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ORIGINAL ARTICLE

Minimally invasive iliac screw fixation in treating painful metastatic lumbosacral deformity: a technique description and clinical results

Gabriel Liu[1] · Muhammed Yaser Hasan[1] · Hee-Kit Wong[1]

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Abstract

Introduction Pelvic fixation via iliac screws is a crucial technique in stabilizing metastatic lumbosacral deformity. MIS iliac screw fixation avoids complications of an open approach and is a viable palliative option in treating patients with painful instability and advanced disease, unsuited for major reconstruction. In this paper we describe the use of MIS iliac screw fixation in treatment of painful metastatic LSJ deformity, highlighting our treatment rationale, selection criteria, technical experience and outcomes.

Methods Five patients with lumbosacral metastatic deformity who underwent MIS lumbopelvic stabilization using iliac screws were prospectively studied. Patients had severe axial back pain in erect posture with significant resolution when supine. All patients had advanced disease with unfavorable tumor scores for major spinal reconstruction.

Results Mean cohort age was 62 years. Median pre-op SIN and Tokuhashi scores were 13 and 9, respectively. All patients were instrumented successfully without conversion to open technique. Mean preoperative and postoperative Cobb angle was 11° and 5.4°, respectively. There were no neurological deficits or wound complications postop. Postoperative CT scans showed no iliac screw and sacroiliac joint bony violation. Mean time for commencement of adjuvant therapy was 2.8 weeks. Average follow-up was 13.2 months. No screw breakage, wound complication, symptomatic implant prominence and SI joint pain were noted at last follow-up.

Conclusion MIS iliac screw fixation is feasible, reproducible and can be employed without complications in metastatic spine. This opens a new avenue of surgical management for metastatic lumbosacral disease patients, who otherwise may be inoperable and provide better soft tissue control and earlier postoperative adjuvant treatment opportunity.

Keywords Bone screws · Spine · Metastasis · Lumbosacral region · Pathological fracture

Introduction

Spinal column is a common site for skeletal metastatic deposits [1]. Autopsy studies show up to 70 % of terminal cancer patients have spine involvement at demise [2]. Tumor invasion into the vertebrae creates pathological fractures leading to column instability and deformity. Mechanical pain is a common presentation in symptomatic patients. This pain subtype is due to loss of structural integrity of the spinal column precipitating pain upon axial loading of the spine. The patient's quality of life is severely affected as even without neurological deficits these patients are bed bound due to pain. This mechanical pain from pathological metastatic spinal fractures fails to respond to pharmacologic or radiation therapy and requires surgical stabilization [3, 4].

Thirty percent of spinal metastatic disease involves the lumbosacral spine [2]. This area includes the lumbosacral junction (LSJ), a transition zone from mobile to a relatively fixed pelvis. Fixation in this location has additional stress

✉ Gabriel Liu
gabriel_liu@nuhs.edu.sg

[1] University Orthopaedic, Hand and Reconstructive Microsurgery Surgery Cluster, National University Health System, National University Hospital, 1E Kent Ridge Road, NUHS Tower Block, Level 11, Singapore 119228, Singapore

