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Clinical Case Studies

The posterior superior iliac rim screw as an adjunct to pelvic fixation in complex spinopelvic stabilization ☆

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ABSTRACT

Background: Fixation to the ilium is a commonly used alternative or supplement to sacral fixation in complex spinopelvic reconstructions. This can be achieved with traditional posterior superior iliac spine or S2 alar-iliac screws. Posterior superior iliac rim screws may be considered to achieve or enhance pelvic fixation. The objective of this case series was to describe the use of and indications for posterior superior iliac rim screws.

Methods: A retrospective review was performed of the medical records and radiographic data for three patients who underwent complex lumbosacral reconstructions involving the use of posterior superior iliac rim screws to enhance pelvic fixation. The cases included a 35-year-old with bilateral sacral fractures, a 43-year-old with extensive metastatic sarcoma to the sacrum, and a 48-year-old with multiple lumbar and pelvic fractures. An overview of the key surgical techniques is provided.

Results: All three patients tolerated the procedure, without any unexpected post-operative complications or deficits. Radiographs at last follow-up showed stable fixation and no hardware issues.

Conclusions: The use of posterior superior iliac rim screws as an adjunct method of fixation in complex spinopelvic reconstructions is a feasible option that can be considered in the fixation armamentarium.

Introduction

Pelvic fixation has been a longstanding challenge in complex spinopelvic reconstructions. Such scenarios are encountered in the management of high-grade spondylolisthesis, complex deformities, sacral fractures, and post-sacrectomy reconstructions. Despite advances in techniques and implants, technical limitations, fixation complications and hardware failures continue to present clinical challenges following complex spinopelvic reconstructions [1, 2].

In particular, fixation to the sacrum alone is limited by poor sacral bone quality, as it is mainly cancellous bone with thin cortices. This is compounded by the unique biomechanical forces caused by the transition from the highly mobile lumbar spine to the highly constrained sacrum [3]. Based on these factors, long posterior constructs that stop at S1 alone have been found to have pseudarthrosis rates up to 41% [2, 4, 5] and hardware-related complications in up to 70% of cases [2].

Subsequently, fixation to the ilium has become a widely accepted alternative or supplement to sacral fixation. The introduction of the Galveston technique in the 1980s, which incorporates the ilium into the fusion construct, greatly reduced lumbosacral pseudarthrosis rates [2, 3, 6]. However, technical difficulty in contouring the iliac rods, constraints in the ability to work the rod, and loosening of the iliac portion of the constructs limited the success of this technique. As a result of the above issues, the traditional posterior iliac screw technique with medial offset connectors was developed as a further improvement upon the Galveston technique, offering the advantages of improved biomechanics, greater modularity, and a less technically-demanding procedure [4, 6-10]. Further, S2 alar-iliac (S2AI) fixation has gained popularity to facilitate iliac fixation with lesser surgical dissection and lower profile [11–17].

Despite advantage in iliac fixation, screw loosening, screw breakage, and prominence continue to be reported [4, 17-19]. In order to increase the stability of iliac fixation in cases of particular biomechanical demands, multiple iliac screw constructs have been proposed. The most commonly described screw pattern for dual screws in the ilium is two parallel screws from the posterior superior iliac spine toward the anterior inferior iliac spine [20–22]. Though this offers the advantage of a secondary screw, parallel screws of close proximity theoretically result in less stability and fixation strength than screws that are further apart and/or placed at divergent trajectories [23].

An alternative to two parallel screws per ilium is a single screw in the traditional posterior iliac screw trajectory, with an adjunct screw along

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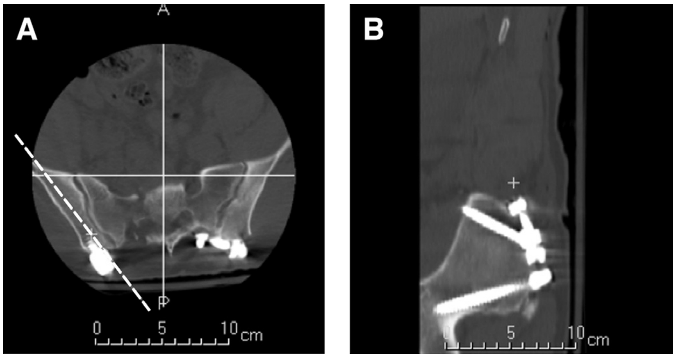

