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EFFECTS OF THE DIFFERENT POSTERIOR FIXATION TECHNIQUES ON CORRECTION AND STABILIZATION OF THE UNSTABLE THORACOLUMBAR VERTEBRAL FRACTURES: A clinical study

Erhan SERİN[1], Lokman KARAKURT[2], Erhan YILMAZ[2], Hikmet GÜZEL[3]

SUMMARY

Following fracture reduction and initial reconstitution of spinal alignment, 1055 of correction over time is frequently observed after posterior instrumentation. The degree of stability to provide a favorable environment for protection of initial correction is not known.

A total of 40 patients with thoracolumbar burst fractures were divided into three groups. Posterior instrumentation was used in all groups. Group 1 included 8 patients treated by pedicle screw fixation, group 2 included 16 patients treated by hook fixation and group 3 included 16 patients treated by combined hook and pedicle screw fixation. The preoperative, early postoperative and 1-year follow-up lateral spinal radiographs were evaluated by measuring the local kyphosis angle (LKA) and the percentage of anterior body height (%ABC).

Correction loss of LKA was 8.8° in group 1, 6.9° in group 2 and 3.2° in group 3. For protecting the initial correction of LKA, group 3 was superior to the other groups (P<0.05) and group 1 and group 2 were the same (P>0.05). Correction loss of %ABC was 7.4 in group 1, 5.6 in group 2 and 3.5 in group 3. For protecting the initial correction of %ABC, group 3 was superior to the group 1 (P<0.05), and other groups were the same (P>0.05). Failure rate was 37.5% in group 1, 12.5% in group 2 and 6.2% in group 3.

For maintenance of initial carrection, posterior instrumentation with combined hook and pedicle screw fixation was superior to posterior instrumentation with hook fixation and posterior instrumentation with pedicle screw fixation.

Key words: *Thoracolumbar burst fracture, posterior fixation, instrumentation, stability.*

ÖZET

Stabil olmayan torakolomber vertebra kırıklarında farklı fiksasyon tekniklerinin korreksiyon ve stabilizasyon üzerindeki etkisi: Klinik çalışma.

Vertebra kırığının posterior enstrümantasyonla sağlanan ilk redüksiyonunu takiben, genellikle zamanla korreksiyon kaybı meydana gelmektedir. Başlangıç redüksiyonunun korunması için gereken uygun stabilitedeki cihazın nasıl olması gerektiği bilinmemektedir.

Torakolomber burst kırığı için cerrahi tedavi uygulanan 40 olgu retrospektif olarak 3 gruba ayrıldı. Tüm olgularda posterior enstrümantasyon uygulandı, Grup 1'deki 8 olguda transpediküler vida ile tespit, grup 2'deki 16 olguda çengel ile tespit ve grup 3'teki 16 olguda çengel ve transpediküler vida ile kombine tespit yöntemleri uygulanmıştır. Ameliyat öncesi, ameliyat sonrası erken ve ameliyat sonrası 1 yıllık dönemlerde çekilen radyogramlarda lokal kifoz açısı (LKA) ve ön korpus yükseklik yüzdesi (ABC%) ölçüldü.

LKA için korreksiyon kaybı grup 1 'de 8.8°, grup 2'de 6.9° ve grup 3'te 3,2° idi. LKA için sağlanan başlangıç redüksiyonunun korunmasında grup 3 diğer gruplardan daha üstündü (P<0,05), grup 1 ve grup 2 ise benzerdi (P>0.05). ABC% için korreksiyon kaybı grup 1'de 7.4, grup 2'de 5.6 ve grup 3'te 3.5 idi. ABC% için sağlanan başlangıç redüksiyonunun korunmasında grup 3, grup 1'den daha üstündü (P<0.05), diğer gruplar ise benzerdi (P>0.05). Yetersizlik oranı grup 1'de %37.5, grup 2'de % 12.5 ve grup 3'te %6.2 idi.

