ORIGINAL ARTICLE

Traumatic multiple-level continuous and noncontinuous thoracolumbar spinal fractures management in adult patients: A single-center experience

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ABSTRACT

BACKGROUND: This study aimed to describe our clinical experience with surgical approaches and patient management for traumatic multiple-level continuous and noncontinuous thoracolumbar spinal fractures.

METHODS: We retrospectively evaluated patients with continuous and noncontinuous multiple-level thoracolumbar fractures who were operated on by the same surgical team from 2019 to 2021. These patients were divided into two groups: Group 1 (n=12, continuous fractures) and Group 2 (n=14, noncontinuous fractures). We assessed the patients' age, gender, fracture levels, fracture type, classification according to the AO (Arbeitsgemeinschaft für Osteosynthesefragen) Spine Thoracolumbar Fracture Classification, status of posterior ligament damage, presence of additional traumatic pathology, status of decompression via laminectomy, levels of stabilization and fusion, preoperative and postoperative neurological status, presence of cervical trauma, duration of operation, amount of blood loss, duration of hospitalization, and lordosis and kyphosis angles in terms of fusion status and postoperative follow-up over two years. The study excluded patients over the age of 65, those with single-level fractures, and pathological fractures caused by osteoporosis, infection, or spinal tumors.

RESULTS: Gender, age, neurological status, application of laminectomy, surgical complications, status of cervical fracture, duration of operation, amount of blood loss, duration of hospitalization, lordosis, and kyphosis angles were uniformly distributed between the groups. All patients underwent fusions, ranging from three to eight, with a median of two (range 2-4) fracture levels, and a median of five instrumented vertebrae, ranging from four to seven. Significant differences between the two groups were observed in terms of operation duration (p=0.001), blood loss (p=0.010), duration of hospitalization (p=0.003), number of fusions (p<0.001), and instrumented vertebral segments (p=0.011).

CONCLUSION: Thus, a surgical approach involving decompression, vertebral fusion screws, allografts, and bone substitutes can enhance surgical outcomes for patients with continuous and noncontinuous vertebral fractures.

Keywords: Continuous fracture; laminectomy; neurological status; noncontinuous fracture; spinal fusion; thoracolumbar fractures.

INTRODUCTION

Trauma, infections, and metabolic or metastatic diseases from unbalanced axial loading, with or without an accompanying rotational component or dislocation, can cause vertebral fractures.[1,2] Compression forces, distraction, and torsion help stabilize the spinal column.[3] In trauma cases, pathology arises from axial loading, which may or may not include flexion, leading to various degrees of compression fractures, from mild to severe burst fractures.[4] Traumatic spinal fractures are among the most common causes of vertebral fractures. Furthermore, vehicular accidents and falls from heights are considered ma-

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jor sources of high-energy trauma.[5] Spinal fractures resulting from high-energy traumas cause damage, particularly in the thoracolumbar region, which serves as the transition point between the immobile thoracic spine (where the ribs attach to the sternum and bilateral spine) and the mobile lumbar spine. Increased biomechanical stress makes this level of the spinal column more susceptible to stress.[6,7]

High-energy traumas often cause multiple fractures in the spinal column. Fractures in the thoracolumbar region exhibit specific characteristics regarding their causes, morphology, location, and anticipated outcomes.[6,8] A continuous spinal fracture involves two or more consecutive vertebrae; however, when intact vertebral segments are present between successive multifracture sites, it is termed a noncontinuous multifracture, a rare condition with distinctive features.[2,9]

Patients with multiple spinal fractures are treated with long segment fixations and other surgical procedures, depending on the state and stability of the fractures and any accompanying neurological symptoms. However, there are no established guidelines or standard approaches for patient management.[5,10,11]

Several studies in the existing literature focus on multilevel spinal fractures in osteoporotic patients, while non-osteoporotic patients have received relatively little attention, resulting in a limited number of relevant studies.

Furthermore, as reported by Cho et al.,[10] there are even fewer studies on the surgical management of multiple thoracolumbar spine fractures based on fracture continuity. This study compares surgical approaches and management for multiple-level continuous and noncontinuous thoracolumbar fractures in patients without osteoporosis. Thus, this study aims to help spine surgeons better understand and treat multiple-level continuous and noncontinuous thoracolumbar fractures and make their management more informed.