Fig. 1. Multi-planar reconstruction MRI with the orientation (dotted line, A) of the iliac "en face" view (B), showing the relative trajectories of the traditional posterior iliac screw and the posterior superior iliac rim screw.

the superior iliac rim [23]. The trajectory of this posterior superior iliac rim screw in relation to the traditional posterior iliac screw is shown in Figure 1. In a biomechanical study with a sacrectomy model, Yu *et al* found that fixation with bilateral dual iliac screws, regardless of whether they were both in the inferior iliac column or with one screw in each of the superior and inferior columns, was significantly stronger than bilateral single iliac screws [21]. In fact, the dual iliac screw constructs were biomechanically similar to their intact control models.

Although iliac fixation with adjunct screws in the posterior superior iliac rim have been proposed, this has not been well represented in the literature. Therefore, we present a series of three patients that were treated with the adjunct posterior superior iliac rim screw technique to describe potential candidates for this technique. We also describe clinical pearls related to performing this technique.

Materials and methods

We retrospectively reviewed the medical records and imaging studies of three patients who underwent complex lumbosacral reconstructions involving posterior superior iliac rim screws, due to greater than standard biomechanical demands on the constructs, or the inability to place traditional posterior iliac screws due to their pathology. Approval was obtained from our institution's Human Investigation Committee.

Descriptions of the management of the cases are provided, followed by a brief overview of the surgical technique.

Case 1 – Bilateral Sacral Fractures

A 35-year-old male presented following a motorcycle collision from which he suffered a subarachnoid hemorrhage, numerous facial bone and rib fractures, pubic symphyseal diathesis, and a complex sacral fracture. He had a Glasgow Coma Score (GCS) of 15 and examination revealed neurologic deficit to the right lower extremity. The initial exam revealed decreased sensation below the right knee with inability to extend the knee, dorsiflex or plantarflex the foot, and extend the great toe.

Computed tomography (CT) of the pelvis showed bilateral sacral fractures (zone II on the right and zone III on the left) with anterior and superior displacement of the right sacral alae and ilium. (Figure 2) Provisional stabilization was achieved with a pelvic binder and right lower extremity traction through a distal femoral traction pin. After clearance from the other clinical services, on hospital day 2, the patient underwent open reduction internal fixation (ORIF) of the symphysis pubis. The following day, the patient underwent L4 to pelvis instrumentation and fusion with bilateral traditional posterior iliac screws and bilateral posterior superior iliac rim screws. (Figure 3A) Of note, the patient's fracture pattern precluded the placement of S1 screws.

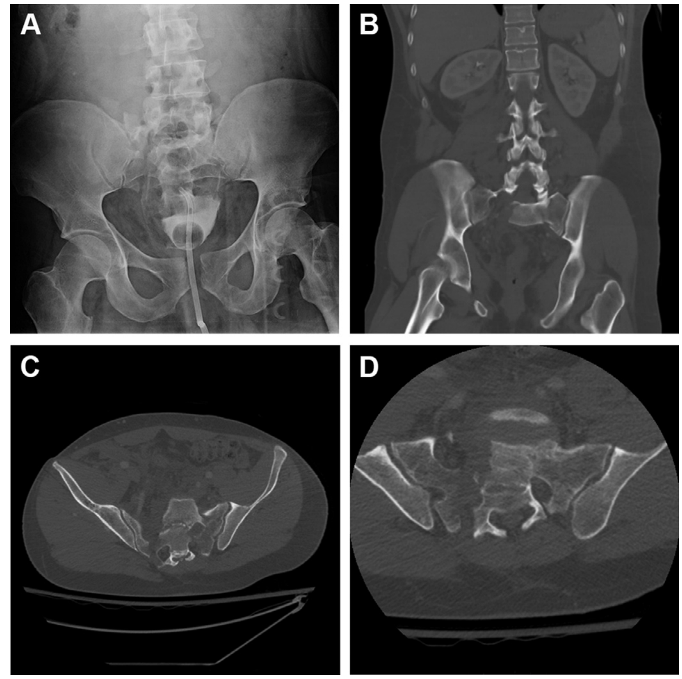

Fig. 2. Case 1 – bilateral sacral fractures. Pre-operative coronal plain film (A) with coronal CT (B), as well as axial CT (C, D) shows bilateral sacral fractures (zone II on the right and zone III on the left) with anterior and superior displacement of the right sacral alae and ilium.

