Complications in minimally invasive percutaneous fixation of thoracic and lumbar spine fractures and tumors

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Received: 16 August 2013 / Revised: 8 September 2013 / Accepted: 8 September 2013 / Published online: 21 September 2013
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Abstract

Purpose We propose to evaluate the complication rate in minimally invasive stabilization (MIS) for spine fractures and tumors, as a common alternative to open fusion and conservative treatment.

Methods From 2000 to 2010, 187 patients were treated by minimally invasive percutaneous fixation in 133 traumatic fractures and 54 primitive and/or secondary spine tumors. Complications were classified, according to the period of onset as intraoperative and postoperative, and according to the severity, as major and minor.

Results A total of 15 complications (8 %) were recorded: 5 intraoperative (3 %), 6 early postoperative (3 %) and 4 late postoperative (2 %); 6 were minor complications (3 %) and 9 were major complications (5 %).

Conclusions Minimally invasive stabilization of selected spine pathologies appears to be a safe technique with low complication rate and high patient satisfaction. MIS reduces hospitalization and allows a fast functional recovery improving the quality of life.

Keywords Vertebral fracture · Spine tumors · Minimally invasive spine surgery · Percutaneous stabilization · Complications

Introduction

In the last 10 years, minimally invasive stabilization (MIS) in spine surgery has expanded not only in trauma, but also in degenerative and oncological diseases. In trauma, the borderline between conservative and surgical indication is sometimes blurred. In spine tumors, the main indication is for patients in bad clinical conditions that need a fast functional recovery and for patients affected by tumors that are sensitive to chemo- or radiotherapy without clinical signs of spinal cord compression.

MIS allows an easier nursing of the polytrauma/obese patients as well as an easier management of patients with psychosocial problems, who hardly understand and follow the rules of nonoperative treatment.

Bed rest and reduced mobility result in a higher risk of deep vein thrombosis and a reduction of muscle and cartilage tropism, all of this resulting in delayed recovery. Nowadays, many patients also have work obligations that are not compatible with prolonged abstaining from labor [1, 2].

There is a low level of evidence related to lack of publications, in using MIS treatment on spine fractures of the adult and in tumor pathology, but many centers have been developing an increasingly significant clinical experience [3]. MIS can be considered a viable alternative to conservative treatment, in mono-trauma or in selected tumor patients; it is crucial to understand and assess the limitations and complications of this surgical procedure to avoid exposure of patients to undue risks.

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Table 1 Fracture distribution according to the type (Magerl classification) and the level

	A1	A2	A3	B1	B2	C1	C2	TOT
T4							1	1
T5	2				1			3
T6	2	1						3
T7	1	1						2
T8	2			1	2		1	6
T9	2							2
T10	3							3
T11	5	1						6
T12	10	2	13					25
L1	14	3	23	1	1	1		43
L2	5	3	6	1				15
L3	3	1	5		1		1	11
L4	4	2	3		1			10
L5	1		2					3
TOT	54	14	52	3	6	1	3	133

Materials and methods

From 2000 to 2010, 187 patients were treated by minimally invasive fixation: 133 cases of vertebral fractures and 54 cases primitive and/or secondary spine tumors. Thirty-two trauma cases were excluded because of incomplete follow-up. Two different groups were considered: vertebral fractures and tumors. The mean follow-up period in the vertebral

fracture group was 52 months, with a minimum of 36 months and a maximum of 90 months. The mean follow-up period in the tumor patient group was 11 months, with a minimum of 2 months and a maximum of 85 months.

In the fracture group, 101 cases involved the thoracic and the lumbar spine. Sixty-seven patients were male and 34 were female, with mean age 47 years (range 15–82). Eighty-four patients had a spine injury alone, while 17 patients had polytrauma with an average Injury Severity Score of 25.2 (range 17–34). In those patients, percutaneous fixation was also intended as damage control procedure. The most frequent location of vertebral fracture was the thoracolumbar junction (T12–L1). Fractures were classified according to the Magerl AO classification: the vast majority were type A fractures (A1 and A3), while type B or type C were recorded in a few cases (Table 1). The most frequent construct was the mono-segmental, one level above and one below the fractured vertebra in 79 cases (Fig. 1). A multi-level construction was performed in 22 cases of multiple injuries. Overall, 462 pedicle screws were implanted with a percutaneous technique.

