SPINE Volume 29, Number 5, pp 564–567

Weight-Bearing Radiographs in Thoracolumbar Fractures

Do They Influence Management?

J. S. Mehta, MCh (Orth), M. R. Reed, FRCS, J. L. McVie, FRCS, and P. L. Sanderson, FRCS (Orth)

Study Design. Prospective observational study.

Objective. Our objective was to compare supine and erect (weight-bearing) radiographs in patients with thoracolumbar fractures without a neurologic deficit and to determine whether the erect radiographs alter the deformity and the management plan.

Summary of Background Data. Nonoperative treatment for thoracolumbar fracture without a neurologic deficit is safe and effective. There are some guidelines in the literature that provide objective standards to identify the patients that are suitable for nonoperative treatment. These guidelines are based on measurements on supine radiographs. The role of weight-bearing radiographs in influencing the management plan of these injuries has not been explored.

Methods. Fractures between T11 and L2 in 28 patients were considered suitable for nonoperative treatment initially. Radiographic measurements included anterior and posterior vertebral body heights, interpedicular distance, and the Cobb angle on the supine and erect radiographs. A change in the treatment from the initial nonoperative management plan, based on the radiographic findings, was recorded.

Results. Mean supine Cobb angle of 11° increased to 18° on weight-bearing films. The mean anterior vertebral compression increased from 34% to 46%. No change was noted between the posterior vertebral heights and the interpedicular distance. Seven of the 28 patients were subjected to surgical stabilization based on these findings.

Conclusion. Performing erect radiographs in patients with thoracolumbar fractures without a neurologic deficit provides additional information and did alter the management plan in a significant proportion (25%) of our patients. [Key words: kyphosis, anterior vertebral compression, supine radiographs, weight-bearing radiographs] **Spine 2004; 29:564–567**

Nonoperative treatment for stable and burst compression type of thoracolumbar fractures have been shown to be safe and effective.[1,2] In the absence of a neurologic deficit, the decision to operate often depends on the extent of the loss of vertebral body height and the degree of kyphosis. Some authors have suggested that the presence of retropulsed fragments in the canal may influence the surgeon to operate to "clear the canal." However, several longitudinal studies have shown that the remodeling process that occurs in the years following the injury restores normality to the canal geometry.[3,4] It is now accepted that in the absence of a neurologic deficit, retropulsed fragments can be left well alone and do not represent an absolute surgical indication.

There are guidelines available in the literature, with regards to the vertebral height collapse and kyphotic angle, which suggest objective standards for defining the patients that could be considered safe for nonoperative treatment.[5–10] The absolute measurements are debated. In all the previous series, measurements are based on supine radiographs. We noticed that films taken 3 months after the initial injury show an increase in the deformity in some cases. Based on this anecdotal observation, we have postulated that weight-bearing radiographs may give us some indication of the "stability" of the fracture. We could thereby identify the patients that were collapsing further and consequently alter our management. With this in mind, we performed supine and erect radiographs. By comparing these, we determined whether a change in the deformity and consequently the management plan occurred, on the basis of these radiographic findings.

Methods

We report prospectively on 28 consecutively treated patients with nonpathologic, thoracolumbar fractures, between T11 and L2. These are the most commonly involved levels in the thoracolumbar spine[2] and behave in a similar manner, being unsupported by the thoracic rib cage.[9] These were treated nonoperatively at our unit, which is a tertiary referral center, between August 2000 and August 2002. The mechanisms of injury in all the patients are highlighted in Table 1.

Management Protocol. A careful documentation was made of the posterior interspinous tenderness, bruising, and widening. The radiologic assessment included supine radiographs. A CT scan was performed to document the level and type of the fracture. Surgery was indicated if the patients had an unstable configuration of the injury such as a fracture dislocation, a neurologic deficit, a vertebral collapse >50%, or a kyphosis exceeding 20°. These patients were excluded from this study.

