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Early mobilization with customized TLSO brace in thoracolumbar burst fractures

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Objective: This study aimed to research the effectiveness of customized thoracolumbosacral orthosis treatment for stable burst type thoracolumbar vertebral fractures without neurological deficits.

Methods: The study included 26 patients (14 males, 12 females; mean age: 46.03 years; range: 18 to 64 years) conservatively treated for thoracolumbar (T11-L2) burst type vertebral fractures according to Denis classification between 2002 and 2009. Etiology were a fall from various heights in 12 patients (46.2%), motor vehicle accidents as an occupant in 7 (26.9%) and as a pedestrian in 4 (15.4%), and simple fall in 3 (11.5%). None of the patients had neurologic deficit and no damage was found in the posterior ligamentous complex in MRI evaluations. Denis pain and functional scales were used in the clinical evaluation. Local kyphosis angle, sagittal index and height loss percentage were measured in the radiologic evaluation. Post-fracture and follow-up values were compared. Mean follow-up period was 41.30 (range: 14 to 80) months.

Results: Mean pain and functional scores were 1.65 and 1.15 points, respectively, at the final follow-up. Twenty patients returned to their pre-trauma work and activities completely and six patients with small limitations. Mean period for returning to work was 3.64 (range: 2 to 6) months. Local kyphosis angle, sagittal index and height loss percentage values increased significantly at follow-up ($p<0.05$).

Conclusion: The conservative treatment of stable thoracolumbar burst fractures is widely accepted. Early mobilization with customized TLSO brace appears to produce effective functional results despite loss of vertebral body height.

Key words: Mobilization; stable burst fracture; thoracolumbar fracture; TLSO brace.

The thoracolumbar region is the most susceptible portion of the vertebral column to trauma. Anatomical and biomechanical characteristics of the region (having greatest mobility, lacking rib and sufficient muscular support, differing of facet orientations and structure of spinous processes) play a role in the injury frequency.[1-3]

The majority of systems used in the classification of vertebral fractures are based on the mechanism of injury and depend on defining or predetermining stability. Denis classified burst type fractures separately whereas they are listed more recently in the Magerl and Vaccaro systems as a subtype of fractures occurring as a result of the compression mechanism.[4-6] The widely accepted approach in the treatment of stable burst fractures is conservative while instable types are treated surgically. The determination of stability is currently a matter of debate.[5-7]

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Table 1. Patient data. Number 1 measures for SI, LKA and HLP are after trauma values, number 2 post-brace application values, and number 3 last follow-up values.

Patient	Age	Sex	TM	Level	SI-1	SI-2	SI-3	LKA-1	LKA-2	LKA-3	HLP-1	HLP-2	HLP-3	PS	FS	RW	Follow-up (wks)
1	49	M	PA	L1	25	22	25	22	20	25	20	20	25	1	1	3	34
2	60	F	FH	L1	12	10	14	15	14	16	16	15	20	1	0	4	80
3	63	M	MVA	L1	19	15	20	22	20	20	25	22	25	2	2	3	46
4	56	M	FH	L2	18	16	20	24	20	25	28	25	30	3	1	5	58
5	48	M	FH	L1	14	10	15	16	16	18	18	18	22	1	2	4	52
6	45	F	MVA	L1	20	16	20	22	20	24	26	24	30	1	1	5	35
7	64	M	FH	T12	20	15	22	20	20	22	25	25	28	2	1	3	56
8	54	F	MVA	T12	3	3	6	5	5	8	10	8	10	2	2	2	31
9	18	F	FH	L1	15	12	18	18	16	20	20	15	23	1	1	4	47
10	43	F	FH	T11	8	6	10	10	8	12	12	12	20	1	0	2	25
11	60	M	PA	L2	20	16	18	22	18	26	28	25	30	1	1	4	36
12	33	M	MVA	L1	20	18	22	24	20	25	25	22	28	2	1	4	26
13	54	F	FH	T12	4	4	6	8	6	10	10	10	15	2	1	3	44
14	18	M	MVA	T11	10	8	12	14	12	15	12	10	15	1	1	2	78
15	35	M	SF	L2	19	16	20	22	16	20	25	25	28	2	2	4	35
16	55	F	FH	T12	15	15	18	20	18	22	20	18	22	3	3	6	15
17	62	F	MVA	L1	11	10	12	15	15	18	15	14	18	1	1	3	64
18	25	F	PA	L2	14	14	15	17	14	20	20	20	25	1	1	5	22
19	63	M	FH	L1	16	15	17	20	16	18	22	20	25	2	0	4	20
20	57	M	SF	T12	20	16	22	24	20	25	30	26	34	3	2	5	15
21	37	F	PA	T12	6	6	12	8	6	8	10	10	15	2	1	3	58
22	51	F	FH	L1	8	6	10	10	10	12	12	10	15	2	1	3	49
23	45	M	FH	L1	10	10	12	12	10	15	15	15	18	1	1	2	68
24	28	M	SF	L2	15	12	15	16	16	20	20	18	22	1	0	3	14
25	36	F	MVA	T12	18	16	18	20	18	20	26	25	28	3	2	5	18
26	38	M	FH	L1	8	6	8	12	10	10	15	12	18	1	1	4	48

