



# The effectiveness of short-segment posterior instrumentation of thoracolumbar burst fractures

## *Torakolomber vertebranın patlama kırıklarında kısa segment posterior enstrümantasyonun etkinliği*

Levent CELEBI, Ozgur DOGAN, Hasan Hilmi MURATLI, Mehmet Fırat YAGMURLU, Ali BICIMOGLU

Ankara Numune Education and Research Hospital 3.Department of Orthopaedics and Traumatology

**Amaç:** Torakolomber vertebra kırıklarının kısa segment posterior enstrümantasyonunun sonuçları değerlendirildi, radyografik ve fonksiyonel sonuçlar arasındaki ilişki incelendi ve düzeltme kaybına etki eden faktörler araştırıldı.

**Çalışma planı:** Çalışmaya torakal veya lomber vertebra patlama kırığı nedeniyle pedikül vidaları ile kısa segment posterior enstrümantasyon ve füzyon uygulanan 48 hasta (30 erkek, 18 kadın; ort. yaş 40±14; dağılım 18-67) alındı. En sık tutulum seviyesi 18 hastada L<sub>1</sub> (%37.5), 11 hastada T<sub>12</sub> (%22.9) idi. Frankel derecelenmesine göre altı hastada tam, 14 hastada incomplete nörolojik defisit vardı. Tüm hastalarda Cobb açıları ve bilgisayarlı tomografide kanal işgali ölçüldü. Fonksiyonel değerlendirmede Denis ağrı ve iş skalaları kullanıldı; bu skalalardan modifiye fonksiyonel sonuçlar (MFS) çıkarıldı. Ortalama takip süresi 21.7±9.1 ay (dağılım 12-48 ay) idi.

**Sonuçlar:** Cobb açısındaki ortalama düzelme 18.2±8.6° (p<0.01), ortalama düzeltme kaybı 7.4±5.7° (p<0.01), ortalama kanal remodelizasyonu %51.3±9.3 (p<0.001) bulundu. Cobb açısındaki düzelme ile düzeltme kaybı arasında anlamlı ilişki görüldü (r=0.38, p<0.01). Ameliyattaki düzeltme miktarının 15 dereceden fazla olduğu hastalarda düzeltme kaybı anlamlı derecede fazla idi (p<0.05). Düzeltme kaybının 10 dereceden fazla olduğu hastalarda Denis iş skoru ve MFS anlamlı derecede kötü bulundu (p<0.05). Modifiye fonksiyonel sonuçlar 16 hastada (%33.3) mükemmel, 23 hastada (%47.9) iyi, yedi hastada (%14.6) orta, iki hastada (%4.2) kötü bulundu. Son kontrollerde Cobb açısı ile fonksiyonel sonuçlar arasında ilişki yoktu (p>0.05). Ameliyat öncesinde incomplete nörolojik defisiti olan tüm hastalarda en az 1 Frankel derecesi kadar iyileşme görüldü.

**Çıkarımlar:** Ameliyattaki düzeltme 15 dereceyi geçtiğinde düzeltme kaybı anlamlı derecede fazla olmakta ve bu durum fonksiyonel sonuçları anlamlı derecede etkilemektedir.

**Anahtar sözcükler:** Kırık tespiti, internal; kifoz/etyoloji; lomber vertebra/cerrahi/radyografi; omurga kanalı/patoloji; omurga kırığı/cerrahi; torasik vertebra/cerrahi/radyografi.

**Objectives:** We evaluated the results of short-segment posterior instrumentation of thoracolumbar burst fractures and investigated correlations between radiographic and functional results as well as factors that affected correction losses.

