type C – failure inferiorly; type D – burst fracture with associated rotational deformity; and type E – failure of both anterior and middle column from lateral flexion (20).

Table 2. Neurological and general recovery of patients undergoing anterior (n=13) and posterior surgical approach (n=12)

Characteristic	Finding after surgical approach		
	anterior	p	posterior
ASIA/IMSOP grading scale:[a]			
Patients with grade E at admission	7	0.418	5
Improvement (median, range)	1.50 (1-2)	0.856	1.57 (1-3)
Prolo economic and functional rating scale:[b]			
Patients with E4 and E5	8/10	0.542	8/9
Patients with F4 and F5	9/10	0.526	9/9

[a]Classification of spinal cord injury based on the International Standards for Neurological and Functional Classification of Spinal Cord Injury by the American Spinal Injury Association (ASIA) and the International Medical Society of Paraplegia (IMSOP): *Grade A-complete*, no motor or sensory function is preserved in the sacral segments S4 and S5; *Grade B-incomplete*, sensory but not motor function is preserved below the neurological level and extends through the sacral segment S4-S5; *Grade C-incomplete,* motor function is preserved below the neurological level, and the majority of key muscles below the neurological level have a muscle grade less than 3; *Grade D-incomplete,* motor function is preserved below the neurological level, and the majority of key muscles below the neurological level have a muscle grade greater than or equal to 3; *Grade E-normal*, motor and sensory function are normal (19).
[b]Prolo economic and functional rating scale: *economic (activity) status*: E1 – completely disabled; E2 – no gainful occupation; E3 – working/activity but not at premorbid level; E4 – working/active at previous level with limitation; E5 – working/active at previous level without limitations; *functional (pain) status*: F1 – total incapacity; F2 – moderate-to-severe daily pain; F3 – low level of daily pain; F4 – occasional or episodic pain; F5 – no pain (22).

bias in favor of posterior approach fixation, which is preferred technique in our institution.

Anterior neurodecompression after a few days of patient's stabilization (9) still remains the practice in many institutions, although experimental data have shown that early neurodecompression is crucial for regeneration of nerve tissue (24). Our results showed that the choice of either anterior or posterior approach for decompression did not influence the neurological or functional outcome. Preference of the anterior approach technique should not be the reason for a delay in surgery.

We hypothesized (17) that the problem of insufficient stiffness of pedicle screw fixation could be solved if both hook/rod and pedicle screw system were used together. Later on we confirmed it by computed mathematical analysis with finite element method and on small number of patients (18). Such fixation system is slightly stiffer than needed for unstable fracture fixation following reduction (25), but it is not as rigid as front/back fixation (17). Computed mathematical modeling data showed that two posterior fixation systems used together greatly reduced loadings of the fractured vertebra. According to Wolff's law, minute forces are needed for the stimulation of the bone healing process, and a semirigid fixation system reduces loadings to the required values (26). Loss of correction smaller than 5 degrees on a 12-month follow-up examination does not present recurrent kyphosis but subsidence, which is a part of natural history.

Table 3. Secondary endpoints (median, range) of the trial of anterior and posterior approach in surgical tretment of vertebral fracture

Characteristic	Finding after surgical approach		
	anterior	p	posterior
Operative time (min)	250 (200-295)	<0.001	174 (130-215)
Blood loss (mL)	1362 (1,150-1,500)	<0.001	750 (500-1,100)
Cosmetic result (1-5)	3.4 (2-5)	0.024	4.1 (3-5)
Incision length (cm)	17.8 (16-20)	<0.001	13.2 (12-15)
Hospital stay (days)	17.3 (12-25)	0.002	10.9 (7-15)
Hospital cost (US$)	2,700 (2,400-2,850)	<0.001	2,250 (1,900-2,450)
Complications (No. of patients)	2	0.531	1
Donor site pain (No. of patients)	2	0.260	0

All secondary endpoints speak in favor of the posterior technique. Its shorter operative time and smaller blood loss should also be taken into account when surgery is to be performed on an emergency basis, because the incidence of multisystem injuries in patients with unstable thoracolumbar fracture may be up to 52% (27). Donor site pain was noticed only in patients with anterior decompression and fixation, but it was absent in the posterior approach group. Also, a shorter hospital stay and lower hospital costs in posterior surgical approach technique are important to health care providers.

These results, although obtained on a relatively small group of patients, confirmed our hypothesis. The next step should be a randomized controlled trial within the time interval of 5 years with proper supply of needed implants.

Acknowledgments

We thank Izabela Jugovac, medical student, who was responsible for the incision length measurement, and aesthetic outcome and donor site pain assessment. We also thank Dr Mladen Petrovečki for his advice on the analysis of the data.

References

1 Knightly JJ, Sonntag VKH. Thoracolumbar fractures. In: Menezes AH, Sonntag VKH, Benzel EC, Cahill DW, McCormick P, Papadopulous SM, editors. Principles of spinal surgery. New York (NY): McGrew-Hill; 1996. p. 919-49.

2 Danisa OA, Shaffrey CI, Jane JA, Whitehill R, Wang GJ, Szabo TA, et al. Surgical approaches for the correction of unstable thoracolumbar burst fractures: a retrospective analysis of treatment outcome. J Neurosurg 1995;83:977-83.