TM: trauma mechanism, PA: pedestrian accident, MVA: motor vehicle accident, FH: fall from height, SF: simple fall, SI: sagittal index, LKA: local kyphosis angle, HLP: height loss percentage, PS: pain score, FS: functional score, RW: return-to-work time in weeks

In this study, the radiological and functional results of the conservative treatment with custom made thoracolumbosacral orthosis (TLSO) used in the treatment of stable burst type fractures with no concurrent posterior ligamentous injuries were analyzed.

Patients and methods

Thirty-two patients underwent conservative treatment for thoracolumbar (T11-L2) burst type vertebral fracture between 2002 and 2009. Of these, 26 patients (14 males, 12 females; mean age: 46.03 years; range: 18 to 64 years) with adequate follow-up were included in the study. Patients with additional fractures, pathological fractures or comorbidities such as osteoporosis were excluded. Etiology was a fall from a height in 12 patients (46.2%), motor vehicle accidents as an occupant in seven (26.9%) and as a pedestrian in four (15.4%), and a simple fall in three (11.5%). Twelve patients had L1 (46.2%), seven had T12 (26.9%), five had L2 (19.2%), and two had T11 (7.7%) vertebral fractures (Table 1).

In addition to complete physical examination, bidirectional vertebral radiographs, computed tomography (CT) and magnetic resonance imaging (MRI) were obtained. All patients had burst type fractures according to the Denis classification.[4] None of the patients had neurological deficits and no damage was found in the posterior ligamentous complex (PLC) on MRI evaluation. Presence of rupture in any of the components of PLC (supraspinous ligament, interspinous ligament, ligamentum flavum, facet joint capsule) was considered as PLC damage. Cases solely with edema in the PLC were included in the stable fracture group. Kyphosis angle, the percentage of height loss and spinal stenosis measurements were not regarded in treatment selection.

Customized braces were prepared through measurements on the first day of hospitalization and produced by the same expert (Fig. 1). All patients were mobilized on the third day after trauma following TLSO brace application with no limitation. The patients were asked to use their braces the whole day for 12 weeks and then for half a day for an additional 3 weeks. Patients were evaluated radiologically and clinically every four months for the first year and then annually. The Denis Score for pain and functioning was used in the evaluation of the patients during their follow-ups (Table 2).[8]

Following the post-fracture brace application, the sagittal index, kyphosis angle and the percentage of height loss were measured in standing lateral radi-