All the patients that were considered for nonoperative treatment were allowed to mobilize as comfort permitted within 48 hours. On achieving trunk control, an erect radiograph of the spine was performed with the patients either sitting or standing. The management plan was reviewed based on the weight-bearing radiographs. Patients that did not achieve trunk con-

From Newcastle General Hospital, Newcastle upon Tyne, United Kingdom.
Acknowledgment date: November 13, 2002. First revision date: February 19, 2003. Acceptance date: June 2, 2003.
The manuscript submitted does not contain information about medical device(s)/drug(s).
No funds were received in support of this work. No benefits in any form have been or will be received from a commercial party related directly or indirectly to the subject of this manuscript.
Address correspondence to P. L. Sanderson FRCS (Orth), Newcastle General Hospital, Westgate Road, Newcastle upon Tyne NE4 6BE, United Kingdfom; E-mail: Jwalant_mehta@hotmail.com

Table 1. Mechanism of the Injury

Mechanism	Burst	Wedge
Fall > 10 feet	4	4
Fall < 10 feet	4	6
RTA	2	1
Direct blow	2	5
Total	12	16

trol at 48 hours were considered for surgery. Likewise, those that collapsed >50% and/or developed a kyphotic angle >20° were considered for surgical stabilization.

Radiographic Assessment. The supine and erect radiographs were assessed to determine anterior and posterior vertebral height at the level of the fracture and the lower level. Degree of the vertebral collapse could be calculated as a percentage fraction of the intact lower vertebra, by the formula 100 − A0/A1. The Cobb angle was measured as the angle between the perpendicular lines from the upper endplate of the vertebra above the fractured level and the lower endplate of the vertebra below. This method has been shown to be the most accurate in measuring the kyphos angle in fractures.[11] The interpedicular distance was measured on the anteroposterior radiographs at the level of the fracture (I0), the level above (I1), and the level below (I2). The effect of the fracture on the interpedicular distance was calculated by the formula: [(I1 + I2) ÷ 2 − I0] ÷ [(I1 + I2) ÷ 2].

Inclusion criteria are as follows:

Normal neurology,

Nonpathologic fracture between T11 and L2,

Initial vertebral collapse <50%,

Initial kyphosis <20°,

No other major limb, chest, or head injuries.

■ Results

Patient Demographics

The average age of the cohort in our series was 46.3 years (range, 19–72 years), with 18 patients being male and 10 female. L1 was the commonest level affected in 18 cases, T12 being the next commonest in 7, with 1 fracture at T11, and 2 at L2. One patient sustained two fractures with an intact intervening level. These fractures were considered separately. We classified the fractures according to Denis' 3-column classification. CT scan assessment of the fractures suggested that 16 patients had a disruption of 1 column and were classified as a wedge compression fracture and 12 demonstrated a disruption of the anterior and the middle columns and were classed as a burst type of fracture. In addition, 3 patients were noted to have a posterior element fracture in association to the vertebral body fracture, suggesting a 3-column injury. Sixteen patients demonstrated posterior tenderness at the level of the fracture on initial examination (Table 2).

Cobb Angle

The mean supine Cobb angle was 11° (confidence interval [CI] 8.32°–13.67°), which increased to 17.8° (CI 14.75°–20.81°) on erect films. The mean change in the Cobb angle on the standing radiographs was 7° (CI 4.76°–8.79°). On performing a paired *t* test, there was a statistically significant change in the Cobb angles between the supine and the erect radiographs ($P < 0.0001$) for 95% confidence interval (Table 3).

Table 2. Posterior Tenderness and Change of Plan From Conservative to Operative Treatment

	Posterior Tenderness	Changed Plan
Burst	7	5
Wedge	9	2
Total	16	7

Vertebral Compression

The mean anterior compression of the vertebral bodies at the injured level on the supine radiographs was 34% compared to the lower vertebra (CI 29.5%–39.2%). The mean anterior compression on the erect radiographs was 46% (CI 39.3%–52.5%), with a change in height of 11.5% (CI 6.2%–16.9%). This change was statistically significant on the paired *t* test ($P = 0.0002$) for 95% confidence interval (Table 3). Posterior heights and the interpedicular distance were compared, but there was no significant change in these.