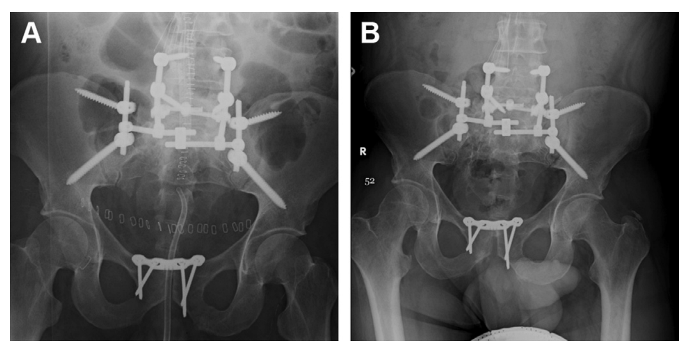

Fig. 3. Case 1 – bilateral sacral fractures. Immediate post-operative films (A) and at last follow-up at 6 months (B) show bilateral posterior superior iliac rim screws in place, with stable fixation and no hardware issues.

Post-operatively, the patient had partial return of neurologic function. By post-operative day 7, he regained function of his right quadriceps with 0-90 degrees of active knee flexion/extension and was able to tolerate limited weight bearing in both lower extremities and ambulate minimally with a walker. However, function below the knee remained absent. He was discharged to subacute rehabilitation on post-operative day 26. At his 6-week follow-up, the patient was ambulating well with a walker, and at his last follow-up (6 months after surgery), he was ambulating with just one crutch. He was noted to be independent with his activities of daily living at this point. Radiographs at this time showed a stable construct. (Figure 3B)

Case 2 – Metastatic Sarcoma

A 43-year-old female presented for worsening low back pain during her course of adjuvant radiation therapy following diagnosis and surgical excision of fibromyxoid sarcoma of the left medial thigh. Work-up revealed isolated metastasis to the right sacral S1-S3 segments with local extraosseous soft tissue extension. (Figure 4) Biopsy confirmed this to

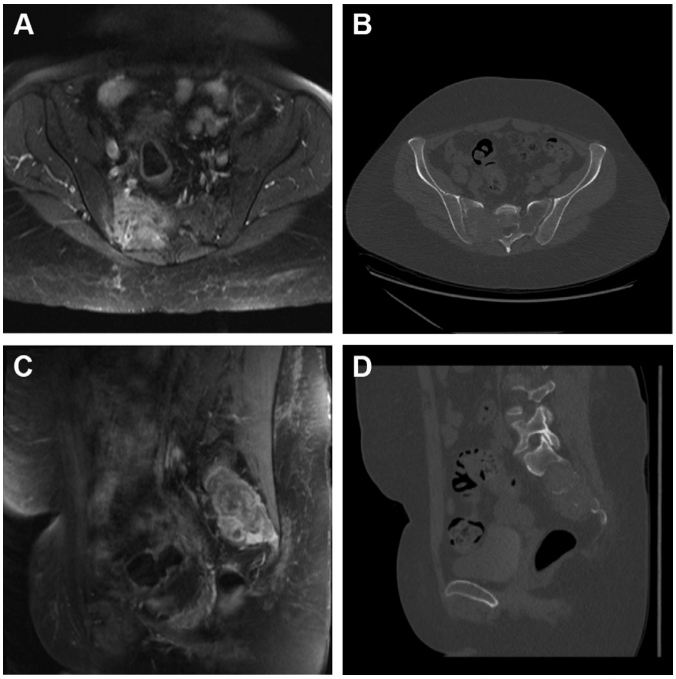

Fig. 4. Case 2 – metastatic sarcoma. Pre-operative axial MRI (A) and CT (B) studies, as well as sagittal MRI (C) and CT (D), shows isolated metastasis of the patient's known primary fibromyxoid sarcoma to the right sacral S1-S3 segments, with local extraosseous soft tissue extension.

be a metastatic lesion from the known primary. As this was an isolated metastatic lesion, and after extensive discussion with the patient, treatment with surgical resection with adjuvant chemotherapy was elected.

