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Effect of loss of correction on functional outcomes in thoracolumbar burst fractures treated with short segment posterior instrumentation

Kısa segment posterior enstrümentasyon ile tedavi edilen torakolomber burst kırıklarında korreksiyon kaybının fonksiyonel sonuçlar üzerine etkisi

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Abstract

Aim: Burst fractures are defined as vertebra fractures involving the anterior and middle columns and are associated with kyphotic deformity and retropulsion of bone fragment into the spinal canal. Although their treatment is controversial in the literature, use of transpedicular screws and short segment posterior instrumentation are increasingly common practices. The aim of this study is to investigate the radiological and functional outcomes of thoracolumbar vertebra burst fractures treated with short segment posterior instrumentation and to examine the effects of postoperative correction loss on these results.

Methods: Patients who were surgically treated for thoracolumbar burst fractures and prospectively followed-up between 2000-2003 were scanned retrospectively for this cohort study. 48 patients were included in the study, of which 18 were females (37.5%) and 30 were males (62.5%). Denis Pain Scale (DPS) and Denis Work Scale (DWS) were used for functional analysis. Cobb angles that were measured preoperatively, on the first postoperative day, and at the last follow-up visit were used for evaluation of radiological outcomes. Spinal stenosis and remodelization rates were also calculated by computerized tomography obtained preoperatively and at the last follow-up. One-way ANOVA and Pearson correlation tests were used for statistical analysis.

Results: No patient had any chronic pain complaints, and none were unable to work. The mean Cobb angles in the preoperative, early post-operative and final controls were measured as 23.2, 4.9, and 12.3 degrees, respectively. While preoperative mean Cobb angle and mean correction were positively correlated (r=0.85, $P<0.001$), there was no correlation between preoperative mean Cobb angle and loss of correction (r=0.27, $P=0.43$). There was a correlation between correction and loss of correction (r=0.38, $P=0.008$). Spinal stenosis, which was 35.7% preoperatively, reduced to 17.1% in the last follow-up. The mean remodelization was 51.3%, which was significant ($P<0.001$). Loss of correction was found significant in patients with poor DWS ($P=0.003$), and no such relationship was found in DPS. No correlation was found between the Cobb angle at the last follow-up, DPS and DWS.

Conclusion: In conclusion, the loss of correction after short segment posterior instrumentation and fusion surgery is significantly higher in thoracolumbar burst fractures, especially when intraoperative correction exceeds 15 degrees. Denis Work Scale was significantly worse in patients with loss of correction above 10 degrees. The degree of loss of correction at the last follow-up is directly related to clinical and functional outcomes.

Keywords: Burst fractures, Kyphosis, Cobb angle, Remodelization, Loss of correction, Short segment posterior instrumentation

Öz

Amaç: Burst kırıkları, ön ve orta kolonu içeren, kifotik deformite ve kemik fragmanının spinal kanala retropülsiyonu ile ilişkili vertebra kırıkları olarak tanımlanır. Tedavileri literatürde tartışmalı olsa da transpediküler vida ve kısa segment posterior enstrümentasyon oldukça sık uygulanmaktadır. Bu çalışmanın amacı kısa segment posterior enstrümentasyon ile tedavi edilen torakolomber vertebra burst kırıklarının radyolojik ve fonksiyonel sonuçlarını ve postoperatif korreksiyon kaybının bu sonuçlar üzerine etkisini incelemektir.

Yöntemler: 2000-2003 yılları arasında torakolomber burst kırığı nedeniyle cerrahi olarak tedavi edilen ve prospektif olarak takip edilen hastalar, bu retrospektif kohort çalışması için retrospektif olarak tarandı. Çalışmaya 18'i kadın (%37,5), 30'u erkek (%62,5) olan 48 hasta alındı. Fonksiyonel analiz için Denis Ağrı Skoru (DPS) ve Denis İş Skoru (DWS) kullanıldı. Radyolojik analiz için preoperatif, postoperatif ilk gün ve son takipte ölçülen Cobb açıları kullanıldı. Ayrıca preoperatif ve son takipte çekilen bilgisayarlı tomografi aracılığı ile spinal stenoz ve remodelizasyon oranları hesaplandı. İstatistiksel analiz için tek yönlü ANOVA ve Pearson korelasyon testleri kullanıldı.