Change in Management Based on Radiographs

Two patients with wedge fractures (Figure 1) and 5 with burst fracture were subject to a change in the management plan from the initial plan of proposed nonoperative treatment and underwent operative fixation and stabilization of the fracture (Table 2). A total of 21 patients continued to be treated nonoperatively. One patient was offered an operation but had a pulmonary embolus and hence was treated nonoperatively (Figure 2), and another was considered as an operative candidate but was deemed medically unfit for the procedure. We have not seen any increase in the deformity in the patients managed conservatively.

■ Discussion

Nonoperative treatment of spinal fractures has found proponents since the time of Hippocrates. However, earlier reports highlighted a large proportion of suboptimal results. These reports included a variety of different types of injuries and hence did not form a homogenous group.[1] An understanding of differences in the injuries resulting from different mechanisms and anatomic locations has improved our understanding of the treatment of these

Table 3. Changes in the Cobb Angle and the Anterior Vertebral Body Compression

Parameter	Supine	Erect
Mean change in Cobb angle	11° (1°–27°)	18° (3°–36°)
Mean anterior vertebral compression	34% (6.5%–53%)	46% (10%–81%)

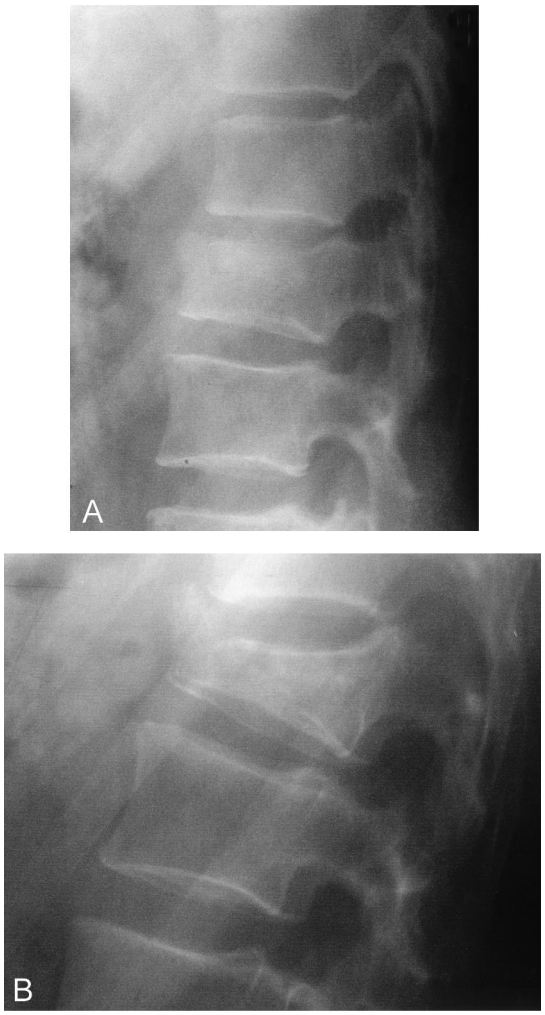

Figure 1. **A, B:** A 44-year-old man fell off a scaffolding and sustained a wedge fracture of L1. The supine Cobb angle of 16° increased to 22° on erect radiographs. The vertebral body compression increased from 22% to 65%.

