Pure percutaneous pedicle screw fixation without arthrodesis of 32 thoraco-lumbar fractures: clinical and radiological outcome with 36-month follow-up

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Abstract

Purpose To evaluate the outcome of pure percutaneous fixation of unstable single level fractures at the thoraco-lumbar junction (A1 to B2 Magerl/AO Spine).

Method Neurological intact patients were included in a 2-year prospective study (follow-up 36 months). Two groups were considered: the group in which additional short bilateral screws in the fractured vertebra were placed was called lordorizing screw group (LSG), the other was called non lordorizing screw group (nLSG). Clinical outcome was evaluated using the SF-36, the Oswestry disability index and the recovery time needed to go back work. The following radiological parameters were also evaluated on the follow-up exams: the Mid-Sagittal Index, the Cobb's angle and the Sagittal Index.

Results In the LSG, the correction values of MSI, Cobb's angle and SI were statistically significantly higher than in nLSG.

Conclusion When feasible we recommend a pure percutaneous short segment pedicle screw fixation adding a lordorizing screw.

Keywords Percutaneous pedicle screw fixation · Additional screw · Thoraco-lumbar fracture · Minimally invasive surgery

Introduction

Spine injury related to trauma is common, especially in the thoraco-lumbar segment [1].

Surgical stabilization of unstable thoraco-lumbar fractures in patients without neurological deficit is widely considered the standard treatment. Differently, the surgical strategy of treatment in terms of choice of both surgical approach and length of the fixation system is still controversial [2, 3].

As standard open surgery and minimally invasive spine surgery (MISS) have been often compared in the recent literature, it is quite evident that the trend is currently moving toward MISS since this technique provides lower amount of blood loss as well as lower rates of infections related to surgery [4], reduces muscle trauma, decreases operative site pain and for the above mentioned reasons contributes in shortening hospitalization [2, 5]. Moreover, both techniques (MISS and open surgery) seem to provide the same results in terms of both correcting spine kyphosis angle and restoring vertebral body height [4]. On the whole, MISS seems to be both less invasive and equally effective than open surgery.

Different authors who evaluated the loss of correction in the non fusion group (MISS) found no statistical evidence between the two groups (open vs. MISS) [6] and also stated that posterior fusion is unnecessary when managing patients with thoraco-lumbar burst fractures by short segment pedicle screw fixation [7].

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Additional pedicle screws, so-called “lordorizing screw”, could provide an anterior force once either the rod is simply fixed to the screws or the system undergo distraction, which pushes the injured vertebra ventrally and correct the kyphotic deformity up to succeed in restoring the physiological lordosis [6].

Conservative treatment can be adopted in patients without neurologically deficit by means of prolonged bed rest and orthosis [8–21] with severe impairment of social, economic quality of life as well as significantly increased costs of medical care.

This background was the reason why we treated 32 patients without neurological deficit affected by unstable thoraco-lumbar post traumatic fractures by a pure percutaneous short segments pedicles screws fixation system adding a “lordorizing screw” on the fractured vertebra in one group. We compared the patients’ outcome, with a 36 months of follow-up, evaluating radiological and clinical results, quality of life and return to daily activities.

Materials and methods

Patients affected by posttraumatic vertebral fracture, single level at T10–L3 segments, ranging from type A1 to type B2 according to Magerl AO Spine classification system, were included in a 2-year prospective study (2010–2011), with a minimum follow-up of 36 months. Patients enrolled were admitted in two different hospitals. The different types and mechanisms of trauma were meticulously reported for each patient. Patients with neurological symptoms were excluded. Computed tomography (CT) scans with reconstructions were performed on admission as ordinary protocol for patients with a proven fracture at the spine X-rays exams.

All patients underwent surgical stabilization with a pure percutaneous short fixation system involving one vertebra above and one below the level of the fracture. Since we believe that screws on the fractured vertebra could increase stability of the fixation system as well as may help during distraction in obtaining a better reduction of kyphosis, restoring lordosis and pushing back fractures fragments bulging in the canal, our first option was to put either bilateral or monolateral pedicle screws on the fractured vertebra, even if pedicles were slightly impaired. For these reasons, indications to the use of screws on the fractured vertebra were particularly pushed in case of bone fragments bulging into the canal and when kyphosis was really severe. Differently, if pedicles were seriously impaired, particularly the medial wall, screws were not placed.