Vertebra kırıklarındaki başlangıç redüksiyonunun korunmasında, çengel ve pedikül vidası ile yapılan kombine posterior tespit yöntemi, sadece çengel ve sadece pedikül vidası ile yapılan posterior tespit yöntemlerinden daha üstün olduğu sürüldü.

Anahtar sözcükler: *Toracolomber vertebra kırığı, posterior tespit, enstrümantasyon, stabilite.*

[1] *Doç. Dr. Fırat Ünıversitesi Tıp Fakültesı Ortopedi ve Travmatolojl Anabılım Dalı, Elazığ*
[2] *Yrd. Doç. Fırat Ünıversitesi Tıp Fakültesı Ortopedi ve Travmatolojl Anabılım Dalı, Elazığ*
[3] *Araştırma Görevlisi, Fırat Ünıversitesi Tıp Fakültesı Ortopedi ve Travmatolojl Anabılım Dalı, Elazığ*

INTRODUCTION

In managing of the thoracolumbar fractures, there is widely held opinion that acute, traumatic, unstable or severely kyphotic fracture patterns should be addressed surgically [1,2,5,6,8,12-14,19,21,22,24-27.30]. The posterior approach has some advantages, such as being technically less challenging and offering the possibility of removing the device at later date. No single method of instrumentation can be suitable for treatment of all kind of spinal injuries. There have been numerous methods of internal fixation described for this injury [6,12,13,19,21,22,25-27,30]. But following fracture reduction and initial reconruction of spinal alignment, 1055 of correction over time is frequently observed after posterior instrumentation[1,2,5,6,12-14,17,19,21,22,25-27].

Most of the fusion process completes within 1-year after surgery[1,13,17,18]. Although posterior instrumentation methods assist in reduction, the essential role of instrumentatıon is to maintain reduction until the fusion process is complet[10,26.30].

Hooks and pedicle screws have different biomechanical characteristics. The primary mechanical advantages of transpedicle screw fixation constructs are that they can provide rigid and 3-column fixation. These techniques, although demanding, do offer unique features not obtainable in rod hook constructs[29].

The purpose of this study was to investigate the effects of posterior fixation with transpedicular screws, posterior fixation with hooks and posterior fixation with combined transpedicular screws and hook systems on protecting the surgical correction of the unstable thoracolumbar vertebral fractures.

MATERIALS AND METHODS

Between 1995 and 2001, 56 patients were admitted to our department with a diagnosis of thoracolumbar burst fracture. Study inclusion was limited to neurologically intact patients who presented with a non-pathological burst fracture in the T10-L3 range, with CT evidence of retro pulsed fragments from middle column disruption, and who were managed with internal fixation. Local kyphosis angle exceeding 20° or loss of anterior body height exceeding 50% was an indication for surgery. A total of 40 patients meeting these criteria were entered into the study. Retrospectively, the patients were divided into three groups. Posterior instrumentation (2-6 segment) with different levels (2-4 levels) fixation was used in all groups. Group 1 included 8 patients treated by transpedicular screw fixation (Figure-1), group 2 included 16 patients treated by hook fixation (Figure-2) and group 3 included 16 patients treated by combined transpedicular screw and hook fixation (Figure-3).

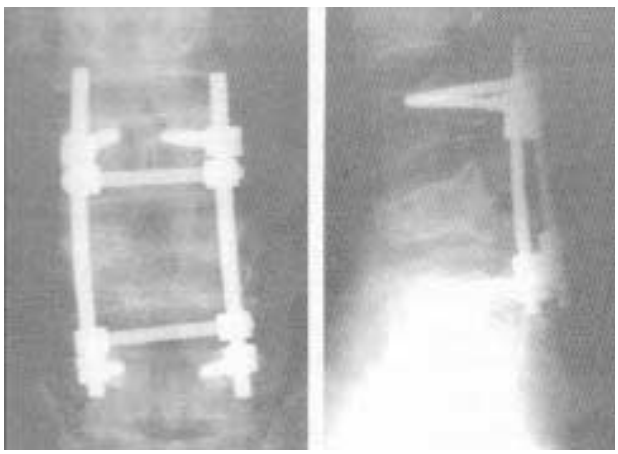

Figure 1. Anteroposterior and lateral view of the posterior instrumentation with pedicle screw fixation of L4 burst fracture.

