Effectiveness of posterior tension band fixation in the thoracolumbar seat-belt type injuries of the young population

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Abstract We report results in the surgical treatment of thoracolumbar flexion–distraction fractures, both associated or not with neurological impairment. Items in the present study include function, pain (back pain rating scale) and neurological recovery (Asia Score). A prospective series of 19 consecutive flexion–extension thoracolumbar injuries (T11–L2), occurred in young patients (20–33 years) due to motor vehicle crashes wearing the 3-point safety belts, includes 2 Chance and 17 seat-belt fractures, with different amount of vertebral dislocation and neurological impairment. Fractures have been evaluated according to the Magerl’s classification. All patients were operated via posterior approach using hybrid instrumentation or short pedicular fixation to reduce dislocation and to obtain spinal fusion. Posterior decompression was performed in all patients with neurological deficit. Posterior instrumented arthodesis was performed by wide constructs that preferably include 2 levels above and below the dislocated vertebra. Most of them were instrumented using thoracic hooks and lumbar pedicular screws. One postoperative vascular complication was successfully treated by

selective embolization. All neurological patients were submitted to a postoperative rehabilitation program. Posterior procedure allows proper reduction and realignment. In our experience, the use of laminar hooks one level above the dislocation seems to reduce the potential risk of neurological and /or vascular damage during the intraoperative maneuvers on the dislocated pedicles. At follow-up, fusion was achieved in all patients. The clinical condition was totally satisfactory due to the absence of significant pain, confirming mechanical stability of the implants. In terms of neurological outcomes, patients presenting as ASIA A–B or ASIA E, maintained their preoperative neurological condition. Surgical treatment, together with an early postoperative rehabilitation program, can be of paramount importance in neurological patients’ quality of life.

Keywords Seat-belt injury · Thoracolumbar fracture · Posterior fixation · Instrumented arthodesis

Introduction

Fractures of the thoracolumbar junction are among the most common injuries involving the spine. The most frequent causes are motor vehicle accidents and falls from height. The morphology of the lesion is influenced by the trauma severity, patient age and body weight, use and type of seat belts and body posture at the time of trauma [2]. Flexion–distraction injuries seat-belt type fractures, accounting for 5–15% of all major vertebral trauma [22], are considered mechanically unstable due to the disruption and the separation of the posterior elements, either ligaments or bones. The presence of severe dislocation indicates the rupture of the anterior longitudinal ligament [32]. Considering these instances as compression or flexion–

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compression injuries, may lead to uneven conservative treatment. Such patients may develop a symptomatic kyphotic deformity [29]. Selection criteria for surgical treatment of severe dislocations still remains controversial, in particular, for patients without neurological involvement [2]. Internal fixation seems to be the most appropriate surgical approach due to continuous developing of surgical technique and instrumentation over the last two decades. This procedure allows an immediate stability, realignment and decompression of the spinal canal [3, 30]. However, the quality of life in patients with seat-belt fracture, conservatively or operatively treated, cannot return to normal after injury [21].

We report our experience in the surgical treatment of 19 thoraco-lumbar seat-belt type fractures, in which was crucial the diagnostic approach to determine the injury pattern, often complex and not only spinal [8], and the surgical strategy to resolve the instability and dislocation, but also to minimize the risk of possible complications.

Materials and methods

A prospective consecutive series of 19 flexion–distraction fractures involving the thoracolumbar junction (T11–L2), was surgically treated from 1999 to 2006. In all cases, review of the records (Table 1) identified a trauma from motor vehicle crash during the use of 3-point safety belts.

All patients were young males, between 20 and 33 years (mean age 24). Associated conditions were four blunt chest trauma, seven blunt abdominal trauma, five other bone fracture and three head injury. The glasgow coma scale (GCS) was over 12 in all cases, except four in which it ranged from 6 to 8. The assessment of neurological condition was carried out with the ASIA impairment scale [9]. According to this classification, 10 patients were included in Group E, 2 in Group B and 7 in Group A. All of these patients were followed up at 6 weeks, 3, 6, 9 and 12 months and then annually postoperatively. Outcomes were based on the back pain and function, according to Anderson et al. criteria [1], which included solid fusion (kyphotic angle, no loosening and/or implant failure), tested by three-dimensional CT scan [12], and neurological evaluation by ASIA score [9].

