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Review Article

The effects of orthosis on thoracolumbar fracture healing: A review of the literature

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ABSTRACT

Background: Various methods have been used as a conservative treatment of stable thoracolumbar fracture. Presently, it is controversial, whether the use of spinal orthoses reduces pain and deformity associated with vertebral fracture or not. Therefore, the aim of this study was to determine the effects of orthoses on vertebral fractures healing in thoracolumbar area.

Materials and methods: A search was carried out on Medline, ISI web of knowledge, Google Scholar and Embase. The keywords used included thoracolumbar fracture; brace, orthosis, and conservative treatment.

Results: Twenty-one papers were selected for final analysis. The quality of the most of the papers was poor, as most of them were retrospective studies with various follow-up periods. **Discussion:** Based on the results of these studies, it can be concluded that subjects with a fracture of thoracolumbar achieved a high ability to return to their jobs. The use of orthosis did not influence the kyphosis angulation in subjects with stable fracture in thoracolumbar spine. The effects of orthoses would be mostly immobilization, protection and remaining.

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1. Introduction

The prevalence of thoracolumbar fracture is high due to trauma (mostly traffic accident) and diseases.^{1–3} Various treatment methods have been used to manage thoracolumbar fracture.^{4–7} The main goals of treatment are to provide stability, to relieve pain, to restore function, and to reduce the deformities such as kyphosis or lordosis associated with spinal fracture.^{4–7} Various conservative treatments have been recommended including postural re-education, bed rest, body cast, and use of orthoses. Currently, bracing is a fundamental part of conservative treatment for thoracolumbar fracture even after surgery.⁶ Most common orthoses for vertebral

fracture include the 3-point hyper extension (Jewett style), Boston overlap orthosis (BO), and Taylor style.^{4,8}

Orthoses help to stabilize fractured vertebra, to relieve pain and to reduce intradiscal pressure.⁹ They also help to reduce the time of hospitalization for patients with vertebra fracture.⁹ They have also been reported to be a cost-effective intervention for this condition.⁹ However, it is controversial that using brace is an effective method to stabilize the vertebral column, reduce the deformities associated with the fracture and reduce pain (it has been shown that the goals of bracing are to prevent failure of osteosynthesis, to facilitate immobilization, and to ensure correct posture).^{10–12}

It has been shown that using spinal brace seems to reduce subjective symptoms during the mobilization phase, however,

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it did not have a significant influence on preventing kyphotic deformity.^{12,13} Similarly, Ohana et al. confirmed that there is no evidence to support the positive influence of brace on treatment of fracture in the lumbosacral region, therefore, this type of fracture should be treated with early ambulation and with no external support.¹⁰ In contrast, Celebi et al. in their study on 26 individuals, recognized with single burst type fracture, showed that the average pain score in patients with spinal fracture decreased follow the use of orthoses.¹⁴ Moreover, it was defined that early mobilizations in a total contact TLSO produce satisfactory functional results.

Although the goals of using an orthosis are to provide support, rest, immobilization, protection, correction and remainder,⁶ it is controversial whether the use of orthosis has the aforementioned benefits for thoracolumbar fractures or not. Therefore, the aim of this review was to determine the effect of using various orthoses in the treatment of vertebral fracture.

2. Materials and methods

An electronic search was performed via PubMed, ISI web of Knowledge, Google scholar, Medline, and Embase. The keywords used were orthosis, thoracolumbar fracture, conservative treatment, and brace. The search was carried out to include articles between 1960 and 2014. The inclusion criteria for selection of the papers include were articles published in English language and having at least one of the

aforementioned keywords. The first selection of the papers was done based on the title and abstract. The following exclusion criteria were used to select the final papers.

- (1) Focus on surgical intervention (if the paper focused on comparison between surgery and brace, the data of brace was selected).
- (2) Published between 1960 and 2014.
- (3) Patients have only vertebral fracture.

The brief description of each paper is provided in Tables 1a–1e. Some parameters including methods of evaluation, type of injury, number of subjects, age of subjects, follow-up period, type of orthosis, pain severity, amount of kyphosis deformity and reduction of vertebral height were considered.

