



# Minimally Invasive Iliac Screw Insertion: Clinical Case Series and Technical Note

Umesh Srikantha<sup>1</sup>, Yadhu K Lokanath<sup>2</sup>, Akshay Hari<sup>3</sup>, Deepak Somasundar<sup>3</sup>, Ravi Gopal Varma<sup>3</sup>

<sup>1</sup>Aster Hospitals, Bangalore Cluster, Bengaluru, India

<sup>2</sup>Department of Neurosurgery, Aster RV Hospital, Bengaluru, India

<sup>3</sup>Department of Neurosurgery, Centre of Excellence: Brain & Spine, Aster CMI Hospital, Bengaluru, India

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### Corresponding Author:

Yadhu K Lokanath, MBBS, MS  
Department of Neurosurgery, Aster  
RV Hospital, CA-37, 24th Main, 1st  
Phase, J.P.Nagar, Bengaluru,  
Karnataka, 560078, India  
Tel: +91-9886312373  
E-mail: dryadhu2498@gmail.com

**Objective:** To describe the technique of minimally invasive iliac screw insertion by freehand technique and using intraoperative navigation guidance.

**Methods:** Bilateral iliac screws were inserted in total of seven patients. Five patients underwent navigation guided iliac screw placement and freehand technique was performed in 2 patients.

**Results:** Total of 7 patients underwent minimally invasive iliac screw fixation in our series. The pathology in 4 of the cases was spondylodiscitis, among them 2 cases each at L5-S1 and L4-L5, one with the destruction of L5 vertebral body and the other with the destruction of both L4 and L5 vertebral bodies. Of the remaining cases, two cases, one case of sacral insufficiency fracture and the last case was implant failure after L2-L5 oblique lumbar fusion. None of the cases required conversion to open procedure or had wound or hardware related complications till the last follow-up. All patients had an uneventful post-operative period with improvement in pain scores and were mobilized on the 1st postoperative day. One 50-year-old female patient suffering from L5-S1 tubercular spondylodiscitis died due to underlying chronic kidney disease three months post-surgery.

**Conclusion:** Minimal invasive iliac screw placement with or without navigation offers the same biomechanical stability as the open approach but without the need for extensive soft tissue exposure needed for a conventional/open procedure; thereby reducing exposure-related complications, enhancing post-operative recovery and early mobilization. Incorporating intra-operative 3D navigation provides real-time multi-planar images which help in easy planning and safe screw placement whilst reducing radiation exposure.

**Key Words:** Iliac screws, Minimally invasive iliac screw, Percutaneous iliac screw, Navigation guided iliac screw, Lumbo-pelvic stabilization

## INTRODUCTION

Posterior lumbo-pelvic instrumentation is used to treat spinal instability caused by a spectrum of lumbosacral or sacral pathologies. The objective is to provide segmental stabilization

and superior biomechanical stability across the lumbosacral junction and to prevent failure of long segment constructs. Lumbo-pelvic fixation involves the insertion of the iliac screws which can be either a conventional iliac screw or S2 alar-iliac (S2AI) screw [1].

The conventional open iliac screw requires extensive exposure of the posterior portion of the iliac crest and dorsal surface of sacrum up to S2 body and proximal extent depending upon the length of the construct. This exposure requires subperiosteal stripping at the origin of gluteus maximus at posterior superior iliac spine (PSIS), attachments of erector spinae, and multifidus at the medial and lateral surface of the posterior part of the sacrum for anatomical orientation, screw entry point, trajectory guidance and to accommodate rod and lateral connectors.

This extensive exposure damages the dorsal sacroiliac, ilio-lumbar and sacrotuberous ligaments losing their primary restraints function. Disruption of these muscles and ligaments in open technique will lead to soft tissue devascularization leading to wound healing problems, deep hematoma formation, and requiring early secondary surgical procedures in 26% of the patients for wound-related complications [2-4].

