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Management of traumatic thoracolumbar fractures: a systematic review of the literature

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Abstract The management of unstable traumatic thoracolumbar fractures without neurological deficits remains controversial. The objective of this study was to compare the effectiveness of operative and conservative treatment of unstable traumatic thoracolumbar fractures. PubMed was used to search for articles published from January 1992 to January 2003 using a variety of keywords. References were checked to identify additional studies. Inclusion criteria were: (1) traumatic lumbar, thoracic or thoracolumbar fractures, (2) unstable fractures without neurological deficits, (3) a comparison between operative and conservative treatment, (4) at least ten patients were included in the study. Seventeen studies were identified; four prospective and 13 retrospective studies. Sample sizes in 15 studies were relatively small (18–100 patients); two studies had larger sample sizes.

Comparison among different studies was difficult due to insufficient description of interventions, different outcome measures, and different length of follow-up periods. The current literature does not provide a reliable answer to whether operative or conservative treatment is more effective for unstable traumatic thoracolumbar fractures. High quality randomised controlled trials are direly needed.

Keywords Traumatic thoracolumbar fractures · Management · Operative · Non-operative treatment

Introduction

In recent decades, the management of unstable traumatic thoracolumbar fractures has moved from more conservative treatment towards more operative treatment. The decision to treat conservatively or surgically is based on clinical and radiological examinations. The distinction between stability and instability and the presence of neurological deficits play an important role in the diagnostic process of spinal fractures. Instability can be

defined as the loss of the ability of the spine under physiological loads to maintain relationships between vertebrae so that there is no initial or additional neurological deficit, no major deformity, and no incapacitating pain [19]. In general, patients with stable fractures without gross deformity are treated conservatively and patients with spinal injury and progressive neurological deficits are treated operatively. The management of unstable fractures without neurological deficits, however, remains controversial, especially for burst type of fractures.

In a previous study, we estimated the direct medical costs of management of thoracolumbar fractures (van der Roer et al. 2004, submitted). The average cost for patients with unstable fractures without neurological deficits treated conservatively amounted to k€ 12.5 per patient, compared with k€ 19.7 for patients treated operatively. Because there is still uncertainty regarding the optimal management of unstable traumatic thoracolumbar fractures, we conducted a systematic review. The objective was to identify and summarize all published studies reporting on the comparison of the effects of operative and conservative treatment to determine whether one treatment is more effective than the other.

Materials and methods

Literature search

PubMed was searched using the keywords: lumbar vertebrae, thoracic vertebrae, thoracolumbar vertebrae, lumbar spine, thoracic spine, thoracolumbar spine, fracture(s), injuries, injury, trauma, recumbency, bed rest, fixation, decompression, surgical technique(s), treatment, therapy and management. The search was limited to studies on humans, published in English or German and in the period from January 1992 up to January 2003. References of retrieved articles and of relevant overview articles were checked to identify additional studies.

Study selection

Two reviewers independently checked eligible articles on title, keywords and abstract. A consensus meeting was used to discuss disagreements. Reports on studies were included if they met the following inclusion criteria: (1) traumatic lumbar, thoracic or thoracolumbar fractures, (2) unstable fractures without neurological deficits, (3) a comparison was made between conservative and operative treatment, (4) at least ten patients were included in the study. Articles were excluded if the used classification system for vertebral fractures or the operation material were obsolete and if fractures were due to osteoporosis. Consequently, articles describing the classification according to Holdsworth or operative techniques not using short segment pedicle fixation were excluded.

Methodological quality and data extraction

The methodological quality of the included studies was very low. Therefore, a formal assessment of the

methodological quality in order to weigh the results of the studies was not conducted.

Data concerning study population, classification of fractures, intervention, indication for treatment and results of the included studies were summarised. The studies were heterogeneous with respect to population, interventions and outcomes. Therefore, data were not statistically pooled but the most important results are described in detail.

Results

Study selection

More than 2,700 references were identified in the literature search. About 2,500 were excluded based on abstract, title and keywords. Hard copies of 203 articles were screened, resulting in 41 articles meeting the inclusion criteria. Applying the exclusion criteria mentioned above left 17 eligible studies for further analysis. These studies are summarised in Table 1.