MATERIALS AND METHODS

Patients with multiple-level continuous and noncontinuous thoracolumbar fractures treated by the same surgeons from 2019 to 2021 were retrospectively evaluated. The patients were divided into two groups: Group 1 (continuous fractures) and Group 2 (noncontinuous fractures). The patients' age, gender, fracture levels, location of the main fracture, fracture type, classification according to the AO (Arbeitsgemeinschaft für Osteosynthesefragen) Spine Thoracolumbar Fracture Classification (neurological status, preoperative American Spinal Injury Association (ASIA) score, and modifiers),[12] status of posterior ligament damage, presence of additional traumatic pathology, status of decompression (laminectomy) application, stabilization and fusion levels, preoperative and postoperative neurological status, and presence of cervical trauma were evaluated in terms of fusion status and postoperative follow-up. The patients were monitored clinically and radiologically for two years after surgery for any clinical

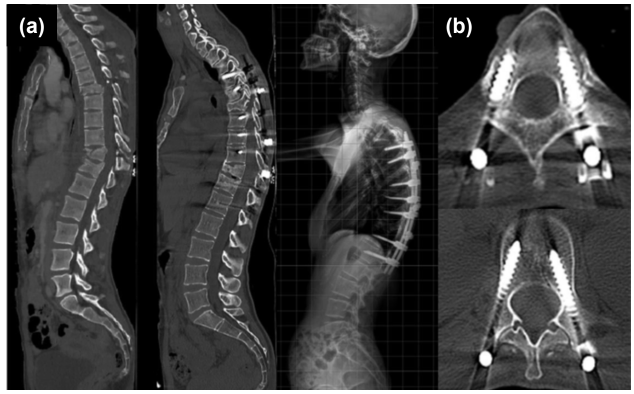

Figure 1. (a) Preoperative sagittal computed tomography (CT) scan, postoperative sagittal CT imaging, and sagittal X-ray image of the patient who underwent surgery for non-continuous fracture. **(b)** Postoperative axial CT scan of the screws at thoracic 5 and lumbar 1 levels of the same patient, respectively.

complaints or radiopathologic findings. The study excluded patients with single-level fractures, pathological fractures caused by osteoporosis, infection, or a spinal tumor, and those over the age of 65 years.

Upon admission to our hospital, all patients underwent a comprehensive neurologic and radiologic evaluation, including magnetic resonance imaging (MRI). Patients with continuous fractures were stabilized by fusing only one level above or below the fracture site. In some cases, screws were used to repair the fractured levels at the upper and lower levels. Indications for laminectomy included more than a 25°-30° kyphotic angle, more than 50% bone loss, the presence of an epidural hematoma, or more than 50% compromised spinal canal.[13-16] To reduce the risk of pseudoarthrosis, long-level stabilization was avoided whenever possible. In all cases, autologous grafts (bone particles from the patient's laminectomy when available) and additional β-tricalcium phosphate grafts were used to help stabilize the fusion. An experienced radiologist conducted blind radiologic assessments of the fusions.[17,18] During their follow-up, all patients underwent computed tomography (CT) scans (Fig. 1).

The design and protocol were approved by the Institutional Ethics Committee (number: 2022/03-03), and this study adheres to the principles of the Helsinki Declaration.

Statistical Analysis

We analyzed the variables using SPSS 25.0 (IBM Corporation, Armonk, New York) and PAST 3 (Hammer, Ø., Harper, D.A.T., Ryan, P.D., 2001, Paleontological Statistics programs) software. The Kolmogorov-Smirnov test and the Shapiro-Wilk Francia test were used to assess the normality of univariate data, while the Levene test was used to assess variance homogeneity. The Mardia (Dornik and Hansen omnibus) test was used to evaluate the conformity of multivariate data to a normal distribution, while the Box-M test assessed variance homogeneity. For comparing two independent groups based on quantitative variables, the independent-samples t-test was used with bootstrap results, and the Mann-Whitney U test was used with Monte Carlo results. The Wilcoxon signed-rank test, applied via Monte Carlo simulation, compared two repeated measurements of dependent quantitative variables, whereas the general linear model repeated analysis of variance test was conducted with bootstrap results. To compare categorical variables, the Pearson Chi-square, Fisher's exact, and Fisher-Freeman-Halton tests were employed using the Monte Carlo simulation technique. In the tables, quantitative variables were expressed as mean (standard deviation) and median (minimum-maximum), and categorical variables were represented as n (%). The variables were analyzed at a 95% confidence level, with a p-value of less than 0.05 indicating significance.