**Methods:** We reviewed 48 patients (30 males, 18 females; mean age 40±14 years; range 18 to 67 years) who underwent short-segment posterior instrumentation with pedicle screws and fusion. The most common involvement was at L<sub>1</sub> in 18 patients (37.5%), followed by T<sub>12</sub> in 11 patients (22.9%). According to the Frankel grading system, six patients had complete, 14 patients had incomplete neurologic deficits. The Cobb angles were measured, and canal remodeling was assessed by computed tomography. Modified functional results were derived using the Denis pain and work scales. The mean follow-up was 21.7±9.1 months (range 12 to 48 months).

**Results:** The mean correction in the Cobb angle was 18.2±8.6° (p<0.01), the mean correction loss was 7.4±5.7° (p<0.01), and the mean canal remodeling was 51.3±9.3% (p<0.001). There was a significant correlation between Cobb angle correction and correction loss (r=0.38, p<0.01). An intraoperative correction of greater than 15° was significantly associated with a greater correction loss (p<0.05). Patients with a correction loss of more than 10° had a significantly poorer Denis pain score and modified functional result (p<0.05). Modified functional results were excellent in 16 patients (33.3%), good in 23 patients (47.9%), fair in seven patients (14.6%), and poor in two patients (4.2%). At final follow-ups, the Cobb angle was not correlated with functional results (p>0.05). All the patients having incomplete neurologic deficits improved by at least 1 Frankel grade.

**Conclusion:** An intraoperative correction exceeding 15° is significantly associated with a greater correction loss, which in turn has a significantly adverse effect on functional results.

**Key words:** Fracture fixation, internal; kyphosis/etiology; lumbar vertebrae/surgery/radiography; spinal canal/pathology; spinal fractures/surgery; thoracic vertebrae/surgery/radiography.

Short segment posterior instrumentation and fusion of thoracolumbar burst fractures is known to be associated with some degree of correction loss and failure rates.<sup>[1,2]</sup> However, the factors influencing correction loss in short segment instrumentation and relation between radiologic and functional results have been evaluated in few studies.<sup>[3,4]</sup> This information may be critical in determining the type of treatment in thoracolumbar burst fractures. The aim of this study is to evaluate clinical and functional results and to determine the factors influencing correction loss and the relation between radiologic and functional results in short segment posterior instrumentation of thoracolumbar burst fractures.

### Patients and method

Between 2000 and 2003 48 patients with unstable thoracolumbar burst fractures had short segment posterior instrumentation with pedicle screws and fusion procedures performed. Eighteen (37.5%) of the patients were female and 30 (62.5%) were male. The mean age was  $39.56 \pm 13.45$  (18-67).

The fracture locations included 1 T7 (2.1%), 1 T9 (2.1%), 2 T10 (4.2%), 4 T11 (8.3%), 11 T12 (22.9%), 18 L1 (37.5%), 7 L2 (14.6%), 3 L3 (6.3%), and 1 L4 (2.1%). According to Frankel classification 6 were Frankel A, 2 were Frankel B, 3 were Frankel C, 9 were Frankel D, and 28 were Frankel E.<sup>[5]</sup> Surgical indications were the presence of neurologic deficit,  $\geq 25$  degrees kyphosis angle,  $\geq 50\%$  anterior vertebral body height loss or  $\geq 40\%$  canal compromise. Autografts were used in all patients. The Cobb's angle was measured for all patients using the superior end plate and inferior end plate of the intact vertebrae over and below the fractured vertebra respectively.<sup>[6]</sup> Canal stenosis was measured in Computerized Tomography (CT) with the method described by Willen et al.<sup>[7]</sup> Patients without neurologic deficit or additional pathology were put in hyperextension corsets and mobilized on postoperative 2nd day. Patients with neurologic deficits were referred to the physical therapy and rehabilitation clinic and begun on a rehabilitation program. When the patients' pain was controlled with oral medication they were discharged from the hospital.

The mean length of hospital stay was 7.4 (5-14) days.

