THE EARLY RESULTS OF THE AO SPINAL INTERNAL FIXATOR IN THE SURGICAL TREATMENT OF THORACOLUMBAR BURST FRACTURES

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The potential for clinical instability following thoracolumbar fractures has evoked a progressive increase in interest in the surgical treatment of unstable thoracolumbar fractures.

From September 1990 to October 1991, 22 thoracolumbar burst fractures were treated surgically by the AO Spinal İnternal Fixator at the Orthopaedics and Traumatology Clinics of Ankara Social Security Hoslpital. Mean follow-up period was 13.7 (7-20 m) months. Fourteen (63.5 %) of the patients were male and 8(36.5 %) were female.

Postoperatively, mean anterior vertebral height loss and spinal canal compromise were corrected by 36.05 % and 33.37 % respectively. Also postoperatively 16° of improvement was obtained in the mean kyphosis angle. In light of these data, it is suggested that the AO Spinal Internal Fixator effectively restores three dimentional alingment of the spine and provides a rigid fixation.

Key Words: *Burst Fracture, Internal Fixator, Pedicle Fixation*

The treatment of thoracolumbar spine fractures remains controversial as there are proponents for both nonoperative and operative procedures (7, 10, 16, 19, 23, 27). The goals of the surgical management include attaintment and maintenance of reduction of normal spinal structures, effective decompression of the spinal canal, providing stability, early and pain-free mobilization, minimizing complications and encouraging effective rehabilitation (3, 8, 12, 22, 23, 27, 28, 38).

The three column concept was described by Denis and the use of computed tomography has increased our konwledge about burst fractures, therefore, the need for surgical stabilization in these fractures has arised as poor results were obtained by conservative methods (5, 10, 11, 18, 19, 20, 24). In 1963 Roy-Camille introduced transpedicular fixation and this has proved to be one of the reliable methods of fixation as biomechanical studies has shown pedicles to be a strong point for instrumentation (9, 14, 17, 26, 33, 34). A pedicle-rod system (External Spinal Skeletal Fixator) was designed by Magerl in 1977 which reduced the instrumentation level to one above and one below the fractured vertebra and sufficiently restored spinal alignment in three planes (29).

The AO spinal internal fixator was developed by Walter Dick in 1982 for the treatment of thoracolumbar fractures and fracture dislocations and has been well accepted (2, 12, 13, 14). This system uses 5.0 mm diameter transpedicular Schanz screws with 7.0 mm diameter fully threaded stainless steel rods. As coupling mechanism between the Schanz screws and the rod is mobile in the sagittal plane, it allows for restoration of lordosis and kyphosis (1-13).

With this study the early results of 22 thoracolumbar burst fractures treated surgically by the AO spinal internal fixator were evaluated.

MATERIAL AND METHODS

From September 1990 to October 1991, 22 thoracolumbar burst fractures were treated surgically by the AO spinal internal fixator (Fixateur Interne) at the Orthopaedics and Traumatology Clinics of Ankara Social Security Hospital. Of all the patients, 8(36.5 %) were female and 14(63.5 %) were male. They ranged in age from 15 to 59 years (mean, 37.6 yrs.). Mean follow-up period was 13.7 (7-20 m) months. Last controls of the patients were done in May 1992.

The cause of injury was traffic accidents in 8(36.4 %) patients, suicide in 2(9 %) and falls from high in 6 (27.3 %) patients. Work-related injuries were seen in 6(27.3 %) patients (Fig 1). The most frequently injured segment was L1 by 9 (40.9 %) cases. This was fallowed by 5T12 (22.7 %), 3L2 (13.7 %), 3L3(13.7 %), 1T11(4.5 %) and 1L4 (4.5 %) fracture.

After admission patients were assessed with a detailed history and complete physical examination. Accompanying system complications were recorded in patients with polytrauma and immeditae appropriate consultations were completed in the emergency room.

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Following a meticulous neurological examination patients's neurological status were classified according to Frankel grading system (37). Thus, complete loss of both motor and sensory functions below a level were recorded as Grade A, preservation of some sensation and complete motor paraylsis as Grade B, some motor function preserved but insufficient to be useful (motor useless) as Grade C, weak but useful motor function as Grade D and neurological intact patients as Grade E. This evaluation was also performed in the postoperative and follow-up period.