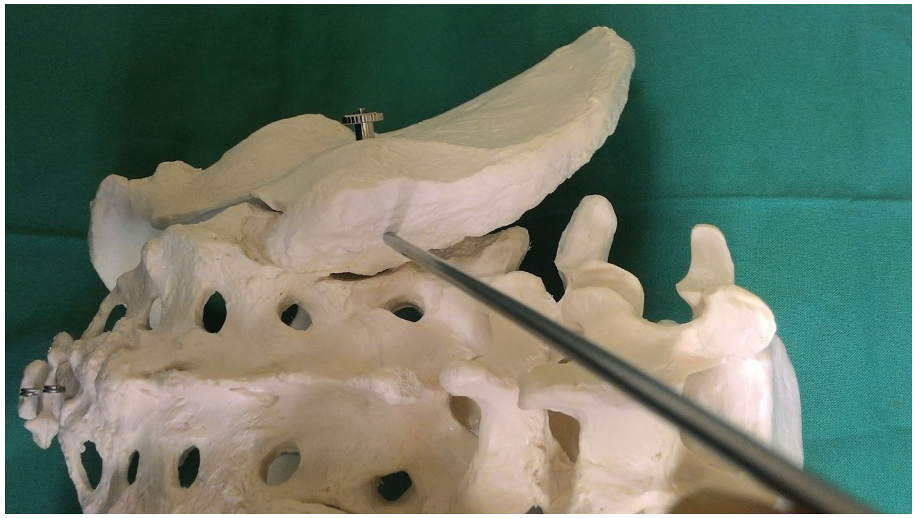

Fig. 1 Iliac screw entry point is medial to the medial iliac crest wall, 2 cm below PSIS, and lateral to S1 foramen. The trajectory is 45° caudally and laterally towards the anterior inferior iliac spine

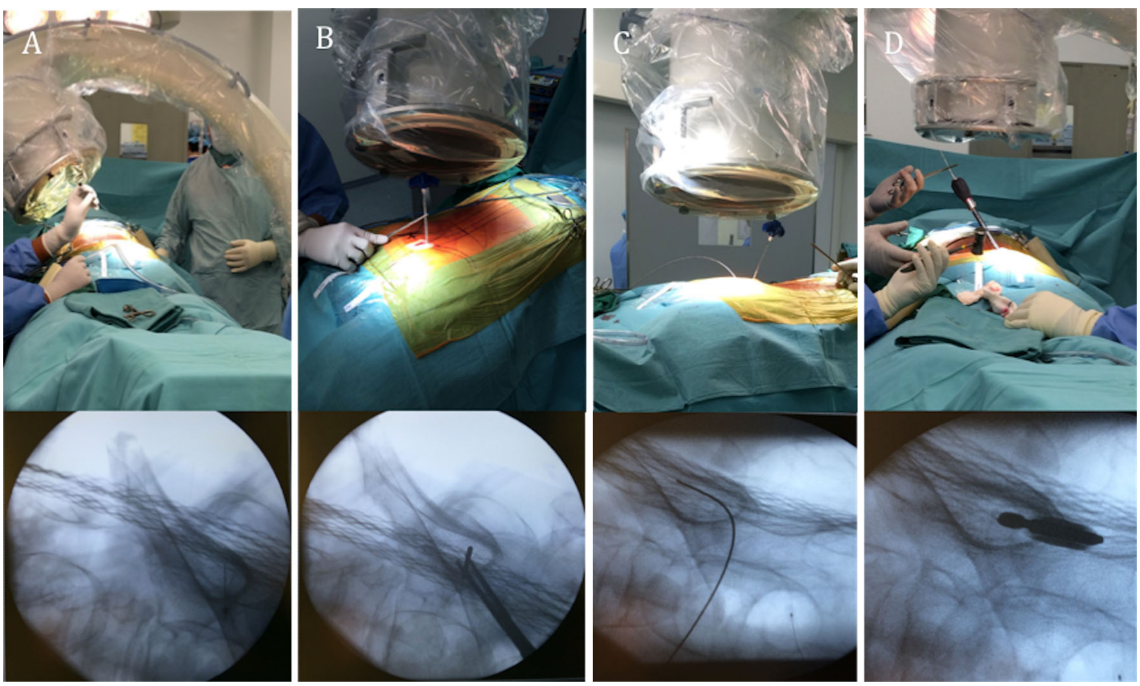

Fig. 2 Intraoperative images and corresponding fluoroscopy views of teardrop showing needle localization (**a**), Jamshidi placement (**b**), guidewire entry (**c**) and screw path tapping (**d**)

due to the unique biomechanics of LSJ [5, 6]. Anatomy of the sacrum with its cancellous composition and wide pedicles can further contribute to implant pullout and fixation failures [6]. Lumbosacral stabilization is a complex surgery often requiring front and back spinal surgery, and presence of neoplastic disease with its destructive elements creates more challenges to an already difficult procedure.