Description of study characteristics

We did not identify any randomised controlled trials. Seventeen observational studies were identified: four prospective studies [7, 9, 12, 18] and 13 retrospective studies. In most studies the treatment groups were not comparable because the indication for operative and conservative treatment differed. Six studies did not mention the indication for treatment [1, 5, 7, 13, 15, 17]. In seven studies, surgery was indicated when radiological assessment showed (a change of) mechanical instability and/or neurological deficits, and conservative treatment when these signs were not present [3, 4, 6, 9, 12, 14, 16]. Surgical intervention was at the discretion of the treating surgeon in two studies, making comparability uncertain [11, 20]. In one study different periods in time were compared [8].

A variety of surgical techniques was used; for example, posterior short segment pedicle fixation with internal fixator, Kaneda fixation, anterior decompression and fusion. Conservative treatment consisted of bed rest, body cast/orthosis, functional rehabilitation or a combination of these. Bed rest varied from 1 week to 2 months and different types of orthoses were used (see Table 1). Except for two studies [7, 14], the sample sizes were generally small, ranging from 18 to 100 patients.

Outcome measures used in the studies varied widely; some studies included radiological outcomes (Beck-index, Cobb-angle) others clinical outcomes (pain, return to work, patient satisfaction with treatment outcome). Heterogeneity also existed in differences in follow-up time, varying from 0 to 12 years. This heterogeneity

Table 1 Eligible studies of the management of unstable traumatic thoracolumbar fractures

Study	Population	Intervention	Results
Andreychik et al [1] (retrospective study)	Seventy-four consecutive patients with a low lumbar (L2-L5) burst fracture treated at Southern Illinois University School of medicine between 1976 and 1992. Inclusion criteria: non-pathological fracture, follow-up of more than 2 years. Two died, six refused to participate and 11 were lost to follow-up; 55 patients were left for the review. Classification: Denis classification	Group I (non-operative); 27 patients treated with bed rest for 10–14 days and body cast or orthosis, three patients had more than 4 weeks of bed rest. Group II (operative): eight patients had a long segment hook-and-rod fixation. Group III (operative): eight patients short segment transpedicular fixation. Group IV (operative): six patients had anterior and posterior arthrodesis. Group V (operative): three patients had anterior decompression and arthrodesis. Indication for treatment; not reported.	Follow-up ranged from 24 to 192 months. The most recent pain scores and the functional outcomes in patients treated non-operatively were not significantly different from operatively treated patients. Thirty-six patients had been neurologically intact and no deterioration was seen regardless of treatment.
Dai [3] (retrospective study)	Fifty-four patients admitted to Xinhua Hospital for low lumbar (L3-L5) fractures between 1983 and 2000. Excluded: patients with pathological fractures. Patients treated non-operatively: 19 compression, four burst, two flexion-distraction fractures and one fracture dislocation. Patients treated operatively: six compression, 17 burst, one flexion distraction fracture and four fracture dislocations. Classification: Denis classification.	Non-operative treatment: 26 patients treated with bed rest or posture reduction and brace or cast mobilization. Operative treatment: eight patients had posterior stabilization with Luque or Harrington rods, 18 patients with transpedicular screw plates or rods. Anterior corpectomy were performed on 12 patients with severe burst fractures. Surgical intervention was indicated in fractures with neurological deficit or potential mechanical instability of the spine. Selection of operative approach was based upon the degree of ventral canal compromise and/or kyphotic deformity.	Follow-up ranged from 1 to 12 years. No deterioration was noted in all patients in both treatment groups. Operative patients had significantly less pain compared to non-operative patients.
Dai [4] (retrospective study)	Eighty-three patients who received the diagnoses of a single level, non-pathologic burst fracture (T12-L2) at Changzheng Hospital from 1988 to 1995. Excluded: multiple spinal fractures or vertebral body fractures and fractures reduced completely with postural reduction or operative treatment; 29 patients were excluded. Included: CT-scans showed middle-column involvement with retro-pulsed bone fragments in the spinal canal; 31 patients met the inclusion criteria. Classification: not reported.	Untreated group: seven patients. Non-operative group: 16 patients wore a hyperextension body cast or brace after postural reduction. Operative group: three patients treated with posterior distraction rods and five with transpedicle screw implants. Surgical intervention was indicated in patients with unstable injuries.	Follow-up ranged from 3 to 7 years. The percentage of spinal canal remodelling for all three groups were not significantly different. None of the patients was neurologically worse at final follow-up.
Domenicucci et al. [5] (retrospective study)	Thirty-one patients with non-neurological vertebral fracture of the D11-L3 segment, admitted between January 1991 and March 1994 to “La Sapienza” University. Included: patients younger than 67 years, burst or wedge compression fracture, the anterior angle of compression greater than 6 degrees. Classification: Denis classification.	Conservative treatment: 20 patients received fracture reduction on a Cotrel bed and immobilization in plaster vest for 2 months. Surgery: 11 patients underwent surgery consisting of pedicular screws, longitudinal and transversal rod (Diapason instrumentation) Indication for treatment: not reported.	Follow-up ranged from 14 to 38 months. Satisfactory short-term radiographic results for both treatment options. Long-term radiographic results were less favourable in patients treated conservatively; but did not negatively influence clinical deterioration (pain and functional recovery) in patients with a sagittal index of less than 20°.