A sacrectomy from the L5-S1 level and distal to the right posterior ilium was performed. Fixation from L4 to the left pelvis was accomplished with traditional posterior iliac and posterior superior iliac rim screws. On the right, however, given removal of a portion of the posterior ilium with the tumor, posterior L4 to a single posterior superior iliac rim screw was performed. (Figure 5A) Bone grafting was used to supplement the construct with an allograft fibula that was placed on the right and tacked with a small fragment screw.

Post-operatively, the patient recovered with the expected neurologic deficits based on the sacrificed L5-S1 nerve roots. Exam revealed inability to dorsiflex at the right ankle with associated foot drop. She was able to transfer independently to a wheelchair and partially bear weight on her legs during therapy. She was discharged to subacute rehabilitation on postoperative day 13. At her 5-month follow-up, her walking continued to improve, and she used a walker most of the time with the wheelchair reserved for long distances. At 8-month follow-up, she continued to ambulate well, and radiographs showed a stable construct. (Figure 5B)

Case 3 – Lumbar and Pelvic Fractures

A 48-year-old male was transferred to our institution with multiple injuries including bilateral pneumothoraces, L1-L3 transverse process fractures, L4 burst fracture with retropulsion, L5 laminar fracture, right zone II sacral fracture, pubic diastasis of 1.8 cm, comminuted distal right femur fracture, right distal diaphyseal tibial fracture with articular extension, left distal femur Hoffa fracture, and a left lateral tibial plateau fracture. (Figure 6) GCS was initially 14, but deteriorated to 8, and he was intubated. He had related neurologic deficit with inability to move his lower extremities bilaterally.

Immediate management included placement of a pelvic binder, incision and drainage of the right tibial wound, and right lower extremity external fixation. Two days later, ORIF of the pubic symphysis was performed. Six days after surgical fixation of his pelvis, with medical clearance, we performed posterior lumbar decompression and posterior L2 to pelvis instrumentation and fusion. In addition to the traditional posterior iliac screws placed at the sciatic notch bilaterally, a posterior superior iliac rim screw was placed on the right, in order to achieve greater stability on the side of the sacral fracture. (Figure 7A)

The patient subsequently underwent ORIF of his remaining lower extremity fractures over the following weeks. After a prolonged intubation due to his multiple injuries, he was extubated, and gradual mobilization was begun. He began to regain function of his bilateral quadriceps, though no function below the knees were noted. The last radiographs at 22 days after surgery showed a stable fixation and no problems with the construct. (Figure 7B) The patient was unfortunately lost to follow-up after discharge.

Surgical Technique

The techniques we specifically highlight in this report are those related to the placement of posterior superior iliac rim screws. This is a potential supplement or alternative to the traditional posterior iliac screws, from the posterior superior iliac spine toward the anterior inferior iliac spine.

With the patient in prone positioning, exposure to the posterior ilium is performed through a standard posterior midline skin incision, with a separate fascial incision over the posterior superior iliac spine. Traditionally, it is common to take a portion of bone from the posterior superior iliac spine for bone graft, and to allow recessing of the traditional iliac screw to decrease hardware prominence [2, 5, 20]. In anticipation of placing a posterior superior iliac rim screw, we advocate taking the posterior ilium down to the level of the sacrum, and parallel to the floor of the prone positioned patient. (Figure 8A)

Placement of the traditional posterior iliac screw(s) is performed first, if indicated. A pedicle probe can be used to cannulate the ilium just over the sciatic notch. To place this screw, we will generally strip the outer table of the ilium and place an instrument in the sciatic notch as a spatial reference. In doing this, the traditional posterior iliac screw can be placed free-hand, directed inferolaterally towards the anterior inferior iliac spine. (Figure 8B) Alternatively, the surgeon may opt to use fluoroscopy to guide the placement of this screw.

The posterior superior iliac rim screw is then placed. The entry site for this screw is at the expanse of cancellous bone at the superior portion of the resected posterior ilium roughly 1-2 cm inferior to the rim, as described above. The surgeon can then slide a finger in a supra-fascial fashion along the iliac rim, and use this to delineate the course of this screw while cannulating with a standard pedicle probe. (Figure 8C & 8D) With this manual palpation, an accurate screw trajectory parallel to the superior rim of the iliac crest can be established. A depth gauge is used to determine the length of the screw. The posterior superior iliac rim screws are typically about 50 – 60 mm in length and correct placement of the screw can be confirmed with fluoroscopy.