The patients were seen for follow-up at the 45th day after discharge, and after 3 months, 6 months, 1 year and yearly after that. Neurologic examinations were repeated during follow-up visits. PA and lateral films were examined. The hyperextension type corset was used for 3-6 months. At the first year follow-up all the patients' residual canal stenosis was evaluated with CT. At final visit neurologic examinations were repeated and patients were evaluated for Frankel classification. PA and lateral films were examined. The results were compared to the results when the patient was hospitalized. The patients were evaluated functionally using Denis's pain (DPS) and work (DWS) scales.<sup>[8]</sup> Then their functional status was classified as excellent, good, average, poor, or very poor using the modified Denis pain and work scales (MFR).<sup>[9]</sup>

### Statistical analysis

Cobb correction, Cobb correction loss and canal remodeling were evaluated with one-way analysis of variance.

Pearson correlation analysis was also used to evaluate for a relationship between Cobb correction loss with Cobb's angle when hospitalized and Cobb correction.

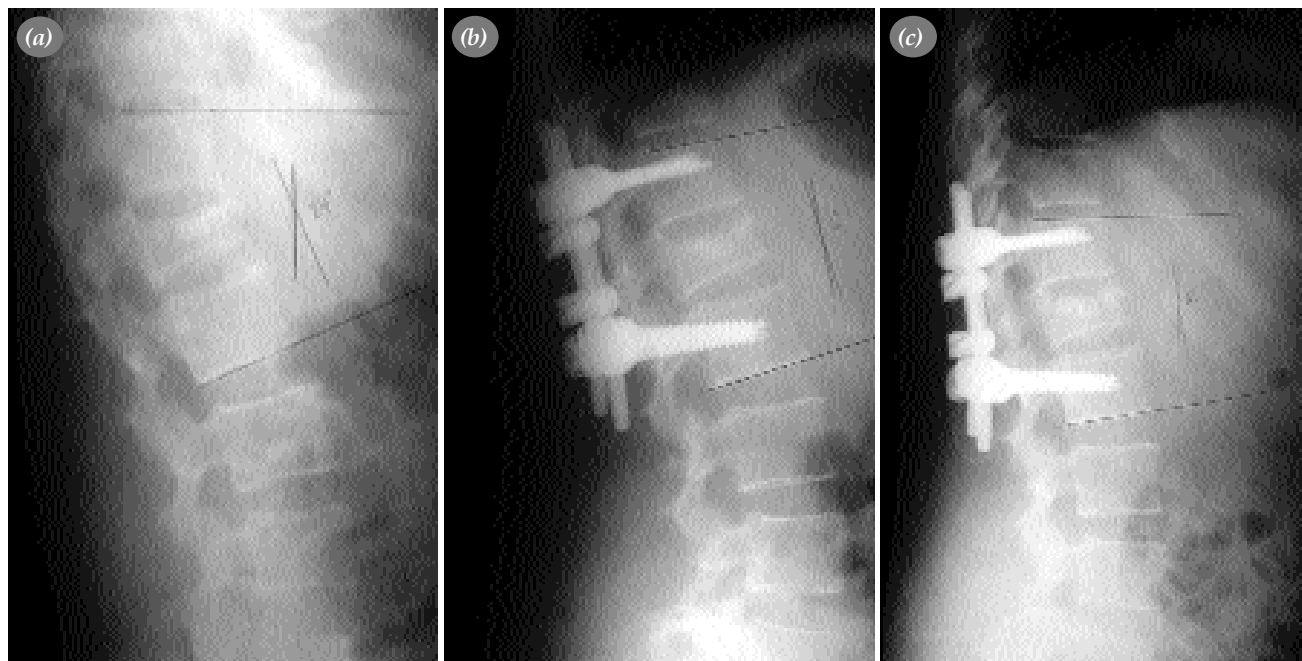
Pearson correlation analysis was also used to evaluate for a relationship between canal remodeling with progressive canal stenosis, correction loss and final follow-up Cobb's angle.

Pearson correlation analysis was also used to evaluate for a relationship between DPS, DWS and MFR with correction loss.