Pelvic fixation is an important concept in stabilizing metastatic lumbosacral deformity [5], utilizing the anatomic advantage of the human pelvis as a stable anchor point. Over the years various implants such as Galveston steel rods [7], Cotrel–Dubousset system [8] and Texas Scottish Rite Hospital instrumentations [9] have been employed for stabilizing the LSJ. In recent times iliac screw fixation has gained prominence, especially in deformity correction surgery where their usage has shown to reduce pseudoarthrosis, protect failure of lumbar implants and prevent sacral fractures at LSJ [6, 10, 11].

Open surgery for iliac fixation is a major procedure associated with bleeding and wound complications [12] and unsuited for patients with advance lumbosacral metastatic disease and spinal deformity. Wang et al. (2008)

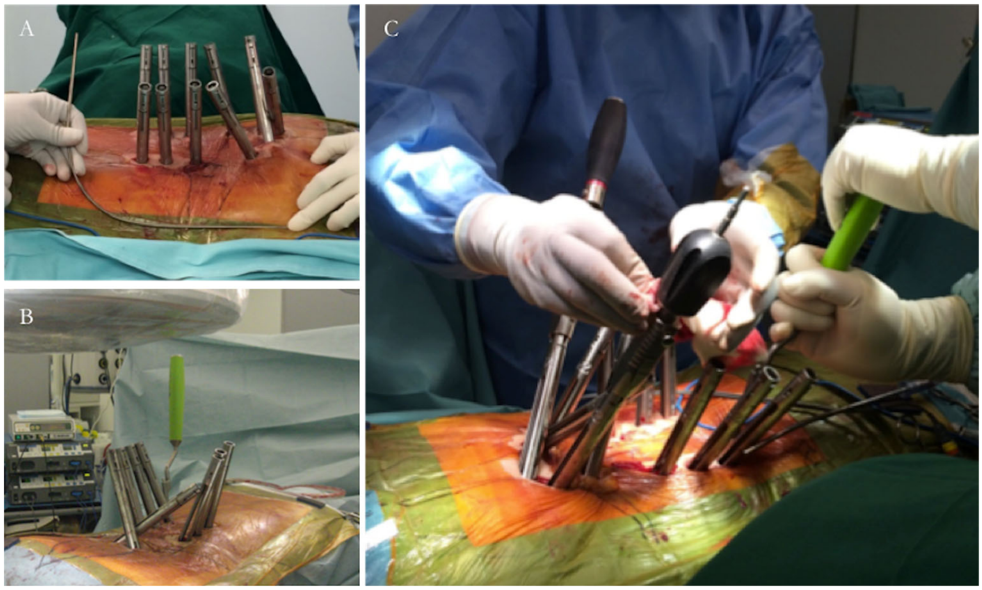

Fig. 3 Percutaneous rod placement (**a**) aided by screw extension posts (**b** and **c**)

Table 1 Preoperative clinical and radiological parameters

Patient	A	B	C	D	E
Age/sex	62/M	52/F	72/F	56/F	70/M
Diagnosis	L4 fracture, metastatic colorectal CA	L4 fracture, metastatic uterine CA	L3 fracture, metastatic breast CA	L4 fracture, metastatic cervical CA	L4 L5 fracture, metastatic renal cell CA
Indication	Mechanical pain	Mechanical pain	Mechanical pain	Mechanical pain	Mechanical pain
Lumbar VAS	7	8	8	7	10
Leg VAS	4	4	5	4	6
Surgery	MIS L1, L2, L3, L5 and iliac	MIS L1, L2, L3, L5 and iliac	MIS L1, L2, L4, iliac	MIS L1, L2, L3, Rt L5, S1 and iliac	MIS L1, L2, L3 and iliac
Cobb angle, °	13	8	6	13	15
Lumbar Lordosis, °	30	35	23	22	27
Tokuhashi score	10	7	4	10	9
SIN score	14	10	13	14	14

SIN Spinal instability neoplastic score, *MIS* minimally invasive surgery, *VAS* visual analog score (range 0–10)

described the use of MIS iliac screw fixation in a cadaveric study and case report for lumbar spine deformity surgery [13]. Clinical safety and feasible of this technique has since been reported by the same author in an extended series of patients with degenerative spinal deformities [14]. To the best of author's knowledge there are no reports on the use of MIS iliac screws in the management of pathological LSJ deformity.