Bulgular: Hiçbir hastada kronik ağrı ya da işe geri dönememe şikâyeti görülmedi. Hastaların ameliyat öncesi, sonrası ve son kontrollerde ortalama Cobb açıları sırası ile 23,2, 4,9 ve 12,3 derece olarak ölçüldü. Ameliyat öncesi ortalama Cobb açısı ile ortalama korreksiyon arasında anlamlı bir korelasyon saptanırken (r=0,85, $P<0,001$); korreksiyon kaybı ile arasında anlamlı ilişki bulunmadı (r=0,27, $P=0,43$). Korreksiyon ve korreksiyon kaybı arasında bir korelasyon tespit edildi (r=0,38, $P=0,008$). Ameliyat öncesi %35,7 olarak hesaplanan spinal darlığın, son takipte %17,1'e gerilediği görüldü. Ortalama remodelizasyon %51,3 olarak hesaplandı. Spinal kanal remodelizasyonu anlamlı bulundu ($P<0,001$). 10 dereceden fazla korreksiyon kaybı olan hastalar ile DWS arasında anlamlı ilişki bulundu ($P=0,003$). DPS'de böyle bir ilişki bulunamadı. Son takipte ölçülen Cobb açısı ile DPS ve DWS arasında ilişki saptanmadı.

Sonuç: Sonuç olarak, kısa segment posterior enstrümentasyon ve füzyon cerrahisi sonrası korreksiyon kaybı, torakolomber burst kırıklarında, özellikle intraoperatif korreksiyon 15 dereceyi aştığında, belirgin olarak daha yüksektir. DWS, 10 derecenin üzerinde korreksiyon kaybı olan hastalarda anlamlı olarak daha kötüdür. Son takipteki korreksiyon kaybının derecesi doğrudan klinik ve fonksiyonel sonuçlarla ilgilidir.

Anahtar kelimeler: Burst kırıkları, Kifoz, Cobb açısı, Remodelizasyon, Korreksiyon kaybı, Kısa segment posterior enstrümentasyon

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Introduction

Burst fractures are defined as vertebra fractures involving the anterior and middle columns and associated with kyphotic deformity and retropulsion of bone fragment into the spinal canal. They are usually related to high-energy traumas [1-3]. The incidence of burst fractures in the thoracolumbar junction, where most of the vertebral fractures occur since it is the transition zone from a mobile thoracic segment to a less mobile lumbar segment, is between 10-20% [1-5]. In the literature, it is mentioned that late neurological deterioration is up to 17% after thoracolumbar vertebra burst fractures' conservative treatment, therefore these fractures are treated surgically [6]. Advantages of surgical treatment include providing early stabilization of the spine, thus reducing the possibility of neurological deterioration, improving kyphosis, and allowing early mobilization [6,7]. There are numerous surgical techniques, such as anterior surgery, long segment posterior instrumentation and transpedicular screws, and short segment posterior instrumentation. Although it is known that after the use of transpedicular screws and short segment posterior instrumentation, some of the correction is lost during follow-up, and correction losses between 3º and 12º [1,8,9] and failure rates of 9-56% have been reported in the literature [10-12], other surgical options with minimal loss of correction have relatively high morbidity [13,14]. To this extent, use of transpedicular screws and short segment posterior instrumentation became increasingly common.

The aim of this study is to investigate the radiological and functional results of thoracolumbar vertebra burst fractures treated with short segment posterior instrumentation and to examine the effects of postoperative correction loss on these results.

Materials and methods

Patients who were surgically treated for thoracolumbar burst fractures and prospectively followed-up between 2000-2003 were scanned retrospectively for this cohort study. After exclusion of polytrauma patients, patients who had neurological deficits, who were lost to follow-up and who had less than 1-year of follow-up, 48 patients [18 females (37.5%); 30 males (62.5%)] were included in the study. Mean age was 39.5 years (Range: 18-67 years). Fractures of all 48 patients were caused by high energy traumas. Among them, 23 (48%) had a car crash, 21(43.7%) fell from high, 3 (6.2%) had work accidents and 1 (2.1%) patient was assaulted. Denis Classification was used for preoperative radiological classification (Table 1) [15].

