



Minimally invasive stabilization of the fractured ankylosed spine: a comparative case series study

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Background: To compare the outcome of minimally invasive fracture stabilization to traditional open methods in the thoracolumbar region in patients with an ankylosing disorder of the spine.

Methods: A prospective, ethics-approved database (Spine Tango) at a tertiary referral center was retrospectively reviewed for results of surgery on fractures of the ankylosed thoracolumbar spine. These were then split by surgical technique into two cohorts: minimally invasive surgical fixation (MIS group) or standard open surgery (open group).

Results: We identified 17 patients who presented with fractures in an ankylosed spine from 2010 to 2017. MIS fixation was performed on 10 and open surgery and fixation on 7. Average age in the MIS group was older than the traditional cohort. There was no difference in the average number of levels stabilized (open =6.9, MIS =7). There was a shorter duration in the operative time and a significant difference in blood loss in favor of the MIS group ($P=0.00079$). Radiation exposure time and dose were significantly higher in the MIS group ($P=0.006$). There were no cases of non-union, implant malposition or failure in either group. Two significant complications occurred with the death of one patient in the MIS group, and one death in the open group.

Conclusions: The MIS technique for fractures of the ankylosed spine has shown an acceptable complication rate and good results comparable to open surgery for a high-risk patient population.

Keywords: Ankylosing spondylitis (AS); diffuse idiopathic skeletal hyperostosis (DISH); minimally invasive surgery (MIS); spinal fractures

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Introduction

Fractures of the ankylosed spine are increasing in incidence and present treating physicians with numerous problems (1). Both diffuse idiopathic skeletal hyperostosis (DISH) and ankylosing spondylitis (AS) affect the axial skeleton making it more rigid which on the background of increased osteoporosis makes them more susceptible to injuries even after minor trauma (2,3). These have a higher rate of spinal cord injury and more risk of significant complication and mortality than fractures of a non-ankylosed spine (4). The long “lever arm” of these fractures, and a potential

high risk of non-union and fracture displacement with conservative treatment has led to surgery being preferred in many centers. However, there is evidence that about a third are still treated conservatively (5), largely due to the increased risk of surgical complications in a generally elderly population. Coupled with the risk of surgical complications the post injury mortality in these patients is 18% at 3 months in AS (5). Furthermore, there are several reports of in-hospital deterioration in the neurological status of patients with ankylosed spines (6). Despite the risk, Robinson et al, have reported an improved survival in patients with AS that undergo surgical stabilization (7).

In thoracolumbar fractures the traditional open techniques have resulted in good results but require long segment fixation, and therefore long operative time and extensive open incisions which may increase the risk of complications. Recently there have been some case series and case reports on the use of minimally invasive surgery (MIS) utilizing percutaneous pedicle screw and rod fixation for the stabilization of these fractures (8-10). These coupled with a recent comparative case series paper have suggested that there may be an advantage in the management of these complex injuries using the MIS method.

The aim of this study is to compare the results of MIS stabilization with traditional open techniques in thoracolumbar fractures of spines with an ankylosing disorder.

Methods

A prospective ethically approved database (Spine Tango) was retrospectively reviewed to identify patients who had undergone stabilization of fractures of an ankylosed spine in the period 2010 (commencement of the database) to 2017. This list was then cross checked with the theatre database at a tertiary referral center to identify all patients who underwent surgical stabilization of their spine in the same period. Radiological studies including X-rays, CT scans and MRI scans were then reviewed to confirm the diagnosis of an ankylosed spine. Information collected included injury level, ASIA score, time in theatre, recorded blood loss in theatre, number of levels stabilized and the number of screws inserted, ASA grade and pre and post op hemoglobin. Where possible final radiographs and CT Scans were reviewed for bony union of the fracture. Medical records and Spine Tango follow-up data were reviewed for information relating to complications following surgery.

Minimally invasive surgical technique

Since 2012 the senior author (M Selby) has used MIS as a preferential technique for fixation of fractures of the ankylosed spine. Prior to this time all operative cases were performed with open techniques.

For the MIS technique at our institute we perform a pre-operative X-ray to assess the ability to visualize the pedicles on plain fluoroscopy. If the pedicles can be visualized, then MIS surgery is feasible. In all patients undergoing MIS the VIPER 2 instrumentation (DepuySynthes Raynham, MA, USA) was inserted and with osteoporotic patients having

cement augmentation via the pedicle screw cannulation (Confidence-DepuySynthes Raynham, MA, USA).

We positioned patients prone and used the Wilson frame (Mizuho Osi, Union City, California, USA) if a pre-existing global kyphosis was present to avoid hyperextension of the fracture. For patients with no significant global kyphosis a standard Jackson Table is utilized (Mizuho Osi, Union City, California, USA).