This technique can be performed bilaterally if indicated. The rest of the instrumentation construct can then be assembled. All spinal instrumentation sets are a bit different in their options, and are not specifically designed for this purpose. A sample construct is shown in Figure 8F. Of note, compressors and distractors can also be used to facilitate reduction during this stage of the case if indicated.

Results

All three patients tolerated their aforementioned procedures with no early postoperative surgery-related complications such as infection, venous thromboembolism, or iatrogenic neurovascular injury. Radiographic studies at their last follow-ups showed stable instrumentation constructs with no hardware issues such as pseudoarthrosis, rod breakage, screw pull-out, or hardware-associated fracture.

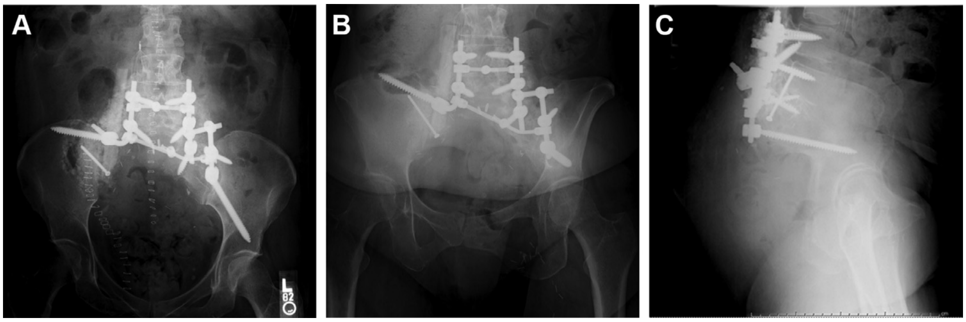

Fig. 5. Case 2 – metastatic sarcoma. Post-operative film (A) following sacrectomy from the L5-S1 level and distal to the right posterior ilium, with lumbosacral reconstruction using the posterior superior iliac rim screw as an alternative to the traditional posterior iliac screw. Radiographic anterior-posterior and lateral studies at 8-month follow-up shows stable fixation (B, C).

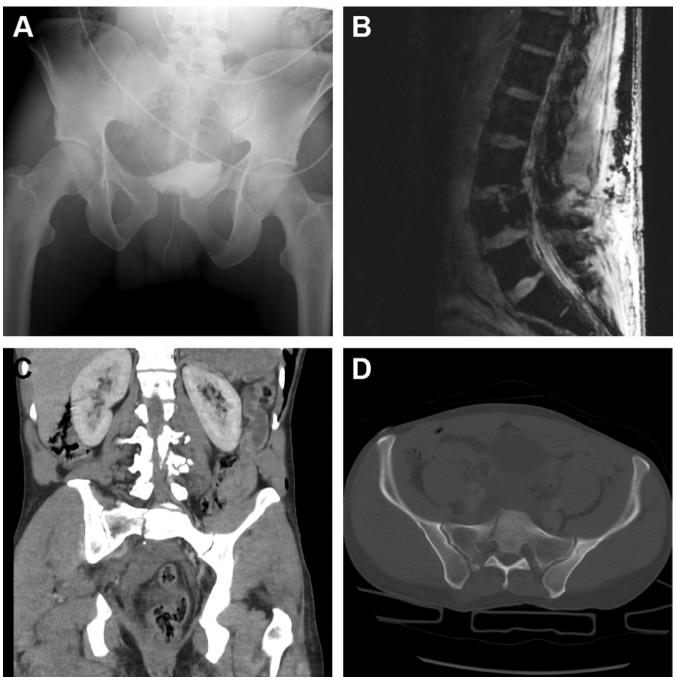

Fig. 6. Case 3 – lumbar and pelvic fractures. Injury plain films (A), MRI (B), and CT (C, D) reveals multiple injuries including L4 burst fracture with retropulsion, L1-L3 transverse process fractures, L5 laminar fracture, right zone II sacral fracture, and pubic diastasis.