Short-segment (2 segment) posterolateral spinal fusion was performed in all patients. No laminectomies or laminotomies were performed. All patients were mobilized within 4 days after surgery, and all used total-contact braces for 6 months. One instrumentation system was used in all patients: Alici Spinal System with the

different size of laminar and pedicular hooks (short, medium, long) and pedicle screws (5 and 6.5 mm), and the same size of rods (6 mm).

Screws in group 1, hooks in group 2 and combined (inserting hooks above and screws below the fractured vertebra) in group 3 were used for fixation. After pedicle screws or hooks were inserted into the vertebrae above and below the fractured vertebrae, fixation was achieved with connecting rods producing distraction and slight lordosis. In all patients, a cross-link system was used to create a quadrilateral construct, providing increased resistance in tortional forces.

The study period was 1-year and instrument removal was planned after this period. The patients were assessed with serial physical examinations as well as anteroposterior and lateral radiographs before and after operation and at 3rd, 6th and 12th month intervals. All preoperative and early postoperative radiographs were performed in the supine position. Follow-up radiographs were obtained upright standing position. The preoperative, early postoperative and last follow-up (one-year) lateral spinal radiographs were evaluated. The sagittal plane contour was assessed by measuring the local kyphosis angle (LKA) and the percentage of anterior body height (%ABC) for determination of the severity of deformity.

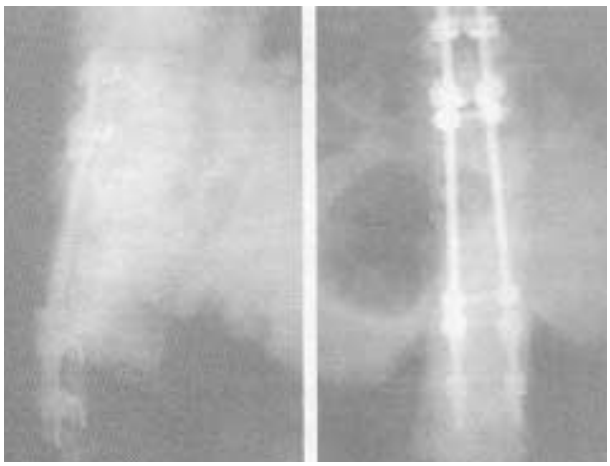

Figure 2. Anteroposterior and lateral view of the posterior instrumentation with hook fixation of T 12 burst fracture.

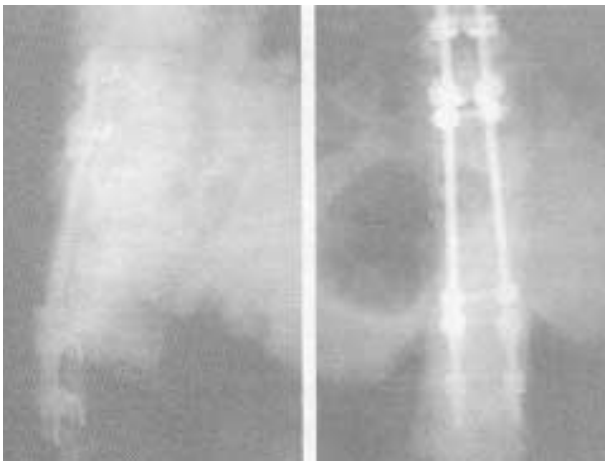

Figure 3. Anteroposterior and lateral view of the posterior instrumentation with combined proximal hook and distal pedicle screw fıxations of L1 burst fracture.