Consequently, patients were divided in two different groups: the group in which additional short bilateral screws

in the fractured vertebra were placed was called “lordorizing screw group” (LSG); differently the remnant was called “non lordorizing screw group” (nLSG).

The clinical outcome was evaluated using the following parameters: the SF-36 Questionnaire, the Oswestry disability index, as well as the recovery time needed to go back to normal working activity and life.

The following radiological parameters were also evaluated on the follow-up exams: the Mid-Sagittal Index (MSI), the Cobb’s angle and the Sagittal Index (SI) [8, 10, 16].

These indexes were compared and statistically evaluated between the two groups, at 6 months, 1 year and 3 year postoperative CT and X-rays scans.

The clinical and radiological outcomes were analyzed and compared in the two groups. The statistical analyses were performed with the use of SPSS version-15 software (Chicago, IL, USA). A P value < 0.05 was considered to be significant (Figs. 1, 2, 3).

Results

Thirty-two patients were treated (16 male and 16 female). Mean age was 48 years (ranging from 17 to 78 years). Traumatic injury to the spine occurred as a consequence of car/motorbike accidents in the majority of cases (75 %) (24 cases); other causes of trauma were severe falls during sport (2 cases), work (2 cases) or domestic activities (4 cases).

According to the AO/Magerl classification, our study included 28 type A fractures (87.5 %): this group was made of, respectively, 1 patient affected by subgroup A1, 7 by A2, 20 by A3. Differently, type B fractures (12.5 %) affected four patients (one case presented a B1 fracture, while the remnant three, a B2 fracture).

Fractures occurred at the following levels of the spine: 2 cases at D11 (6.25 %), 6 at D12 (18.75 %), 16 at L1 (50 %), 4 at L2 (12.5 %), and 4 at L3 (12.5 %).

Mean duration of surgery was about 60 min (range 40–120 min).

According to the surgical treatment performed, 24 patients were included in the non lordorizing screw group (nLSG), and 8 patients in the lordorizing screw group (LSG). All patients were treated within 48 h since admission.

Screws’ sizes ranged in length and diameter, respectively, from 30 to 45 mm and from 4.5 to 7 mm.

All patients but one were mobilized and walked within 1 day after the surgery and had been discharged basically on day 4 after the surgery (ranging from day 3 to day 5 after the surgery). No patients received orthosis or brace treatment in the postoperative course.

Fig. 1 A 24-years-old patient with a diagnosis of L1 fracture, type B1.2 + A3.1 (Magerl classification), with no neurological deficit. **a** Preoperative CT scan. **b** Postoperative CT scan pure percutaneous

transpedicular fixation and stabilization with nLSG. **c** MRI scan at 24-month follow-up, body vertebral restoration and correction of kyphosis angle

All patients underwent routine postoperative CT scan before discharge and we had no revision surgery for screw's misplacement or system failure. No infection occurred, and wound healing was uneventful in all patients but one case.

Restoration of MSI, Cobb's angle and SI were obtained in all patients with significant differences in preoperative and follow-up ($P = 0.001$). The patients' clinical and radiological data are summed up in Tables 1 and 2.

Correction of the MSI occurred in all cases with a statistically significant difference between both the preoperative and postoperative MSI in all cases and the two groups themselves as evidenced by the following data: from 42.7 % preoperatively to 3.3 % postoperatively ($P = 0.005$) in the LSG vs. 29.8 % preoperatively to 11.0 % postoperatively in the nLSG ($P = 0.001$).