3. Results

Based on the aforementioned key words, 1000 papers were found. The selected papers were evaluated with considering title and abstracts. Finally 21 papers have been selected for final analysis. As can be seen from the table the quality of most of the papers was poor. In most of the studies pain severity and evaluation procedure were not mentioned. Moreover, various procedures have been used to represent the severity of fracture and association deformities. Most of the studies were retrospective studies with varying follow-up periods.

Table 1a – The results of some studies done on effect of spinal orthosis on thoracolumbar fracture.

Researcher	Number	Age	Follow-up	Intervention	Procedure	Results
Dai et al. ¹⁶	16 burst fracture (T12–L2)	No information	3–7 years	Hyper extension body brace	Subjects wore a hyper extension body brace after postural reduction	Canal compromise: 8.5%. None of the subjects was neurologically worse at follow-up.
Denis et al. ¹⁷	36 (thoracolumbar fracture without neurologic deficit)	No information	42 month	Body cast	The subjects used body cast. Their abilities to return to their job and neurological complications were evaluated in this study.	75% able to return to work. Neurological complications were 17%.
Hitchon et al. ¹⁸	32 (thoracolumbar fracture)	No information	3–5 months	Thoracolumbar body cast	Frankel score to check neurological compliance. The ability to return to the previous job, and angulation of the vertebra were also evaluated in this study.	Incidence of pain was 42%. Ability to return to previous employment was 60%. Residual canal was $65 \pm 18\%$. Frankel system improved by 0.2 ± 0.4 . Angulation was 13.5 ± 8.5
Shen et al. ¹⁹	47 single level closed burst fracture at T11–L2	18–65	2 years	Hyper extension brace	The patients allowed doing various activities with the brace.	Ability to return to work: 56% Load share score: 4.1 Kyphotic angle worsen by 4 degrees. Low back pain outcome score: 65
Wood et al. ²⁰	23 single level burst fracture at thoracolumbar (T10–L2)	No information	44 month	Body cast	The alignment of the spine in sagittal and coronal planes was analyzed by use of radiograph and CT scan.	Kyphotic angle increase: 13% Canal compromise increase: 19% Complication = 2 Less disability

Table 1b – The results of some studies done on effect of spinal orthosis on thoracolumbar fracture.

Researcher	Number	Age	Follow-up	Intervention	Procedure	Results
Yazici et al. ³²	11 thoracolumbar burst fracture	No information	18–24 month	Orthosis	3 week bed rest followed by mobilization in orthosis (6 month)	No difference between the rate of remodeling between operative and non-operative
Sys et al. ⁸	28 patients with a fracture at pars inter-articularis. Average time of bracing = 15.9 weeks.	17.2 years	13.2 month	Boston overlap brace with a hinge extended to thigh.	The brace was worn for 23 hours per day.	23 (82.2%) rated the outcome as excellent, three (10.7%) as good, 2 (7.1%) as fair. 89.3 returned to work.
Braun et al. ²⁸	55 subjects	No information	11 months	3 points corset was used.	The complicate of subjects was recorded based on a cardinal scale. Narrowing of vertebral based on radiography; scoliosis and pain were also monitored.	Narrowing of vertebra = 6% No pain, no scoliosis were reported. No complication was reported.
Folman et al. ³³	85 subjects	No information	9 years (3–16)	No information	Pain was measured based on an ordinal scale (to 10). The overall disability was evaluated based on Oswestry scale.	Chronic pain of lumbar was reported in 69.4% of the subjects. Mean pain index was 2.94 ± 2.67 . Mean overall disability score was 56.3 (out of 100).
Karjalainen et al. ¹³	126 subjects with fracture of thoracic and lumbar spine. The mean value of follow-up was 7.2 years.	18–43	7.2 years (5.5–10.7)	Extension brace was used for 6 weeks.	Vertebral deformity (compression, scoliosis), functional outcome, pain, and radiological angles of the deformity were evaluated.	The use of extension brace seems to decrease the subjective symptoms during mobility but no effect on kyphosis. Orthosis more suited for those with kyphosis less than 13.

Table 1c – The results of some studies done on effect of spinal orthosis on thoracolumbar fracture.