Table 1 (Contd.)

Study	Population	Intervention	Results
El-Awad et al. [6] (retrospective study)	All patients diagnosed with thoracolumbar fractures (T10-L2) between 1989 and 1999 were reviewed. One hundred patients were treated at the Armed Forces Hospital (Saudi Arabia) in that period. Patients treated conservatively were all fracture type A. Patients treated operatively: three type A, nine type B and 12 type C. Classification: Associate Orthopedic (AO) Classification.	Conservative treatment: nine were treated with a plaster jacket (POP), 40 with a Boston Brace Overlap (BBO) and seven with a POP followed by a BBO. Operative treatment: 13 patients had anterior decompression and posterior instrumentation, four anterior decompression and fusion, five anterior decompression fusion and instrumentation and 22 posterior instrumentation and fusion. Indication for surgery: instability and/or kyphotic deformity and/or retropulsive bony fragment in the canal causing compression to the neural element.	The indication for treatment was different; but both treatment options gave satisfactory results.
Gertzbein [7] (prospective study)	A total of 1,019 patients with traumatic thoracolumbar fractures admitted at 48 centers in 12 countries from January 1986 to March 1988. Non-operative patients: 69 compression, 96 burst, 18 flexion-distraction fractures and 13 fracture dislocations. Operative patients; 36 compression, 545 burst, 81 flexion-distraction fractures and 145 fracture dislocations. Classification: Denis classification.	Operative treatment: 613 patients had posterior surgery and 203 patients had anterior surgery. Conservative treatment: 199 patients were treated conservatively; treatment not described. Indication for treatment: not reported.	Follow-up of 2 years. The distribution of fracture types and neurological scores were not comparable in the different treatment groups. Therefore the effectiveness of treatment was difficult to compare. Surgical patients had less pain at follow-up; the difference was significant at two years follow-up.
Gotzen et al [8] (retrospective study)	Eleven patients treated non-operatively between 1986 and 1989 were compared with 14 patients treated operatively between June 1987 and July 1990. All patients had (unstable) compression fractures Grade II in the thoracolumbar region. Classification of fracture: Denis and McAfee and own classification (Grade I-III)	Operative treated patients underwent monosegmental dorsal spondylodesis; nine had stabilization with plates and cerclage wire and five with an internal fixator. Four patients treated non-operatively wore a Dynacast for 6-8 weeks, three patients had a corset for the same period of time and four patients had functional therapy. Different periods in time were compared.	Follow-up ranged from 8 to 42 months. At clinical (patient satisfaction with treatment outcome, return to work) and radiographic (Beck-Index and Cobb-angle) follow-up evaluation, the results in the operative group were more favourable.
Hitchon et al. [9] (prospective study)	Sixty-eight patients with thoracolumbar burst fractures (T12, L1 and L2) treated by the Division of Neurosurgery at the University of Iowa and VA Medical Centers from 1987. Thirty-two patients were treated non-operatively: 26 with Frankel score E and six with D. And 36 patients underwent surgery; five patients with Frankel score E, 17 with D, five with C, nine with A. Classification: Denis classification.	Operative treatment: stabilization by means of pedicle screws with plates or rods in 15 patients, Luque or Harrington rods in 17 patients and anterior spinal device in four patients. Non-operative treatment: immobilization after ambulation in polyester or acrylic orthosis for 3-5 months. Indication for operation: angular deformity measured more than 10° and the residual spinal canal exceeded 50% of normal.	Follow-up in the non-operative group: 278 ± 303 days and 641 ± 631 days in the surgical group. Neurological improvement and progressive angular deformity appeared in both groups. Incidence of pain and spasm was comparable in both groups. A higher percentage of patients in the non-operative group were able to return to (previous) employment; 80% versus 51%.
Kraemer et al. [11] (retrospective study)	Thirty-six patients with a burst fracture of the thoracolumbar spine (T11-L4) without neurological deficit admitted to St. Michael's Hospital from 1987 to 1992. Eleven patients could not be located, one refused to participate. Classification: not reported.	Operative treatment: 13 patients had posterior fixation, three patients anterior fixation. Non-operative: eight patients were treated non-operatively; treatment not described. Surgical intervention was at the discretion of the treating surgeon based on the degree of kyphosis and canal compromise.	Follow-up of 2 years. There was no significant difference in the functional outcome between both treatment groups.