Standard percutaneous pedicle screw instrumentation was undertaken, typically bilaterally 3 levels above and below the fracture using biplanar fluoroscopy. This screw insertion technique has been well described (11).

In the ankylosed spine pedicle visualization can be challenging on fluoroscopy. Therefore, after tapping the pedicle the walls of the pedicle were additionally palpated under fluoroscopic visualization.

Rod contouring needs to be accurate to avoid hyperextension at the fracture site. The rod is advanced sub-facially from cranial to caudal as the distal pedicle screws tend to be of larger diameter and soft tissue coverage is greater distally. Careful checking of rod passage both by palpation and fluoroscopy is required for the MIS technique.

If required for decompression a mini-open laminectomy is undertaken using the spinous process osteotomy (12) via a 3–4 cm separate midline incision.

For the open technique standard pedicle screw and rod instrumentation was utilized (AO USS 2 and AO URS-DepuySynthes, Raynham, MA, USA).

Patients are mobilized immediately post-operatively if possible and a post-operative CT scan is performed to assess screw position and fracture reduction. Patients would then be discharged when fit although all with a pre-existing neurological deficit received inpatient rehabilitation. All patients were followed up until bony union or death.

Results

We identified 17 patients who met the study inclusion criteria. We identified 10 who were stabilized using MIS techniques and 7 who were stabilized with open techniques. Demographics of the two groups are displayed in *Table 1*. These were similar except for age being significantly higher in the MIS group. The number of levels was similar between the two groups. Most of the patients had AS (13) rather than DISH.

There was a significant difference in terms of pre-op *vs.* post-op hemoglobin level ($P=0.00079$) in favor of surgery performed using the MIS technique and there was

Table 1 Characteristics of the MIS and open surgery groups

Characteristics	Mean	
	MIS [†]	Open
Age (years) [range]	81.1 [55–90]	67.6 [49–85]
Sex (M:F)	9:1	7:0
ASA [‡]	3	3
ASIA [§]	E (64%)	E (86%)
Levels stabilised	7	6.9
Blood loss (mL)	383	533
Follow up (months)	24 (minimum 12)	48 (minimum 12)

[†], minimally invasive surgical group; [‡], ASA Physical Status Classification System; [§], American Spinal Injury Association (ASIA) Impairment Scale. MIS, minimally invasive surgery; E means no loss of neurological function.

Table 2 Change in haemoglobin pre-surgery to post-surgery

Variable	Mean (SD) (g/L)	Range (g/L)
MIS	−8.7 (10.8)	−20 to +14
Open	−36.3 (6.6)	−45 to −27

Negative values indicate reduction in haemoglobin, positive values indicate increase in haemoglobin. Two patients in the MIS group had an increase in their Hb post-operatively, one had a pre-op transfusion prior to the pre-op test (+14) and the other did not have any transfusions (+7). MIS, minimally invasive surgery.

a trend towards significance in favor of the MIS surgery in operating room time. There was no difference in the levels stabilised and the number of screws inserted. There was a statistically significant increase in the amount of radiation exposure to the surgeon with the MIS technique ($P=0.006$). There was blood transfusion seen in two patients in the open group following surgery both requiring two units. One patient in the MIS group required a pre-operative blood transfusion but none required a post-operative transfusion (Table 2).

All the MIS cases had a post-operative CT scan, as is the senior authors standard practice. These scans were then reviewed for pedicle screw accuracy as per Mobbs Raley method (11). We found that 97% of screws inserted were Mobbs Raley grade 0 (within cortex of pedicle); 3% grade 1 (screw thread breach ≤ 2 mm of pedicle), 0% grade 2 (significant breach >2 mm without neurological compromise) and 0% grade 3 (fracture, neurological or vascular complication). No screws in the MIS group needed

to be revised or removed.

All patients in both groups demonstrated complete bony union clinically and radiologically (via CT scan) at a minimum of 12 months following surgery. This was despite some fractures being reduced in mild hyper-extension in both groups (Figure 1).

In this study group we had one patient, aged 91, who had MIS fixation die 14 days post stabilization from their medical comorbidities. One patient in the MIS group developed a superficial infection at one of the percutaneous wound sites requiring oral antibiotic and dressing treatment. One MIS patient developed a deep infection 9 months after surgery following an admission to ICU for a separate medical event and subsequent line related sepsis—this was treated medically with long term antibiotic treatment and retention of metalwork (and is now >24 months following surgery). In the open group, one patient required further surgery due to a proximal junctional fracture with displacement and neurological compromise and another patient died from pulmonary complications 9 days post-surgery.

Discussion

This comparative case series supports the use of MIS techniques in the management of thoracolumbar fractures in an ankylosed spine. Time in theatre and blood loss would suggest that this surgical technique may offer some benefits over the traditional open method.