RESULTS

This study included 26 patients (10 women and 16 men), divided into two groups: Group 1 (n=12) included patients with continuous fractures, and Group 2 (n=14) included patients with noncontinuous fractures. The mean age of patients was 44.3 years with a standard deviation of 13.2 years. Group 1 consisted of 10 cases involving falls from heights and two in-vehicle accidents. All patients sustained high-energy injuries. Five fractures occurred at the thoracolumbar junction, three below it, and two above it. The neurological status of Group 1 was mostly N0, with one N2 patient. Preoperative ASIA scores were predominantly E, except for one C in a patient whose neurological status was N2. Modifiers in this group included M0 and M1. Patient comorbidities included pneumothorax, hemothorax, acute subdural hematoma, and rib and radius fractures (Table 1a).

Group 2 comprised 10 cases of falls from heights, three in-vehicle accidents, and one out-of-vehicle accident. Each patient sustained high-energy injuries. In two cases, the fracture occurred at the thoracolumbar junction, eight at and below the thoracolumbar junction, and three at and above the thoracolumbar junction. The neurological status of Group 1 was predominantly N0, with two patients classified as N2 and one as N3. Preoperative ASIA scores were mostly E, with two patients rated D and one patient rated B, corresponding to an N3 neurological status. Modifiers in this group included M0 and M1. The patients presented with bilateral hemothorax, lung contusion, acute subdural hematoma, pneumocephalus, and fractures of the ribs, skull base, foot, ankle, metacarpal, sacral, calcaneus, and iliac crest (Table 1a).

In Group 1, the median fracture level was 2 (range 2-3), and the median number of instrumented vertebral segments was 4.5 (range 4-6). Laminectomy was performed in three cases, and a median of four fusions (range 3-8) were completed during the operations. Except for one case of partial improvement, the postoperative neurological status was unchanged in 11 cases. Although the neurological examination was normal and the fractures were classified as A1 and B2 by the AO Spine Thoracolumbar Fracture Classification, Case 6 required a laminectomy due to a perioperative spinal epidural hematoma. In Case 7, the indication for laminectomy was a central bony indentation to the dural sac at the L1 level caused by retropulsion in the spinal canal. No surgical complications occurred in the entire group (Table 1b).

In Group 2, the median number of fracture levels was consistent at two (range 2-4), and the median number of instrumented vertebral segments was 5.5 (range 4-7). In one case, a laminectomy was performed, but the median number of fusions performed on patients in this group was five (range 4-8). Although the number of instrumented vertebrae was low in cases 15, 24, and 25, the fusion levels were higher because instrumentation was performed without inserting screws into the primary fracture levels. The postoperative neurological status was normal in 13 patients, with only one paraparetic case. Following decompression and fusion surgeries, all patients were clinically and radiologically monitored via CT scans for at least two years. There were no surgical complications, except for a screw revision in one female patient (Table 1b).

Comparisons of the two groups for basic sociodemographic characteristics (age and gender: p=0.974 and p=0.999, respectively), neurological status (p=0.999), and preoperative ASIA score (p=0.482) yielded no statistically significant differences. Furthermore, relationships between performed laminectomy (p=0.429), presence of surgical complications (p=0.999), concurrent cervical fracture (p=0.999), and differences between postoperative and preoperative lordosis angle (p=0.348) and kyphosis angle (p=0.711) also did not reach statistical significance (Tables 1b and 2).

However, significant correlations were observed between the two groups in terms of duration of operation (p=0.01), amount of blood loss during the operation (p=0.010), duration of hospitalization (p=0.003), number of fusions (p<0.001), and number of instrumented vertebral segments (p=0.011) (Table 2).

DISCUSSION

Traumatic damage to the medulla spinalis can occur due to a sudden and forceful impact on the spine, leading to fractures, dislocations, crushing, or compression of one or more vertebrae. The patient cohort of this study included patients with multiple spinal fractures that were either continuous or noncontinuous, depending on the continuity of the fracture. Studying this patient cohort is significant due to the rarity of the fracture types, the scarcity of available information in the literature on patient treatment strategies, and the opportunity to share insights from a single institution's surgical management experience.

