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Can implant removal restore mobility after fracture of the thoracolumbar segment?

A radiostereometric study

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Submitted 2015-11-23. Accepted 2016-04-19.

Background and purpose — Randomized trials have found that treating spinal burst fractures with reduction and posterior fixation is adequate without the use of bone grafting for definitive fusion. Restitution of intervertebral mobility of such an unfused segment after fracture healing may unload the adjacent parts of the spine and reduce the risk of degeneration of these segments. We used radiostereometry (RSA) to study whether late implant removal would restore the intervertebral mobility of a thoracolumbar segment treated with posterior instrumentation but no bone grafting for unstable spinal fracture.

Patients and methods — We identified 7 patients with implant-related back pain at least 1.5 years after a thoracolumbar fracture (Th12 or L1) treated with reduction and posterior instrumentation. The implants were removed and tantalum indicators for RSA were inserted. 3 months later, each patient was examined with RSA. The intervertebral translations and rotations of the thoracolumbar segment, induced by change in position from flexion to extension, were measured. Progressive deformity was registered by conventional radiography and the overall clinical outcome was assessed by the patients.

Results — According to RSA, all 7 patients regained some mobility of the fractured thoracolumbar segment. In 1 patient who was primarily treated for a flexion-distraction type of injury, conventional radiography revealed a progressive kyphotic deformity 3 months after implant removal and the clinical outcome was poor. According to the patients, 1 had a fair clinical outcome and 5 had good outcome.

Interpretation — Late implant removal may restore segmental mobility after posterior fracture fixation of the thoracolumbar segment if bone grafting has not been used. The clinical consequences, positive or negative, of the residual mobility demonstrated in our small number of patients should be evaluated in studies based on extended patient series and with different fracture types.

Even though there is a great number of publications on the subject in the literature, adequate treatment algorithms for thoracolumbar fractures are difficult to delineate. Non-operative treatment can be a valid alternative (Rechtine 2006), especially for the burst fractures (Gnanenthiran et al. 2012). Fracture classification systems have been created to help the surgeon in clinical decision making when surgery is considered (Sethi et al. 2009). The AO classification system (Magerl et al. 1994) attempted to assess stability and presented 3 main categories based on the mechanism of injury. The definition of instability was, however, unclear and the system included many subgroups with only moderate intraobserver reliability (Vaccaro et al. 2005). The thoracolumbar injury severity score (TLISS) was an attempt to make an objective score for evaluation of fracture instability (Vaccaro et al. 2005). In addition to the mechanism of injury, this system also includes evaluation of the neurological status and the integrity of the posterior ligamentous complex on magnetic resonance imaging (MRI) (Winklhofer et al. 2013).

If surgery is recommended, a decision must be made as to whether to use bone grafting for definitive arthrodesis of the fractured segment. In burst fractures, randomized trials have found that surgical treatment with reduction and posterior stabilization is sufficient. Bone grafting prolongs the operation time and increases the amount of bleeding but does not improve the clinical outcome (Wang et al. 2006, Jindal et al. 2012). For distraction injuries, most surgeons appear to recommend grafting (McLain 2006, Chapman et al. 2008) but future studies are required to determine whether subgroups of distraction injuries can be identified in which bony fusion is not needed.

By following these guidelines for fracture treatment, we will more often face patients with 1 or more immobile segments due to posterior hardware stabilization, but with no definitive bony fusion. We used radiostereometric analysis

DOI 10.1080/17453674.2016.1197531

Table 1. Characteristics of patients and fractures

Case	Sex	Age (years)	Fracture level	Fracture type
1	M	48	L1	Burst
2	M	22	L1	Burst
3	F	19	L1	Flexion-distraction
4	F	41	Th12	Burst
5	M	29	L1	Burst
6	F	27	L1	Flexion-distraction
7	F	20	L1	Flexion-distraction

(RSA) (Selvik 1989, Axelsson et al. 2006) on patients treated with posterior instrumentation without bone grafting to determine whether late implant removal may restore intervertebral mobility to the fractured segment and/or to the adjacent segments included in extended instrumentation.