Radiological examinations of the patients were done by antero-posterior, lateral radiograms and by CT in the preoperative, postoperative and follow-up periods. Anterior vertebral body height loss of the fractured vertebra was measured by the formula that Atlas et al. has suggested.

$$\text{Copression Percentage} = 100 - \frac{F}{\frac{A+B}{2}} \times 100$$

F is the anterior vertebral body height of the fractured vertebra, A and B are the anterior vertebral body height at the vertebra above and below respectively.

In the lateral radiograms the local kyphosis angle was measured by erecting perpendiculars from the inferior end-plate of the vertebra above and the superior end-plate of the vertebra below the injured level. Also compression angles of the fractured vertebrae were determined by bisecting the lines drawn from the inferior and superior end-plates of the injured vertebra.

Spinal canal compromise was quantified in all patients with the use of computed tomography and correction percentages after surgery were calculated. Spinal canal compromise at the injured level (N %) was estimated by measuring the diameter in the mid-sagittal plane and comparing it with the mean value of mid-sagittal diameters in the same level of the vertebra above (A) and below (B) with the formula given above.

Using a standard posterior approach the levels above and below the intended instrumentation (one above-one below the fractured segment) were exposed. The Schanz screws were placed down the pedicles using anatomic landmarks and under C-arm image intensifier control. Reduction and correction of deformity was performed by using long lever-arms of the Schanz screws and distraction. After confirming the adequate reduction of the fracture by image intensifier, the nuts were tightened. A standard posterolateral fusion was also added with the use of bone allografts provided from our bone bank.

All of the patients were turned to both sides on the 1st postoperative day and encouraged to ambulate on the 2nd postoperative day depending on the neurologic status of the patient and accompanying injuries. Postoperative external support wasn't used in any of the patients.

The measurements mentioned above were done in the postoperative, follow-up and control periods and all the data available were recorved. Improvements gained with the instrumentation and complications were noted.

The indications for surgery and stabilization were considered as: prensence of free bony fragment in the spinal canal with neurological deterioration, spinal canal narrowing more than 30 %, anterior vertebral height loss that exceeds 50 %, presence of instability and deterioration of sagittal contours especially in young active patients.

RESULTS:

Among 22 thoracolumbar burst fractures, the time from the original injury to the time of surgery was less than 24 hours in 16(72.7 %) patients, 1-5 days in 2(9 %) and more than 5 days in 4(18.3 %) patients.

Additional orthopaedic injuries were seen in 6(27 %) patients. Three (13.5 %) had multiple costal fractures, 1(4-5 %) had ramus pubis fracture, 1(4.5 %) had calcaneus and remaining 1(4.5 %) had clavicula fracture. These patients were treated conservatively. Also 2 (9 %) patients had craniocerebral injuries and were followed by neurosurgery clinic for the intial 2 days of the trauma.

The frequency of occurence in Denis classification of burst fractures are seen in Fig 2. 6(27 %) type A, 12(55 %) type B and 4(18 %) type D fractures were observed. Type C and D fractures were not noted.

Including all the patients, mean postoperative spinal canal compromise by the retropulsed bony fragment was 55.1 % (range, 32 to 78 %) and mean improvement in canal clearance in the immediate postoperative period was 33.3 %. Assessment of follow-up CT scans of the patients showed a mean improvement of 31.9 % in canal clearance (Table 1). As can be seen from the table, mean preoperative anterior vertebral body height loss was 52.5 % (range, 30 to 68 %). This was corrected to 16 % (range, 6 to 40 %) postoperatively and averagely 0.9 % of loss of correction was noted in the follow-up period.

Table 1: Mean preoperative, postoperative and follow-up measurements of anterior vertebral body height loss and spinal canal compromise.

