Is posterior fixation alone effective to prevent the late kyphosis after T-L fracture?

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Received: 17 August 2013 / Revised: 8 September 2013 / Accepted: 8 September 2013 / Published online: 9 October 2013
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Abstract

Introduction The posterior transpedicular fixation technique is a standard procedure for stabilizing the injured thoracolumbar spine but the long-term results of this approach are controversial. Clear guidelines are missing and the literature shows complete disagreement regarding indications, approaches, surgical techniques, and type of fixation.

Material and method The objective of this study is to investigate if the surgical treatment by posterior approach alone is always enough to prevent the late kyphotic deformity through the retrospective analysis of 219 patients affected with a thoracolumbar injury. Follow-up examinations included radiographic measurements of the sagittal index (SI) and the sagittal plane kyphosis (SPK).

Result Results show that, at the follow-up, the SI remains almost stable after the surgical correction, while the SPK (which describes the eventual injury of the affected intervertebral disc) decreases indicating a progressive regional kyphotic deformity. Thus, in some cases posterior fixation alone is not sufficient for long-term spinal stabilization and often can be not effective to prevent the late kyphotic deformity.

Keywords Thoracolumbar fracture · Sagittal index · Sagittal plane kyphosis

Introduction

The treatment of thoracolumbar (T-L) fractures varies according to the type and the level of injury, and the

kyphosis measured on plain lateral radiographs. Moreover, the sagittal plane deformity after a T-L fracture is most closely associated with prognosis [6, 7, 9, 23].

Conservative treatment is usually the method of choice if there is little kyphotic deformity, no neurological deficit or no unstable fracture pattern [5].

The modern surgical treatment of thoracolumbar fractures is based on posterior transpedicular fixation techniques, which are angular stable and can provide an excellent stability in the three planes of the space [2]. After its introduction, the exclusive dorsal pedicle screw instrumentation with or without transpedicular bone grafting became widely popular and a standard procedure for stabilizing the injured thoracolumbar spine [13]. But the long-term results of this approach today are controversial due to inconsistent reports and to a paucity of data on late outcome [2] and several authors reported increasing instability or a loss in kyphotic correction of the repaired spinal segment [12, 20].

Aims of the surgical treatment are to obtain an anatomical reduction with correction of the kyphotic deformity, an effective stabilization, a spinal cord decompression when necessary, to restore the spine function (motion and load bearing) and a long lasting pain free with early patient mobilization preventing chronic complaints due to a persistent spinal deformity [15, 22].

The problems are to define how and what is the best way to achieve these goals, what are the most suitable and effective strategies and when the cost/benefit ratio is acceptable for the patient and for the Public Health Service. Furthermore, there are no clear indications and an “ideal treatment algorithm” for traumatic thoracolumbar (T1–L5) spinal injuries is not widely accepted. Guide lines of the surgical treatment are confusing and the literature on this argument is controversial showing an almost complete disagreement regarding indications, approaches, surgical techniques, and type of fixation [10–12].

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The objective of the study is to investigate if the surgical treatment by posterior approach alone is always sufficient to prevent the late kyphotic deformity.

Materials and methods

Two hundred and nineteen consecutive patients (126 male, and 93 female) affected with a T-L fracture and a mean age of 51.6 years (13–76) were admitted at the Orthopaedic Department of the University of Ancona, Italy. With regard to the segmental distribution, 68 (31.1 %) were thoracic injuries, 64 (29.2 %) lumbar, and 87 (39.7 %) TL-junction injuries, in six cases a multi-level fracture was present (Table 1).

According to the AO classification [17], there were 166 (75.8 %) type A (compression) fractures, 25 (11.4 %) type B (distraction), and 28 (12.8 %) type C (rotation) (Table 2). The most common injury type was the A1 fracture with 83 cases and burst fracture (A3) with 59 cases (Table 2).

The residual deformity was assessed on sagittal plain X-rays obtained before and after surgery, at 2 years, and at the follow-up (mean FU = 4.2 years). The sagittal index (SI) of the injured vertebral body was calculated using the ratio between the anterior and the posterior height of the vertebral wall: $SI = hA/hP$ [8].