Researcher	Number	Age	Follow-up	Intervention	Procedure	Results
Ohana et al. ¹⁰	33 subjects with type A thoracolumbar fracture (T11–L4).	No information	No information	Subjects ambulate with a lumbar orthosis.	Patients with neurological deficient were excluded. Restriction in body function was measured. Restriction in participation in life was also measured.	90% of the subjects return to their work. 37% of patients were not able to perform dynamic lifting test in normal range. Patients do reasonably well with conservative treatment 5 years after treatment. The results showed that thoracolumbar fractures with compression as much as 30% can be treated with early ambulation with no external support.
Hartman et al. ³⁴	32 patients with stable neurological deficit (23 men, 9 women) at T3–L5. (20 burst fracture, 6 fracture dislocation, 5 compression fracture, 1 gunshot)	3.68	22.3 months (12–60)	Molded TLSO	Frankel system was used for assessing neurological deficient. Molded TLSO orthosis was used for 2–3 months. Radiographic X-Ray evaluation was done.	Kyphosis = Progressed by 5.7 degree Average decrease vertebral height = 9.7% 2 complications Use of non-operative treatment can result in low morbidity and excellent outcome. Neurological injury and multitrauma are not always contraindicated to non-operative treatment.
Argenson et al. ²¹	10 patients with thoracic spine fractures (T1–T10). 57% compression fracture, 20% burst fracture, 2.8% flexion distraction and 23% fracture dislocation.	No information	No information	No information	Use of orthosis	Conservative treatment was difficult because of associated parietal lesions. These subjects had only moderate reductions that maintain poorly in time, but had no major painful sequence.

Table 1d – The results of some studies done on effect of spinal orthosis on thoracolumbar fracture.

Researcher	Number	Age	Follow-up	Intervention	Procedure	Results
Tezer et al. ⁵	48 patients with thoracolumbar fracture (29 treated with TLSO, 7 with Body cast, 6 with body cast following TLSO)	18–76	77.5 months	Body cast and TLSO were used.	In compression fracture, TLSO or body cast was used for 3–6 month with early ambulation, In burst fracture, TLSO or body cast used for 8 weeks. Fractures were classified according to Denis. Kyphosis angle, scoliosis angle, wedging index, vertebral index and loss of height were measured.	For compression fracture Kyphosis angle: 15.8–17.2 Scoliosis angle = 4.2–4.9 Vertebral index = 16.6–16.9 Wedge index = 16.5–18 Height loss = 19–21 Burst fracture Kyphosis angle = 19.9–23.4 Scoliosis angle = 5.4–7.2 Vertebral index = 20.9–24.4 Wedge index = 20.7–24.3 Height loss = 21.6–24.5 Compression-type vertebral fractures with kyphosis less than 30 are stable and good candidate for conservative treatment. In the burst fracture with no neurological deficit and without any injury to posterior longitudinal ligament conservative treatment should be the first choice.
Gumley et al. ³⁵	10 subjects with fracture between T12–L3. Type of fracture (1, 2, 3).	26	No information	Extension cast and Boston brace	Extension cast and Boston brace was used for the patients	No information regarding the outcome of treatment was provided.
Jones et al. ²²	33 patients with thoracic and lumbar fracture (T3–L3). 27 suffered from neurological loss. 6 with no neurological loss.	No information	No information	No information	The extent of vertebral fracture was assessed by AP and lateral X-ray. Lite cast, Hexalite Taylor and molded plastozone lined polyethylene braces were evaluated in this research. Assessment of neurological progress was made by using Frankel grading system	Patients experience problems in using orthosis. PLP brace seems to provide better alignment. Use of brace for period of 16 weeks (after bed rest for 6 to 8 weeks) gave good results. Long term follow-up has been shown persistent stability and alignment. Both Taylor brace and plastozone lined polyethylene brace proved satisfactory results.

Tables 1a–1e summarize the method and findings of the studies. As can be seen from the tables most of the studies were done on burst fracture with no neurological implications. There were also 5 review studies, in which most of them were narrative reviews. The quality of the studies was not examined in most of the review articles.