Patients and methods

Patients

7 patients (mean age 29 (19–48) years, 4 women) who presented with remaining implant-related back pain 1.5 years after fracture of the thoracolumbar segment (Th12 or L1) had their implants removed during the period 2007–2011. At our department, more than 200 patients were treated surgically for a thoracolumbar fracture during this period. 1 patient (case 2) (Table 1) had a minor neurological disturbance with motor weakness in his left foot (Frankel grade D). The other patients had intact sensory and motor function. All patients had been treated primarily with conventional open surgical reduction and posterior pedicular stabilization through a mid-line approach. Bone grafting was not used. 3 patients had a short segmental fixation with pedicular screws 1 level above and below the fractured vertebra, whereas 4 patients had extended instrumentation using 2 levels both proximal and distal to the fracture (Table 1). The fractures were classified as burst fractures in 4 patients, and 3 patients had flexion-distraction injuries (Magerl et al. 1994). At follow-up, the patients were scheduled for a secondary operation with implant removal due to remaining local back pain.

Surgery

The implants were removed using the same posterior approach as in the primary operation. In addition to implant removal, the procedure also involved implantation of 0.8-mm tantalum indicators in all vertebrae previously used for pedicular screw placement. The indicators were placed in the bases of the transverse processes, in the tip of the spinous process, and in the anterior part of the vertebral body through the threaded bony canal left after pedicular screw extraction. Informed consent was obtained from all patients preoperatively, approving the implantation of tantalum indicators and RSA follow-up.

Radiostereometry

All patients had a spinal RSA 3 months after implant removal. The RSA setup included two 40-degree angulated roentgen tubes to provide exposures on 2 separate films. The thoracolumbar segment and a combined reference plate and calibration device with tantalum indicators at known positions in front of the film plane were exposed simultaneously (Axelsson et al. 2006). Each patient was examined in 2 positions, flexion and extension. In flexion, the range of mobility was limited by a horizontal stuffed plate 60 cm in front of the distal tip of the sternum. The patient was instructed to place the forehead on the plate in order to prevent the head and upper part of the trunk from covering the thoracolumbar spine during exposure. In extension, however, the patient was encouraged to reach the extreme position using maximum active mobility. The 3-D translations and rotations of 1 vertebra relative to another induced by the patient changing position from flexion to extension were calculated using the Kinema program for computed data processing.

The experimental error (i.e. the accuracy) of the spinal RSA has been calculated earlier by performing comparative double examinations on fully healed fusions (Johnsson et al. 2002). According to these results, the minimum significant measurements for translation with this RSA setup are 0.5, 0.5, and 0.7 mm along the transverse, vertical, and sagittal axes. The corresponding figures for rotations are 2.0, 0.5, and 0.9 degrees around these axes. Translational and rotational values below these accuracy levels were not considered significant.

Radiography

All patients were examined with conventional radiography (anteroposterior and lateral views) before implant removal and at follow-up 3 months after surgery. The sagittal angulation in kyphosis was registered, and progression over time between the 2 investigations was determined.