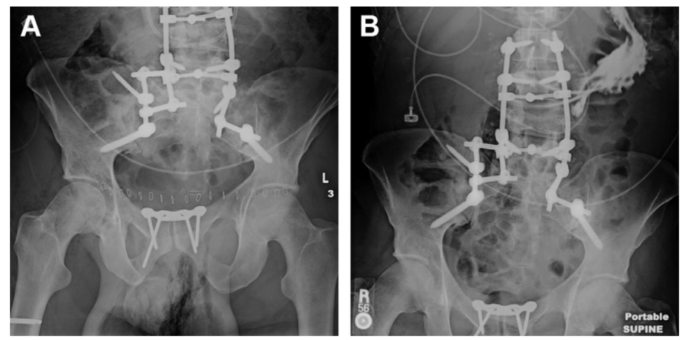

Fig. 7. Case 3 – lumbar and pelvic fractures. Radiographs after surgery (A) and at discharge (B) following posterior lumbar decompression and posterior L2-pelvis instrumented fusion, enhanced with an adjunct posterior superior iliac rim screw on the right.

Discussion

Sacropelvic fixation has been a longstanding challenge in complex spinopelvic reconstructions. The complex anatomy, unique local biomechanical environment, and relatively poor bone quality of the sacrum are all contributing factors to the difficulty of these procedures. In this case series, we have described the technique of using a posterior superior iliac rim screw as an alternative or adjunct to pelvic fixation that we believe has advantages over other iliac constructs. We further elucidated important considerations in patient selection and indications for the posterior superior iliac rim screw.

As described by Yu *et al* in one of the only biomechanical studies of dual iliac screws, the use of bilateral dual iliac screws is biomechanically superior to the more commonly used bilateral single iliac screw in the inferior iliac column [21]. In their testing of multiple dual-screw configurations with a total sacrectomy model, they demonstrated that having one screw each in the superior and inferior columns was biomechanically comparable to the intact control.

However, their biomechanical testing was limited to compression and rotational torsion stiffness. We believe one of the main advantages offered by the adjunct posterior superior iliac rim screw in addition to traditional posterior iliac screws is strength in flexion, which is a major cause of pseudarthrosis and lack of stability in spinopelvic fixation [5]. Similar to the concept of the pivot point pioneered in the landmark study by McCord *et al* [7], in which anterior extension of an iliac screw effectively changes the loading dynamic from a purely in-line pull-out force to a cantilever bend and in-line pull-out mode, the reduced angle between a superior iliac screw and the coronal plane minimizes the pull-out force in flexion. Instead, the flexion force becomes nearly orthogonal to the screw path, thus significantly enhancing the strength of the construct. It is important to consider the technical challenge and learning curve of proper screw placement as further studies are conducted on this novel approach.

The management of the cases presented here were further driven by the clinical anatomy and limited fixation options. General indications for this adjunct iliac rim screw for spinopelvic fixation would include need for increasing the strength of the distal fixation, particularly without adequate sacral purchase, screw orientation considerations to avoid complex 3-dimentional rod contouring, and fracture patterns that prevent adjunct traditional iliac screw placements. Specifically in this study, the extent of the pelvic trauma or metastatic destruction in of sacropelvic anatomy precluded placement of sacral screws. However, there was concern for potential failure of the construct with traditional iliac screws alone. Given the biomechanical advantages of dual iliac screws and the advantage of the posterior superior iliac rim screw in flexion, the decision was made to proceed with this fixation method.

Further clinical considerations for the posterior superior iliac rim screws include patient body habitus. As with the traditional iliac screws, hardware prominence may occur. This is particularly important for patients with a thin body habitus, as hardware prominence without adequate soft tissue coverage can cause disruption in early wound healing, discomfort, pain, and concerns cosmetically. In our cases, we took down the posterior ilium further to the level of the sacrum in anticipation of the posterior superior iliac rim screws and to reduce hardware promi-