This paper aims to describe the use of MIS iliac screw fixation in the treatment of painful metastatic LSJ disease with deformity, highlighting our treatment rationale, patient selection criteria, technical experience and outcomes.

Methodology

Five patients with lumbosacral metastatic deformity who underwent MIS lumbopelvic stabilization using iliac screws between August 2012 and September 2014 were

Table 2 Surgical parameters

Patient	A	B	C	D	E
Surgery	MIS L1, L2, L3, L5 and iliac	MIS L1, L2, L3, L5 and iliac	MIS L1, L2, L4, iliac	MIS L1, L2, L3, Rt L5, S1 and iliac	MIS L1, L2, L3 and iliac
Construct span, vertebral levels[b]	7	7	6[a]	7	7
Iliac screw size (width × length), mm					
Rt	8 × 85	8 × 75	8 × 80	8 × 75	7.5 × 75
Lt	8 × 85	8 × 85	8 × 80	7.5 × 75	7.5 × 75
Op duration, min	500	420	331	390	423
Blood loss, mL	250	200	50	200	100

[a] Sacralized L5 vertebrae

[b] Vertebral levels including S1 and ilium

Table 3 Postoperative clinical and radiological outcomes

Patient	A	B	C	D	E
Post-op hospital stay, day	7	14	5	5	7
Major post-op complications[a]	None	None	None	None	None
Revision surgery	None	None	None	None	None
CT evidence of iliac screw bone violation	None	None	None	None	None
Cobb angle, °	9	4	2	8	4
Lumbar lordosis, °	17	28	43	23	20
Start of adjuvant therapy postop, weeks	3	3	2	3	3
Lumbar VAS (6 months)	3	3	4	3	4
Leg VAS (6 months)	3	2	2	0	3
Follow-up, months	8	7	20	15	16
Survival, months	Alive	Alive	20	15	16

[a] Major post-op complications—wound infection, wound breakage, DVT and implant failure. VAS visual analog score at 6 months

prospectively studied. No decompression, anterior surgery or interbody support was performed during the procedure. Pre- and postoperative clinical, radiological and surgical parameters were reviewed.

Patient selection

Patients presented with severe mechanical back pain and radiculopathy only in erect spinal posture with significant symptom reduction in supine position. All patients had elevated spine instability and neoplastic score (SIN) reflecting underlying structural instability. They also have unfavorable Tokuhashi score rendering them unsuited for extensive open surgery.

Surgical technique

Fluoroscopy guidance is the key step to ensure the success of MIS iliac screw insertion. A teardrop view which marks the zone of entry for the MIS iliac screw is created by rotating the fluoroscopy 45° axial in line with iliac wing and then tilting 45° caudal. The aim is to insert the screw at the center of the widest point of the teardrop. A 2-cm skin incision is made 1 cm medial to the iliac crest inferior to PSIS. Finger dissection is used to locate the medial wall of the crest. The iliac screw entry point is medial to the medial iliac crest wall, 2 cm below PSIS and lateral to S1 foramen (Fig. 1). By keeping the entry point medial to the medial wall of the iliac crest, the screw head is kept under this medial ridge reducing prominence.

Guided by the teardrop, a spinal needle is then directed 45° caudally and laterally, aiming at the anterior inferior iliac spine (Fig. 2a). The needle is then replaced by a Jamshidi needle, which is advanced along similar trajectory (Fig. 2b). Next a guidewire is passed through the Jamshidi followed by length measurement and tap (Fig. 2c, d). Similar steps are performed for the contralateral side, followed by bilateral screw insertion. Manually contoured