Multiple spinal fractures predominantly affect adult men of productive age worldwide.[5,8,9,19] The mean age of our patient cohort was 44.3 years, with men accounting for 61% of the cohort. Falls from heights were the leading cause of trauma in

Table 1a. Sociodemographic and presurgical clinical data of the patients included in the study

No	Groups	Age	Gender	Fracture Level	Location of Main Fracture	Fracture Type	Neurological Status	Preoperative American Spinal Injury Association (ASIA) Score	Modifiers	Coexisting Injuries	Event
1	Continuous	54	Male	TH12, L1	T-L Junction	B2, A3	N0	E	M1, M0	Pneumothorax	Falling from height
2	Continuous	52	Female	TH10, TH11, TH12	T-L Junction+Above	A1, B2, A1	N0	E	M0, M1, M0	Acute Subdural Hematoma, Hemothorax	Falling from height
3	Continuous	57	Female	TH12, L1	T-L Junction	A3, A1	N0	E	M0, M0	None	Falling from height
4	Continuous	28	Female	TH11, TH12, L1	T-L Junction	A1, A1, B2	N0	E	M0, M0, M1	None	Falling from height
5	Continuous	34	Male	TH12, L1	T-L Junction	A1, B2	N0	E	M0, M1	None	Falling from height
6	Continuous	55	Male	TH12, L1	T-L Junction	A1, B2	N0	E	M0, M1	None	Falling from height
7	Continuous	59	Female	L1, L2	T-L Junction+Below	B2, A1	N0	E	M1, M0	Radius Fracture	Falling from height
8	Continuous	43	Male	TH12, L1	T-L Junction	B2, B2	N0	E	M1, M1	None	Falling from height
9	Continuous	48	Male	L1, L2	T-L Junction+Below	A1, A4	N2	C	M0, M0	Rib Fracture	Falling from height
10	Continuous	29	Male	TH11, TH12, L1	T-L Junction	A1, B2, A1	N0	E	M0, M1, M0	None	Falling from height
11	Continuous	45	Female	L2, L3	T-L Junction+Below	A3, A1	N0	E	M0, M0	None	In-vehicle traffic accident
12	Continuous	26	Male	TH5, TH6, TH7	Above	A1, B2, A1	N0	E	M0, M1, M0	None	In-vehicle traffic accident
13	Non-Continuous	42	Female	TH12, L1, L3	T-L Junction+Below	A1, B2, A1	N0	E	M0, M1, M0	Femoral Fracture	Falling from height
14	Non-Continuous	59	Male	TH11, L1	T-L Junction	A1, A4	N3	B	M0, M0	None	Falling from height
15	Non-Continuous	54	Male	TH11, L2	T-L Junction+Below	A1, A4	N0	E	M0, M0	None	Out-of-vehicle traffic accident
16	Non-Continuous	52	Male	TH11, L1	T-L Junction	A1, B2	N0	E	M0, M1	Rib Fracture, Lung Contusion, Hemothorax	Falling from height
17	Non-Continuous	18	Male	TH12, L2, L3, L4	T-L Junction+Below	A1, A1, A4, A1	N0	E	M0, M0, M1, M0	Foot Ankle Fracture	Falling from height
18	Non-Continuous	30	Female	TH12, L3	T-L Junction+Below	A1, A4	N0	E	M0, M0	None	In-vehicle traffic accident
19	Non-Continuous	37	Male	TH10, TH12	T-L Junction+Above	A1, A4	N0	E	M0, M0	Rib Fracture	In-vehicle traffic accident
20	Non-Continuous	53	Male	TH12, L2	T-L Junction+Below	B2, A1	N0	E	M1, M0	Skull Base Fracture, Iliac Crest Fracture, Pneumocephalus	Falling from height
21	Non-Continuous	61	Male	TH12, L1, L4	T-L Junction+Below	A1, A3, A4	N2	D	M0, M0, M0	Humerus Fracture, Lung Contusion	Falling from height
22	Non-Continuous	59	Male	TH11, L1	T-L Junction	A1, A3	N0	E	M0, M0	Rib Fracture, Lung Contusion, Hemothorax	Falling from height
23	Non-Continuous	55	Female	TH11, L3	T-L Junction+Below	A1, A3	N0	E	M0, M0	None	Falling from height
24	Non-Continuous	27	Female	TH7, TH11, TH12	T-L Junction+Above	B2, B2, A1	N0	E	M1, M1, M0	Bilateral Hemothorax,	In-vehicle traffic Metacarpal Fracture accident
25	Non-Continuous	24	Female	TH9, L1, L3	Below+T-L Junction+Above	B2, A4, A4	N0	E	M1, M0, M0	Sacral Fracture, Rib Fracture, Acute Subdural Hematoma, Calcaneus Fracture, Lung Contusion	Falling from
26	Non-Continuous	51	Male	TH10, TH11, L2	T-L Junction+Above+Below	B2, B2, A3	N2	D	M1, M1, M0	Rib Fracture, Hemothorax	Falling from heights