Minimal invasive (MI) techniques can overcome the disadvantages of traditional open techniques with better biomechanical stability rates and clinical results. MI approach follows the principles of percutaneous pedicle screw insertion and offers several advantages such as minimizing blood loss and tissue trauma-minimizing paraspinal muscle injury, preserving the attachments to the sacrum and posterior superior iliac spine, lesser infection rates, and faster recovery than the standard open techniques [5]. The intraoperative image guidance assists the surgeons to determine the ideal entry point of the screw and screw trajectory [6,7] in real-time reducing the radiation exposure.

Iliac screws can be inserted either in a conventional open method or by MI technique which can be either navigated (2D/3D) or non-navigated. The non-navigated freehand technique involves screw placement relying on anatomical landmarks minimizing extensive exposure of the ilium to access the entry point and does not require extensive intraoperative fluoroscopy for screw trajectory guidance. On the other hand, navigated iliac screw insertions are entirely image-dependent. This article describes the least invasive techniques of iliac screw insertion which can add to the surgeon's armamentarium for a better outcome.

## MATERIALS AND METHODS

A consecutive series of seven patients were treated with lumbo-pelvic instrumentation for various diseases of the lumbosacral junction. All patients had significant back pain and or leg pain affecting their daily activities. All patients underwent

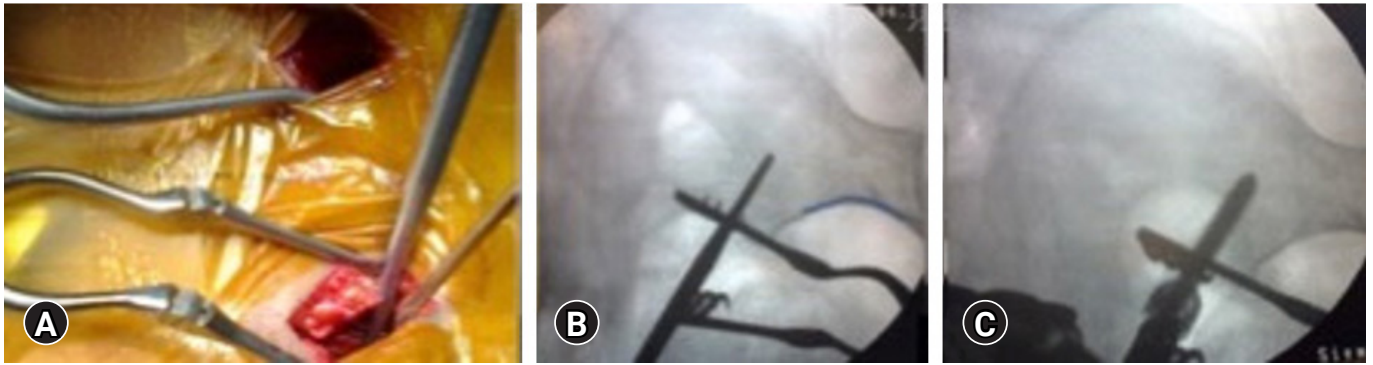
MI insertion of iliac screw bilaterally using navigation guidance (2D/3D) (n=5) or using the free hand-guided technique (n=2). Patients with underlying spondylodiscitis (n=4), osteoporosis (n=2) received antibiotics, antitubercular therapy, and osteoporosis treatment respectively. Post-operative outcome was assessed with respect to post-operative ambulatory status, status of primary disease, wound and implant related complication at last follow up.

### 1. Description of Technique

#### 1) *Freehand Non-Navigated-Guided Iliac Screw Insertion*

The patient is positioned prone on the operative table. The required area is scrubbed and draped maintaining sterile precautions. A 2-3 cm vertical skin incision is made approximately 2 cm medial to PSIS on either side of the midline, using AP (Anterior-posterior) fluoroscopy. Pre-operative assessment of the iliac slope and direction can guide us towards choosing our skin incision. In cases with a wide pelvis, the angulation for the screw may be higher and skin incisions converge more towards the midline, whereas in patients with a narrow pelvis, the iliac wings are more straighter and the screw angulation will be less angulated, placing the skin incisions relatively farther away from the midline. Sharp dissection is carried down towards the PSIS and the fascia over PSIS is split along the entire length of the incision. It is important to correctly orient the direction in which dissection is being to expose the PSIS. After exposure of PSIS, a bony prominence can be palpated at the inferior portion of PSIS and the entry point is 1 cm cranial and medial to that point. Choosing this entry point is important as the ridge of PSIS buries the screw head avoiding screw head prominence. The entry point is again confirmed with an AP fluoroscopic image. Once the entry point is chosen, a cortical window is made using a high-speed drill.