One-way analysis of variance was used to evaluate for a relationship between DPS, DWS and MFR with final follow-up Cobb's angle and residual canal stenosis.

### Results

Mean follow-up was  $21.7 \pm 9.12$  (12-48) months. At the final follow-up examination 16 (33.3%) patients had no complaints of pain (P1), 23 (47.9%) patients had rare complaints of pain but felt the need for treatment (P2). Nine (18.75%) patients had pain that did not interfere with their daily activities or work but required treatment (P3). Nineteen (39.58%) patients had returned to their former jobs



**Figure 1.** (a) 29 years old female patient with an L1 vertebral fracture. (a) Preoperative Cobb angle is 24°. (b) Early postoperative Cobb angle is 6°, (c) Postoperative 12th month Cobb angle is 12°.

and were able to do physically difficult jobs when necessary (W1). Twenty-two (45.83%) patients had returned to their former jobs but were not able to do physically difficult jobs (W2). Five (10.41%) patients had been forced to transfer to physically easier jobs (W3). Two (4.16%) patients were unable to work for a full day because of pain (W4).

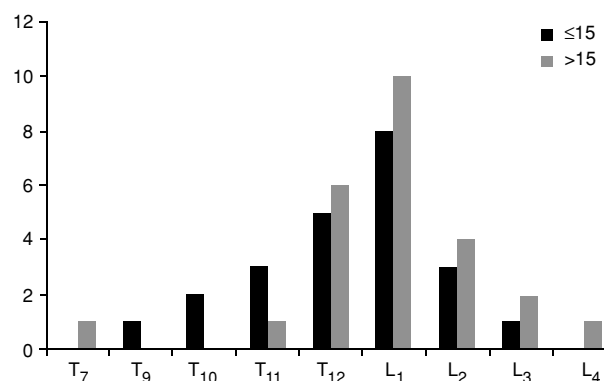
In the evaluation of the modified functional results, 16 (33.3%) patients had excellent results, 23 (47.9%) had good, 7 (14.58%) had average and 2 (4.16%) patients had poor results. No patients were found to have very poor results.

Mean preoperative Cobb's angle was  $23.20 \pm 10.04$ . In the early postoperative period the mean Cobb's angle was  $4.97 \pm 5.15$ . The mean amount of correction in the Cobb's angle was  $18.14 \pm 8.56$  and this correction was found to be significant ( $p < 0.01$ ). (Fig.1 and Fig.2) The final examination mean Cobb's angle was  $12.37 \pm 8.90$ . Mean correction loss was  $7.39 \pm 7.70$ , which was found to be significant ( $p < 0.01$ ). (Fig.3) Mean preoperative canal compromise was  $35.68 \pm 8.52\%$ . The final examination mean canal compromise was  $17.14 \pm 4.56\%$ . Mean canal remodeling was  $51.26 \pm 9.27\%$ , which was significant ( $p < 0.001$ ).

There was a significant correlation between mean preoperative Cobb's angle and mean correction

( $r = 0.85$ ,  $p < 0.001$ ). A correlation was not found between mean preoperative Cobb's angle and mean correction loss ( $r = 0.27$ ,  $p > 0.05$ ). There was a correlation between mean Cobb correction and correction loss ( $r = 0.38$ ,  $p < 0.01$ ) In patients who had an intraoperative correction amount greater than 15°, the correction loss was found to be significantly greater ( $p < 0.05$ ). Fracture locations and demographic data for patients with an intraoperative correction more and less than 15° were presented in figure 4 and Table 1.