4. Discussion

The incidence of thoracolumbar fracture is high mostly due to traffic accident. Various methods have been used to treat the subjects with spinal fracture, including operative and conservative treatment.^{5,6,14,15} Using spinal brace is one of the important treatments used for managing thoracolumbar fracture. Although there were some studies on the effects of using orthosis on thoracolumbar fracture, it is controversial, whether the use of orthosis is of any benefits to the patients or not. Therefore, the aim of this review article was to evaluate the available evidence on the use of orthosis in the treatment of spinal fracture.

As can be seen from Tables 1a–1g, 21 original and 7 review papers have been published on the effects of orthosis on spine fracture. The first question is to answer to this question that the use of orthosis is influential on bone healing or not. To answer to this question it is required to clarify the method used to evaluate the effects of treatment. Various parameters have been used to represent the severity of fracture and also the effects of orthosis including: neurological status, canal compromise, ability to return to work, severity of pain, kyphosis angulations, complication, rate of remodeling, narrowing, vertebral height reduction and vertebral alignment.^{5,7,8,10,12,13,16–22} However, the most important ones include, vertebral height,^{4,12,13,23} functional outcome,^{8,21,22} kyphosis angulations,^{4,7,20,23,24} severity of pain¹⁸ and ability to return to the previous occupations.^{8,10,17,19}

4.1. Comparison based on Functional outcome, alignment and return to work

As can be seen from Tables 1a–1g, 6 studies reported functional outcome as a main important parameter for

Table 1e – The results of some studies done on effect of spinal orthosis on thoracolumbar fracture.

Researcher	Number	Age	Follow-up	Intervention	Procedure	Results
Celebi et al. ¹⁴	26 patients with single level burst fracture with no neurological deficient (Frankel E). No posterior column involvement. Pain was also scored in this research.	36 (18–67)	Follow-up for a mean period of 42.9 months (12–63) months.	Hyper extension brace was used.	The kyphosis were measured based on the X-Ray of the subjects. After pain relief, hyper extension brace was applied to 21 patients and hyperextension cast to 5 patients. Functional assessment was done with modified Denis scale.	Functional results were excellent or good in 65.5% and poor in 7.7%. Follow-up evaluation showed a significant progression in cob angle. Although non-operative management of thoracolumbar fracture has considerable efficiency, it may have poor results in small percentage of patient.
Aligizakis et al. ⁷	60 patients with single thoracolumbar fracture (T11–L2) (38 male, 22 female). The mean age was 46.8 follow-up 42-month.	No information	42 months	Custom-made TLSO	The anterior vertebral body compression percentage (AVC) and amount of kyphosis at the fracture side were evaluated. Kyphosis was measured based on the Cobb angle.	Initial percentage of AVC averaged $35 \pm 27.8\%$. At follow-up it was $44.5 \pm 29.5\%$. Cob angle was 6 ± 4 at injury and 8 ± 3.5 at follow-up. Functional outcome was satisfactory in 91% and unsatisfactory in 9%.
Kansal et al. ²⁵	48 conservative patients with single level thoracolumbar spinal injuries with no neurological deficient were managed none operatively. The mean value of follow-up was 26.6 months	46.8	6 months	Custom molded TLSO	Cob angle and loss of fracture reduction was measured based on X-ray. Clinical outcome was evaluated by Denis pain and work scales.	Functional outcome was satisfactory in 40 out of 48 with no complications.

Table 1f – The results of some studies done on effect of spinal orthosis on thoracolumbar fracture.

Researcher	Number	Age	Follow-up	Intervention	Procedure	Results
Cantor et al. ²⁴	18 neurological intact patients with burst fracture	No data	Follow-up = 19 month	Custom molded TLSO	Kyphosis was measured based on X-ray. Pain and ability of the subject to return to the previous job were also measured.	Mean kyphosis= 19 at time of injury and 20 at follow-up. 15 patients reported no pain. Early mobilization in patient provide satisfactory results
Reid et al. ²³	21 patients with burst fracture who were neurological intact out of 404 patients.	No data	1 years	Custom molded TLSO	Subjects used brace for 6 months. Kyphosis angle and vertebral height were analyzed based on x ray.	Change in kyphosis angle at follow-up was 4.6 degrees. Change in anterior vertebral height was 6.1 degree. The subjects had a satisfactory pain score and most of the subjects returned to full employment.
Chow et al. ²⁷	A retrospective review of 26 patients with unstable burst fracture in the thoracolumbar region (T11–L2).	No data	34.3 months	Hyperextension casting and bracing	A questionnaire was used to ask the patients about their pain, ability to work, ability to perform in recreational activities. Overall satisfaction with treatment was also monitored in this study.	Kyphosis deformity could be corrected with hyperextension casting 79% of the subjects had no or little pain. 75% returned to their previous job. 75% had no restriction in their abilities to participate in recreational activities. Use of brace is a safe and effective method of treatment of spine fracture.