Table 1b. Postsurgical and follow-up data of the patients included in the study

No	Groups	Age	Gender	Number of Fracture Levels	Number of Instrumented Vertebral Segments	Laminectomy	Postoperative Neurological Status	Surgical Complication	Cervical Fracture	Number of Fusions (N)	Fusion Status
1	Continuous	54	Male	2	4	Absent	Intact	Absent	Absent	4	Present
2	Continuous	52	Female	3	5	Absent	Intact	Absent	Absent	4	Present
3	Continuous	57	Female	2	4	Absent	Intact	Absent	Absent	4	Present
4	Continuous	28	Female	3	5	Absent	Intact	Absent	Absent	4	Present
5	Continuous	34	Male	2	4	Absent	Intact	Absent	Absent	4	Present
6	Continuous	55	Male	2	4	Present	Intact	Absent	Absent	3	Present
7	Continuous	59	Female	2	6	Present	Intact	Absent	Absent	5	Present
8	Continuous	43	Male	2	5	Absent	Intact	Absent	Absent	4	Present
9	Continuous	48	Male	2	4	Present	Partial Improvement	Absent	Absent	3	Present
10	Continuous	29	Male	3	5	Absent	Intact	Absent	Absent	4	Present
11	Continuous	45	Female	2	5	Absent	Intact	Absent	Absent	4	Present
12	Continuous	26	Male	3	5	Absent	Intact	Absent	Present	4	Present
13	Non-Continuous	42	Female	3	7	Absent	Intact	Absent	Absent	6	Present
14	Non-Continuous	59	Male	2	5	Present	Paraparesis	Absent	Absent	4	Present
15	Non-Continuous	54	Male	2	5	Absent	Intact	Absent	Absent	6	Present
16	Non-Continuous	52	Male	2	5	Absent	Intact	Absent	Absent	5	Present
17	Non-Continuous	18	Male	4	6	Present	Intact	Absent	Absent	5	Present
18	Non-Continuous	30	Female	2	6	Present	Intact	Absent	Absent	5	Present
19	Non-Continuous	37	Male	2	5	Absent	Intact	Absent	Absent	5	Present
20	Non-Continuous	53	Male	2	5	Absent	Intact	Absent	Absent	4	Present
21	Non-Continuous	61	Male	3	5	Present	Intact	Absent	Absent	5	Present
22	Non-Continuous	59	Male	2	5	Absent	Intact	Absent	Absent	5	Present
23	Non-Continuous	55	Female	2	4	Absent	Intact	Absent	Absent	4	Present
24	Non-Continuous	27	Female	3	7	Absent	Intact	Screw Revision	Present	8	Present
25	Non-Continuous	24	Female	3	7	Present	Intact	Absent	Absent	8	Present
26	Non-Continuous	51	Male	3	7	Present	Intact	Absent	Absent	6	Present