In 14 cases, a bone substitute (cement, hydroxyapatite) was introduced in the fractured vertebra to fill the anterior gap left after reduction, in order to better support the middle and anterior column.

In one case, the fracture stabilization was associated with a minimally invasive endoscopic-assisted discectomy and interbody fusion for a pre-existing symptomatic degenerative disc disease at the same level.

Fig. 1 Mono-level percutaneous fixation in traumatic fracture

Table 2 Malignancies distribution in the spine according to the histological diagnosis and the level

	Cases	Histological diagnosis
T2	2	1 Liver carcinoma 1 Hemangioma
T5	1	1 Lung carcinoma
T6	2	1 Thyroid carcinoma 1 Renal cell carcinoma
T7	4	2 Breast carcinoma 1 Plasmocytoma 1 Hemangioma
T10	6	6 Plasmocytoma
T11	6	1 Liver carcinoma 1 Plasmocytoma 1 Breast carcinoma 1 Renal cell carcinoma 1 Colon carcinoma 1 Angiosarcoma
T12	4	1 Plasmocytoma 1 Adrenocortical carcinoma 1 Lymphoma 1 Hemangioma
L1	6	2 Plasmocytoma 2 Lymphoma 1 Liver carcinoma 1 Breast carcinoma
L2	9	5 Plasmocytoma 3 Liver carcinoma 1 Osteoblastoma
L3	5	2 Breast carcinoma 1 Plasmocytoma 1 Lung carcinoma 1 Mesothelioma
L4	2	1 Colon carcinoma 1 Plasmocytoma
L5	7	2 Plasmocytoma 1 Liver carcinoma 1 Breast carcinoma 1 Lung carcinoma 1 Hemangioma 1 Prostatic carcinoma
TOT	54	

In another case where T11, T12 and L3 type A fractures were associated with L1 and L2 type B fractures, we performed a percutaneous stabilization from T10 to L4 and an L1–L2 arthrodesis with a mini-open approach. In any other case the fusion was associated with MIS.

To mono-trauma patients with type A1, A2 and A3.1 fractures without significant spinal stenosis, a conservative

option consisting of cast and bed rest was offered, but it was rejected in 85 % of cases. In all cases, the impairment of the spinal canal was less than 30 % and local kyphosis was less than 20°, except in one case.

Four different spinal implants, called A, B, C and D, were used with predominant use of the first two: A in 31 cases, B in 56 cases, C1 in 2 cases, C2 (the evolution of C1) in 8 cases and D in 4 cases.

In 54 patients affected by spine tumors, 29 were female and 25 male, and the mean age was 45 years (range 12–70). The main diagnosis was metastases (22 cases), plasmocytoma (20 cases) and others (12 cases) (Table 2).

The most frequent location for vertebral tumors was the thoracolumbar or lumbar spine. All tumors were classified according to Enneking and WBB classification [4, 5]. Finally, surgical treatment was a consequence of a multi-disciplinary approach according to the algorithm previously proposed [6].

The most frequent construct was the mono-segmental, one level above and one below the tumor vertebra in 45 cases. A multi-level construction was performed in nine cases. Overall, 252 pedicle screws were implanted with a percutaneous technique. In some tumor cases augmentation was used to secure screws grip at the instrumented levels (Fig. 2). In some cases, pathological fracture stabilization was associated with a minimally invasive endoscopic-assisted curettage. Postoperative analgesia was performed in all cases with a 36 h lasting elastomeric pump containing an opioid and an NSAID.

All patients underwent plain radiographs and CT scan preoperatively and immediately postoperatively and were followed over time with systematic clinical–radiographic controls at 1, 3, 6, 12 and 24 months after surgery.