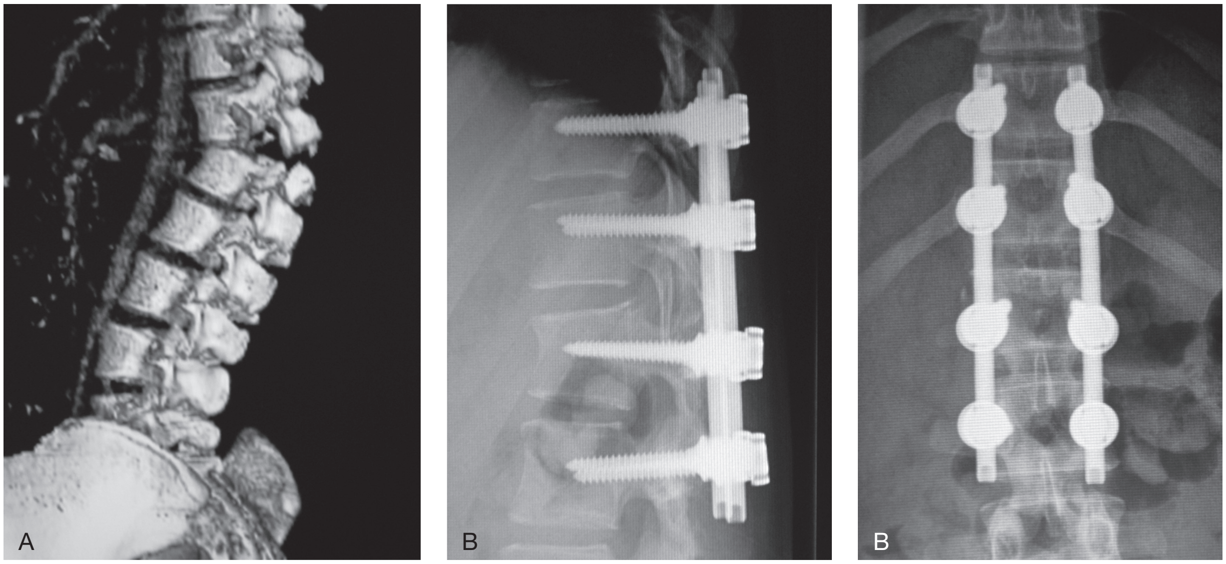
Clinical evaluation

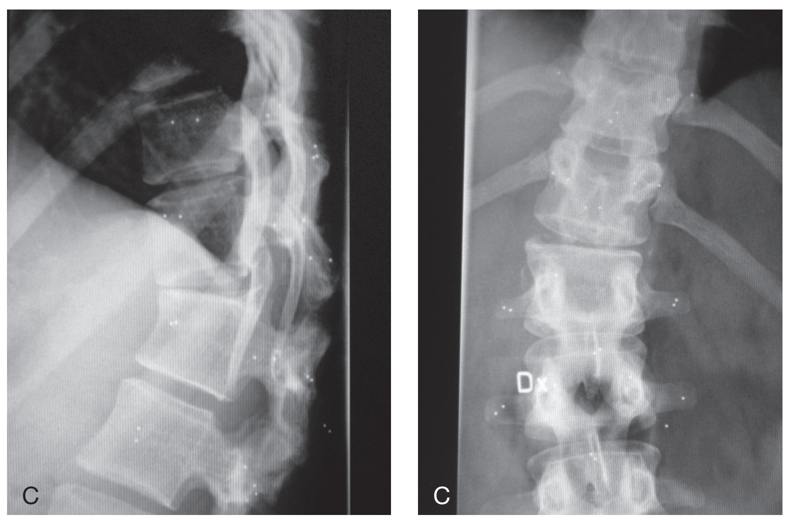
At the 3-month follow-up after implant removal, the overall clinical outcome was assessed by the patients and graded into 1 of 3 categories: good (minor or no residual pain), fair (some pain relief but residual pain), and poor (unchanged or worse than preoperatively).

Results

At surgery, the 2 most distal pedicular screws in case number 7 (Table 1) were fractured and the threaded parts of the screws were therefore left. Screw fracture was also seen distally on the right side in case number 4. In case 1, all 4 pedicular screws were loose at surgery with an obvious zone of bone resorption around the screws.

Conventional radiography 3 months after implant removal showed progressive deformity in 1 patient (case 3), kyphosis





Case 3. Flexion-distraction injury Th12–L1 in a 17-year-old girl.
A 3-D reconstruction from preoperative CT.
B After reduction and posterior instrumentation.
C Redislocation 3 months after implant removal.

(35 degrees), and scoliosis (20 degrees) (Figure). The facet joints were redislocated between the twelfth thoracic and the first lumbar vertebra, with the articular processes being separated in distraction. 2 patients (cases 6 and 7) had a minor kyphosis of less than 20 degrees caused by a progressive disc height reduction at a level proximal to the fractured vertebra. 4 patients were unchanged concerning these parameters.

The clinical outcome was good in 5 patients, fair in 1 patient (case 6), and poor in 1 patient (case 3).