Surgical technique

Using posterior longitudinal incision, paravertebral muscles were scraped by using electrocautery. Care was taken to protect the posterior ligamentous complex. Fractured vertebra was detected using fluoroscopy. The cartilage faces of the facet joints were removed along the instrumentation site. Transpedicular polyaxial screws of appropriate length and diameter were placed at the upper and lower levels of the fractured vertebra. Properly inclined shaped rods were placed on transpedicular screws. The fracture line was distracted, and indirect reduction technique was performed using 3-point principle. Stability was improved by locking the system with transverse connectors. After indirect reduction and stabilization of the fractures were achieved by posterior instrumentation, the field was grafted by autograft which was taken from the posterior iliac wing and fusion was completed. After the insertion of one in hemovac drain in the operation lodge and one in the iliac wing, operation was completed. The same surgical team performed all operations. All complications were recorded.

Rehabilitation

Patients were mobilized on the second postoperative day with a Steindler type hyperextension full steel brace. Brace was used for 3-6 months (Mean: 4.5 months). Mean hospital stay was 7.4 days (Range: 5-14 days).

Sutures were removed in the second postoperative week. The patients were called for annual follow-ups after 45 days, 3 months, 6 months and 1 year. Mean follow-up time was 26.2 months (Range: 13- 38 months). Neurological examinations were repeated at all follow-ups. Anteroposterior and lateral radiographs were seen.

Functional analysis

Denis Pain Scale (DPS) and Denis Work Scale (DWS) were used to evaluate the postoperative clinical outcome [6,16]. According to the DPS, P1 has no pain; P2 has minimal pain but does not require treatment; P3 has moderate pain that does not interfere with work; P4 has moderate-to-severe pain and requires frequent treatment, and P5 has severe chronic pain [6]. According to DWS, W1 was specified as return to heavy work; W2 was specified as return to sedentary work or heavy work with restrictions; W3, a different full-time new job; W4, a different part time new job, and W5, unable to work [6].

Radiological analysis

In addition to the anteroposterior and lateral thoracic and lumbar radiographs at every follow-up, all patients underwent computed tomography preoperatively and at the first-year follow-up visit.

As an evaluation criterion, Cobb angle (calculated by using the upper endplate of the vertebra which is above the fracture level and the lower endplate of the vertebra which is below the fracture level) was measured on lateral radiographs of all patients, preoperatively, on the first postoperative day and last follow-up visit. In computed tomography, the narrowing of the spinal canal and remodelization were measured by the method described by Willen et al. [17,18]. The same surgeon performed all measurements (Figure 1).

Statistical analysis

Statistical analysis was performed using the SPSS 16.0 software version. The variables were investigated using visual (histogram, probability plots) and analytical methods (Kolmogorov-Smirnov test) to determine whether they were normally distributed. One-way ANOVA analysis was performed for Cobb angle correction, loss of correction angle and remodelization. Pearson analysis was used to detect correlation between normally distributed variables such as follow-up time, loss of correction, Cobb angle, remodelization, DPS, DWS. A *P*-value of less than 0.05 was considered to show a statistically significant result.

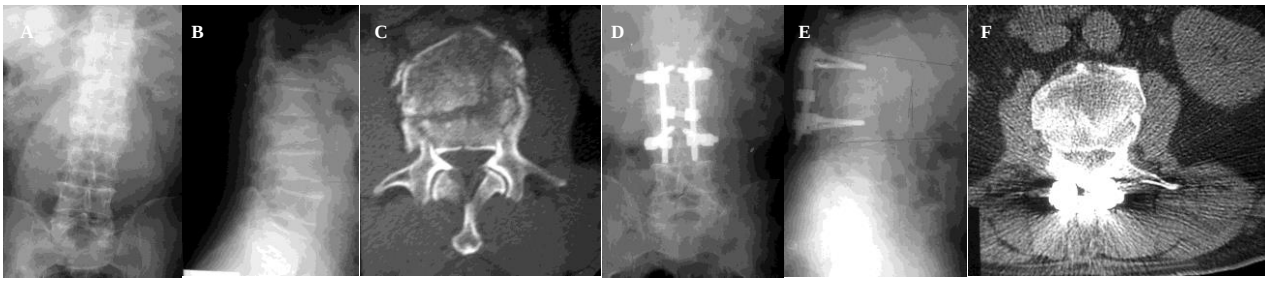

Figure 1: Case example of 59 years-old male patient with L2 vertebra burst fracture (A: Preoperative antero-posterior view, B: Preoperative lateral view, C: Preoperative computed tomography section, D: Postoperative 1-year antero-posterior view, E: Postoperative 1-year lateral view, F: Postoperative 1-year computed tomography section)

Results

No patients had chronic pain complaints, and none were unable to work. DWS and DPS were positively correlated (r=0.31, *P*=0.009). Detailed distribution of DPS and DWS of the patients are presented in Table 2.