evaluating the efficiency of orthotic treatment. Ability to return to the work was assessed in 4 studies. Sys et al. used the Boston overlap brace with thigh extension.⁸ The results of this research showed that more than 80% of the subjects rated the outcome as excellent. Based on alignment, it was also shown that 91% of the subjects reported excellent outcome. The effects of using hyperextension brace on functional outcome

of subjects studied by Celebi et al.¹⁴ They reported 65% excellent results.

A high percentage of excellent results follow the use orthosis in patients with spinal fracture has been reported.^{4,24–26} However, it should be noted that in all of these studies the participants with stable fracture (burst thoracolumbar fracture) with no neurological deficient were selected. Therefore, it

Table 1g – The results of some studies done on effect of spinal orthosis on thoracolumbar fracture.

Researcher	Number	Age	Follow-up	Intervention	Procedure	Results
Melchiorre ²⁶	27 patients with one or more thoracolumbar fracture. Used custom molded TLSO and physiotherapy	35.2 ± 12	No data	TLSO	The subjects used custom molded TLSO and physiotherapy.	A majority of neurological intact subjects with thoracolumbar fracture managed conservatively with TLSO and ambulate independency.
Tonbul et al. ⁴	43 patients (28 male, 15 female), mean age 39 years (L1–T12), with no neurologically deficient	39 (24–54)	Mean follow-up 7.5 years	Body cast followed by TLSO orthosis	Treatment includes use of body cast for two months and TLSO for four months. Radiological evaluation was done.	Kyphosis angle= 12.6 degrees before and 5.9 after follow-up. Sagittal index = 13.7 degree before treatment and 7 degree after casting. Mean pain and functional scores were 1.4 and 1.6, respectively before and after treatment. If kyphosis angle is less than 30 degrees, compression fracture seems to be stable to be treated by orthosis.

can be concluded that the outcome of stable burst thoracolumbar fracture is mostly excellent if treated with hyperextension and Boston overlap orthoses.

The ability of the subjects to return to work was studied by Denis et al., Sys et al., Ohana et al., Reid et al. and Chow et al.^{8,10,17,23,27} Based on the findings of Denis et al., 75% of the subjects returned to work,¹⁷ compared to 89.3% in the study of Sys et al.⁸ The percentage of the subjects that returned to work was more than 75% in the research of Ohana et al., Reid et al. and Chow et al.^{10,23,27} As the number of participants and follow-up period were reasonably high in these studies, it can be concluded that the subject with a fracture at thoracolumbar achieved a high ability to return to work.

4.2. Pain severity

Hitchon et al. reported an incidence of 42% of pain in the subjects treated with a body cast.¹⁸ In contrast Shen et al. reported that 65% of the subjects with burst fracture had back pain.¹⁹ In contrast, none of the participants in the research of Braun et al. and Argenson et al. reported any pain after treatment with orthosis.^{21,28} Chow showed that more than 75% of the subjects had no or a little pain.²⁷ Based on the results of these studies, it can be concluded that the subjects with stable trunk fracture had mostly no pain following the use of orthosis.