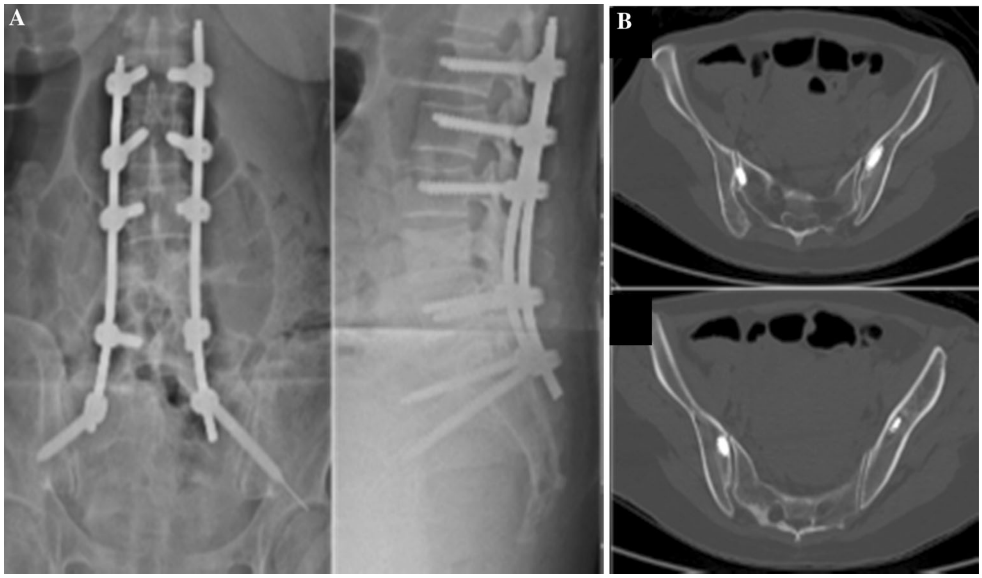

Fig. 4 Patient B had underlying metastatic uterine cancer and presented with a pathological L4 fracture. Post-op radiographs (**a**) and axial CT images (**b**) showing MIS L1, L2, L3, L5 and iliac instrumentation

rods are inserted percutaneously once the desired vertebral levels are instrumented. Screw extension posts are used to assist with rod passage and screw connection by pushing the rod onto the screw head (Fig. 3).

Results

The patient cohort comprised of three females and two males with a mean age of 62 years (52–72). There was one case each of metastatic lung, cervical, renal, uterine and breast cancer. Four cases had a pathological fracture at L4 while one case had a fracture at L3. Preoperative median visual analog scores for back and leg were 8 and 4, respectively. Preoperative median spinal instability and neoplastic score (SIN) and Tokuhashi score were 13 (range 10–14) and 9 (range 4–10), respectively (Table 1).

All five patients were instrumented successfully without conversion to an open technique. Mean surgery duration was 412 min (331–500) with average blood loss of 160 mL (50–250). Average iliac screw length used was 79 mm (75–85) (Table 2). Mean preoperative and postoperatively scoliosis Cobb angle was 11° (6–15) and 5.4° (2–9), respectively. None of the cases had any neurological deficits or wound complications post-surgery (Table 3). Postoperative CT scans were performed for all cases and showed no iliac screw bony violation and SI joint infiltration (Figs. 4, 5, 6). In one case (patient B) the right iliac screw guidewire broke during drilling and could not be retrieved. However, on subsequent follow-up assessments there were no postoperative symptoms related to broken wire.

Three patients required HD admission for routine postoperative monitoring. Mean postoperative hospital stay was 7 days (5–14). To further add stability to the underlying construct, post-surgery all patients were fitted with a customized thoracolumbosacro-femur orthosis (TLSFO) with a mobile hinged thigh extension allowing hip flexion to aid sitting and standing without removing the cast. The fabrication of the TLSFO may have added to slight increase in mean hospital stay.

Mean time for commencement of adjuvant therapy after surgery was 2.8 weeks (2–3). At 6-month follow-up the visual analog score (VAS) for each case was considerably better than at pre-op (median scores for back and leg were 3 and 2, respectively) (Table 3). Average patient follow-up was 13.2 months (7–20). No iliac screw breakage, iliac wound complication, symptom of implant prominence and SI joint pain were noted at last follow-up visit. Three patients (Patients C, D and E) have since succumbed to the primary metastatic disease at 20, 15 and 16 months post-surgery, respectively.