A correlation was found between preoperative canal compromise and canal remodeling ( $r = 0.30$ ,



**Figure 2.** Fracture locations of patients with an intraoperative correction more and less than 15°.

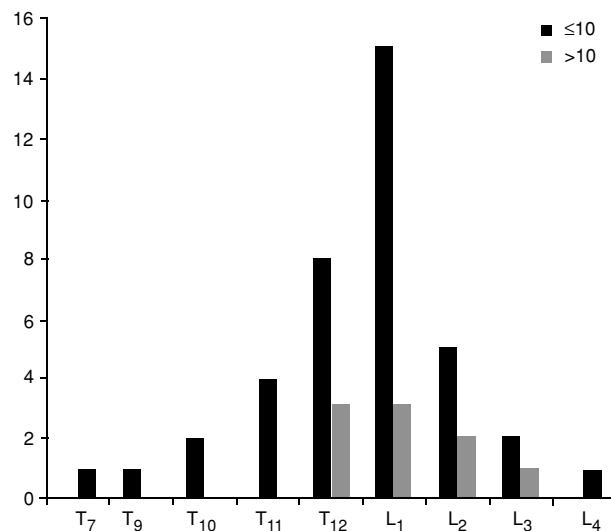
**Table 1.** Demographic data of patients with an intraoperative correction of more and less than 15°.

	Correction ≤15°			Correction >15°			p
	Number	Percent	Mean±SD	Number	Percent	Mean±SD	
Cases	23	47.9	–	25	52.1	–	
Mean Age			37.7±13.3			41.3±13.7	>0.05
Correction			11.1±2.4			24.6±6.8	<0.01
Correction Loss			5.2±4.3			9.4±9.5	<0.05

p<0.05). No correlation was found between mean Cobb correction and mean canal remodeling (r=0.22, p>0.05). No correlation was found between correction loss and canal remodeling (r=0.04, p>0.05).

No correlation was found between correction loss and DPS (r=0.27, p>0.05). However there was a correlation between correction loss and DWS (r=0.39, p<0.01), and between correction loss and MFS (r=-0.39, p<0.01). In patients with a poor DWS the mean of those with correction loss greater than 10° was significant (p<0.05). In those with poor MFR the mean of those with correction loss greater than 10° was significantly higher (p<0.05). A similar correlation with the DPS was not found. Fracture locations and demographic data for patients with an intraoperative correction more and less than 10° were presented in figure 5 and Table 2.

At the final follow-up examination no correlation was found between mean Cobb's angle and DPS (r=0.25 p>0.05), or DWS (r=0.195 p>0.05) or MFR (r=-0.268 p>0.05).

**Figure 3.** Fracture locations in patients with a correction loss of more and less than 10°.

Patients with incomplete neurologic deficit preoperatively were all found to have neurologically improved at least 1 Frankel grade at the final follow-up examination. No patients had late neurologic deficit. (Table 3)

### Complications

Superficial wound infection developed in 5 of the patients but healed with antibiotic use and local wound care. One (2.08%) patient without sign of infection at discharge later returned with findings of infection. This patient's wound site was surgically debrided and there were no signs of infection at the final follow-up examination.

During follow-up radiographic films, 4 (8.32%) of the patients had implant breakage (pedicle screw). Because there were no clinical complaints, no further surgical procedures were warranted.

### Discussion

After Denis's<sup>[8]</sup> report of late neurologic decline in a mean of 17% of patients followed with conservative treatment after thoracolumbar vertebra burst fractures, these fractures began to be treated surgically intensively. The advantages of surgical treatment are the early stabilization of the spine and for that reason a decrease in the possibility of neurological decline, improvement in kyphosis that occurs after fracture, and ability to mobilize early.<sup>[8]</sup> The introduction of transpedicular screws by Roy-Camille and Demeulenaer<sup>[10]</sup> made possible the frequently used short segment posterior instrumentation. However, with the posterior approach, correction loss between 3° and 12° in postoperative follow-up has been reported in the literature. Again there is a reported failure rate of 9-56% with posterior instrumentation.<sup>[1,2,4,11,12]</sup> Procedures such as anterior approach, which has a minimal correction loss, long segment posterior instrumentation and 2HS-1SH structure (Argenson method) have a high relative