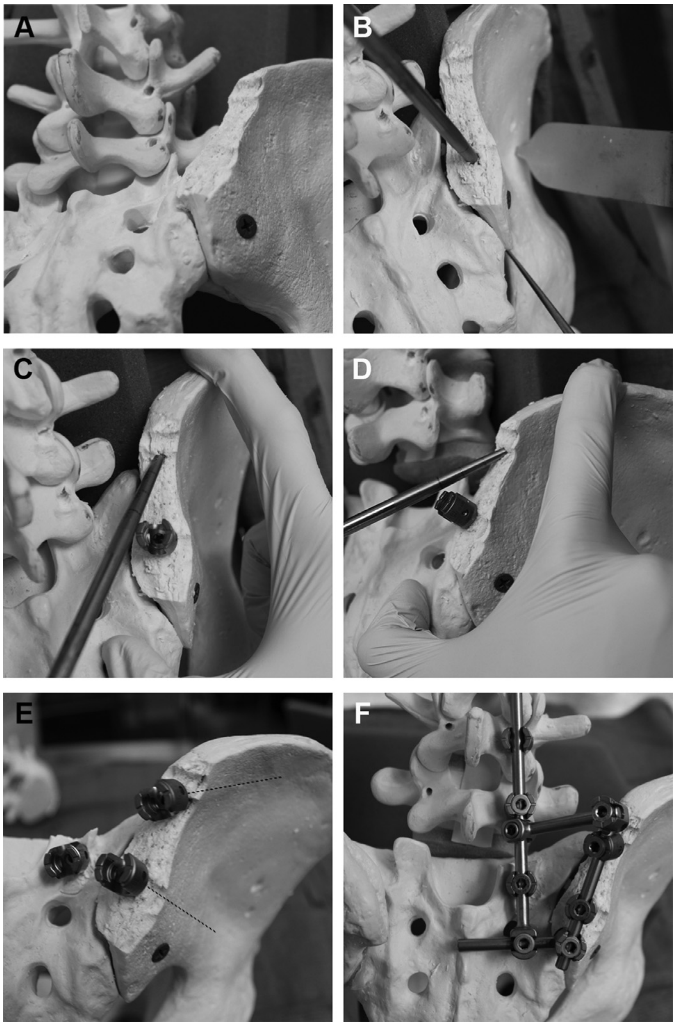

Fig. 8. Key steps of the surgical technique, including resecting the posterior ilium down to the level of the sacrum to decrease hardware prominence (A), placing an instrument at the sciatic notch as a spatial reference to help place the traditional posterior iliac screw (B), sliding a finger along the iliac rim to delineate the course for the posterior superior iliac rim screw with trajectory shown posteriorly (C) and laterally (D), placed screws with sample trajectories outlined using dashed lines (E), and a sample final construct (F).

nence. (Figure 8A) As more cases and studies of this novel technique are performed, further elucidation of optimal patient selection and contraindications is important to determine.

Other salvage techniques for pelvic fixation exist, including the combined S1 and S2 sacral-alar iliac screws and the S3 sacral alar-iliac screw. Mattei et al. describe a case series of five patients that underwent bilateral combined S1 and S2 sacral alar-iliac screws for treatment of pseudoarthrosis after failed pelvic fixation [24]. Mattei further describes an S3 sacral-alar-iliac screw as a salvage technique for those with unfavorable sacral anatomy, with a case report [25]. Both studies present alternative options to the classic S2 sacral-alar iliac screw, but still rely on the integrity of the sacral anatomy. In cases with compromised anatomy of the sacrum as described in the present study, the posterior superior iliac rim screw presents an alternative for pelvic fixation in cases that prevent proper placement of sacral-alar iliac screws.

Our study was too small and the follow-up too short to make definitive conclusions about the longevity and complications of the posterior superior iliac rim screw, but the early experience with this technique appears promising, particularly for anatomically complex fixation. Intraoperative complications such as neurological damage and breaches in the iliac rim cortex were carefully monitored using intraoperative neuromonitoring and fluoroscopy, though the major advantage of this technique is that significant structures at risk in sacral-alar iliac screws such as the superior gluteal vessels and nerve and the sciatic nerve are not at risk. However, as all three patients had notable postoperative functional limitations in ambulation that may affect biomechanical challenges to the construct, the outcomes may not be generalizable to the broader population. Additional clinical and biomechanical investigations are necessary to establish construct strength and clinical applications.

In summary, we have shown that the posterior superior iliac rim screw as an adjunct in spinopelvic reconstruction is a feasible technique for achieving fixation in the lumbosacral spine. This report contributes to the literature on construct augmentation for more complex abnormalities requiring fixation to the pelvis. Though further biomechanical studies and longer follow-up are required before drawing definitive conclusions, mastery of this technique may further enable surgeons to safely achieve lasting sacropelvic fixation.

Informed Patient Consent

The authors declare that informed patient consent was taken from all the patients.

Declaration of Competing Interest

One or more authors declare potential competing financial interests or personal relationships as specified on required ICMJE-NASSJ Disclosure Forms.

Summary sentence

Posterior superior iliac rim screws are a viable adjunct method of fixation for complex spinopelvic reconstructions.

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