Discussion

Iliac screw fixation due to its superior biomechanics has now become the standard mode of pelvic fixation. Iliac instrumentation extends anterior to the lumbosacral pivot and creates a long lever arm within the ilium to counteract the LSJ forces, resulting in an extremely stable construct [15, 16]. In vitro biomechanical comparison between various lumbopelvic fixation techniques found iliac screw fixation to be the most resistant to

Fig. 5 Patient C had metastatic breast disease and presented with a pathological L3 fracture (**a**, **b**). Post-op radiographs (**c**) and axial CT images (**d**) showing MIS L1, L2, L4 and iliac fixation

stress failure [15–17]. In clinical practice, the advantages of iliac screw fixation have been well described in adult spinal deformity literature [6, 10, 11]. Open iliac screw fixation, however, is a major surgical procedure with a potential for significant morbidity and wound complication due to the extensive exposure needed for safe screw placement [12]. This is a genuine concern when extrapolating this technique in managing metastatic LSJ deformity, though McGhee and colleagues in 2000 did report effective use of iliac bolts for stabilizing LSJ in a series of six patients with pathological sacral fractures and intractable pain [18].

Minimally invasive approach is routinely being used in spinal surgery due to its potential advantages of reduced blood loss, early mobilization and decreased wound problems [19, 20]. Recently published MiSLAT (Mummaneni, M. Wang, Silva, Lenke, Amin, Tu) algorithm has highlighted and guided the use of various MIS approaches in treatment of degenerative scoliosis [21]. In 2008 when Wang et al. first described percutaneous iliac screw insertion during MIS fixation for an L5 burst fracture, they combined the advantages of MIS surgery with iliac fixation superiority [13]. This approach has since provided a new surgical option in the management of patients with painful