Whilst we are advocates of the MIS techniques there are some issues which may need to be considered. We did experience some loss of reduction of the fracture position in this cohort of patients managed with MIS techniques. This was felt to occur due to the contour of the rod not being curved enough to accommodate the patients pre-existing deformity. We can report that this patient despite the slight extension of the fracture did go on to unite their fracture (Figure 2).

The radiation exposure in our series was significantly increased in the MIS group. Methods to reduce the radiation the surgeon experience would be beneficial due to the reported incidence of thyroid cancer and cataracts. We would advocate wearing full lead including thyroid shield and lead eye protection where possible. Methods such as navigation may also help reduce this but are not currently available in our institution.

It has been shown in several studies and in two systematic reviews that MIS surgery is superior to open techniques in general (12–16). It has been shown to reduce the length

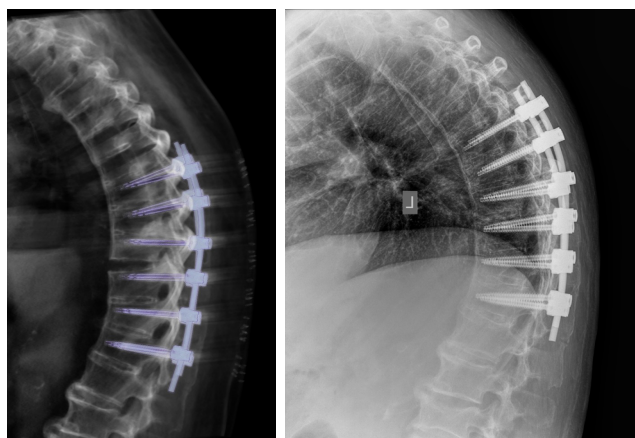


Figure 1 Post-op CT three-dimensional reconstruction with a follow-up plain radiograph showing fracture healing.

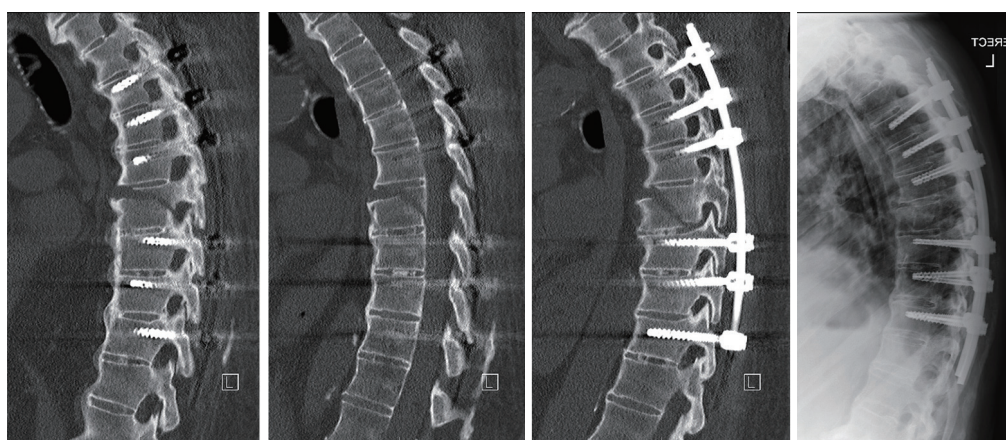


Figure 2 CT scan demonstrating a slightly hyperextended and distracted position immediately post-op with a follow-up plain radiograph showing bone union.

of stay, reduce the intra-operative blood loss and reduce operative time. Our results would support this in the setting of the ankylosed spine. We feel our blood loss would have been even lower if there had not been the clinical need to perform a laminectomy on two of the MIS patients which increased the reported blood loss. This is supported by the recent publication which has shown that there was a clinically significant difference in transfusion rates between the MIS group and open group (17).

Limitations of this study are the small size of the patient groups. Despite this, we feel that the results can still be supportive of the use of this method of stabilization in this population. Another limitation is that not all blood loss can be quantified in MIS cases. We therefore compared pre-op and post-op hemoglobin levels and looked at the

need for blood transfusion after surgery. Whilst a drop in hemoglobin was statistically significant between the groups, blood transfusion rates were not.

Overall, we feel this paper adds to the growing evidence of the use of MIS techniques in the challenging setting of thoracolumbar fractures in the ankylosed spine. There may be a further benefit to the healthcare provider in shortened length of stay. Unfortunately, this study was not able to assess this due to the low number of patients and several confounds amongst the patient population.

Conclusions

The surgically demanding MIS technique may offer benefits to the patient and appears to be comparable to the

open technique. Further evidence to support this method is required in terms of larger studies.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

Ethical Statement: Ethics approval was not required for this study. Consent was obtained from all patients.

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