Classification

The spinal injury pattern is closely related to the position of axis of rotation at the time of trauma. In flexion–distraction fractures, the axis of rotation is always dislocated anteriorly and the combination of hyperflexion and distraction of the posterior elements cause damage to the posterior and middle column [31]. Also, the larger is the flexion angle, the more anterior is the motion axis of fracture (MAF), therefore the higher is the risk of vertebral body compression injury [19]. From the original description of

Table 1 Records in 19 young males with seat-belt type injury of the thoracolumbar junction

Case	Age	Level	Type	Other injuries	Fixation	GCS	Asia	Kyphosis		Back pain
								pre-op (°)	post-op (°)	
1	21	T11–T12	B1.2.2	Yes	T9–L2	7	B	15	4	1
2	27	L2	B2.1	No	L1–L3	14	E	4	0	0
3	29	L1	B2.1	No	T12–L2	13	E	7	3	1
4	22	L1	B1.1.1	No	T12–L2	13	E	10	3	1
5	33	T12	B1.1.1	No	T11–L1	12	E	4	0	0
6	20	L1	B1.1.1	Yes	T12–L2	13	E	12	0	0
7	20	L2	B1.1.1	Yes	L1–L3	14	E	7	3	1
8	21	T12	B1.1.1	No	T11–L1	13	E	4	0	0
9	25	L1	B1.1.1	No	T12–L2	14	E	8	4	1
10	23	T11–T12	B1.1.3	No	T10–L2	6	A	35	11	2
11	24	T11–T12	B1.2.3	Yes	T10–L2	13	A	32	10	2
12	20	L1–L2	B1.1.3	Yes	T11–L3	8	B	22	8	1
13	21	T12–L1	B1.1.3	Yes	T10–L2	8	A	15	6	1
14	20	T12–L1	B1.1.3	Yes	T10–L2	13	A	11	3	0
15	22	L1–L2	B1.1.3	Yes	T11–L2	12	A	10	0	0
16	23	T11–T12	B1.1.3	Yes	T9–L2	14	A	8	3	1
17	27	T11–T12	B1.1.2	No	T10–L1	14	E	7	0	0
18	29	L1–L2	B1.1.2	Yes	T11–L3	12	A	17	5	1
19	30	T12–L1	B1.1.2	Yes	T10–L2	13	E	25	10	2

Chance [7], Denis [11] classified these fractures as type B or “one level seat-belt type injury through bone” with an horizontal fracture through the posterior arch and pedicles extending into the vertebral body (true Chance) and type A or “one level seat-belt type injury through the ligaments”. In type A, the load bearing may lead to compression or more rarely burst fracture of the vertebral body [16]. The leading feature is the disruption of the posterior ligamentous complex, with possible uni or bilateral articular dislocation [5]. High energy impacts may also determine injuries one level above and/or below, with more complex lesions that Denis has defined “two level injuries through the ligaments or bone”, and classified as type C and D.

Our case series has been evaluated according to Magerl et al. [24], including flexion–distraction fractures in Group B. In particular, the Group B distinguishes B1 fractures (with posterior disruption predominantly ligamentous) and B2 (with prevalent bone damage). It is also possible that a combination between B1 fracture and compression injury of the disk and vertebral body, which corresponds to a type A fracture. Anterior translation may be actual or potential, while the degree of instability ranges from partial to complete [27]. Neurological impairment can be significantly high.

Our series includes 17 fractures B1 and 2 fractures B2. Six were B1.1.1 fractures, while three were B1.1.2 and six B1.1.3.

B1 fractures with type A injuries were 2: one was B1.2.2 and one B1.2.3. Dislocation was present in 11 cases, with one case of luxation. Two B2 cases presented with transverse column fractures also described by Bohler [6] and Howland [20], and classified as B2.1. No adjacent segment lesions have been detected in our series.

Surgical treatment

All cases were operated by posterior approach. In B1.1.1 and B2.1 fractures, all classified as ASIA E, a short stabilization with transpedicular screws without the decompression of the spinal canal was the option. Fusion was performed in all B1.1.1 patients, but not in the B2.1 fractures. In fracture-dislocation or luxation, the posterior instrumented arthrodesis was achieved by distal screws and proximal hooks (Fig. 1 a–c). Reduction was reached by soft traction and distraction forces applied on the laminar hooks anchored on the vertebra above the dislocation (Fig. 2 a, b). Following the spinal realignment, we performed wide decompression. In all implants, final fixation was achieved by the compression mode, according to Benezel [4], restoring the posterior tension band described by Harms [17]. For internal fixation, we always used the same instrumentation system and its derivatives. Autologous bone graft and/or hydroxyapatite were used for fusion. Postoperatively, all patients were placed in thoracolumbar rigid or semirigid orthosis. In neurologically intact patients, walking was allowed immediately after the brace application, while paraplegic patients entered the spinal unit for rehabilitation after the surgical healing.

Results

Average time of surgery was 7.8 days, ranging from 1 to 18 days. In patients with associated thoracic, abdominal and head trauma, average timing of surgery increased to 12.5 days, ranging from 6 to 18. Lapbelt sign, associated with abdominal wall contusion, has been detected in five of

Fig. 1 Case 11. **a** CT scan (sagittal reconstruction) shows seat-belt fracture T11–T12 type B1.2.3; **b** Posterior instrumented arthrodesis T10–L2; **c** CT three-dimensional reconstruction shows good sagittal profile and posterior fusion

Fig. 2 Case 1. **a** Intraoperative fluoroscopy shows anterior dislocation of the T11 on the T12 vertebral body; **b** Reduction and realignment achieved by slight and progressive traction–distraction applied on the T10 sublaminar hooks (see the text)

seven cases with intraabdominal injury. In the only case of vertebral luxation, the ASIA A patient developed vascular complications 7 days after surgery, showing a pseudoaneurysm of the L1 lumbar artery. This was successfully treated by selective angiography and embolization [13].