Table 2. Statistical comparisons between patient groups

	Total (n=26)	Continuous (n=12)	Non-Continuous (n=14)	p
	Mean (SD) (min-max)	**Mean (SD) (min-max)**	**Mean (SD) (min-max)**	
Age	44.3 (13.2) (18-61)	44.2 (12.1) (26-59)	44.4 (14.6) (18-61)	0.974[t]
	n (%)	**n (%)**	**n (%)**	
Gender				0.999[c]
Female	10 (38.5)	5 (41.7)	5 (35.7)	
Male	16 (61.5)	7 (58.3)	9 (64.3)	
Neurological Status				0.999[ff]
N0	22 (84.6)	11 (91.7)	11 (78.6)	
N2	3 (11.5)	1 (8.3)	2 (14.3)	
N3	1 (3.8)	0 (0.0)	1 (7.1)	
Preoperative American Spinal Injury Association (ASIA) Score				0.482[ff]
B	1 (3.8)	0 (0.0)	1 (7.1)	
C	1 (3.8)	1 (8.3)	0 (0.0)	
D	2 (7.7)	0 (0.0)	2 (14.3)	
E	22 (84.6)	11 (91.7)	11 (78.6)	
Laminectomy				0.429[f]
No	17 (65.4)	9 (75.0)	8 (57.1)	
Yes	9 (34.6)	3 (25.0)	6 (42.9)	
Surgical Complication				0.999[f]
No	25 (96.2)	12 (100.0)	13 (92.9)	
Yes	1 (3.8)	0 (0.0)	1 (7.1)	
Cervical Fracture				0.999[f]
No	24 (92.3)	11 (91.7)	13 (92.9)	
Yes	2 (7.7)	1 (8.3)	1 (7.1)	
	Mean (SD)	**Mean (SD)**	**Mean (SD)**	
Duration of Operation (minutes)	208.1 (52.1)	171.7 (34.1)	239.3 (44.2)	0.001[t]
Amount of Blood Loss (Cc)	397.7 (195.2)	295 (153.8)	485.7 (187.5)	0.010[t]
Duration of Hospitalization (days)	9.7 (3.9)	7.2 (2.8)	11.8 (3.5)	0.003ra
Lordosis Angle				
Preoperative	45.3 (6)	47.3 (4.5)	43.6 (6.7)	0.124[t]
Postoperative	50.1 (3.2)	51 (3)	49.3 (3.3)	0.194[t]
Difference (Postoperative-Preoperative)	4.8 (5.4)	3.7 (5.6)	5.7 (5.3)	0.348[t]
p-Value for Preoperative vs. Postoperative Analysisra	-	0.046	0.001	
	Median (min/max)	**Median (min/max)**	**Median (min/max)**	
Kyphosis Angle				
Preoperative	28.5 (20/54)	28.5 (22/45)	28.5 (20/54)	0.609[u]
Postoperative	27.5 (22/45)	28.5 (24/41)	26.5 (22/45)	0.653[u]
Difference (Postoperative-Preoperative)	-1 (-13/15)	-1 (-6/4)	-0.5 (-13/15)	0.711[u]
p-Value for Preoperative vs. Postoperative Analysis[w]	-	0.268	0.558	
Number of Fusions	4 (3/8)	4 (3/5)	5 (4/8)	<0.001[u]
Number of Fracture Levels	2 (2/4)	2 (2/3)	2 (2/4)	0.589[u]
Number of Instrumented Vertebral Segments	5 (4/7)	4.5 (4/6)	5.5 (4/7)	0.011[u]

[t]Independent Samples t-test (Bootstrap); [u]Mann-Whitney U test (Monte Carlo); [c]Pearson Chi-Square Test (Monte Carlo); [f]Fisher's Exact Test (Monte Carlo); [ff]Fisher-Freeman-Halton Test (Monte Carlo); raGeneral Linear Model Repeated Analysis of Variance (ANOVA) (Wilks' Lambda); [w]Wilcoxon Signed-Rank Test; SD: Standard Deviation.

this study cohort. It is consistent with the findings reported by Lizbeth et al.,[9,20,21] in contrast to previously published articles, which indicated that vehicle accidents accounted for half of all trauma causes, with falls from heights accounting for one-fifth of cases.[9,20,21]

Patients with high-energy multiple spinal fractures are more likely to sustain associated injuries involving the head, intrathoracic and intra-abdominal organs, and extremities.[7,21] Up to 8% of polytrauma patients in this study had coexisting injuries such as acute subdural hematoma, pneumocephalus, skull base fracture, pneumothorax, hemothorax, lung contusion, rib fracture, humerus fracture, femur fracture, iliac crest fracture, and sacral fracture. There was a cervical fracture in two patients (one in each group), but it was not statistically significant (p=0.999).