The sagittal plane kyphosis (SPK) was measured as the α angle between the superior end plate of the vertebral body above the fracture and the inferior end plate of the fractured body (Fig. 1) [14]. SPK does not only describe the deformity of the fractured vertebral body, but also the eventual disruption of the intervertebral disc.

Table 1 Level of injury

Segmental distribution	No. of cases
Thoracic	68
T-L	87
Lumbar	64
Total	219

Table 2 Type of fracture

	Total
Type A	166 (75 %)
Type A1	83
Type A2	24
Type A3	59
Type B	25 (11.4 %)
Type C	28 (12.8 %)
Total	219

Fig. 1 Determination of the SPK

Table 3 Type of treatment for each subtype of fracture

	Total	Conservative	Surgical (%)
Type A	166	120	46 (28)
Type A1	83	82	1 (1.2)
Type A2	24	10	14 (58)
Type A3	59	28	31 (53)
Type B	25	2	23 (92)
Type C	28	–	28 (100)
Total	219	122	97 (44)

Table 4 Type of surgical approach for each type of fracture

	Total	Posterior	Anterior	Combined
Type A	46	28	3	15
A1	1	1	–	–
A2	14	6	2	6
A3	31	21	1	9
Type B	23	23	–	–
Type C	28	25	–	3
Total	97	76 (78 %)	3 (3 %)	18 (19 %)

Results

44 % of patients underwent surgery, above all type B and C fractures (98 and 100 %, respectively), followed by type A2 fractures (58 %) (Table 3).

The surgical treatment of choice was posterior fixation in 76 cases (78 %), anterior fusion in three cases (3 %), and a combined treatment (anterior and posterior) in 18 cases (19 %) (Table 4).

Analysis of SI data at follow-up, which reflects the fracture-induced wedge shape of the vertebral body, revealed that dorsal instrumentation prevent the de novo height reduction of the vertebral body corrected at surgery. A slight but not significant reduction of the SI, indeed, was shown (Fig. 2).

Fig. 2 Changes of the SI over the time

Fig. 3 Changes of the SPK over the time

Despite the good initial kyphotic correction, as shown by the SI, we observed a return towards the pre-operative kyphotic angle (SPK) in most of patients with significant loss of correction at follow-up (Fig. 3). Thus, the SPK at follow-up did not differ significantly from the kyphotic angle, which was determined before correction. Compared to normal, we observed a persistent loss of about 15 %.

SPK, unlike SI, reflects additional changes of the intervertebral disc space, probably due to the progressive mechanical failure of the disc. So this loss of correction can be almost completely attributed to a mechanical failure of the disc. The addition of transpedicular cancellous bone grafting did not decrease the loss of correction.

Discussion

The modern treatment of thoracolumbar fractures is based on posterior transpedicular fixation techniques, which are angular stable and can provide an excellent stability in the three planes of the space [2, 21]. Nevertheless, a widely accepted agreement and clear guidelines for the optimal treatment of T-L fractures are lacking, and the evidence is based above all on School or Individual “Philosophies” for the management of this pathology.

The results of the present study show that almost the 78 % of T-L fractures are successfully treated by posterior reduction and fixation, and this can be considered the first empirical “truth”: posterior surgery alone is almost always

adequate to treat T-L fractures (Figs. 4, 5). Posterior reduction and fixation can be considered the treatment of choice in T-L fractures if the typical segmental mechanical behaviour of the spine is considered and a proper solution is adopted to solve the problems related to surgical treatment such as the type of fixation, the strategy of reduction, the geometry of the construct, and the extension of the fusion area.

The mechanical strength of the construct must be related to the type of lesion and the degree of instability. In axial compression fractures (type A) the construct must be able to bear compression force and the bending moment in the upright position, avoiding the kyphotic deformity. Instead, in flexion fractures (type B) the construct must be able to work in extension (increasing lordosis) and to withstand the bending moment, which tends to worsen the reduction. Finally, in multidirectional instability (type C fracture) the construct must be able to gradually reduce the deformity and to bear stress in each plane of the space. Furthermore, the convergent orientation of the screws in the transverse plane realizes a triangle, which increases the torsional strength of the system and a correct sagittal contour of the roads optimizes load distribution between the spine and the device.