Results

The average surgical time in the fracture group was 116 min (range 35–240 min) and it was directly related to the number of levels stabilized and therefore to the number of screws implanted: the average time was reduced to 106 min using four pedicle screws, became 144 min with six screws and 171 min with eight screws. In the tumor group, the surgical time was not considered as an important parameter for patients, because in some cases the stabilization was associated with a mini-open curettage of the tumor that prolonged the surgical time. In tumor patients, the skin conditions (after, for example, radiation therapy) or the fast clinical recovery after surgery were considered as crucial for quality of life and for the feasibility of a fast adjuvant therapy. Blood losses were not assessable intra-operatively. All mono-trauma and tumor patients recovered the standing position on the second postoperative day and

Fig. 2 Mono-level percutaneous fixation in a plasmocytoma case

Table 3 Radiographic evaluation in vertebral fractures

	Segmental kyphosis			Vertebral wedging		
	Preop	Postop	F.U.	Preop	Postop	F.U.
Overall	6.1	1.2	4.7	12.2	7.5	9.4
Polyaxial screws	4.6	1.5	5.1	12.6	7.2	9.3
Monoaxial screws	7.5	1	3.8	11.5	8	9.5

were discharged on the fifth day. In poly-trauma patients an immediate mobilization in the bed was granted.

In vertebral fractures, radiological examinations confirmed good spontaneous reconstruction of the anterior and posterior columns. Radiographic evaluation was performed through the measurement of segmental kyphosis and the wedging deformity of the involved vertebral body [7]. Back pain, evaluated by VAS scale, was 1.9 points at FU.

Radiographic evaluation at 12 months showed a real improvement in the postoperative period, but also a worsening of the segmentary kyphosis in the cases treated with polyaxial screws (Table 3). In two patients the postoperative CT scan showed that a screw was placed medially to the spinal canal, without any clinical consequence.

The instrumentation was removed in 23 patients (19 %), in 5 cases due to a local complication and in 17 cases as scheduled because it was implanted in the lumbar spine.

In the tumor group radiological examinations (with X-ray and CT scan) showed in 53 cases a good reconstruction of the vertebral body after adjuvant therapy. Only one case had a local recurrence (lumbar metastases from colon carcinoma) after 6 months of follow-up (the patient was subjected to a mini-invasive stabilization with a mini-open curettage of the tumor). This patient did not have adjuvant radiotherapy after surgery as indicated and required another surgical treatment of decompression and stabilization. Every patient had good control of pain after surgery according to the VAS scale (mean of two points). Finally, in one case after 4 months follow-up the CT scan

showed a loosening of the distal screws, requiring another surgical revision.

Questionnaires for clinical evaluation were self-administered to the patients from both study groups. All the patients were satisfied with the results of the surgical procedure.

Complications

Complications were divided according to the chronological order of appearance in the intraoperative and postoperative period. The latter were divided into early postoperative (if they appeared within 1 month from the date of surgery) and late postoperative (when they occurred after that period).

Depending on the severity, complications were divided into major and minor. Major complications were those involving a longer hospitalization, or a second not scheduled intervention.

Fifteen complications (8 %) were recorded and divided into 5 intraoperative (3 %), 6 early postoperative (3 %) and 4 late postoperative (2 %) (Table 4). Six complications were minor (3 %) and 9 major (5 %).

Intraoperative complications were all minor, related to mechanical instruments, and prolonged the surgical time without consequences for patients. Early postoperative complications were five major complications: four mechanical, one neurological and one infectious complication. In two patients the screw head disconnected from the stem on the first postoperative day.

In two patients treated for fracture, we recorded a pull-out of the pedicle screws, 15 and 20 days after surgery. The first case was a 63-year-old patient with two non-contiguous type A1 fractures (T11 and L1) undergoing T10–L3 MIS with bilateral pedicle screws in L1. The second case was a 67-year-old patient undergoing T12–L2 MIS for a type A3 fracture in L1. The implant removal and a percutaneous augmentation of the vertebral bodies with cement (PVP) were performed in both patients.