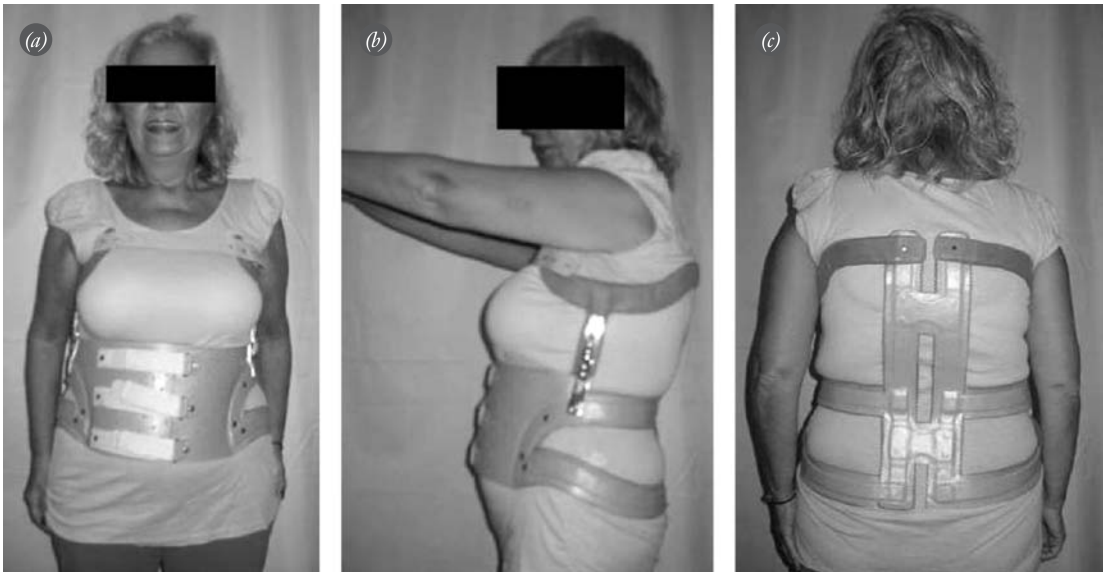

Fig. 1. **(a-c)** Figures showing a patient with thoracolumbosacral orthosis. Daily activities of patients were allowed after brace application.

ographs and the reduction provided by the brace was evaluated. The same values were measured at the final follow-up (Table 1). Local kyphosis angle was determined by measuring the angle between the line drawn tangential to the superior endplate of the superior vertebra and the line drawn tangential to the inferior endplate of the inferior vertebrate.[9] Sagittal index was calculated by subtracting the kyphosis angle on the affected level from the normal sagittal contour.[10] The percentage of height loss was calculated by proportioning the mean value of the heights of the anterior parts of the inferior and superior vertebral corpuses to the height of the affected vertebra.[11] The time necessary for returning to work was also determined. Mean follow-up period was 48.5 (range: 12 to 77) months.

Statistical evaluation was performed by using Student's t-test according to bidirectional p values. P values of less than 0.05 were considered significant.

Results

Mean hospitalization period was 3.4 (range: 2 to 6) days. Ambulation with TLSO brace was allowed for all patients on the third day after injury. Mean pain score was 1.65 (range: 0 to 3) points and mean functional score was 1.15 (range: 0 to 2) points at the final follow-up. Twenty patients returned to their pre-trauma work and activities completely and six patients with small limitations. Those 6 patients had hard working conditions requiring long durations of standing that caused back pain. The mean period between injury and return to work was 3.6 (range: 2 to 6) months. After the brace application, sagittal index values improved by 15%, local kyphosis angle values by 12.4% and the percentage of height loss values by 8.1%. The changes obtained were statistically significant ($p<0.05$). Mean sagittal index measurement was 12° (range: 3 to 25°) after the brace application and 15.7° (range: 5 to 24°)

Table 2. Scale used for assessment of pain and function.[8]