The mean Cobb angles in the preoperative, early post-operative and final controls were measured as 23.2 (0.1), 4.9 (5.1), and 12.3 (8.9) degrees, respectively. The mean Cobb angle correction in early post-operative period was 18.1 (8.5) and the mean loss of correction at the last follow-up was 7.4 (7.7) degrees. While preoperative mean Cobb angle and mean correction were positively correlated (r=0.85, *P*<0.001), there was no correlation between preoperative mean Cobb angle and loss of correction (r=0.27, *P*=0.43). There was a positive correlation between correction angle and loss of correction (r=0.38, *P*=0.008). Finally, it was found that the loss of correction was significantly higher in patients with intraoperative correction rates above 15 degrees (*P*=0.006).

Spinal stenosis, which was calculated as 35.7% (SD:8.5) preoperatively, was reduced to 17.1% (SD:4.6) in the last follow-up (*P*<0.001). The mean remodelization was 51.3% (SD:9.3). The spinal canal remodelization was significant (*P*<0.001). There was a correlation between preoperative spinal stenosis and canal remodelization (r=0.30, *P*=0.04). No correlation was detected between canal remodelization and correction angle or loss of correction (r=0.22; *P*=0.07; r=-0.04, *P*=0.14, respectively).

The rate of loss of corrections greater than 10 degrees was statistically significant in patients with poor DWS (*P*=0.003). No such relationship was found in DPS. Correlation between correction angles and functional results are presented in Table 3 (Table 3)

Superficial wound infection occurred in 6 patients (12.5%) and were treated with antibiotherapy. Pedicle screw fractures were observed in 4 patients (8.3%) during the follow-ups, but no new surgical interventions were needed since there were no clinical complaints.

Table 1: Preoperative fracture classification

Denis classification	n	%
A	11	22.8
B	31	64.5
C	1	2.1
D	3	6.3
E	2	4.3

Table 2: Detailed distribution of DPS and DWS

		DWS					
		W1	W2	W3	W4	W5	Total
DPS	P1	16	0	0	0	0	16 (33.3.%)
	P2	3	20	0	0	0	23 (47.9%)
	P3	0	2	5	2	0	9 (18.8%)
	P4	0	0	0	0	0	0
	P5	0	0	0	0	0	0
	Total	19	22	5	2	0	r=0.31
		(39.6%)	(45.8%)	(10.4%)	(4.2%)		*P*=0.009

DPS: Denis Pain Score, DWS: Denis Work Score, P: Pain, W: Work, *P*: statistical significance value, r: correlation value

Table 3: Correlation between radiological and functional results

	DPS	DWS
Preoperative Cobb Angle	r=0.32	r=0.30
	P=0.002	*P*=0.004
Last Follow-up Cobb Angle	r=0.251	r=0.159
	P=0.54	*P*=0.77
Spinal Stenosis	r=0.26	r=0.17
	P=0.19	*P*=0.17
Correction	r=0.19	r=0.24
	P=0.36	*P*=0.48
Loss of Correction	r=0.27	r=0.39
	P=0.09	*P*=0.003

DPS: Denis Pain Score, DWS: Denis Work Score, *P*: statistical significance value, r: correlation value

Discussion

The use of transpedicular screws and short segment posterior instrumentation are still of preference in clinical practice, despite the rate of loss of correction and failure rates specified in the literature [8-12]. One of the most important reasons is that other surgical options known to have lower loss of correction during follow-ups are directly related to high morbidity [13,14]. Furthermore, it is still controversial in the literature whether loss of correction is associated with clinical functional outcomes. Therefore, this study investigating the relationship between loss of correction in short segment posterior instrumentation and radiological and functional outcomes is important because of its large cohort number.