Table 4 Type of complications and their treatment

Complications	n°	Type	Treatment
Intraoperative			
Mechanical	1	Screw head/stem disconnection	Screw replacement
	4	Rod disconnection	Manual connection
Early postoperative			
Mechanical	2	Screw head/stem disconnection	Screw replacement 3-point brace
	2	Pedicle screws pull-out	Implant removal + PVP
Neurological	1	Paraplegia with cauda syndrome	Intradural decompression
Infectious	1	Septic surgical wound dehiscence	Debridement + implant removal
Late postoperative			
Mechanical	1	Aseptic pedicle screw loosening	Implant removal
	1	Pedicle screw pull-out	Implant removal and new fixation
Surgical	1	Delayed union	Anterior arthrodesis
Neurological	1	Local recurrence	Decompression and stabilization

The neurological complication was cauda equina syndrome with worsening paraplegia, which appeared on the second postoperative day in a patient treated for a type A L1 fracture by T12–L2 MIS. The patient underwent urgent surgical revision. During surgery we found an organized intradural hematoma sleeve surrounding the conus medullaris. A complete removal of the hematoma with a microsurgical technique, without finding the source of bleeding, was performed. Surprisingly, no screw was found in the spinal canal during the revision surgery. The patient was subsequently sent to a rehabilitation center and completely regained his neurological functions in 2 months.

A 35-year-old patient had a *Staphylococcus epidermidis* infection with wound dehiscence. The patient had been submitted to MIS for a type A2 T11 fracture. Two-and-a-half days after surgery, the patient underwent surgical debridement and removal of the instrumentation resulting in healing of the infection. The patient wore a three-point brace for a further 45 days and the fracture healed with a residual 18° kyphosis.

The four late postoperative complications were major complications: two cases of mechanical complications, 1 case of neurological complication and finally a new surgery for local recurrence of tumor.

In the first case, there was a non-union in a patient with a type A3 T12 fracture, with initial 25° kyphosis. Three months after surgery, the patient complained of persistent

pain under load and no bone fusion was evident. The patient underwent anterior fusion by thoracoscopic approach with incomplete pain relief.

The second case was treated for plasmocytoma pathological fracture of T10 with an MIS fixation from T8 to T11 (cemented screws in T8) after radiation therapy. Four months later, the patient presented on CT scan a loosening of the distal screws and needed a revision surgery with implant removal and new fixation (Figs. 3, 4).

In the third case there was an aseptic loosening of the screws in L5 in a young patient of 28 years, treated 3 years earlier by L3–L5 MIS (instrument A) for a type B2 L4 fracture. The patient had been scheduled for instrumentation removal 6 months after surgery, but refused the operation. The patient underwent minimally invasive removal of fixation, with immediate disappearance of pain.

Finally, one patient had a local recurrence of tumor (colon carcinoma lumbar metastases) after 6 months of follow-up (pathological fracture stabilization was associated with a minimally invasive endoscopic-assisted curettage). The patient did not undergo adjuvant radiotherapy as indicated after surgery and needed another surgical treatment of decompression and stabilization at the 1 year of follow-up.

Discussion

The treatment of choice for thoracic and lumbar spine injuries or tumors is related to many factors such as the type of fracture, presence of neurological damage, associated injuries, age, general conditions, sensitivity to neo-adjuvant therapy and many more.

Conservative treatment of stable vertebral fractures has been successfully proposed by many authors [7–11], with bed rest followed by external orthoses, extension gymnastic, plaster jacket in bed or stand reduction [12]. These treatments should be continued for a period of at least 3–4 months during which patient care and cooperation are essential. Problems related to bed rest, particularly in the elderly, are countless [13]. Deep vein thrombosis may affect up to 30 % of patients. Obesity, chronic obstructive pulmonary disease, venous incompetence, psychiatric disorders and cardiac disease are almost absolute contraindications to conservative treatment or for a major open surgery.

In the literature, the complication rates of nonoperative treatment for vertebral fracture vary from 6.7 to 23.6 % [10, 14–17]. Some authors compared posterior instrumented arthrodesis with conservative management: surgical treatment showed better results in the short term, but results comparable to conservative treatment in the long term, despite the greater number of complications related to the surgical procedure [10].