Assessment of pain		Assessment of function
No pain	0	Returning to previous occupation
Intermittent pain not requiring analgesics	1	Returning to previous occupation or daily activities with mild limitations
Frequent mild pain occasionally requiring non-narcotic analgesics	2	Returning to previous occupation or daily activities with major limitations
Infrequent moderate pain requiring analgesics	3	Not completely returning to previous occupation and daily activities and needing energy saving life style
Intense pain occasionally requiring narcotic analgesics	4	Significant loss of function, limitations even in routine daily activities
Very intense pain requiring regular narcotic analgesic intake	5	Complete loss of function

after the follow-up period. Mean local kyphosis angle was 16.8° (range: 5 to 24°) after the brace application and 18.6° (range: 8 to 26°) at the final follow-up. Mean height loss percentage values were 19.4% (range: 10 to 30%) after the brace application and 22.7% (range: 10 to 34%) after the follow-up period. Differences between all compared parameters were statistically significant (p<0.05). Three patients experienced difficulties wearing the brace and were referred for a psychiatry consultation. There were no other complications related to brace usage.

Discussion

The thoracolumbar transition zone includes the T11, T12, L1 and L2 vertebrae. Most vertebral fractures occur in this region due to its anatomical and biomechanical characteristics. This region, with no rib or sufficient muscle support, is the junction of two mobile and immobile segments. These unique characteristics facilitating fracture formation also have roles in treatment selection.[1-3] In our study, thoracolumbar transition zone fractures were analyzed by excluding other vertebral fractures, thus providing standardization.

Treatment objectives in thoracolumbar vertebral fractures are to protect neural elements, provide or restore neurological function, correct or protect segmental collapse or deformity, prevent spinal instability and pain, and repair normal spinal mechanics.[6,12] Another common objective is to provide early mobilization and function. The literature reports the most common treatment choice for stable fractures to be conservative treatment, with surgery preferred for unstable fractures. However, the proper definition of stability is still a matter of debate. The concept of stability depends on a three column model with the application of CT proposed by Denis[13] in 1984. Denis defined spinal instability as mechanical instability (first degree), neurological instability (second degree), and mechanical and neurological instability (third degree). He claimed that the participation of the middle column would be enough to define the injury as unstable regardless of the causing power vector.[8,13] The efforts to classify spinal fractures were also based on the definition or predetermination of stability. Burst type fractures are defined as unstable in the classification system designed by Denis.[4] All cases in our study were burst type fractures in the middle column.

Nicoll[14] first discussed the evaluation of the posterior structures regarding stability and counted the lack of fracture in posterior elements as criteria for stability. Holdsworth defined the PLC and its importance in stability.[15] Currently, the most widely accepted definition for stable burst fractures was first defined by McAfee et al. who assessed burst fractures without damage in posterior structures according to CT examination as stable.[16] With the recent wide-spread use of MRI evaluation, a clearer determination of PLC is possible and it has become the most important structure determining stability.[17-19] Vaccaro et al. named the PLC, consisting of the supraspinous ligament, interspinous ligament, ligamentum flavum and facet joint capsule the posterior tension band. Stability of this structure was a key in the evaluation of the injury severity score.[6] Both Vaccaro and Magerl classified burst type fractures as a subtype of fractures occurring with compression mechanisms.[5,6] All cases in our study were of burst type fractures. In all cases, stability of PLC was confirmed by MRI and conservative treatment was performed.

Several studies have considered the role of various angular measurements rather than posterior structures in the determination of stability. Krompinger et al.[20] defined fractures with a kyphosis angle of below 30° and canal narrowing below 50% as stable. They advised surgical treatment for flexion-rotation fractures; fractures with translation and three column involvement and for cases with neurologic deficit except single root lesion. Reid et al. classified anterior and middle column injuries with kyphosis of less than 35° and collapse less than 60% as stable.[21] Knight et al. reported conservative treatment indications for neurologically stable single level fractures with anterior height loss of less than 20%, kyphosis angle of less than 20°, canal narrowing of less than 20% and cases without multiple trauma.[22] Hitchon et al. stated that a height loss of less than 50% and a kyphosis angle of less than 20°, together with an intact PLC, were adequate to define stability.[23] Agus et al. further recommended conservative treatment in cases with Denis Type A, B and C burst fractures with intact facet joints.[24] In our opinion, measurements performed by radiography or CT can be beneficial to determine stability in cases where MRI cannot be performed. In our study, PLC injury evaluated using MR imaging was accepted as the single criterion to determine stability in burst fractures.