Table 1 (Contd.)

Study	Population	Intervention	Results
Oner et al. [12] (prospective study)	All patients with a traumatic thoracolumbar fracture necessitating active treatment were included. Excluded: pathologic fractures, psychotic patients and seriously ill polytraumas. Twenty-four patients were treated conservatively (19 type A, four type B and one type C fracture) and 29 were treated operatively. Classification: AO classification by Magerl.	Conservative treatment: Stable fractures: immediate ambulation with a removable cast. Unstable fractures: immobilization with same cast and bed rest for 4–6 weeks. The cast was worn until 12 weeks after the injury. Operative treatment: Posterior short segment pedicle fixation with AO internal fixator (21 patients) Isola system for long segment fixation (seven patients), Kaneda fixation (one patient) Patients with stable fractures (A1, A2, A3.1 with < 15° kyphosis and without neurologic involvement) were treated conservatively. Patients with unstable fractures without neurologic involvement were asked to make a choice. All patients with neurologic involvement were treated operatively.	Follow-up of 2 years. Thirteen of the 24 patients treated conservatively had no pain or occasional pain versus 27 of the 29 patients treated operatively. In the conservative group 11 patients reported moderate to severe pain versus two in the operative group.
Ramieri et al. [13] (retrospective study)	Forty single, non-neurological compression type fractures, that involved the T11–L3 region. Excluded were mild type A1.1 fractures because they were believed to be stable and not at risk for late deformity. Twenty fractures were treated conservatively (eight type A1, seven type A2 and five type A3) and 20 were treated operatively (four type A1, ten type A2 and six type A3) Magerl classification and McCormack scale	Conservative treatment: reduction on a Cotrel bed and immobilization for 3 months in a plaster brace. Operative treatment: short posterior fixation (four transpedicle screws, two longitudinal bars, one transverse bar connector) and posterolateral fusion with autologous and/or bank bone transplants. Indication for treatment: not reported.	Follow-up ranged from 9 to 32 months. Restructuring of the vertebral bodies, the residual kyphotic deformity and post-surgical complications were assessed. Results were defined as good in four A1 and three A2/A3 fractures treated conservatively, results in 13 fractures (four A1 and nine A2/A3) were defined as insufficient. Good results were reported in four A1 and in six A2/A3 fractures treated operatively. Insufficient results were reported in ten A2/A3 fractures.
Rechtine et al. [14] (retrospective study)	Hospital charts of 235 patients with unstable thoracolumbar injuries treated by authors of article were reviewed. All injuries included were deemed to be appropriate for surgical stabilization. Excluded: simple and stable compression fractures. 117 patients were treated surgically and 118 were treated non-operatively Classification: not reported.	Surgical treatment: 21 patients were treated with an anterior surgical approach, the rest underwent posterior instrumentation and fusion. Non-operative treatment: six weeks on a kinetic bed (Roto-Rest) with sequential compression devices and antiembolism stockings and an exercise program. Patients were given the option of immobilization or surgical stabilization. Surgery was the only option if a predominantly ligamentous injury was identified.	No significant difference in the occurrence of decubitis, deep venous thromboses, pulmonary emboli or mortality between treatment options. Significantly more wound infections in the operative group and a significant longer stay in the conservative group.
Resch et al. [15] (retrospective study)	Eighty-six patients with fractures of the thoracolumbar spine; 56 were treated operatively (66% type A, 29% type B and 5% type C fractures) and 30 were treated conservatively (all type A fractures). Classification: AO/ASIF classification.	Operative treatment: dorsal locking instrumentation with pedicular fixation and, apart from six patients with transpedicular cancellous bone grafting. Conservative treatment: according to the guidelines of Böhler with closed reduction, plaster cast and rehabilitation program. Indication for treatment: not reported.	Follow-up ranged from 12 to 98 months. For comparison of results between both groups only fracture type A were compared. In the conservative group the kyphosis increased significantly compared with the surgical group. There was no relationship between radiological and clinical outcome. All patients were (very) satisfied in the conservative group; 15% of the patients in the surgical group were not satisfied.