**Table 2.** Demographic data of patients with a correction loss of more and less than 10°.

	Correction Loss ≤10°			Correction Loss >10°			p
	Number	Percent	Mean ± SD	Number	Percent	Mean ± SD	
Cases	39	81.3		9	18.8		
Mean Age			36.5±11.6			52.7±13.7	<0.05
Female	15	38.5		3	33.3	–	>0.05
Male	24	61.5		6	66.7	–	<0.05

morbidity.<sup>[13,14]</sup> Short segment posterior instrumentation combined with transpedicular intracorporeal bone grafting is done for the purpose of protecting obtained correction, however there have been contradictory results in these studies. Daniaux et al.<sup>[15]</sup> recommended transpedicular grafting for the purpose of supporting the anterior column to prevent correction loss, however Knop et al.<sup>[2]</sup> and Alanay et al.<sup>[16]</sup> reported that there was no clear decrease in correction loss with the intracorporeal transpedicular graft.

Carl et al.<sup>[11]</sup> applied short segment posterior instrumentation to 38 patients and followed them for a mean of 22.73 months. At the final follow-up examination they found a mean of 6-degree correction loss and at most an obtained correction of 1 degree remained. Bending or breakage of the implant was found in 9 of the patients. However 32 of the 33 patients of whom they were able to do functional assessments were satisfied with their results and 28 had returned to work. Sasso et al.<sup>[17]</sup> followed 23 patients for a mean of 20 months after short segment posterior instrumentation and although in the early postoperative period they obtained significant kyphosis correction by the 3rd month they had lost the correction that they had obtained. The authors reported that there was no significant difference between the 3rd month postoper-

ative kyphosis angle and the preoperative kyphosis angle. However except for 1 patient all the patients in the series had solid fusion obtained. Ebelke et al.<sup>[18]</sup> reported insufficiency in 8 of 13 patients and the mean implant survive was 92% at 6 months postoperatively, and 60% at the 13th month postoperatively. We were able to obtain a significant correction in kyphotic deformity in all the patients in our series with the short segment posterior instrumentation and fusion method. However at the final follow-up examination there was a significant, 7.39±7.70 degree, correction loss. Although there was breakage of the pedicle screw in 4 cases (4.32%), we obtained solid fusion in all of the cases. A correlation was not found in our series between mean preoperative Cobb's angle and mean correction loss, however there was a correlation between mean Cobb correction and final follow-up examination correction loss. This result suggests that as the amount of intraoperative correction increases there is also an increase in the correction loss. In addition, in patients with an intraoperative correction greater than 15 degrees, a significantly high correction loss was found. When patients with an intraoperative correction of over 15° were compared to ones with an intraoperative correction of less than 15°, there was no significant difference regarding fracture locations and mean patient ages. From this point of

**Table 3.** Changes in neurologic status according to Frankel classification.

Frankel Grade	Preoperative	Early Postoperative Period					Latest Follow-up				
		A	B	C	D	E	A	B	C	D	E
A	6	6	–	–	–	–	6	–	–	–	–
B	2	–	–	2	–	–	–	–	1	1	–
C	3	–	–	–	3	–	–	–	–	2	1
D	9	–	–	–	6	3	–	–	–	1	8
E	28	–	–	–	–	28	–	–	–	–	28

view we can not make a comment on a relation between intraoperative correction and fracture location or patient age. At final follow-up examination no correlation was found between mean Cobb's angle and DPS, DWS or MFS. In other words, no correlation was established between final kyphosis and functional and clinical results. However in an animal study by Oda et al.<sup>[19]</sup>, they found hyperlordosis at the adjacent cranial level of the kyphotic segment, lordotic contracture at the Posterior ligamentous complex, increase in lamina stress and, again, degeneration in the adjacent cephalad facet. When evaluated in light of this, it is clear that these patients need long-term follow-up because of the effects that can occur later from the final kyphosis.