3 Haas N, Blauth M, Tscherne H. Anterior plating in thoracolumbar spine injuries. Indication, technique, and results. Spine 1991;16(3 Suppl):S100-11.

4 Schnee CL, Ansell LV. Selection criteria and outcome of operative approaches for thoracolumbar burst fractures with and without neurological deficit. J Neurosurg 1997;86:48-55.

5 Gertzbein SD, Court-Brown CM, Jacobs RR, Marks P, Martin C, Stoll J, et al. Decompression and circumferential

stabilization of unstable spinal fractures. Spine 1988;13:892-5.

6 Gertzbein SD, Crowe PJ, Fazl M, Schwartz M, Rowed D. Canal clearance in burst fractures using the AO internal fixator. Spine 1992;17:558-60.

7 Kaneda K, Abumi K, Fujiya M. Burst fractures with neurologic deficit of the thoracolumbar-lumbar spine. Results of anterior decompression and stabilization with anterior instrumentation. Spine 1984; 9:788-95.

8 Kim M, Nolan P, Finkelstein JA. Evaluation of 11th rib extrapleural-retroperitoneal approach to the thoracolumbar junction. Technical note. J Neurosurg 2000;93(1 Suppl):168-74.

9 Kostuik JP. Anterior fixation for burst fractures of the thoracic and lumbar spine with or without neurological involvement. Spine 1988;13:286-93.

10 McAfee PC, Bohlman HH, Yuan HA. Anterior decompression of traumatic thoracolumbar fractures with incomplete neurological deficit using a retroperitoneal approach. J Bone Joint Surg (Am) 1985; 67:89-104.

11 McCormick PC. Retropleural approach to the thoracic and thoracolumbar spine. Neurosurgery 1995; 37:908-4.

12 Muhlbauer M, Pfisterer W, Eyb R, Knosp E. Minimally invasive retroperitoneal approach for lumbar corpectomy and anterior reconstruction. Technical note. J Neurosurg 2000;93(1 Suppl):161-7.

13 Riska EB, Myllynen P, Bostman O. Anterolateral decompression for neural involvement in thoracolumbar fractures. A review of 78 cases. J Bone Joint Surg (Br) 1987;69:704-8.

14 Crutcher JP Jr, Anderson PA, King HA, Montesano PX. Indirect spinal canal decompression in patients with thoracolumbar burst fractures treated by posterior distraction rods. J Spinal Disord 1991;4:39-48.

15 Malcolm BW, Bradford DS, Winter RB, Chou SN. Post-traumatic kyphosis. A review of forty-eight surgically treated patients. J Bone Joint Surg (Am) 1981; 63:891-9.

16 McLain RF, Sparling E, Benson DR. Early failure of short-segment pedicle instrumentation for thoracolumbar fractures. A preliminary report. J Bone Joint Surg (Am) 1993;75:162-7.

17 Stančić MF, Mićović V, Stošić A, Potočnjak M, Kolić Z. Posterior approach to circumferential fixation of unstable burst thoracolumbar fractures. Proceedings of the 4th International Neurotrauma Symposium; 1997Aug 23-26, Seoul, South Korea. J Neurotrauma 1998;15:38.

18 Stančić MF, Mićović V, Potočnjak M. Hook-rod with pedicle screw fixation for unstable spinal fracture. Technical note. J Neurosurg 2000;92(1 Suppl):117-21.

19 Tator CH. Spinal cord syndromes with physiological and anatomic correlations. In: Menezes AH, Sonntag VKH, Benzel EC, Cahill DW, McCormick P, Papadopulous SM, editors. Principles of spinal surgery. New York (NY): McGrew-Hill; 1996. p. 785-99.

20 Denis F. The three column spine and its significance in the classification of acute thoracolumbar spinal injuries. Spine 1983;8:817-31.

21 Cobb JR. Outline for the study of scoliosis. Instructional Course Lectures. American Academy of Orthopedic Surgeons 1948;5:261-75.

22 Prolo DJ, Oklund SA, Butcher M. Toward uniformity in evaluating results of lumbar spine operations. A paradigm applied to posterior lumbar interbody fusions. Spine 1986;11:601-6.

23 Marshall LF, Knowlton S, Garfin SR, Klauber MR, Eisenberg HM, Kopaniky D, et al. Deterioration following spinal cord injury. A multicenter study. J Neurosurg 1987;66:400-4.

24 Fehlings MG, Tator CH. An evidence-based review of decompressive surgery in acute spinal cord injury: rationale, indications, and timing based on experimental and clinical studies. J Neurosurg 1999;91 (1 Suppl):1-11.

25 Oxland TR, Panjabi MM, Lin RM. Axes of motion of thoracolumbar burst fractures. J Spinal Disord 1994; 7:130-8.

26 Dorland NW, editor. Dorland's illustrated medical dictionary. 25th rev ed. Philadelphia (PA): WB Saunders; 1974.

27 Hartman MB, Chrin AM, Rechtine GR. Non-operative treatment of thoracolumbar fractures. Paraplegia 1995;33:73-6.

Received: September 25, 2000
Accepted: November 28, 2000

Correspondence to:
Marin Stančić
Division of Neurosurgery
General Hospital/ Marine-Spital MDCCCLXI
Negrijeva 6
52100 Pula, Croatia
marin.stancic@pu.tel.hr