Fig. 3 MIS fixation in a T10 pathological fracture for plasmocytoma. **a** Preoperative CT scan; **b** postoperative sagittal CT scan; **c** CT scan control after 4 months of follow-up showing loosening of distal screws

Fig. 4 CT scan control of the case reported in Fig. 3 performed after a new fixation

There are only two prospective studies that compared conservative and surgical complication rates: 13 vs. 66.7 % in one study and 20 vs. 29 % in the other [14, 17].

In a review of the surgical treatment of thoracic and lumbar fractures, Verlaan et al. [18] also reported a large blood loss with posterior open fusion, depending on the length of the implant and exposure. They analyzed 138 articles that in the average reported complication rates varying from 11.7 to 22.4 %. There is no distinction between major and minor complications, but specifically analyzing the different complications it should be noted that minor complications are only a fraction and the percentage of major complications is approximately 95 % of those reported [18].

In a multicenter study of the “Spine Study Group of the German Trauma”, complication rate is 14 % for posterior approach, with a surgical revision rate of 4.7 % [19].

In literature there is agreement that in the posterior approach complications are fewer than in the anterior approach, and prospective studies report a higher rate of complications compared to retrospective studies (19.9 vs. 16.1 % in Nasser’s review of thoraco-lumbar procedures). Furthermore, there is no statistically significant difference related to age for the complications rate [20].

There are no prospective studies analyzing the complications of MIS in thoracic and lumbar spine fractures. A retrospective study compares two groups of patients treated by MIS (ten patients) and arthrodesis with conventional technique (11 patients), with a minimum follow-up of 5 years. There is evidence of reduced blood loss for the group treated with MIS, but the study did not consider the complications that occurred [3].

Conclusions

The main target of fracture and in tumor treatments is fast functional recovery with rapid return to normal activity.

In tumor patients the feasibility to perform a local radio or chemotherapy has to be an important consideration in surgical treatment choice, being a minimally invasive approach the best option, allowing to start immediate adjuvant treatment. The reason supporting a minimally invasive treatment is that it equilibrates the need to stabilize the spine while avoiding morbidity associated with open procedures [21]. The correct surgical indication remains essential and especially in tumors a multidisciplinary approach is required.

Minimally invasive stabilization appears to be a safe surgical technique with a low rate of complications and high patient satisfaction. A minimally invasive approach reduces hospitalization and allows fast functional recovery, improving the quality of life (crucial point for tumor patients).

As disadvantages, it can be mentioned that an adequate learning curve is important to minimize complications and radiation exposure of the surgeon is high. Major complications primarily occur in the immediate postoperative period and can be related both to the implant and to the surgical procedure. Patients should be informed about the potential complications and the possible need for instrumentation removal.

This study analyzed the complications in MIS for trauma and tumor patients in a retrospective way with encouraging results for the use of this technique. Further studies will need to compare the results of MIS with other types of interventions.

Acknowledgments The authors thank Carlo Piovani for image storage and processing and Dr. Cristiana Griffoni for contribution in manuscript editing.

Conflict of interest Nothing to declare for all authors.