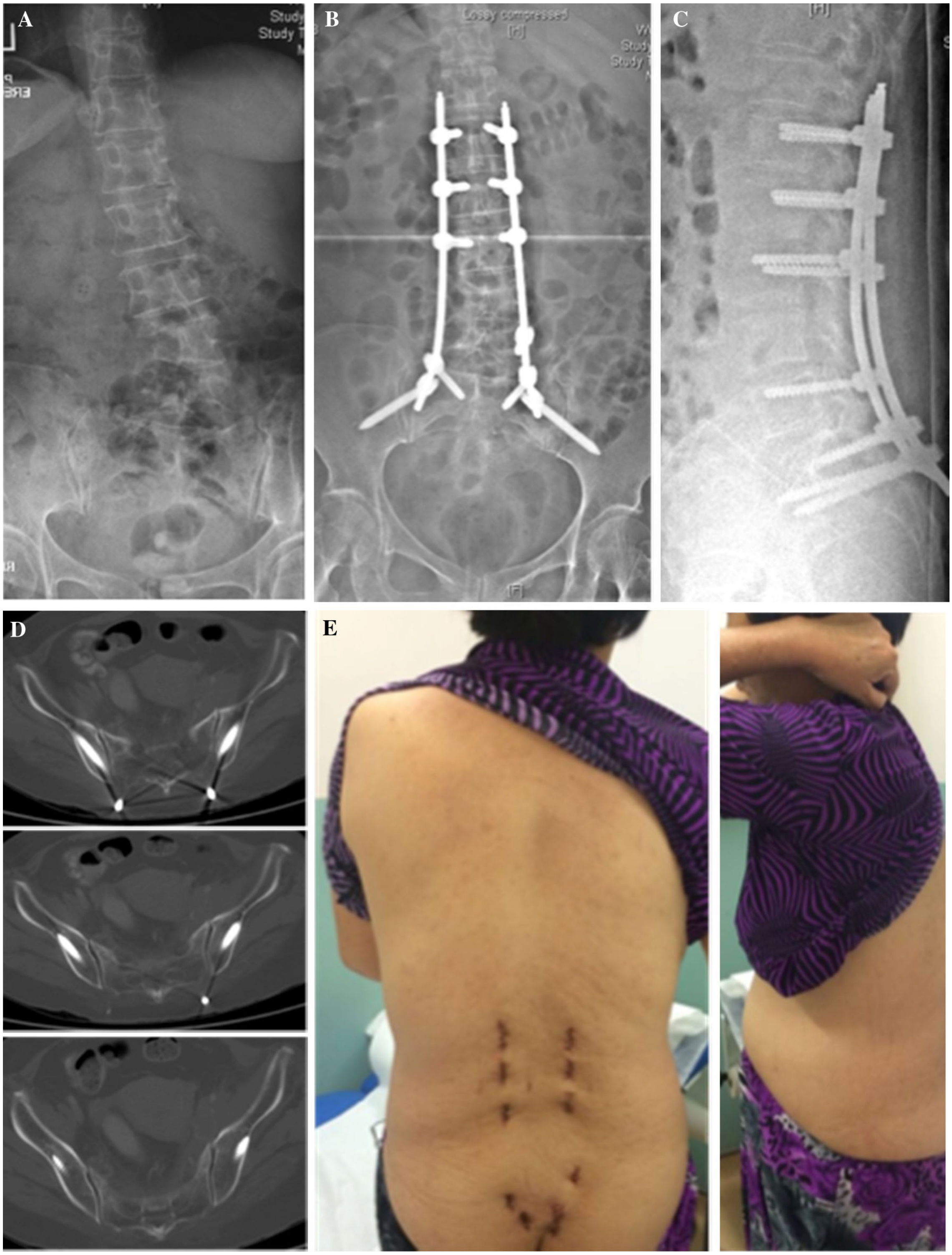

Fig. 6 Patient D had metastatic cervical cancer presented with a pathological L4/L5 fracture and deformity (**a**). Post-op radiographs (**b** and **c**) and CT imaging (**d**) show MIS L1, L2, L3, right L5, SI and iliac instrumentation. Clinical photos (**e**) at 2 weeks post-op show complete healing, allowing an earlier initiation of adjuvant radiotherapy

metastatic LSJ deformity and advanced disease, otherwise unsuited for major anterior and posterior surgery. Another critical advantage of MIS surgery is a potential earlier transition to adjuvant treatment such as chemotherapy or radiotherapy, which may otherwise be delayed in an open procedure due to longer recovery times and wound issues.

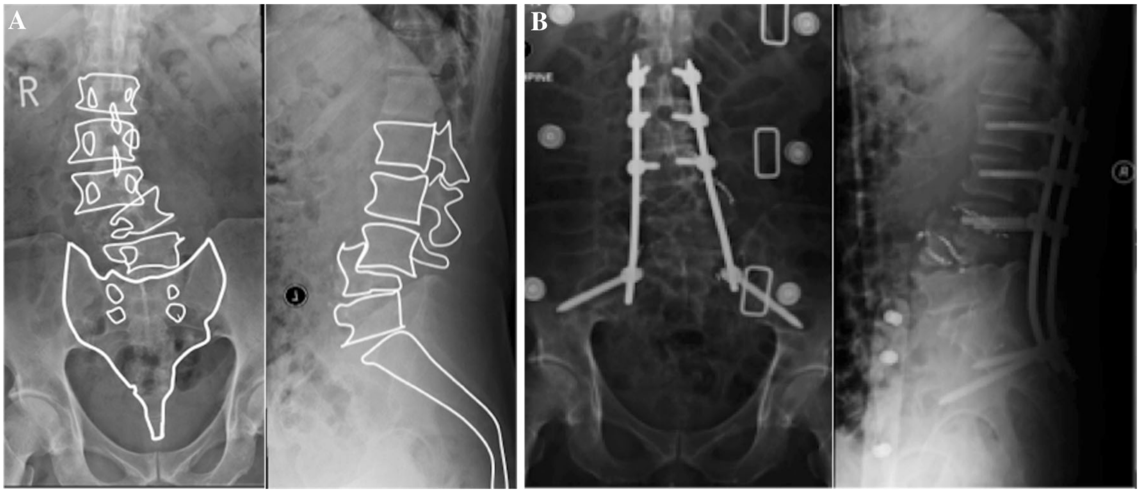

Fig. 7 Patient E had metastatic renal cell carcinoma with extensive vertebral involvement result in LSJ deformity (**a**). Post-op radiographs (**b**) showing L1, L2 and L3 and bilateral iliac instrumentation