Table 1 (Contd.)

Study	Population	Intervention	Results
Romero et al. [16] (retrospective study)	Seventy-nine patients with spinal cord injuries caused by dorso-lumbar fractures admitted at the center between January 1989 and February 1991. Sixteen patients were treated conservatively (seven compression, five burst and four fracture-dislocations) and 63 were treated operatively (six compression, 25 burst and 32 fracture dislocations). Classification: Denis classification.	Operative: laminectomy (nine), Harrington rods (15), supplemented Harrington (19) and the Malaga transpedicular fixator (20) Conservative treatment was based on the postural measures described by Guttman and others. Indications for operation were fracture dislocation; an unstable burst fracture, retropulsed fragments occupying more than one third of the canal, progressive neurological deficit and severe kyphosis with vertebral wedging of more than 50%.	Mean follow-up was 29 ± 3 months. Radiological outcomes were significantly better for the Malaga fixator. No significant differences were found in neurological improvement or hospital stay.
Seybold et al. [17] (retrospective study)	Forty-two patients treated at three medical centers from 1980 to 1996 for burst fractures of L3, L4, L5. Inclusion: damage to at least one vertebral endplate, loss of both anterior and posterior vertebral height with retropulsion of bone into the canal documented by CT-scanning. Fracture had to be non-pathological. Twenty patients received nonoperative treatment, 22 underwent surgery. Classification: Denis classification.	Conservative: bed rest (1–7 days) ambulation in orthosis. Operative: short transpedicle instrumentation, anterior decompression and fusion, combined procedure, hook and rod instrumentation. Indication for treatment: no reported.	Mean follow-up in the non-operative group was 45.5 months and in the operative group 51 months. Radiographical evaluation: no significant difference between groups. Return to work and functional outcome were comparable
Shen et al. [18] (prospective study)	Eighty patients met the inclusion criteria: neurologically intact patients, single level closed burst fracture involving T11-L2, no fracture dislocations or pedicle fractures, age 18–65 years (non-pathologic adult) and no other major organ system or musculoskeletal injuries. Forty-seven patient were treated non-operatively and 33 were treated operatively. Classification of fractures: not reported.	Operative: three-level fixation using VSP or TSRH instrumentation Conservative: activity to point of pain tolerance using a hyperextension brace. Initially patients were assigned randomly to treatment groups. Because of local belief; patients who refused surgery were placed in the non-surgical group.	Follow-up of 2 years. Operative treatment provides partial kyphosis correction and earlier pain relief, but functional outcome at 2 years is similar.
Yazici et al. [20] (retrospective study)	Eighteen patients treated with thoracolumbar burst fractures in the Department of Orthopedics and Traumatology between May 1993 and May 1994. Seven patients were treated operatively (two were paraplegic), 11 were treated non-operatively (none of the patients had neurological deficits). Classification of fractures: not reported.	Conservative: 3 weeks of bed rest, followed by mobilization in orthosis (6 months). Operative: posterior instrumentation and fusion. Assignment of the patients to groups was based on the surgeon's preference.	The follow-up ranged from 18 to 29 months for the operative treatment group and 18–24 months for the non-operative group. The study focused primarily on the effects on canal remodelling. There was no statistical difference between postoperative values of operative group and postinjury values of non-operative group. Resorption of retropulsed fragments was less favourable in non-operative group.

makes it difficult to compare the results of the various studies (see Table 1).