McLain et al.<sup>[4]</sup> determined that 10 of the 19 patients that had been treated with short segment pedicle instrumentation were unsuccessful in the early period. In addition the authors found that patients with kyphosis progression had clearly more complaints of pain than those with less kyphosis progression. Also, Oner et al.<sup>[20]</sup> reported that there was a correlation between correction loss in the kyphosis, not final kyphosis, and residual pain. In our study, as well, a statistically significant mean of those with a correction loss greater than 10° in patients had a poor DWS. Those with a mean poor MFR had a significantly higher mean correction loss greater than 10°. However a difference from the study by McLain et al.<sup>[4]</sup> was the lack of correlation between DPS and correction loss.

McCormack et al.<sup>[3]</sup> presented load-sharing classification for the purpose of determining the reasons for short segment instrumentation and fusion related complications and, particularly, correction loss. In the study by Parker et al.<sup>[21]</sup> they used the load-sharing classification system in choice of anterior or posterior short segment instrumentation, and they had successful results with short segment instrumentation in patients with a score of 6 or less according to this classification. We did not use the load-sharing classification in our series. This classification is based on fracture comminution, fracture displacement and the need for correction. We determined in our study that patients with an intraoperative correction amount of more than 15° clearly had higher rates of correction loss. Thus our results, in part, supports the concept of load sharing. Another para-

meter to be considered in the treatment of thoracolumbar vertebra burst fractures is the percentage of canal compromise and decompression of the canal compromise or remodelization. A variety of studies have reported that remodelization occurs in approximately 50% of canal compromise that occurs after thoracolumbar vertebra burst fracture.<sup>[19,22,23]</sup> None of the patients in our series had direct canal decompression. However canal compromise was remodeled in all of our patients. A mean of 51.26±9.27% remodelization occurred and this remodelization is statistically significant. Canal remodelization is not affected by the intraoperative Cobb's angle or the correction loss. A correlation was not found between the canal stenosis at the final follow-up and the DPS, DWS, or MFR. However it is currently not possible to state how the residual canal stenosis will be affected by the degenerative process in long-term follow-up or how it will affect the clinical and functional results. Bohlman et al.<sup>[24]</sup> treated 45 patients, who had received a variety of treatments previously, with anterior decompression within a mean of 4.5 years after their initial treatment because of late period chronic pain and/or paralysis. They reported that 41 of the patients were benefited by the anterior decompression. The writers proposed that pain or paralysis that occurs late is secondary to chronic neural compression and that this compression is a result of traumatic kyphosis and related retropulse bone or disc fragments that continue to cause stenosis of the neural canal. When considered from this point of view we believe that it is necessary to follow these patients long-term for late period canal stenosis. The reason for this is that various studies have shown that canal remodelization generally continues until the 12th month after treatment and that significant remodeling does not occur after the 12th month.<sup>[22]</sup>

Although it has been reported in some research studies that spinal canal decompression that is obtained with ligamentotaxis is insufficient in most cases<sup>[25]</sup>, we did not surgically decompress any of our patients. However all 14 of our patients with incomplete neurologic deficits improved at least 1 Frankel degree and complete healing was obtained in 9 (64%) of our patients. None of our patients suffered a worsening in neurologic status.

*An evaluation of the results from our series leads to the following conclusions:*

A significant correction loss occurs after short segment posterior instrumentation and fusion in thoracolumbar vertebra burst fractures. There is clearly more of a correction loss when the intraoperative correction obtained exceeds 15 degrees.

The final kyphosis angle has no effect on the clinical and functional results. However the degree of correction loss is related to the clinical and functional results. Both the DWS and the MFR were clearer poorer in patients with correction loss greater than 10 degrees. Following short segment posterior instrumentation and fusion surgical procedure a clear remodelization of the percentage of canal compromise occurs. There is no relationship between residual canal stenosis and clinical and functional results and all patients with incomplete neurologic deficit were able to obtain neurologic improvement in Frankel degrees.

However it is necessary to follow the patients long-term to be able to more clearly evaluate all of these results.

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