In our study, correction of kyphotic deformity was achieved in all patients by short segment posterior instrumentation and fusion method, and the change in Cobb angle before and after the surgery was found significant. However, at the last follow-up, a significant loss of correction of 7.4 (7.7) degrees were found. These values were consistent with the literature. Esses et al. [19], in their study of short segment posterior instrumentation and fusion, reportedly encountered a mean loss of correction of 11.2 degrees. Sasso et al. [20] followed 23 patients with short segment posterior instrumentation for an average of 20 months and reported that they lost the correction they achieved in the 3rd postoperative month. The reason of this loss is not completely understood, but there are some explanations. Some writers believe that the large bone defect which is created in the fractured vertebra during the restoration of the height is the main reason of this loss. Also, the change of the intervertebral disc height is important. During surgery, the distraction affects the bone, not the discs. As time

goes by, the disc heights decrease in value, which is related with the post-traumatic degeneration [3,21,22]. Furthermore, overcorrection may affect the biomechanics of the posterior ligamentous complex and the whole vertebra. This may also explain the loss of correction.

Carl et al. [23], in their study of 38 patients who had short segment posterior instrumentation, a mean loss of 6 degrees of correction at the last follow-up and a final correction of 1 degree, reported that 32 of 33 patients were satisfied with the surgical results and 28 of them returned to work. On the other hand, Öner et al. [24] reported that loss of correction in kyphosis but not final kyphosis was associated with permanent pain. In our series, the preoperative Cobb angle and loss of correction were not correlated, but correction angle and loss of correction were found to correlate. Loss of correction was significantly higher in patients with intraoperative correction rate above 15 degrees. The rate of loss of correction greater than 10º was positively correlated with a poor DWS. On the other hand, no correlation was found between Cobb angle at the last follow-ups, DPS and DWS. In other words, a relationship between final kyphosis and functional and clinical outcomes could not be established whereas loss of correction was positively correlated with functional outcomes.

One of the parameters considered in the treatment of burst fractures of the thoracolumbar vertebra is the rate of spinal stenosis and decompression or remodeling of stenosis [19,25]. In their prospective study, Esses et al. [19,25] found that the rate of stenosis decreased from 58% to 4% in the anterior decompression group in the early postoperative period, and from 44.5% to 16.5% in the posterior surgery group. Authors believe that interventions with posterior distraction and instrumentation effectively decompress the spinal canal. Yazıcı et al. [26] compared patients treated with posterior surgery and conservatively in terms of canal remodeling and reported that the rate of canal remodelization in the surgically treated group was significantly higher than in the conservatively treated group, but that there was no significant difference between the two groups in terms of stenosis after treatment. Several studies report that stenosis following thoracolumbar vertebral burst fracture is remodelized by conservative treatment at a rate of approximately 50% [16]. In our cohort, we did not perform canal decompression to any of the patients; however, remodelization was seen in all. The mean remodelization was 51.3% (SD: 9.3), which was statistically significant (P<0.001). Remodeling was not affected by intraoperative correction or loss of correction. There was no relationship between stenosis and DPS and DWS in the last follow-ups. However, it is currently not possible to comment on how residual spinal stenosis can be affected by the degenerative process and how it will affect clinical and functional outcomes. Bohlman et al. [27] treated 45 patients due to late chronic pain and/or paralysis, using anterior decompression method at an average of 4.5 years after the first treatment, which were performed in numerous ways. The authors suggest that late-onset pain or paralysis occurs secondary to chronic neural compression, and this compression is due to the retropulsion of bone or disc fragments associated with traumatic kyphosis continue to narrow the neural canal. From this perspective, we think that patients should be followed up for a long time in terms of late spinal stenosis.

Limitations

There are some limitations in our study. The first is the short follow-up period. Although several studies have indicated that canal remodelization usually lasts up to 12 months after treatment and no significant remodelization occurs after 12 months, longer follow-up is required for neurological problems secondary to degeneration in the late period [28]. A second limitation is the absence of a control group. Controlled studies may support our results. Another limitation is that only subjective functional analysis was performed in our study. Objective analysis was not used.

Conclusion

The loss of correction after short segment posterior instrumentation and fusion surgery is significantly higher in thoracolumbar burst fractures, especially when intraoperative correction exceeds 15 degrees. Denis Work Scale was significantly worse in patients with loss of correction above 10 degrees. The degree of loss of correction at the last follow-up is directly related to clinical and functional outcomes.

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