Results in the correction of the Cobb's angle were as follows; preoperative 6.2° to postoperative 2.9° in the

Fig. 2 A 38-years-old patient with a diagnosis of L1 fracture, type A3.2 following Magerl classification, no neurological deficit. **a** Pre-operative CT scan. **b** Postoperative CT scan pure percutaneous

transpedicular fixation and stabilization with LSG. **c** MRI scan at 24-month follow-up; correction of MSI, body vertebral restoration and correction of kyphosis angle

nLSG ($P = 0.005$), preoperative 9.2° to postoperative 1.9° in the LSG ($P = 0.017$).

Similar improvements also involved the SI value: from preoperative 11 to postoperative 7.5 in the nLSG ($P = 0.005$), and from 11.3 to 5.6 postoperatively ($P = 0.035$) in the LSG.

AO/Magerl fractures type A3 occurred in 62.5 % of the cases of our series, affecting 20 patients (Table 3). Five patients were included in the LSG (A3.2 type in 3 cases and A3.3 in 2 cases, respectively). Vertebral segments involved were L1 and T12 in four and one case, respectively. Mean preoperative MSI, Cobb's angle and SI were 57.4 %, 8.1 and 11.8, respectively; mean postoperative

MSI, Cobb's angle and SI were 5.38 % ($P = 0.01$), -0.1 ($P = 0.012$) and 4.1 ($P = 0.036$), respectively. Improvement of all covariates (MSI, Cobb's angle and SI) was significant between the preoperative and postoperative status in the LSG.

Fifteen patients were included in the nLSG (A3.1 in 5 cases, A3.2 in 6 cases, A3.3 in 4 cases). Vertebral segments involved T12, L1, L2 and L3 in two, eight, three and two cases, respectively.

Mean preoperative MSI, Cobb's angle, SI were 40.75 %, 4.8 and 10.4, respectively; mean postoperative MSI, Cobb's angle and SI were 13.14 % ($P = 0.001$),

Fig. 3 Radiologic measurement technique: mid-sagittal CT scan. Vertebral bodies angle: Cobb angle (*lines a*) and Sagittal Index (*lines b*). Mid-Sagittal Index (*lines c*): half of the sum of the superior and the inferior mid-sagittal diameter of the canal of the vertebrae divided by the same result, all minus the mid-sagittal diameter of the fracture level

1.1 ($P = 0.019$) and 7.4 ($P = 0.053$), respectively. Improvement of all covariates (MSI, Cobb's angle and SI) was significant between the preoperative and postoperative status in the nLSG.

The ODI average score at the last follow-up was 5.84/50 (range 0–15/50), that means a final result of 11.68 %, where 0–20 % indicates a minimal disability.

Concerning the SF-36 physical scale, patients achieved 46.43 points for male and 46.19 points for female. Comparing these results to the back pain population (44.79), we had a better outcome, but worst compared with the score achieved by the norm population (50.21). Regarding SF-36 psychological scale, the average score achieved was 56.22, which is actually very good, if one considers that norm population achieves a mean score of 51.54 and the back pain population only 48.25.

Within 4 weeks (range 2–8 weeks) from discharge, 14 patients could return without restrictions to normal working activity (43.75 %), 5 patients had different assignments by their employers (NO) (15.62 %), and 4 patients changed job (NP) (12.5 %). Two patients kept their condition of

being unemployed (UE) (6.25 %), while seven decide to retire (RT) (21.87 %).

Discussion

Regarding conservative treatment of thoraco-lumbar type A and B1–B2 fractures we have to consider the following issues: (a) mean duration of hospitalization has been reported to be 28.5 ± 13.6 days, followed by a period of 31.3 ± 14.2 days of bed rest and 11.9 ± 6.1 weeks of bracing; (b) mean interval from injury to return to work was 11 months. Only 41 % of patients returned to the same/similar job at the same activity level [8, 11, 14, 15, 17, 19, 21].

Surgical stabilization facilitates the most rapid functional recovery of the spine, hence shortening the time needed to come back to normal social, sportive and working activity by patients affected by unstable fractures [19].