In this study, all patients had a preoperative ASIA score of E, which differed from Cho et al.[10] In their study, patients with continuous-type spinal fractures had more neurological issues than those with noncontinuous-type spinal fractures. However, there was no statistically significant difference between the two groups (p=0.085). Similarly, the difference in preoperative ASIA scores between patients in our two study groups was not statistically significant (p=0.482).

Initial neurological examination is critical for determining the lesions in patients with multiple spinal fractures. However, patients may exhibit complete neurological impairment or have normal neurological examination findings. Thus, it is critical to perform a thorough radiological scan, using MRI or CT, that includes an examination of consecutive vertebrae and the entire spinal column as a supplement to the neurological examination.[22-24] Only such an approach would effectively eliminate the possibility of secondary or tertiary fractures, and allow for the evaluation of spinal instability or deformity as well as for optimal surgical planning for the primary fracture. In our study, all patients underwent an MRI scan of the entire spinal column, although 84% had neurological status N0 and a preoperative ASIA score of E. In cases of noncontinuous multiple fractures, a comprehensive neurological and radiological evaluation of patients is particularly important to avoid missing the diagnosis of concurrent fractures. According to recent research, if subsequent fracture sites are not thoroughly evaluated, the diagnosis can be delayed by up to 52.6 days.[25,26] In this study, 14 of the 26 patients had noncontinuous multiple spinal fractures, accompanied by additional fractures and intracranial, intrathoracic, and intra-abdominal injuries. Following initial physical and radiological assessment, the optimal surgical strategy for patients with multiple spinal fractures involved spinal cord decompression and vertebral structure realignment. Seçer et al.[5] recommend surgical intervention for patients who have four or fewer intact vertebral segments between multiple spinal fractures.

In single-level fractures, surgeons typically use screw stabilization and fusion up to two levels above and below the fracture. In suitable cases, screws can be placed at the fracture level. Considering these data, fusion-stabilization levels should be increased in multilevel fractures.[27,28] In this study, a posterior surgical approach with long segment stabilization was used to achieve proper alignment of the noncontinuous multiple spinal fractures. For continuous fractures, stabilization fusion was applied only one level above or below the fracture level, particularly at the upper and lower levels in some cases. Thus, by improving power distribution within the system, the number of stabilized segments was reduced by strategically placing screws at fractured levels to the greatest extent possible.[29] Additionally, laminectomy was performed in areas with neurological deficits at the fracture level, epidural hematoma, or more than 50% bone compression in the spinal canal. This procedure had not been used in previous cases. The risk of pseudoarthrosis was minimized by avoiding long-term stabilization as much as possible.

Our study used a median of five vertebrae to instrument a segment, but this segment was longer in noncontinuous fractures than in continuous fractures. Determining the thoracic kyphotic angle and performing additional surgical instrumentation with more short-level fusions in patients without significant kyphotic deformity could be one strategy for reducing non-sequential instrumentation. Gertzbein et al.[30] previously reported inferior neurological outcomes in patients with a kyphosis angle greater than 30°; however, Shen et al.[31] observed a poor correlation between clinical outcomes and kyphosis greater than 30°. Krompinger et al.[32] classified the condition as stable if the kyphosis angle is less than 30° and the spinal canal narrowing is less than 50%. Our patients' preoperative and postoperative kyphotic angles differed by less than 30°, indicating that they were stable. Therefore, although the number of instrumented vertebral segments differed significantly between groups 1 and 2 in this study, the clinical outcomes were identical.

Bone graft substitutes have become popular for promoting spinal fusion due to their osteogenic properties. Autologous bone grafts and ceramic-based substitutes, such as tricalcium phosphate, are the most commonly used alternatives for the surgical treatment of spinal fractures.[33,34] In all cases in this study, in addition to fusion stabilization, autologous grafts (when available) and additional β-tricalcium phosphate grafts were used if autologous grafts were insufficient. Both groups showed significant differences in the number of fusions (p<0.001) and instrumented vertebral segments (p=0.011). This discovery emphasizes the effectiveness of vertebral fusion using bone graft substitutes, as it produces satisfactory neurological outcomes even when performed across extended segments in noncontinuous fractures and over shorter segments in continuous fractures.