LKA (Cobb angle) was measured between the superior endplate of the upper and the inferior endplate of the lower noninjured vertebrae[16]. Anterior body height of the injured and noninjured adjacent vertebrae above and below was measured, and the percentage of anterior body height compression (%ABC) was calculated using the formula adopted by Mumford et al[23].

Failure was defined as an increase of 10° or more in local kyphosis in the latest follow-up radiographs compared with the measurements on the early postoperative radiographs and for implant failure[2].

A computed tomographic scan (CT) of the injured vertebra ewas routinely performed in all patients on admission and early postoperative period. In relation to the canal width at adjacent, uninjured levels, the percentage of spinal canal compromise (%SCC) was measured using the formula adapted by Katonis et al[12].

Pain was evaluated using the Denis pain scale and work status was evaluated using the Denis work scale[7].

Chi-square, paired and unpaired t tests were used to compare the features of groups and values of the radiological measurements before and after surgery. A p value less than 0,05 were considered significant.

RESULTS

Patient's demographic data is presented in Table-1. There were no significant differences between the three groups for age, gender, fracture distribution according to level and Denis fracture classification (P>0.05). Between the groups, preoperative and early postoperative LKA, %ABC and %SCO measurements were also similar (P>0.05).

The average time to trauma and operation, operation time and length of hospital stay of groups were in Table 2.

(Table 3). Group 1 had significant failure rate than other groups (P<0.05).

Percentage of anterior body height compression

In group 1, the average preoperative %ABC of 45.5, was corrected to 18.4 but progressed to 25.7.

According to pain and function scale, there was no statistically significant difference between the groups (P>0.05).

Local kyphosis angle

In group I, the average preoperative LKA of 17.1°, was corrected to 5.6° but later progressed to 14.5°. The LKA in group 2 was corrected from 16.1° to 6.1° but progressed to 12.7° at the final follow-up. In group 3, the average preoperative LKA was 19.2˚and corrected to 7.4° but progressed to 10.6°. The average correction loss in LKA between the early postoperative and 1-year follow-up periods were 8.8±7.9° in group 1, 6.9± 3.6° in group 2 and 3.2±2.1° in group 3 (Table-3). Statistically significant initial correction was obtained in all groups (P<0.05). The correction loss of for LKA was statistically in group 2 was corrected from 41.8 to 15.8 but progressed to 22.1 at the final follow-up. In group 3, the average preoperative %ABC was 38.6 and corrected to 12.4 but progressed to 15.9. The average loss of correction in %ABC between the early postoperative and 1-year follow-up periods was 7.4±2.6 in group 1,5.6±2.8 in group 2 and 3.5±3.2 in group 3 (Table 4). Statistically signifi-

Table I. Patient's Demographic Data.

	Group 1	Group 2	Group 3	Statistic
No. of patients	8	16	16	
Avarage age at surgery: years	35.1±15.2	36.2±15.8	30.2±9.3	P > 0.05
Gender (male: female)	4:4	9:7	7:9	P > 0.05
Fracture level				
(T10:T11:T 12:L1 :L2:L3:L4)	0:1:1:2:1:2	1:1:3:8:2:1:0	0:0:4:9:3:0:0	P > 0.05
Denis fracture classification				
(A:B:C:D:E)	6:2:0:0:0	6:6:2:0:2	8:7:1:0:0	P > 0.05
Lokal kyphosis angle (preop.)	17.1±7.8˚	16.1±7.3˚	19.2±6.6˚	P > 0.05
Lokal kyphosis angle (early postop.)	5.6±3.7˚	6.1±3.5˚	7.4±3.2˚	P > 0.05
% Anterior body height (preop.)	45.5±12.3	41.8±15.8	38.6±11.8	P > 0.05
% Anterior body height (early postop,)	18.4±8.9	16.1±9.7	12.4±6.6	P > 0.05
% Spinal canal compromise (preop.)	35.5±10.1	32.2±14.3	35.7±17.6	P > 0.05
% Spinal canal compromise (early postop.)	12.6±8.1	10.7±7.1	12.9±8.2	P > 0.05

Preop.: Preoperative - **Postop.:** Postoperative

cant initial correction was obtained in all groups (p<0.05). The loss of correction for %ABC was not statistically significant in all groups (p>0.05). For correction loss, significant difference were found between the group 1 and group 3 (p<0.05), but no significant difference was fo und between the other groups (p>0.05).