Effectiveness of operative versus conservative treatment

Eight studies reported no differences between the operative and conservative group [1, 4, 6, 11, 13, 15, 17, 18]. In six studies, radiographical and/or clinical outcome were found to be more favourable in the operative group [3, 5, 8, 12, 16, 20]. Gertzbein [7] and Hitchon et al. [9] concluded that the effectiveness of operative and conservative treatment was difficult to compare, because the treatment groups in their studies were not comparable. Rehtine et al. [14] only looked at short term follow-up and reported a significantly longer hospital stay in the conservative group, but significantly less wound infections.

The results of this systematic review indicate that the current literature does not clearly show that operative or conservative treatment is the most effective for patients with unstable traumatic fractures. The methodological quality of studies was low, and characteristics between studies were heterogeneous with respect to study population, interventions and outcome measures.

Discussion

This systematic review shows that there is no scientifically sound evidence from high quality randomised trials on the effectiveness of operative and conservative treatment of unstable traumatic thoracolumbar fractures. Studies that were identified were all observational studies with relatively small sample sizes and only a few had used a prospective study design. The majority of the studies had a retrospective design and merely described a series of patients who had received either operative or conservative treatment. Indications for treatment might have differed, but were not explicitly described in most studies. Therefore confounding by indication seems very likely.

Also, sample sizes were small and studies consequently might have lacked the power to detect clinically relevant difference in effect. Formal sample size calculations were not reported. Outcome measures varied among studies. Although some studies included clinical outcome measures such as pain and functioning, many studies focused on radiological outcomes only. In our opinion, at least clinical outcome measures should be included in an evaluation of success of treatment of thoracolumbar fractures. One could argue that radiological changes are only relevant if they are strongly associated with changes in clinical outcomes, which is not necessarily true.

The assessment of instability in fractures is still not straightforward; the definition of instability by White and Panjabi [19] is abstract, and in clinical practice different classification systems are applied. Of the 17 studies in our review, eight studies used the Denis classification system, four used the AO-classification by Magerl and five studies did not report the applied classification system. The Denis classification, defining four categories of fractures, is a relatively simple classification, but it has some weaknesses. It is incomplete and incomprehensive, it does not cover all the traumatic lesions of the thoracolumbar spine and the principle of the middle column has no anatomical basis. The AO classification includes three types of fractures with 55 different subtypes allowing to identify the variety of the lesion. However, Blauth et al. [2] reported a kappa value of 0.33 (0.30–0.35). The use of different classification systems and the lack of evidence on the reliability of these systems further hinder the comparability of these studies.

Because of the rapid developments in surgical techniques over the last two decades we excluded studies before 1992. Even then a comparison of study results from different years is hardly possible. There is an enormous variety of operation techniques, such as laminectomy, anterior and posterior approaches with varying instrumentation, and, more recently, the thoracoscopic spine surgery. Not only have the techniques changed but also the material of the instrumentation has been modernised, and indications for different techniques have been altered. In order to draw conclusions from different studies, a thorough description of the interventions is necessary. However, this was lacking in most studies.

Conclusions

Due to differences between studies, as mentioned above, the results from different studies are not directly comparable and it remains unclear if operative or conservative treatment is more effective. There definitely is a need for randomised controlled trials with sufficient sample size to detect clinically relevant differences and with sufficient methodological quality to avoid potential selection, performance, exclusion and detection bias. Obviously, it is impossible to blind patients and care providers for treatment; it is therefore of utmost importance to establish adequate concealment of treatment allocation. Also relevant patient-centred outcomes should be measured, such as pain, functional status, return to work and quality of life. Adverse events, compliance to treatment, (especially conservative treatment) co-interventions and drop-out rate should be adequately reported.

Long-term follow-up and intention-to-treat analysis are strongly recommended. Conducting an economic evaluation [10] alongside such a trial would be essential to adequately inform policy makers about the most efficient treatment for unstable traumatic thoracolumbar fractures.

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