Existing studies on MIS iliac screw fixation mainly in degenerative deformity and trauma report no instances of major complications [14, 22]. Similarly in our cohort of tumor cases no major complications were noted. Adjuvant radiotherapy was started for all patients within 3 weeks post-surgery.

A technical difficulty with this approach as mentioned in prior studies [13, 14] has been the rod contouring and connecting iliac screws to the proximal instrumentation. During contouring we recommend a hyperacute lordotic bend of 30°–40° of the distal 2–3 cm of the rod to enable easier connection. In the presence of S1 screws, this contouring can become even more complex as a shorter rod segment needs to be contoured in two planes to link S1 and iliac screw heads. In our series we placed S1 screws in only one case (Fig. 6), while for the rest of the cohort lumbar segments were connected directly to iliac screws, easing rod insertion. As these patients are functionally low demand with advanced disease, a lumbopelvic construct without S1 screws though weaker is still able to sustain the functional demand and outlive the patient. For instance in Patient E with severe L4 and L5 deformity, L3 screws were connected directly to the iliac screws which provided the only distal anchor below the fracture site (Fig. 7). This construct was still noted to be intact at the last follow-up 20 months post-surgery.

Screw prominence has been a concern with iliac screws [10–12]. Our technique reduces prominence by keeping the screw entry point below the iliac crest, medial to the iliac crest ridge (Fig. 1). During the procedure both fluoroscopy and manual palpation of the screw head location through the skin and subcutaneous tissues ensures a non-prominent screw head position. This approach is different from the recently described sacral alar-iliac (S2AI) approach, as our entry point lies above the sacroiliac joint and the screw path does not violate the joint. Guler et al. in a recent study on lumbosacral fixations noted that in cases with suboptimal sagittal plane correction, S2AI polyaxial screws seem to have higher risk of short-term acute failure compared to iliac wing screws [23].

A major limitation in our series is the patient number and follow-up duration. The small sample size is due to our stringent selection criteria, which is critical for a successful outcome. We recommend this strategy only for patients with mechanical back symptoms during spine loading posture, with pain relief in supine position. This key element in history suggests that spinal stabilization without surgical decompression will suffice for symptom relief. Even in patients with significant malalignment (Patient E—Fig. 7), though MIS approach may not allow extensive correction, it does provide adequate stabilization and sufficient pain relief from mechanical instability. Early adjuvant radiotherapy is an important part of the management to reduce construct failure and neuro-element compression due to progression of metastatic disease.

As MIS iliac screw insertion is a relatively recent technique, there is a learning curve for surgeons as well as the entire operative team, i.e., scrub nurse, radiographer, etc. The small patient number in our series was a limitation to do a formal learning curve analysis. However, in our anecdotal experience we feel that teams experienced in open iliac and MIS pedicle screw techniques can gain surgical proficiency in a short span, i.e., four or more cases. Our apparent long surgical time (average operative time of around 7 h and average iliac screw insertion time of around 40 min) can be attributed to the early learning phase for the surgical team. These durations are expected to improve as experience builds and the team becomes more proficient.

Conclusion

MIS iliac screw fixation is feasible, reproducible and can be employed without complications in metastatic spine. It opens a new avenue with minimal complications in the management of metastatic lumbosacral disease, which may otherwise be inoperable and provide better soft tissue control and earlier postoperative adjuvant treatment opportunity. Early results for this technique are encouraging, but more research is warranted to establish its long-term safety.

Compliance with ethical standards

Conflict of interest None of the authors has any potential conflict of interest.

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