According to RSA 3 months after implant removal, all 7 patients had some mobility of the previously fractured thoracolumbar segment, expressed as significant intervertebral translations (i.e. exceeding the measurement error) along at least 1 of the axes (Table 2). Significant rotations were seen in 5 patients. The magnitude of mobility differed to a great extent between individuals, and the least mobility was seen in case 3 with a minor translation of 0.6 mm along the x-axis and 0.7 degrees of rotation around the y-axis.

Table 2. Intervertebral translations (in mm) and rotations (in degrees) in 7 patients after fracture of the thoracolumbar segment [a].

Case	Fracture level	RSA measured between:	RSA translations at fractured level (mm) x	y	z	RSA rotations at fractured level (°) x	y	z
1	L1	Th12–L2	0.4	1.8 [b]	1.2 [b]	4.7 [b]	0.2	0.4
2	L1	Th12–L2	0.6 [b]	0.4	1.7 [b]	2.9 [b]	0.1	0.6
3	L1	Th12–L1	0.6 [b]	0.4	0.6	1.0	0.7 [b]	0.1
4	Th12	Th11–L1	0.1	1.7 [b]	2.2 [b]	3.6 [b]	0.1	0.4
5	L1	Th12–L2	0.3	0.1	1.3 [b]	1.2	0.2	0.3
6	L1	Th12–L2	0.7 [b]	0.4	1.2 [b]	1.6	0.0	0.5
7	L1	Th12–L2	0.8 [b]	9.1 [b]	8.8 [b]	11.3 [b]	0.1	0.2

[a] Minimum significant measurement for translation is 0.5 mm (x), 0.5 mm (y), and 0.7 mm (z). Corresponding figures for rotation are 2.0˚, 0.5˚, and 0.9˚ around these axes.
[b] Significant mobility responses

Table 3. Intervertebral translations (in mm) and rotations (in degrees) of the adjacent segment proximal and distal to the fracture level measured in 4 patients [a]

Case	Fracture level	RSA proximal to fracture level translation (mm) x	y	z	rotations (degrees) x	y	z	RSA distal to fracture level translation (mm) x	y	z	rotations (degrees) x	y	z
1 [b]	L1	-	-	-	-	-	-	-	-	-	-	-	-
2	L1	0.2	0.1	0.2	0.3	0.2	0.3	0.8 [c]	3.9 [c]	4.2 [c]	8.0 [c]	0.2	2.6 [c]
3	L1	0.1	0.2	0.1	0.3	0.1	0.1	0.1	1.4 [c]	0.2	2.0 [c]	0.1	0.0
4 [b]	Th12	-	-	-	-	-	-	-	-	-	-	-	-
5 [b]	L1	-	-	-	-	-	-	-	-	-	-	-	-
6	L1	0.2	0.1	0.1	0.2	0.1	0.1	0.6 [c]	0.1	0.8 [c]	1.0	0.3	0.1
7	L1	0.1	0.2	0.1	0.8	0.1	0.4	0.8 [c]	4.7 [c]	0.9 [c]	7.2 [c]	2.9 [c]	1.9 [c]

[a] Minimum significant measurement for translation is 0.5 mm (x), 0.5 mm (y), and 0.7 mm (z). Corresponding figures for rotation are 2.0˚, 0.5˚, and 0.9˚ around these axes.
[b] Missing values in 3 patients with short segmental instrumentation and no tantalum indicators in the adjacent segments.
[c] Significant mobility responses.

The adjacent lumbar segment distal to the fracture was mobile in all 4 patients examined (Table 3). On the other hand, the adjacent thoracic segment proximally had no such mobility—either as translation or rotation in these patients.

Discussion

Both pedicular screw breakage and screw loosening may be seen late after operation on spinal fractures with an otherwise uncomplicated healing course. These radiographic findings indicate residual mobility of the treated segment. With the high measurement accuracy of spinal RSA (Axelsson et al. 2006), our study confirms that removal of the posterior implant after fracture fixation can restore mobility to the thoracolumbar segment. The patient series was not consecutive, but only symptomatic patients were included. Implant removal has not been a general recommendation at our department for asymptomatic patients. The absence of any asymptomatic patients does of course call for caution when trying to make general conclusions and treatment guidelines based on the present study. The actual mobility results, however, have possible implications—both positive and negative. A regained mobility of the fractured segment will unload the stress on the adjacent segments and reduce the risk of degenerative adjacent segment disease (Park et al. 2004). On the other hand, the mobility can also indicate a situation of instability with the risk of a secondary deformity induced by destabilization from implant removal, as exemplified by case 3.