Using a blunt curved pedicle gear shift probe at the entry point directed towards the anterior inferior iliac spine (AIIS) (Figure 1A), the probe is initially aimed laterally avoiding entry into the sacroiliac joint and rotated medially after a length of 2 cm advancing towards AIIS. As the blunt tip of the instrument encounters the dense cortical bone, the probe needs to be rotated 180 degree, thus guiding between the inner and outer iliac tables via tactile feedback maintaining trajectory cephalad to sciatic notch and acetabulum with intermittent AP fluoroscopy (Figure 1B). The screw path is palpated with a ball tip probe to check for cortical breach in the walls of the ilium. If there is doubt of cortical breach, teardrop view after placing a probe can be used to confirm appropriateness on intraosseous screw



**Figure 1.** Intraoperative photograph showing PIS insertion using free hand technique. (A) Using self-retaining retractor the PSIS is exposed and pedicle probe is placed at starting point and advanced towards AIIS. (B) Intraoperative AP fluoroscopy showing pedicle probe to establish the iliac screw pathway above sciatic notch (blue outline) directing towards AIIS. (C) Intraoperative fluoroscopy showing iliac screw in the desired trajectory.

path. Dilatation is carried out in standard fashion and an iliac screw of appropriate length and diameter is inserted after tapping along the screw trajectory (Figure 1C) and screws are interconnected with the rod.

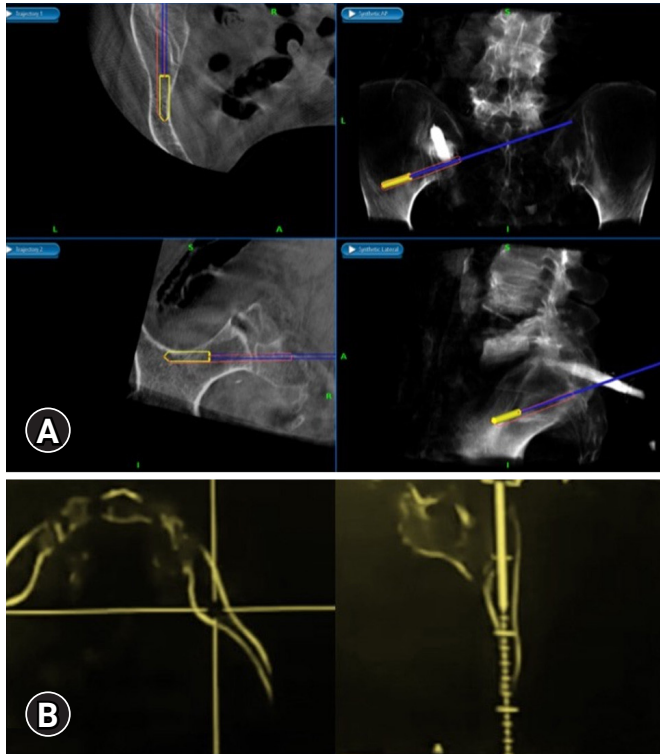
## 2) Image-Guided Navigated Iliac Screw Insertion

The patient is positioned prone on allen table and draping of the patient is performed as illustrated before. PSIS is palpated and the reference frame for navigation is inserted either on the right or left side at the superior lateral margin of PSIS via stab incision. The frame is angled slightly caudally to have an unobscured working field and is important to remain at a fixed position throughout the procedure which is essential for the accuracy of navigation. Next is the image acquisition phase during which the O arm (O-arm<sup>®</sup> O2 Imaging System, Medtronic, 300 Foster St, Littleton, MA 01460, United States) is centred over the lumbosacral junction and spin is performed after confirming the required extent on AP and lateral images. On completion, image data is transferred to the navigation system.