	Preoperative	Postoperative	% Corr.	Follow-up	% Corr.
Aterior Vertebral Body Height Loss	52.52 %	16.47 %	36.05 %	17.37 %	35.15 %
Spinal Canal Compromise	55.51 %	22.14 %	33.37 %	23.53 %	31.98 %

Table 2: Neurologic Status by Frankel Grading System.
* (1 patient died by pulmonary embolism)

Frankel Grade	Preoperative (22 patients) %	→ (same grade)	↘ (next grade)	Postoperative (22 patients) %	→ (same grade)	↘ (next grade)	Follow-up (21 patients)* %
A	4 (18.2)	3	1	3 (13.6)	2	1	2 (9.1)
B	1 (4.5)	1	3	2 (9.1)	1	1	2 (9.1)
C	4 (18.2)	2	2	2 (9.1)		2	1 (4.5)
D	4 (18.2)	3	1	5 (22.7)	4		6 (28.3) (1.ex.)*
E	9 (40.9)	9		10 (45.5)	10		10 (45.5)

Table 3: Mean preoperative, postoperative and follow-up measurements of local kyphosis and compression angles

	Preoperative	Postoperative	İmprovement	Follow-up	İmprovement
Local Kyphosis Angle	20.13°	5.95°	16°	8.14°	13°
Compression Angle	19.22°	7.77°	11.45°	8.38°	10.28°

The preoperative neurologic status of the patients and their postoperative and follow-up evaluation is seen in Table II. According to Frankel classification, preoperatively, 4 patients (18 %) were Grade B, 4(18 %) were Grade C, 4(18 %) were Grade D and remaining 9 (41 %) were Grade E. Postoperatively, 1 patient improved from Grade A to B, 2 improved from Grade C to D, 1 were found to improve from Grade D to E and none of them deteriorated. In the last controls also 4 patients improved one neurologic level with 1 patient from Grade A to B, 1 from B to C and 2 from C to D. As a result, from preoperative evaluation to last controls, 1(4.5 %) patient improved 2 and 7(31.8 %) improved one full neurologic level.

Measurement of plain lateral radiographs showed that mean local kyphotic deformity was 20.1° (range, 7°-38°) preoperatively (Table III). This was reduced to 5.9° (range, -7° to 2°) in the immediate postoperative period. The mean improvement in the kyphotic deformity was 16° (range, 6° to 28°) postoperatively. At the follow-up, there was minimal loss of reduction to an average of 8.1° (range, -5° to 22°) kyphosis. The mean compression angle which was 19.2° (range, 3°-32°) preoparatively was corrected by averagely 60 % and came to an average of 7.7° (range, 0°-24°) in the initial postoperative period.

COMPLICATIONS:

One exitus was noted due to pulmonary embolism in the postoperative 8th day. In 3 patients Schanz screws perforated the anterior cortex of the vertebral body. (2 screws in the same patients, 2 screws in one in each remaining patients, a total of 4(4.4 % screws). Also 6 (6.7 %) Schanz screw misplacement was noted. In none of the patients any neurologic or vascular injury was not noted as a result of the instrumentation. Two Schanz screw breakages were observed in the 10th postoperative month in the same patient and the implant was removed. There was no wound infections or pseudoatrhrosis.

DISCUSSION:

Although there were advocates of conservative methods in the treatlment of unstable thoracolumbar burst fractures, problems such as late deformity, back pain and insufficient results obtained in spinal canal restorement has increased the need for surgical reduction and stabilization in the past few decades (7, 10, 16, 19, 23). The concepts of treatment of burst fractures has changed since the introduction of CT (7, 18).

Berthold Ernest Hadra was the first surgeon to fix a vertebral fracture at the end of last century. Laminectomy was a choice of treatment up to mid 1900's, but, since its deteriorational effect to spinal stability has been understood, its use has been limited to the cases which showed protrudement of fractured vertebral arch to the spinal canal (1, 14, 19, 27, 35). Fixation of the spinous processes by plates was used by Holdsworth and Hardy, Meurig et al. but were abandoned because of poor results 4). In 1958 Harrington first used his system for stabilization of spinal fractures, but its disadvantages such as immobilization of long segments, implant failure, lack of rotational stability, pseudoarthosis and the need for prolonged external immobilization were reported in a broad spectrum of literature (2, 3, 13, 14, 16, 18, 23, 25, 27, 28, 31, 38).

Harrington system modifications and segmental sublaminar wiring systems such as Luque also used multi-level fixation and couldn't prevent vertebral collapse when posterior wall of the vertebral body or dorsal structures were damaged (1, 2, 13, 30, 32).