Percentage of spinal canal occupation

In group 1, the average preoperative %SCC of 33.5, significant in all groups (p<0.05). For loss of correction, significant difference was found between the group 3 and other groups (P<0.05), but no significant difference was found between the group 1 and group 2 (P>0.05). Three patients (37.5%) in group 1, two patients (12.5%) in group 2 and one patient (6.2%) in group 3 had failure was corrected to 12.6. The %SCC in group 2 was corrected from 32.2 to i 0.4. In group 3, the average preoperative %SCC was 35.7 and corrected to 12.9. Statistically significant initial correction was obtained in all groups (p<0.05).

Complications included one distal screw breakage in group 1, one superficial and one deep infection in group 2, and four superficial infections and one hook dislodging in group 3. The infections were treated by antibiotics but deep infection needed drainage. The patient with screw breakage had no failure but the patient with hook dislodging had failure.

DISCUSSION

The degree of stability to provide a favourable environment for protection of initial correction is not known. If fracture is to be reduced, it is very important to remember that the spine must be aligned in the coronal and sagittal planes.

Table 2. Average time to trauma and operation, operation time and hospitalization time.

	Time to trauma and op. (days)	Op. time (min)	Hosp. (days)
Group 1	2±1.2	118±25	10.7±2.2
Group 2	4±2.7	133±29	10.4±2.1
Group 3	6.2±5.6	141±20	11.4±1.7

Time to trauma and op. (days): Time to trauma and operation in days
Op. Time (min): operation time in minutes
Hosp. (days): Hospitalization time in days

Table 3. Local kyphosis angle.

	Preoperative	Early postoperative	1 year postoperative	Correction loss	Failure rate
Group 1	17.1±7.8°	5.6 ±3,7˚	14.5±11˚	8.8±7.9˚	3 of 8 (37.5%)
Group 2	16.1±7.3°	6.1±3.5˚	12.7±4.9°	6.9±3.6°	2 of 16 (12.5%)
Group 3	19.2±6.6°	7.4±3.2°	10.6±4.2°	3.2±2.1 °	1 of 16 (6.2%)

Table 4. Percentage of anterior body height compression

	Preoperative	Early postoperative	1 year postoperative	Correction loss
Group 1	45.5±12.3	18.4±8.9	25.7±10.7	7.4±2.6
Group 2	41.8±15.8	16.1±9.7	22.1±10.9	5.6±2.8
Group 3	38.6±11.8	12.4±6.6	15.9±8.1	3.5±3.2

The sagittal plane deformity after a thoracolumbar fracture is most closely associated with prognosis[16]. The true test of an instrumentation method is maintenance of stability when the patient resumes the upright position, as in sitting and walking[30]. In this study, patients were neurologically intact and all were mobilized within 4 days after surgery.

We achieved reduction with connecting rods and statistically significant initial sagittal plane correction were obtained in all groups ($p<0.05$).

In the literature, there is numerous posterior instrumentation techniques used for unstable thoracolumbar vertebral fractures with different correction loss rate[1,2,5,6, 12-14, 17,19,21,22,25-27].

It has been demonstrated by results in several studies that posterior instrumentation with pedicle screw fixation of thoracolumbar burst fractures is associated with an unacceptable rate of failure. Considering 10° or more correction loss and/or implant failure as a criterion for failure, the rate of failure has been reported to be 25-50% in several studies [2,3,5,15,20,21]. But, Katonis et al and Roy-Camille et al used pedicle screw fixation in thoracolumbar fractures and found no significant correction loss for all radiographic measurements[12,25]. We used posterior instrumentation with transpedicular screw fixation in group 1 and significant correction loss were found for LKA ($p<0.05$). Failure rate was 37.5% in group 1.