There are many techniques and entry points for iliac screw insertion. Choosing an optimal screw entry point is based on the patient's anatomy and required trajectory which is aimed towards AIIS above the greater sciatic notch not penetrating the sacroiliac joint. With the help of a navigable probe, the skin incision is planned after visualizing the intended trajectory on the navigation screen (Figure 2A) and entry points are marked. 1.5 cm vertical incision, either a paramedian incision on both sides (Figure 3A) or a midline (Figure 3B) incision is made based on the entry points chosen under navigation guidance. Skin, subcutaneous tissue, and fascia are incised without the need for any subperiosteal dissection and without disrupting the muscular and ligamentous attachments. After choosing

the optimal trajectory a navigable jamshidi needle is docked at the starting point and is advanced simultaneously allowing for real-time multiplanar images on the navigation screen (Figure 2B). Once the jamshidi crosses around 50 mm to 60 mm in length, the guidewire (K wire) is inserted internally and the jamshidi needle is removed. Cannulated cancellous screw tap is threaded over the guidewire and is tapped along the trajectory of the screw and ideal screw length is measured on the navigation screen. Iliac screw of adequate length and diameter is inserted under navigation guidance and similar steps are performed on the opposite side. Pedicle screws are cannulated proximally across the lumbar spine in a standard percutaneous fashion. The entire construct is interconnected with the rod after contouring it in the coronal and sagittal plane (two planes) and is passed in sub facial plane from the cephalad to the caudal direction. Wounds are closed in a subcuticular fashion (Case examples; Figure 4-6). Case example 1, 77-year-old female who presented with low back pain affecting her daily activities, examination revealed no deficits. X ray of lumbar spine revealed collapse of L5 vertebral body with endplate destruction at L4 (Figure 4A B). MRI showed L5 vertebral body collapse with altered signal intensity with spondylodiscitis at L4-L5 with enhancing prevertebral soft tissue component causing nerve root compression (Figure 4C-E). Patient was planned for L3 – pelvis stabilization, decompression at L4-L5 with biopsy. Histopathology report was suggestive of tubercular spondylodiscitis and antitubercular therapy was initiated. Follow up MRI and X ray at 1 year revealed disease resolution with symptomatic improvement (Figure 4F-I).

Case example 2, 69-year-old female, known case of rheumatoid arthritis presented with severe low back pain, inability to stand and walk, normal neurology on examination. Imaging



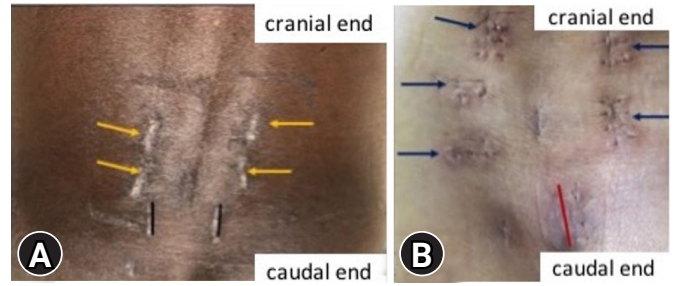
**Figure 2.** (A) Showing multiplanar navigated image demonstrating planned trajectory (red line) and real-time screw trajectory (blue line) and estimating screw length (yellow box). (B) Real-time navigation multiplanar images showing screw trajectory.

revealed zone 1 sacral insufficiency with displacement (Figure 5A–D) with T score of –3.3 on DEXA scan. Patient underwent MI pedicle and iliac screw fixation (L3–pelvis) and was mobilized on day 1 with good reduction in her back pain. Immediate postoperative X-ray showing lumbopelvic construct from L3 to the pelvis (Figure 5E).