The rigidity and stability of dorsal plates with transpedicular screws introduced by Roy-Camille has been well accepted as it used the most resistant part of the vertebra, restoration of physiological curve of the spine with a lumbar lordosis was possible and was independent from ligamentous or bony involvement, but, techniqual difficulty, fixation of multiple levels and its limited reduction capability was considered as disadvantages (4, 9, 12, 17, 22, 34).

The external spinal skeletal fixator (ESSF) developed by Magerl which also used transpedicular screws, allowed effective reduction of thoracolumbar burst fractures while immobilizing only the level above and below the affected vertebra (25). With a modification, Dick introduced the internal spinal fixator in 1982 and eliminated disadvantage of not being implantable (12, 13).

In modern vertebral fracture treatment the main aims are to stabilize and achieve anatomic reduction of the deformity, maximize patential for neurologic recovery, minimize the length of fusion, prevent late loss of correction and eliminate the need for external supports (3, 37).

Up to date many authors believed there was no relationship between spinal canal narrowing, neurologic deficit and improvement in neurologic status after surgery (1, 19). Although there is no agreement as to whether surgical treatment with internal fixation facilitates neurological recovery or not, recent reports in increasing number points the importance of decompression in cases with neurological defficit and unstable fractures (10, 15, 18). Anterior surgery is considered to be the most effective way of decompressing the spinal canal but, it is a rather demanding method (2, 35). Another difficulty is lack of ability to stabilize the spine adequately using only an anterior approach (18). In the study which Esses et al. examined AO spinal fixator's effect on spinal canal decompression and compared with anterior decompression, they supported the hyphothesis that AO spinal fixator can effectively decompress the canal but accepted anterior decompression's superiority (18). In our series which is limited to 22 cases, we obtained averagely 33.3 % of improvement in canal clearance. Post operative and follow-up examinations showed 1(4.5 %) patient improved 2 (from Grade A to C) and 731.3 %) improved one full neurologic level. This is comparable to the results of other operative and conservative methods of treatment. The effect of early surgery was determined in series which used internal fixator (17, 18).

In 1986 Aebi reported satisfactory results of the AO spinal internal fixator in correction of kyphosis and maintenance of reduction (2). Also Dick and Esses has emphasized the success of the system in correction of the deformity (12, 17, 18, 28). Small amounts of loss of corrections were adressed to the loss of disk space height and viscoelosticity of the system (28). In this study an average of 20° of kyphosis is reduced to 5.9° in the immediate postoperative period and is held to 8.2° at follow-up. Furthermore correction amounts and maintenance of anterior vertebral body height and compression angle are found to be satisfactory in this study.

Transpedicular fixation of burst fractures has proven to be rigid and safe through clinical and biomechanical studies (4, 9, 23). Two (2.3 %) Schanz screw breakage is observed in our study. Lindsey and Dİck 28 reported 5, Esses 17 reported 2 Schanz screws to be fractured in their series, however, as Schanz screws are longer in diameter compared to screws used with plates and threaded part of the screws remains in the vertebral body, danger of a fracture is suggested to be reduced (14). Furthermore stability in torsion stresses are reported to be superior to distraction rods and segmental sublaminar wiring.

In our series 6(6.7 %) screw misplacement was noted, but majority of them were early in the study. Presence of learning curve in pedicle screw insertion has been demonstrated (16, 21).

The AO spinal internal fixator, with Schanz screws' mechanical advantages for reduction of the spinal column fracture deformity which span the anteroposterior width of the vertebral segment and long lever arms, allows fixation and reduction in all three columns (2, 3). Its distractive effect in reduction of middle column including posterior retropulsed fragments by ligamentotaxis has been well proven (17, 18). It also independently permits restoration of lordosis (12, 16).

The purpose of this study is to review early results of the AO spinal internal fixator used in 22 thoracolumbar burst fractures.

In view of the results presented in this study, though our series is a limited one, it is suggested that the AO spinal internal fixator, with its:

1. multiplanar reduction capabilities
2. limited segmetal fixation levels of two spinal motion units
3. high success in decompressing the spinal canal
4. low rates in loss of reduction
5. eliminating effect of the need for external supports,

fulfills the aims in modern vertebral burst fracture treatment.

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