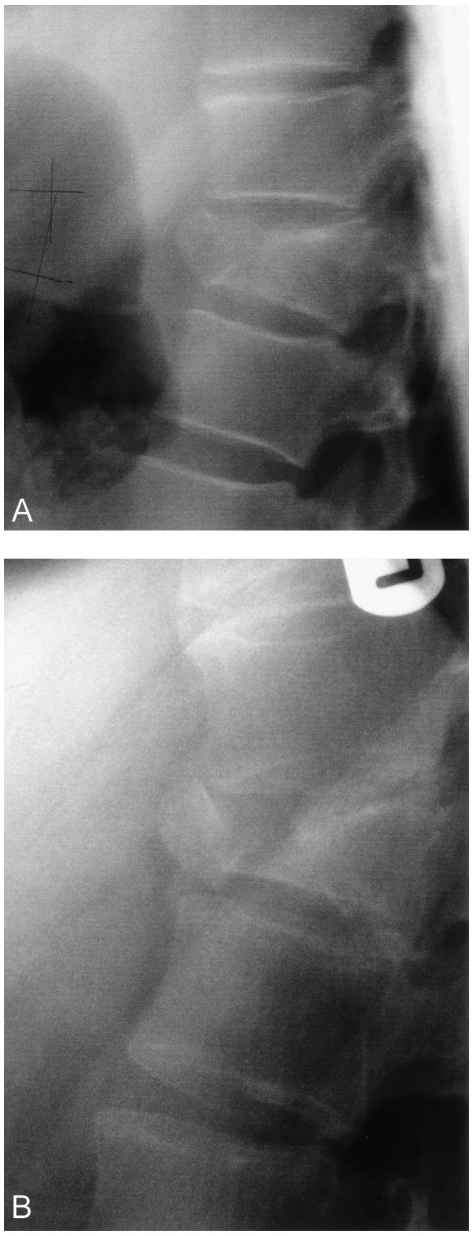

Figure 2. **A, B:** A 52-year-old man sustained a burst fracture of T12 following a convulsion. The Cobb angle increased from 15° to 30°. The vertebral body compression increased from 40% to 60%.

injuries. We now have ample evidence in the literature to suggest that nonoperative treatment leads to an acceptable outcome in thoracolumbar fractures without neurologic deficit.[1,2,9] A long-term review of patients by Weinstein *et al* of burst type of thoracolumbar fractures reported acceptable results with nonoperative treatment; the outcome measures considered were pain, clinical, radiologic criteria and a return to preinjury levels of activity.[2]

In the absence of a neurologic deficit, the main consideration when treating thoracolumbar fractures is the presence of stability in the injured motion segment. The stability and the deformity can be quantitated in terms of the vertebral height and the kyphosis. The integrity of the anterior column can be assessed by routine radiologic imaging. Assessment of the posterior column can be more subtle. Posterior tenderness can be sought as a clinical indicator.[1] We found posterior tenderness in just half the patients. Three of these had laminar fractures as demonstrated by the CT scan; the remaining had posterior ligamentous injury. Posterior tenderness did not correlate with an increased vertebral collapse.

Indications for surgical treatment of the fractures in the absence of a neurologic lesion can be defined in terms of the percentage of the vertebral height and the degree of kyphosis. Although several papers have attempted to provide guidelines, no absolute measurements have been agreed on. In our study, we have chosen a vertebral collapse of $>50\%$ and a kyphosis of $>20°$ as indications for surgical intervention. A kyphos angle of $>20°$ was chosen as it has been shown that a kyphosis $>30°$ at 1 year follow-up is associated with an increase in back pain.[12] It is well recognized that there is a gradual progression of the severity of the kyphosis between presentation and 1-year follow-up, which averages 8°[9]; therefore, a cutoff

value of 20° at presentation was chosen. Weitzman[10] has suggested that a compression of ≥50% should be fixed.

Although some reports have supported the use of a molded acrylic thoracolumbar orthosis, its usefulness is contentious. We do not use braces at our institution as there appears to be little difference in outcome between active mobilization with or without a brace.[13]

Furthermore, short segment fixation provides partial kyphosis correction and earlier pain relief than bracing.[14] However, we recognize that this is a controversial area and that many centers do use bracing. If this is going to be the chosen method of treatment, then our findings are just as relevant. Weight-bearing views should be performed in the brace before bracing is chosen as the treatment. We used clinical indicators such as a lack of pain on sitting and a reasonable trunk control to permit free mobilization.