Case example 3, a 50-year-old male presented with low back pain, bilateral lower limb radiculopathy, and difficulty in walking. Imaging and biopsy at L4–L5, was suggestive of bacterial spondylodiscitis. Because of his worsening clinical condition, repeat imaging was performed revealed progression of disease with L5–S1 endplate irregularity, enhancing intervertebral disc and epidural collection causing neural compression (Figure 6A–D). Patient underwent MI L5–S1 transforaminal interbody fusion, pedicle, and iliac screw placement. Postoperatively, patient had good reduction of radicular and back pain with the resolution of disease in follow up period (Figure 6E–H).

## RESULTS

A total of 7 patients (5 women and 2 men) underwent per-



**Figure 3.** Showing iliac screw entry points. (A) Paramedian region (black line). (B) Midline (redline). Yellow and blue arrows indicate pedicle screw entry points.

cutaneous iliac screw (PIS) fixation (5 navigated and 2 non navigated- freehand) for various pathological conditions of the lumbosacral spine. Two patients had interbody cages with allografts within and around them placed at the L5–S1 level. The majority of the cases (n=4) were spondylodiscitis. All patients underwent successful PIS fixation, with no intraoperative and immediate postoperative complications. No patients required conversion to open procedure and all patients were mobilized on postoperative day 1 with significant relief in pre-operative back pain. None of the patients had wound or hardware related complications till the last follow-up. However, one patient of L5–S1 tubercular spondylodiscitis succumbed three months post-surgery due to a cause unrelated to surgery but due to pre-existing chronic kidney disease (Table 1).

## DISCUSSION

The objective of the lumbo-pelvic construct is to produce triangulation effect, reducing screw pull-out, torsional stability [8], reducing stress on S1 screw, and provide adequate stabilization.

Although there are several methods for pelvic fixation which have been described, iliac screws offer superior biomechanical stability as it involves placing the screw in zone III-both iliac wings (O’Brien et al. classification) making the construct biomechanically superior as the screw is inserted anterior to the lumbosacral pivot point in sagittal and lateral to it in coronal plane acting as stable distal anchors [9].

Conventional open iliac screw fixation has been the standard of treatment for various conditions requiring lumbo-pelvic fixation, but owing to its potential complication there is an increasing trend towards adapting MI technique of iliac screw insertion. MI placement of iliac screws requires accurate pre-operative strategy in terms of incision planning and placement, desired screw trajectory, appropriate rod contouring, and opti-



**Figure 4.** Case example 1. (A, B) Preoperative AP/lateral X rays showing 50% collapse of L5 vertebral body with the destruction of the inferior endplate of L4 and superior endplate L5 (red circle). (C–E) Sagittal T2 and coronal STIR images showing L5 vertebral body collapse with loss of 50%–60% height with alerted signal intensity involving inferior endplate of L4 and superior endplate of L5 with prevertebral enhancing soft tissue component causing nerve root compression. (F, G) Postoperative MRI sagittal T1 and T2 at 1 year follow up (after completion of full course of antitubercular therapy) showing remodelling of L5 vertebral body with signal intensity changes. (H, I) Post-operative lateral/AP X-rays showing L3 – pelvis instrumentation at 1 year follow up.

mal screw characteristic in terms of screw diameter and length.