Conservative treatment options for vertebral fractures include rest, body plaster, brace applications or mobilization without braces. Shen et al.[25] applied brace treatment in 9 of 38 patients with single level T11-L2 burst fractures without neurological damage and mobilization without braces for the remaining 29 patients. Average kyphosis angle values increased from

20° to 24° in the follow-up period and improvement was observed in 32 patients with no or mild pain. Consequently, the Jewett brace was found to be ineffective in preventing deformity increase and did not change the long-term results despite its effectiveness in controlling initial pain. In our opinion, mobilizing patients without limiting procedures is not as effective as brace treatment as far as pain and deformity are concerned, especially in thoracolumbar junction fractures. In a study by Mehta et al., weight-bearing radiographs proved an increase in the Cobb angle from 11° to 18° and anterior vertebral compression percentage from 34% to 46% on average with no brace application.[26]

It is debated whether fracture reduction should be performed before brace or plaster application. Tropiano et al.[27] conducted a study on patients with burst fractures that were treated with closed reduction with Cotrel traction device and body plasters and observed that the mean sagittal index value, which decreased initially to 2.7° from 13° after the reduction, increased up to 15.2° on average in the follow-up period. Similarly, the percentage of anterior height loss, which initially decreased to 13.7% from 37.1%, increased back up to 22.8%. Weninger et al. also indicated that angular values increased again in the late-term follow-up in patients who used plasters after closed reduction.[28] Thus, it is apparent that the reduction that is initially achieved cannot be conserved. In our study, TLSO brace treatment was applied without any reduction and we obtained an initial improvement of 14.98% in sagittal index values, 12.35% in local kyphosis angle values and 8.13% in height loss values. While there was a significant increase in the angular values to some extent in the follow-up period, none of the patients experienced an increase in deformity of more than 7 degrees.

In the literature, it was demonstrated that radiological measurement values do not always correspond to clinical results.[29,30] In the Cochrane study compiled by Yi et al.,[31] conservative and surgical treatments were compared in patients with thoracolumbar burst fractures without neurological deficit and no difference between the two treatment methods, regarding kyphosis angles, pain, function-related results and return to employment rates were found. It was also determined that there was no correlation between the degree of kyphosis and the severity of pain. In a comparative study by Shen et al., a weak correlation was demonstrated between residual kyphosis values above 30° and the clinical results.[25] In our study, we obtained a significant increase in sagittal index, local kyphosis angle and the percentage of height loss values between brace application and post-follow-up measurements. Despite the advance of deformity in radiological terms, 20 patients returned to their pre-trauma employment or activities completely while 6 patients were healed with negligible limitations. Average pain and functional scores were 1.65 and 1.15, respectively. The controversial results we obtained support the discrepancy between radiological measurements and clinical outcomes. In our series, the highest post-follow-up sagittal index value among the burst fractures was 25° and percentage of height loss was 30%. No complications other than adaptation problems concerning brace application were encountered in the study group. We assume that the application of patient-customized braces played a positive role in these results.

The main limitations to this study were the small number of patients, short follow-up period and wide range of patient age. Standardization was attempted through the exclusion of patients with pathologic fractures and concomitant injuries. Treatment duration was consistent with the literature. Prospective studies with larger patient numbers and equally distributed age groups are needed for a better evaluation and to define the optimal treatment duration.

In conclusion, we suggest early mobilization with customized TLSO brace application as an effective treatment option for patients with stable burst fractures. The evaluation of the PLC using MRI in the determination of stability appears to be an effective method for treatment selection.

Conflicts of Interest: No conflicts declared.

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