Mean follow-up was 45.6 months (range 35–72). All patients achieved a solid fusion. None of them suffered from wound infection, mechanical failure or significant kyphotic deformity (average pre-operative kyphosis 13°, ranging 4–35; average final follow-up kyphosis 4°, ranging 0–11). Neurological evaluation in intact patients remained normal (ASIA E), while ASIA A and B patients did not recovered. Outcomes on back pain rating scale was good in 16 cases (84%) and fair in 3 (16%). Average hospital stay was 17 days, ranged from 7 to 50. In neurologically intact patients, average hospital stay decreased to 5.4 days, ranging from 3 to 10.

Discussion

When a high energy impact happens secondary to motor-vehicle collision with the spine being protected by safety belts, thoracolumbar flexion–distraction injuries may occur, with severe disruption of the posterior elements. Magerl et al. [24] have classified these injuries, as B1 and B2 respectively.

In B2 injury, the fracture line is classically horizontal, involving the full thickness of the vertebra, through the laminae, pedicles, transverse processes and vertebral body. B2 injuries affect the two columns described by Holdsworth [18]. In our series, these injuries included Chance fractures, similar to those described by Böhler [6], Howland [20] and illustrated with CT scan and MRI by Bernstein et al. [5]. Usually, in this type of fractures, the spinal

canal is not significantly deformed and the spinal cord is free from compression. Therefore, our B2 patients were all ASIA E. They can be conservatively treated by thoracolumbar rigid orthosis [24, 25], even if some complications as pseudoarthrosis [26] and painful kyphosis [28, 29] have been reported. Surgical treatment by means of posterior short transpedicular fixation, today also percutaneously available, allows early mobilization and discharge, avoiding rigid postoperative immobilization and late painful deformity. Fusion in young patients does not seem mandatory [22] and the removal of the implant can be performed after healing.

B1 fractures and their subgroups present more complex injury patterns with different degree of vertebral dislocation. Spinal canal and its content may be intact and free from compression, but partially or totally deformed with neurological impairment. This variety of morphological issues with varying degrees of canal and spinal cord compromise, can justify the clinical presentation of our patients, all being ASIA E or ASIA A–B at first observation.

B1 patients, with or without spinal cord injury, should be considered unstable or potentially unstable, in relation to the severe disco-ligamentous disruption. Surgical stabilization and fusion is the treatment of choice [23]. Decompression procedure is also generally performed.

In B1.1.1 patients without dislocation, the instrumented arthrodesis was achieved with short construct by pedicular screws and rods, applied in compression–fixation mode. Decompression was not necessary in ASIA E patients. In fracture–dislocation or luxation, frequently ASIA A, we prefer hybrid long implants with distal screws and proximal hooks. The sublaminar hooks, anchored on levels above the dislocation, was useful to apply traction and distraction forces to realign the spine. These forces are

always slight and progressive. In our hands, the procedure should be preferred with respect to the transpedicular fixation. The direct insertion of the screws into pedicles of the dislocated and mobile vertebral body, can provide potential risk of iatrogenic damage, especially neurological and/or vascular, during tunnels preparation. Once realignment has been reached, we fix the implant in compression to restore the posterior tension band, as described in the orthopedic and neurosurgical literature [4, 17]. If necessary, posterior decompression is performed after realignment: this is to prevent dural tears from complicating surgery, thus increasing the procedure duration.

Lesions associated with B fractures depend on the severity of the trauma. The lapbelt sign may be indicative of an intraabdominal injury (IAI). Chapman et al. [8] report that IAI is frequently associated with spinal cord injury (SCI). Recently Bernstein et al [5] remark the association between Chance-type fractures and abdominal traumas in 40% of cases.

The severity of associated injuries has influenced our timing of surgery. In patients with important abdominal, thoracic or brain damage, treatment of spinal fracture have been procrastinated.

Frequent observation of severe parenchymal or vascular injuries requires a complete radiological examination by thoracic and abdomino-pelvic CT, to exclude seat-belt syndrome and seat-belt aorta [10, 15].

Like in other case series [14, 31], the spinal level most affected by flexion–distraction fractures is the thoracolumbar junction. Anatomical and biomechanical characteristics justify this high incidence [22]. In our experience, the surgical treatment of these injuries made it possible to avoid junctional deformities, often painful and limiting activities of daily life.

The clinical follow-up was totally satisfactory due to the absence of significant pain, confirming mechanical stability of the implants. In terms of neurological outcomes, patients presenting as ASIA A-B or ASIA E, maintained their preoperative neurological condition. Unfortunately, we did not observe intermediate neurological situations, potentially improving with surgery and all ASIA E patients did not worsen during the follow-up.

Conflict of interest statement None of the authors has any potential conflict of interest.

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