Operative treatment entails higher costs related to surgery and implant cost, but because of faster mobilization,

Table 1 Patients data: sex, age, fracture localization, Magerl classification, group of fixation

Patients	Sex	Age	Fracture	Magerl classification	Fixation
1	F	74	12	A1.3	nLSG
2	F	17	12	A2.1	nLSG
3	F	76	12	A3.2	nLSG
4	F	36	1	A3.1	nLSG
5	F	34	1	A2.2	nLSG
6	F	65	1	A3.2	nLSG
7	F	56	1	A3.1	nLSG
8	F	75	2	A3.2	nLSG
9	F	35	2	A3.2	nLSG
10	F	70	3	B2.3 + A2.3	nLSG
11	F	69	3	A3.3	nLSG
12	F	78	11	A2.3	LSG
13	F	20	1	A3.2	LSG
14	F	38	1	A3.2	LSG
15	F	54	2	A2.3	LSG
16	F	17	1	A3.3	LSG
17	M	52	11	B2.3 + A2.2	nLSG
18	M	74	12	A2.3	nLSG
19	M	36	12	A3.2	nLSG
20	M	39	1	A2.2	nLSG
21	M	65	1	A3.1	nLSG
22	M	36	1	A3.1	nLSG
23	M	24	1	B1.2 + A3.1	nLSG
24	M	58	1	B2.3 + A3.3	nLSG
25	M	71	1	A3.1	nLSG
26	M	19	1	A3.2	nLSG
27	M	36	1	A3.3	nLSG
28	M	55	2	A3.3	nLSG
29	M	56	3	A3.3	nLSG
30	M	60	1	A3.2	LGS
31	M	17	3	A2.1	LGS
32	M	24	12	A3.3	LGS

shorter rehabilitation period and earlier return to work the overall cost at 1 year after injury might turn out in favor of operative therapy [20].

Spinal canal invasion by bone or soft-tissue fragment may require surgical decompression. In case of no neurological deficit, canal decompression is not mandatory. Indirect posterior decompression by means of distraction and lordosis forces can be very effective in obtaining a “closed” decompression in the thoracic spine and at the thoraco-lumbar junction. Particularly, in cases of early surgery (within 48–72 h from trauma), distraction instrumentation has been shown to be effective in reducing bone fragments bulged in the spinal canal and restoring both a normal vertebra shape and physiological lordosis. Pedicles

Table 2 The changes in MSI, COBB angle and SI in the preoperative, postoperative and follow-up according to the group of fixation

Group	nLSG	LSG	Total	P value
Mid-Sagittal Index (MSI)				
Preoperatively	29.83 %	42.75 %	33.06 %	<0.05
Postoperatively	19.10 %	17.76 %	18.76 %	
Follow-up	11.00 %	3.36 %	9.09 %	
Preoperatively vs. follow-up	0.001	0.005	0.001	
Cobb angle				
Preoperatively	6.2	9.2	7	<0.05
Postoperatively	2.7	1.6	2.5	
Follow-up	2.9	1.9	2.6	
Preoperatively vs. follow-up	0.005	0.017	0.001	
Sagittal Index				
Preoperatively	11	11.3	11.1	<0.05
Postoperatively	7.43	5.3	6.9	
Follow-up	7.5	5.6	7.1	
Preoperatively vs. follow-up	0.005	0.035	0.001	

screws fixation systems that allow distraction and lordosing forces applications are, hence, useful beyond their purpose of stabilization hardware for fractures reduction and healing [19].

According to our results, satisfactory results can also be obtained with instrumentation only, with neither posterior/posterolateral nor anterior fusion. The advantages of non fusion are several including elimination of donor site complications [22], sparing more motion segments, reduction of operative time during the surgery, of blood loss as well as reduced risks of infections, which is crucial in case of multi trauma or severely injured patients with multi organ posttraumatic failure syndrome [6].

The rationale for applying minimally invasive techniques is to reduce the approach-related morbidity associated with conventional techniques [2, 23–25].

MIS techniques in spine surgery provide several advantages to the patient, including decrease postoperative pain, shorter hospitalization time, less trauma to muscle and soft tissues, an inferior rate of infection and on the whole a faster recovery and return to normal life [5].

Moreover, the MISS procedures provide comparable results to those obtained with open procedures in terms of kyphosis correction and vertebral body height recovering [4, 17].