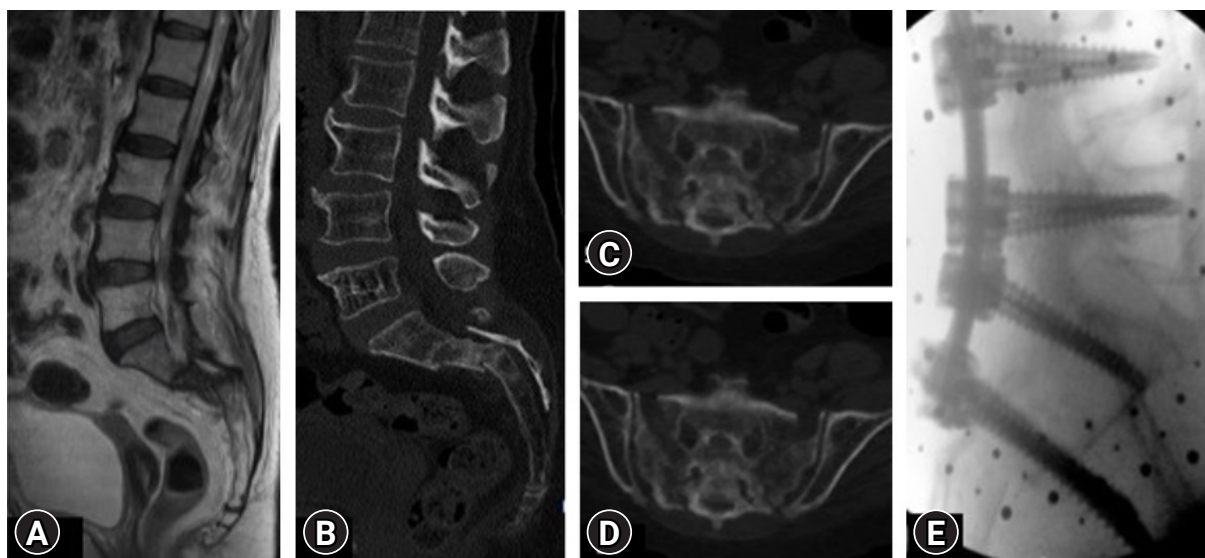
In MI insertion a midline incision can be planned based on navigation and in a non-navigated freehand technique, an incision can be placed medial to PSIS. The advantage with the midline incision is, there would be roughly 1.5–2 cm depth at which screw head is placed and soft tissue acts as an envelope covering the screw head and avoiding screw head prominence especially in thin individuals. The other advantage of a single midline incision is it would reduce the total number of incisions.

About trajectory planning, two trajectories are available for iliac screw placement, the first one is guided towards the superior rim of the acetabulum, and the second one directs to AIIS [10], with entry points starting at the PSIS. The trajectory towards AIIS offers a longer screw and avoids the risk of ace-

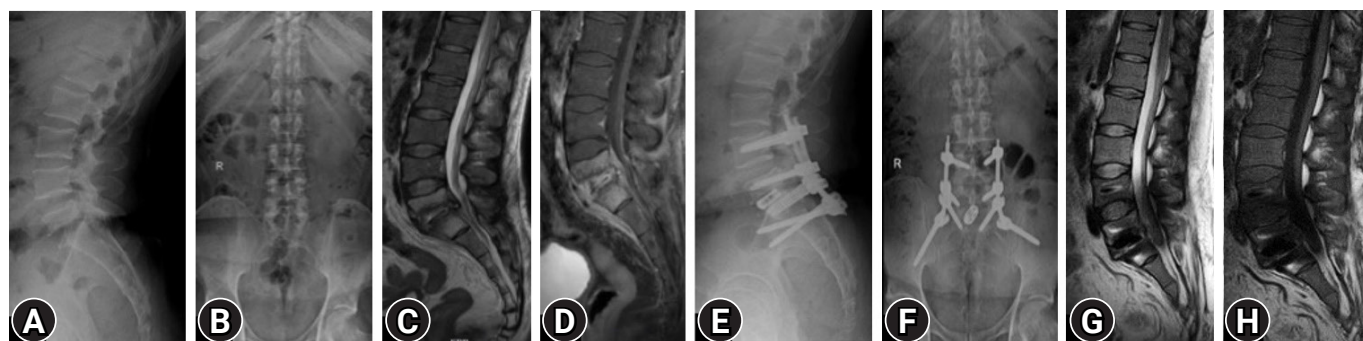
tabular violation [11]. Irrespective of the technique and image assistance used the ideal trajectory would aim to direct screw towards AIIS above 1–2 cm of the sciatic notch, above the acetabulum with 20–45 degrees caudal inclination and lateral inclination of around 30–45 degrees.

Imaging is the key to safe screw placement, with intraoperative O arm and navigation multiplanar real-time images are obtained on the screen which facilitates choosing the right screw entry point, desired trajectory, and right screw length and diameter. On the other hand, freehand techniques are based on anatomical points.