This study has several limitations, including a retrospective design, a lack of bone mineral density scans to confirm that patients were nonosteoporotic despite their relatively young age, a lack of preoperative or postoperative kyphotic angle and lordosis data, an insufficient diversity of tools to evaluate functional outcomes during the follow-up period, a small study sample size, and a short follow-up period.

CONCLUSION

An initial neurological examination is crucial for assessing lesions in all patients with multiple spinal fractures. Even if the neurological examination results are normal, it is imperative to perform a thorough radiological scan, using either MRI or CT, that includes an examination of consecutive vertebrae and the entire spinal column as a supplement to the neurological examination. A posterior surgical approach is appropriate for both continuous and noncontinuous multiple spinal fractures, including decompression and fusion of fractured vertebrae. Stabilization should occur both one level above and one level below the fracture site. Fusion stabilization should be extended in cases of multiple noncontinuous fractures. When necessary, autologous bone and/or β-tricalcium phosphate grafts can be used to achieve stronger fusions and avoid pseudoarthrosis and related surgical complications. More extensive research should be conducted with a larger number of patients and in multiple locations around the world.

Ethics Committee Approval: This study was approved by the Tepecik Training and Research Hospital Ethics Committee (Date: 15.03.2022, Decision No: 2022/03-03).

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ORİJİNAL ÇALIŞMA - *ÖZ*

Yetişkin hastalarda travmatik çok seviyeli ardışık ve ardışık olmayan torakolomber spinal kırıkların yönetimi: Tek merkez deneyimi

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AMAÇ: Bu çalışmanın amacı travmatik çok seviyeli ardışık ve ardışık olmayan torakolomber omurga kırıklarında cerrahi yaklaşımlar ve hasta yönetimi konusundaki klinik deneyimimizi aktarmaktır.

GEREÇ VE YÖNTEM: 2019-2021 yılları arasında aynı cerrahlar tarafından ameliyat edilen ardışık ve ardışık olmayan torakolomber çok seviye kırıklı hastalar retrospektif olarak değerlendirildi. Hastalar iki gruba ayrıldı: grup 1 (n=12, ardışık kırıklar) ve grup 2 (n=14, ardışık olmayan kırıklar). Hastaların yaşı, cinsiyeti, kırık seviyeleri, kırık tipi, AO Spine Torakolomber Kırık Sınıflamasına göre sınıflandırılması, arka ligaman hasar durumu, ek travmatik patolojinin varlığı, dekompresyon (laminektomi) durumu, stabilizasyon ve füzyon düzeyleri, ameliyat öncesi ve sonrası nörolojik durum, servikal travma varlığı, operasyon süresi, kan kaybı miktarı, hastanede kalış süresi, lordoz açıları ve kifoz açıları, füzyon durumu ve postoperatif takip (2 yıl) açısından değerlendirildi. Çalışmaya 65 yaş üstü, tek seviyeli kırıkları, osteoporoza bağlı patolojik kırıkları, enfeksiyon ve spinal tümörleri olan hastalar dahil edilmedi.

BULGULAR: Cinsiyet, yaş, nörolojik durum, laminektomi uygulaması, cerrahi komplikasyonlar, servikal kırık durumu, operasyon süresi, kan kaybı miktarı, hastanede kalış süresi, lordoz ve kifoz açıları gruplar arasında eşit olarak dağıldı. Ayrıca, tüm hastalarda medyan 2 (2-4) kırık seviyesinde, medyan 4 (3-8) füzyon ve medyan 5 (4-7) enstrümante vertebral segment vardı. İki grup operasyon süresi (p=0.001), kan kaybı miktarız(p=0.010), hastanede kalış süresi (p=0.003), füzyon sayısı (p<0.001) ve enstrümante vertebra segmentler (p=0.011) açısından anlamlı şekilde farklılık gösterdi.

SONUÇ: Dekompresyon, vertebral vida fiksasyonu ile allogreft ve otogrefler tarafından desteklenen bir cerrahi yaklaşım, ardışık ve ardışık olmayan vertebra kırığı hastaları için başarılı cerrahi sonuçlar sağlayabilmektedir.

Anahtar sözcükler: Ardışık kırık; ardışık olmayan kırık; laminektomi; nörolojik durum; spinal füzyon; torakolomber kırıklar.

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