In our series, short segment pedicle screw fixation of thoraco-lumbar fractures without fusion provides satisfactory results. Routine posterior or posterolateral fusion is not mandatory in the operative management of these fractures,

Table 3 The changes in MSI, COBB angle and SI in the preoperative, postoperative and follow-up according to the group of fixation in only AO/Magerl fractures type A3

Group	nLSG	LSG	Total	<i>P</i> value
Magerl/AO classification				<0.05
A3.1	5	0	5	
A3.2	6	3	9	
A3.3	4	2	6	
Fracture level				
T12	2	1	3	
L1	8	4	12	
L2	3	0	3	
L3	2	0	2	
Mid-Sagittal Index (MSI)				
Preoperatively	40.75 %	57.40 %	44.91 %	
Postoperatively	23.94 %	25.81 %	24.40 %	
Follow-up	13.14 %	5.38 %	11.20 %	
Preoperatively vs. follow-up	0.001	0.01	0.001	
Cobb angle				<0.05
Preoperatively	4.8	8.1	5.62	
Postoperatively	0.7	−1.8	0.07	
Follow-up	1.1	−0.1	0.8	
Preoperatively vs. follow-up	0.019	0.012	0.001	
Sagittal Index				<0.05
Preoperatively	10.4	11.8	10.77	
Postoperatively	6.8	3.1	5.92	
Follow-up	7.4	4.1	6.57	
Preoperatively vs. follow-up	0.053	0.036	0.004	

as well as could impair a fast recovery of the patient and also increase the risk of postoperative pain and complications [7].

Routine removal of the internal fixation device may not be necessary, but could be advised years after the surgery in cases of young patients with a complete healed fracture at the thoraco-lumbar junction [7].

An intact anterior longitudinal ligament (ALL) prevents the occurrence of over-distraction of the fractured vertebra. A fragment bulging posteriorly with a ligamentous attachment in the spinal canal can be reduced to a certain degree by ligamentotaxis. Fragments bulging posteriorly near the midline are pulled back into place partly by the 0.5- to 1-cm-wide superficial fibers of the posterior longitudinal ligament (PLL) and fragments lying more laterally are reduced by their attachment to the 1-cm-wide segmental deep layer of PLL [12]. The efficacy of indirect decompression was greater when surgery was performed as early as possible, particularly within 3 days after the trauma [18]. Distraction, not lordosis, have been shown to

be the major reduction force, and a combination of distraction and lordosis was found to provide the optimal indirect reduction forces necessary for spinal realignment [19]. Anyhow, the initial remodeling of the bone fragment tended to involve a “widow’s peak” at the anterior of the canal, rendering the canal somewhat heart shaped. This peak, however, tended to disappear or reabsorb as evidenced in CT scans performed at 1 year and 3 years in our series, returning the canal to its more typical oval shape. The basis of this remodeling is unclear. Anatomically, the lateral areas of maximal bone resorption correspond to the anterior internal longitudinal venous plexus. The remodeling process was felt to be time and age dependent, following expected principles of bone remodeling to applied stress [8]. We agree with all suggested in the mechanical theory expressed by Mumford et al. [8], but one issue: the drain could not be produced from the vein system but from the dura mater sac. In fact the “pulsations effect” could be generated by the physiological pulsation of the cerebrospinal fluid (CSF) that produce a continual and rhythmic pulse of the dura mater sac against the bone fragment bulging posteriorly in the canal.

Conclusions

The treatment of unstable posttraumatic thoraco-lumbar fractures in patients without neurological deficit should be only percutaneous. The advantage of MISS surgery on blood loss and muscle damage is nowadays proven, as well as long-term results on kyphosis correction were comparable to those obtained with open surgery.

An additional screw in the fractured vertebra should be placed in order to optimize the kyphosis correction, especially when a bone fragment encroaches the spine canal. The progressive spinal canal remodeling and the restoration of a normal canal diameter have been demonstrated in the radiological long-term follow-up. Consequently, these cases should not undergo open decompression.

Conflict of interest None.

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