Significant correction loss in sagittal plane alignment was found in posterior instrumentation with hook fixation. Dekutoski et al, Sasso and Cotler, Akbarnia et al and Kornberg et al found significant correction loss of kyphosis angle [1,6,14,27]. But, McBride found minimal correction loss in sagittal plane alignment[19]. We used posterior instrumentation with hook fixation in group 2 and significant correction loss were found for LKA ($P<0.05$). Failure rate was 12.5% in group 2.

Ruan et al used Shen instrumentation which consist of four component; superior pedicle screw with slot for rod holders, Harrington distraction rods, inferior laminar hooks and rod sleeves and found minimal correction loss in sagittal plane alignment at the end of 2-years follow-up period[26]. In group 3, we used combined posterior fixation (inserting hooks above and screws below the fractured vertebrae) and significant correction loss were found for LKA ($p<0.05$). Failure rate was 6.2% in group 3.

Significant initial correction was found in all groups for LKA, %ABC and %SCC ($p<0.05$). The average correction loss of LKA was 8.8° in group 1, 6.9° in group 2 and 3.2° in group 3. For protecting the initial correction of LKA, group 3 was superior to the other groups ($p<0.05$), and no significant difference was found between the group 1 and group 2 ($p>0.05$). The average correction loss of %ABC was 7.4 in group 1, 5.6 in group 2 and 3.5 in group 3. For protecting the initial correction of %ABC, group 3 was superior to group 1 ($p<0.05$), and no significant difference was found between the other groups ($p>0.05$). Group 1 had significant failure rate than other groups ($p<0.05$). These data showed that; for protecting the initial correction, combined posterior fixation system was more stable than posterior fixation with hooks and posterior fixation with pedicle screws systems.

Maximum values of forces and moments in the device are greater in compression than in torsion[28]. The loss of correction occurred at both the vertebral level and the level of the disc[1]. The kyphosis increases while the hardware remains intact, probably thorough combined fatigue bending of the rod, motion at the screw-rod or hook-rod junction (connector loosening), and motion at the screw-bone or hook-bone junction.

The anatomical reduction has been correlated to the reduction of the intracanal fragments and loss of correction of deformity generally means higher risk of complications in the future[31]. Radiographic measurements often play a central role in orthopaedic decision making. Measurement of post-fracture kyphosis is an important factor in clinical decision making and LKA (Cobb angle) found to be the least variable and most reliable measurement technique[16]. If the late kyphosis develops it usually presents with pain and symptoms of spinal stenosis[4,8,14,21]. In this study, there was no significant difference between the all groups according to pain and work score ($p>0.05$), but follow-up period was short (1 year) and we are waiting worse subjective scores in future especially for group 1.

We used usually long-segment instrumentation and always short-segment fusion. Jacobs attempted to minimize the normal motion segments compromised by his "rod long fuse short" technique. Although his instrumentation extended two segments above and three below fracture, Jacobs theorised that removing the rods by 1 year would allow unfused segments to function normally[11]. Long instrumentation with limited arthrodesis of injured vertebrae and early removal of the rod is an effective technique for restoration of vertebral motion[1,6,9]. We planned instrument extraction after the 1-year postoperative period.

All posterior fixation systems in this study were suitable for initial reduction of sagittal plane deformity and spinal canal occupation. For maintenance of initial correction, posterior combined hook and pedicle screw fixation system was superior to posterior hook fixation and posterior pedicle screw fixation systems. Ideal internal fixation method must not be permitting any significant correction loss in sagittal plane, but the correction loss for LKA was statistically significant for all systems in this study.

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Corresponding address:
Dr. Lokman Karakurt
Fırat Üniversitesi Tıp Fakültesi
Ortopedi ve Travmatoloji Anabilim Dalı
23200 Elazığ
Tlf.: 0.424.2388080 • Faks: 0.424.2335038
e-posta: lkarakurt@hotmail.com