Cancellous bone fails in compression in a predictable manner.[15,16] With an increasing force, the trabecular struts fracture and collapse on themselves, providing a self-stabilizing mechanism. The porous trabecular bone thus fills in progressively. This process is limited by the magnitude of the compressive force and the time over which the force is exerted. Low velocity falls and impacts cause less cancellous trabecular crushing and hence will result in a relatively lesser magnitude of vertebral body collapse and kyphotic deformity. Weight-bearing views in the immediate aftermath of the injury allows us to estimate the true extent of the cancellous crushing.

We found that one fourth of our patients had a higher magnitude of the injury than that suggested by supine radiographs alone. Furthermore, we have seen no evidence of a further collapse of the vertebral body height in the fractures treated conservatively following this protocol.

■ Conclusion

We think that supine radiographs show only a part of the picture. Weight-bearing radiographs should always be taken if conservative treatment is planned. Assessments such as CT scan and posterior tenderness do not gives adequate information about the potential for further deformity. By following this protocol, we have altered the management from conservative to operative in 25% of our patients.

■ Key Points

- There is a marked increase in the deformity in some patients with thoracolumbar fractures, when weight-bearing radiographs are performed.
- A total of 25% of the patients in our series had a significant change in the deformity, as quantified by kyphosis and vertebral body compression, leading to change in the management plan in favor of surgical stabilization.
- Weight-bearing radiographs are a useful additional investigation in assessing the stability of fractures.

References

1. Cantor JB, Lebwohl NH, Garvey T, et al. Non-operative management of stable thoracolumbar burst fractures with early ambulation and bracing. *Spine*. 1993;18:971–976.
2. Weinstein JN, Collalto P, Lehmann TR. Thoracolumbar 'burst' fractures treated conservatively: a long term follow-up. *Spine*. 1988;13:33–38.
3. Dai LY. Remodelling of the spinal canal after thoracolumbar burst fractures. *Clin Orthop*. 2001;382:119–123.
4. Fidler NW. Remodelling of the spinal canal after burst fracture. *J Bone Joint Surg Br*. 1988;70:730–732.
5. Bohler L. *The Treatment of Fractures*, 5th ed. New York: Grune & Stratton, 1956:330.
6. Garfin SR. Thoracolumbar spine trauma. In: Poss R, ed. *Orthopaedic Knowledge Update*, vol. 3. Park Ridge, IL: American Academy of Orthopaedic Surgeons, 1990:425–440.
7. Jacobs RR, Casey MP. Surgical management of thoracolumbar spinal injuries. *Clin Orthop*. 1984;189:22–35.
8. Kropinger WJ, Frederickson BE, Mino DE, et al. Conservative treatment of fractures of the thoracic and lumbar spine. *Orthop Clin North Am*. 1986; 17:161–170.
9. Mumford J, Weinstein JN, Spratt KF, et al. Thoracolumbar burst fracture: the clinical efficacy and outcome of non-operative management. *Spine*. 1993; 18:955–970.
10. Weitzman G. Treatment of stable thoracolumbar spine compression fractures by early ambulation. *Clin Orthop*. 1971;76:116–122.
11. Kuklo TR, Polly DW, Owens BD, et al. Measurement of thoracic and lumbar fracture kyphosis, evaluation of intraobserver, interobserver and technical variability. *Spine*. 2001;26:61–65.
12. Gertzbein SD. Scoliosis Research Society: Multicentre Spine Fracture Study. *Spine*. 1992;17:528–540.
13. Shen WJ, Shen YS. Non surgical treatment of three-column thoracolumbar junction burst fractures without neurological deficit. *Spine*. 1999;24:412–415.
14. Shen WJ, Liu TJ, Shen YS. Nonoperative treatment versus posterior fixation for thoracolumbar junction burst fractures without neurological deficit. *Spine*. 2001;26:1038–1045.
15. Gibson LJ. The mechanical behaviour of cancellous bone. *J Biomech*. 1985; 18:317–328.
16. Carter DR, Schwab GH, Spengler DM. Tensile fracture of cancellous bone. *Acta Orthop Scand*. 1980;51:733–741.