For thoracolumbar burst fractures, randomized trials have found that surgical treatment with reduction and posterior stabilization should not involve the use of a bone graft and definitive fusion is not an aim (Wang et al. 2006, Jindal et al. 2012). Bone grafting prolongs the operation, increases the amount of bleeding, and does not improve the long-term clinical result. Donor site pain is also a problem when fusion is included. Without the use of bone grafting, we found restored segmental mobility after fracture healing and late implant removal in the 4 patients with burst fractures examined. No adverse effects such as increased pain or redislocation were registered, which can (at least partly) be explained by the fact that these fractures are seldom combined with injuries to the posterior ligamentous complex.

Our study included 3 patients with flexion-distraction injuries, AO type B1 and B2 (Magerl et al. 1994). 1 of these patients, case 3, showed the least mobility among the fractured segments measured in the study. This patient reported increased pain 3 months after implant removal and conventional radiography revealed a progressive deformity both in kyphosis and scoliosis. With the lack of a bony fusion combined with an underestimated non-healing of the posterior ligamentous complex, the implant removal induced instability. The segment was obviously unstable, but the local pain made it impossible for the patient to fulfill an adequate mobility provocation at RSA. The patient was recommended a third operation where the secondary deformity was reduced and again stabilized with posterior instrumentation. This time, the procedure did include bone grafting from the iliac crest to the decorticated posterolateral surfaces of the fracture level. The final clinical outcome was good after definitive bony fusion.

For the flexion-distraction injuries, most authors advocate primary fusion with bone grafting (McLain 2006, Chapman et al. 2008). These injuries have a higher score for instability in fracture classification systems (Rihn et al. 2008) since the posterior ligamentous complex is partly or completely disrupted. According to our results, some patients with distraction injuries run an obvious risk of delayed union or non-union, causing implant failure and pain. In future studies, one aim must be to identify the subgroups in which primary bone grafting is indicated—to create a definite bony fusion. In case 3, the injury mainly engaged soft tissue components, afflicting the disc anteriorly and the capsule of the dislocated facet joints posteriorly. This case may represent a subgroup requiring primary bone grafting.

For the adjacent segments, RSA was possible in 4 patients with extended 2-level instrumentation proximal and distal to the fracture. The lumbar segments showed regained mobility after implant removal and the thoracic segments did not. The results illustrate the difference in mobility effects between thoracic and lumbar fixation, and further justify the aim of avoiding prolonged immobilization of lumbar segments if the clinical situation so allows.

In conclusion, our study demonstrates that implant removal may restore mobility after posterior fracture fixation without bone grafting of the thoracolumbar segment. Whether regaining of intervertebral mobility after implant removal is a frequently occurring phenomenon cannot be deduced from our study, which merely demonstrates that the phenomenon as such exists, and to our knowledge has never been shown previously. The magnitude of the mobility response was highly variable, and assessment of the clinical relevance is uncertain since corresponding measurements are not available for a normal population. In spite of these limitations, we can state that no arthrodesis of the facet joints was induced by the trauma itself, by the surgical procedure (placing pedicular screws in close relation to the joints), or by the long postoperative period of internal fixation. The restitution of mobility seen in our patients after implant removal has a potentially positive influence in unloading the adjacent segments. On the other hand, our mobility findings may also indicate instability—as seen in one patient with a flexion-distraction injury and delayed healing of the ruptured posterior ligamentous complex. The clinical consequences, positive or negative, of the restored mobility demonstrated in a small number of patients should therefore be evaluated in future studies based on extended patient series and with the different fracture types.

PA: all aspects of the work including radiostereometry, surgery, and writing of the manuscript. BS: study design and revision of the manuscript.

We thank Håkan Leijon of the RSA Laboratory, Skåne University Hospital, Lund for help in computerizing the RSA radiographs.

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