References

1. Foley KT, Gupta SK (2001) Percutaneous pedicle screw fixation of the lumbar spine. *Neurosurg Focus* 10:1–8
2. Palmisani M, Gasbarrini A, Brodano GB, De Iure F, Cappuccio M, Boriani S, Amendola L, Boriani S (2009) Minimally invasive percutaneous fixation in the treatment of thoracic and lumbar spine fractures. *Eur Spine J* 18(Suppl 1):71–74
3. Wild MH, Glees M, Plieschnegger C, Wenda K (2007) Five-year follow-up examination after purely minimally invasive posterior stabilization of thoracolumbar fractures: a comparison of minimally invasive percutaneously and conventionally open treated patients. *Arch Orthop Trauma Surg* 127(5):335–343
4. Enneking WF (1986) A system of staging musculoskeletal neoplasms. *Clin Orthop Relat Res* 204:9–24
5. Boriani S, Weinstein JN, Biagini R (1997) Primary bone tumors of the spine. Terminology and surgical staging. *Spine (Phila Pa 1976)* 22(9):1036–1044
6. Gasbarrini A, Li H, Cappuccio M, Mirabile L, Paderni S, Terzi S, Boriani S (2010) Efficacy evaluation of a new treatment algorithm for spinal metastases. *Spine (Phila Pa 1976)* 35(15):1466–1470
7. Been HD, Poolman RW, Ubags LH (2004) Clinical outcome and radiographic results after surgical treatment of post-traumatic thoracolumbar kyphosis following simple type A fractures. *Eur Spine J* 13(2):101–107
8. Mumford J, Weinstein JN, Spratt KF, Goel VK (1993) Thoracolumbar burst fractures. The clinical efficacy and outcome of nonoperative management. *Spine* 18(8):955–970
9. Seybold EA, Sweeney CA, Fredrickson BE, Warhold LG, Bernini PM (1999) Functional outcome of low lumbar burst fractures. A multicenter review of operative and nonoperative treatment of L3–L5. *Spine* 24(20):2154–2161
10. Shen WJ, Shen YS (1999) Nonsurgical treatment of three-column thoracolumbar junction burst fractures without neurologic deficit. *Spine* 24(4):412–415
11. Shen WJ, Liu TJ, Shen YS (2001) Nonoperative treatment versus posterior fixation for thoracolumbar junction burst fractures without neurologic deficit. *Spine* 26(9):1038–1045
12. Chow GH, Nelson BJ, Gebhard JS, Brugman JL, Brown CW, Donaldson DH (1996) Functional outcome of thoracolumbar burst fractures managed with hyperextension casting or bracing and early mobilization. *Spine* 21(18):2170–2175
13. Pape HC, Giannoudis P, Krettek C (2002) The timing of fracture treatment in polytrauma patients: relevance of damage control orthopedic surgery. *Am J Surg* 183(6):622–629
14. Siebenga J, Leferink VJ, Segers MJ, Elzinga MJ, Bakker FC, Haarman HJ, Rommens PM, ten Duis HJ, Patka P (2006) Treatment of traumatic thoracolumbar spine fractures: a multicenter prospective randomized study of operative versus non-surgical treatment. *Spine* 31(25):2881–2890
15. Tezer M, Erturur RE, Ozturk C, Ozturk I, Kuzgun U (2005) Conservative treatment of fractures of the thoracolumbar spine. *Int Orthop* 29(2):78–82
16. Tropiano P, Huang RC, Louis CA, Poitout DG, Louis RP (2003) Functional and radiographic outcome of thoracolumbar and lumbar burst fractures managed by closed orthopaedic reduction and casting. *Spine (Phila Pa 1976)* 28(21):2459–2465
17. Wood K, Buttermann G, Mehdod A, Garvey T, Jhanjee R, Sechriest V, Buttermann G (2003) Operative compared with nonoperative treatment of a thoracolumbar burst fracture without neurological deficit. A prospective, randomized study. *J Bone Joint Surg Am* 85(5):773–781
18. Verlaan JJ, Diekerhof CH, Buskens E et al (2004) Surgical treatment of traumatic fractures of the thoracic and lumbar spine: a systematic review of the literature on techniques, complications, and outcome. *Spine* 29:803–814
19. Knop C, Bastian L, Lange U, Oeser M, Zdichavsky M, Blauth M (2002) Complications in surgical treatment of thoracolumbar injuries. *Eur Spine J* 11(3):214–226
20. Nasser R, Yadla S, Maltenfort MG, Harrop JS, Anderson DG, Vaccaro AR, Sharan AD, Ratliff JK (2010) Complications in spine surgery. *J Neurosurg Spine* 13(2):144–157
21. Kawaguchi Y, Matsui H, Tsuji H (1994) Back muscle injury after posterior lumbar spine surgery. Part 1: histologic and histochemical analyses in rats. *Spine* 19:2590–2597