Considering the large bone defect created inside the fractured vertebral body after geometric restoration, Daniaux et al. [3] introduced the method of transpedicular bone grafting to place spongiosa intra- and intercorporally, thus eliminating anatomic dead spaces and cavities after surgical correction, restoring the sagittal balance and mechanical competence of the anterior column, and avoiding anterior reconstruction and loss of correction [4]. They suggested that bone grafting may be more effective because a substantial amount of correction loss occurs at the injured disc space [4].

However, the real efficacy of this method is controversial. Recent studies have shown that a transpedicular intracorporeal bone graft could not prevent failure of fixation in thoracolumbar fractures with loss of kyphotic correction, and it could not influence the shape of fractured vertebral body, especially the depression of the central endplates, so could not prevent the disc from creeping [1, 12, 18]. As other authors, in our series we did not find any contribution of the spongiosa grafting to prevent a post-operative loss of kyphotic correction.

In agreement with other studies [13, 16, 19], we did not find any significant loss in geometry of the fractured vertebral body at follow-up, even after removal of implants, indicating that the fractured vertebral body had healed. The analysis of the results, indeed, showed a slight and not significant reduction of the sagittal index. On the other hand, the analysis of the SPK of the spinal segment, that reflects additional changes of the intervertebral disc space,

Fig. 4 L1 (type A3) fracture treated with posterior fixation

Fig. 5 T5–T6–T7 (type A1), T8 (type A3), and T9 (type B2) fractures treated with a long posterior implant

showed a loss of correction that can be almost completely attributed to the progressive mechanical failure of the disc [2]. The worsening of SPK suggests that the posterior pedicle screw fixation has only a temporary protective effect against collapse of the disc space, but cannot prevent disc collapse after implant removal [24].

So we can identify a second empirical “truth”: posterior surgery sometimes is not sufficient.

Burst fractures typically involve violation of the inferior and/or superior endplates, and therefore the deformity may progress by gradual settling of the discs into the fractured endplates and vertebral body [22]. Even Wang et al. [24]

showed that the recurrence of a kyphotic deformity occurs after the removal of the posterior fixation and emphasized that it is due above all to the collapse of the disc space which is the major contribution to the loss of correction (90 %). The mechanism of this process remains debated: disruption of vascularity of the endplates has been considered one of the major reasons for degenerative disc disease; rigid dorsal fixation with fusion might lead to a stress shielding of the intervertebral disc with biochemically changes; at last the disc space narrowing might be the result of the adaptation to morphological changes in the subchondral plate. Therefore, one of the main mechanisms

Fig. 6 L3 type A2 fracture treated with minimal invasive, retroperitoneal video-assisted anterio-lateral fusion and fixation. One year F.U shows a correction preserved and anterior fusion

of kyphosis recurrence may be the creeping of the disc back into the central depression of the endplate, as supported by studies of Muller et al. [18] and Wang et al. [24].

Conclusion

Results indicate that the anterior or the combined approach is indicated when the sagittal plane kyphotic angle is higher than $25^{\circ}/30^{\circ}$, above all when a fracture of the pedicles is associated, because with those injuries the degree of instability is high. In cases like these, posterior instrumentation alone, with or without transpedicular bone grafting, is not sufficient for spinal stabilization and often can be not effective to prevent the late kyphotic deformity and a return of the kyphotic angle towards pre-operative values. Cancellous transpedicular bone grafting not always restores the anterior load bearing and not prevent a post-operative loss of kyphotic correction [12].

The gold standard to prevent kyphosis and to restore the anterior support is the combined approach with anterior cortical bone graft and posterior transpedicular screwing, an anterior cage can decrease the risk for graft failure.

In the case of a type A (2 or 3) fracture with intact posterior elements, use of an anterior primary stable implant with bone graft represents an alternative method (Fig. 6). In cases like these, an anterior minimally invasive approach, in the respect of the same biomechanical principles of the open surgery, can decrease the surgical trauma [2].

Conflict of interest None.

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