4.3. Kyphotic angle, and vertebral high

In 8 of studies, kyphotic angle before and after the use of orthosis was reported as one of the main parameters.^{4,5,7,13,19,20,24,27} In the research done by Wood et al. the kyphosis angle was reported to be 11.3 and 13.8 before and after orthotic treatment, respectively.²⁰ Krajaline et al. showed that the use of orthosis did not influence the kyphotic angle.¹³ They recommend the use of orthosis for those with kyphotic angle less than 13. Tezer et al. claimed that kyphotic angle of the subjects with stable fracture at T3–L5 progressed by 5.7%.⁵ Although Tezer, Celebi et al., Aligizakis, Cantor et al., and Reid

et al. confirmed an increase in kyphotic angle after follow-up,^{5,7,14,23,24} Chow et al. and Tezer et al. claimed that the use of hyperextension brace decreased kyphosis angulation in subjects with fracture between T11 and L2.^{5,27} It can be concluded that the use of orthosis does not influence kyphotic angle in subjects with a stable fracture in thoracolumbar spine.

4.4. Vertebral height

The height of vertebra in anterior side was the other indicator used to represent the efficiency of an orthosis. In the research done by Tezer et al. it was mentioned that average decrease of vertebral height was 9.7% after follow-up.⁵

Tezer et al. also showed that the vertebral high decreased after follow-up in both burst fracture and compression-type fractures.⁵ The same results were reported by Reid et al. and Aligizakis et al.^{7,23} Based on these studies, it can be concluded that the use of brace for traumatic stable fracture did not influence the vertebral height. It means that the use of the brace cannot decrease the reduction in anterior height of vertebra.

From the above-mentioned studies, it can be concluded that use of orthosis increases the functional outcome following spinal fracture. It decreases pain, improves independently, increases the chance of returning to the previous jobs; however, it cannot control and decrease kyphotic angle and also reduction in vertebral height. In all of these studies, the use of orthosis was recommended for those with stable fracture at thoracolumbar spine with no neurological complications. It should be emphasized that the role orthosis is a combination of support, rest, immobilization, protection, correction and reminding.¹² Based on the results of various studies, the role of orthosis for fracture of spine would be mostly immobilization, protection and reminding.¹²

4.5. Outputs obtained from other review studies

As can be seen from Table 1h, most of the reviewers on this topic were related to comparison between conservative and

Table 1h – The results of some studies done on effect of spinal orthosis on thoracolumbar fracture.

Name	Type	Number reviewed and included	Quality assessment	Finding
Longo et al. ⁶	Narrative	1548-13	No quality assessment was done	The influence of using orthosis on osteoporotic VCF remains controversial. There is only one controlled trial study in this regard.
Yang et al. ²⁹	Narrative	16 studies	No quality assessment was done	Nonseparation of treatment remains a valuable alternative to operative intervention in burst fracture with neurologically intact subjects. There is defiantly a need for randomized control trial with sufficient sample size to determine the effect of treatment with orthosis.
Giele et al. ¹²	Systematic	1082-8 studies	The quality of the papers was evaluated by two reviewers independently.	Based on the current literature there is no evidence for effectiveness of bracing in patient with traumatic thoracolumbar fracture. The use of bracing in patients with stable and unstable thoracolumbar fracture remains unclear.
Thomas et al. ³⁰	Meta-analysis	696-4 studies	Two independent observers select and assess the quality of the studies	There are some evidences regarding the effective of non-operative treatment. However there is lack of evidence regarding the superiority of one approach over the other as measured.
Liao et al. ³¹	Systematic	2 studies selected	Was done	There was only a clinical trial comparing operative with non-operative treatment. There was no difference between the outcomes of both treatment protocols.

surgical approaches.²⁹⁻³¹ Moreover, most of these reviews are narrative reviews. Frag et al. in review of literature concluded that non-operative treatment remains a variable alternative to operative intervention for subjects with stable, non-neurological complicate fracture.³⁰

In contrast Giele et al. concluded that there is no evidence to show the effectiveness of bracing in patients with traumatic thoracolumbar fracture.¹² As it was mentioned before, most of these review articles are on comparison of brace and surgery. Therefore, it can be concluded that the present study is the first review done in this regard which clearly shows that the use of orthosis influences the outcome of treatment and reduces pain in patients with a stable fracture in thoracolumbar spine.

5. Conclusion

The results of this review confirmed that the use of orthosis influences the outcome of treatment in patient with a stable fracture in the thoracolumbar spine. Also, the use of orthosis reduces pain and increases the functional output. The use of orthosis did not influence the vertebral height and kyphotic angle.

Conflicts of interest

The authors has none to declare.

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