The freehand technique as described by Fridley et al. [12] uses the superior edge of the lamina and spinous process of L5 as anatomical landmarks. The shafts of the pedicle probe should be parallel to the L5 lamina and the shaft of the pedicle



**Figure 5.** Case example 2. (A–D) MRI T2 sagittal, CT sagittal, and axial sections revealed zone 1 sacral insufficiency with displacement with linear fracture extending from S1 to S5 on the right side, and S1 to S3 left side. (E) Postoperative X-ray (lateral view) showing lumbo-pelvic construct from L3 to the pelvis.



**Figure 6.** Case example 3. (A, B) Preoperative AP/lateral X-rays showing with endplate irregularity (L5 lower and S1 upper endplate). (C, D) Preoperative MRI-Sagittal T2 and T1+C showing signal changes in vertebral bodies with erosions of adjoining endplates involving L5 & S1 and the intervening disc with epidural collection causing compression on thecal sac and nerve roots. (E, F) Post-operative X-rays AP/lateral at one month showing L4–L5 interbody cage, pedicle, and iliac screw at 1 month. (G, H) Post-operative MRI sagittal T2, T1 at 6 months revealing remodelling of L5, S1 vertebral body with no evidence of epidural collection.

probe of both sides should intersect each other at the L5 spinous process. If the screw follows the correct path, the path of the probe never goes over the L5–S1 facet joint on the AP fluoroscopy view, and also AP view will assist in preventing sciatic notch violations.

Intraoperative fluoroscopy is of absolute necessity, there are numerous fluoroscopic views and true lateral view in which sciatic notches are superimposed is the primary view for screw insertion. The teardrop view will help in inserting a screw in the widest part ilium which is the centre part on the teardrop view and the screw should be confined within the bony margins of the teardrop on the obturator outlet view. The others additional views which can be used are the obturator inlet view and iliac

oblique view. Screw characteristics are of paramount importance, the most commonly used iliac screws are 7.5 cm in diameter and length of 60–80 mm [13,14]. In our series, all screws were more than 6.5 mm in diameter and 60 mm in length with the largest measuring 7 mm in diameter and 70 mm in length. Another technical difficulty is rod contouring and connecting to the proximal construct which needs special attention, rod is always fashioned in two planes – coronal and sagittal. The rod has to be contoured to have a hyperacute lordotic bend of around 30 degrees in the distal-most segment of the rod to facilitate easier connection and the rod has to be always passed from cephalad to caudal. The presence of S1 screw necessitates contouring of a shorter segment of the rod to link S1 and iliac

**Table 1.** Showing demographic details of clinical series

Age	Sex	Diagnosis	Procedure	Post-operative ambulatory status	Primary pathology	Follow up duration (mo)	Implant status at last follow-up	Wound Complications
1	50	M	L4-L5 tubercular spondylodiscitis destruction of L5 body	MIS L3-Iliac navigated screw fixation	Healed	15	No implant related complication	None
2	77	F	L4-L5 tubercular spondylodiscitis destruction of L4, L5 body	MIS L3-Iliac non navigated screw fixation	Healed	24	No implant related complication	None
3	59	F	Zone 1 sacral insufficiency fracture with linear fracture along with S2 with osteoporosis and RA	MIS L4-S1-Iliac navigated screw fixation	Healed	36	No implant related complication	None
4	50	M	Zone 2 sacral insufficiency fracture osteoporosis	MIS L4-S1-Iliac non navigated screw fixation	Healed	24	No implant related complication	None
5	60	F	Implant failure with screw loosening in operated case of L2-3, L3-4, L4-5 OLIIF	MIS L1-Iliac navigated screw fixation	Healed	12	No implant related complication	None
6	50	F	L5-S1 tubercular spondylodiscitis with chronic kidney disease	RT MIS L5-S1 navigated TLIF with L4 to Iliac screw fixation	Death at 3 months due to underlying chronic kidney disease	3	No implant related complication	None
7	69	F	L5-S1 E. coli spondylodiscitis with cirrhosis of the liver	RT MIS L5-S1 navigated TLIF with L4 to Iliac screw fixation	Healed	36	No implant related complication	None

screw head. In indicated cases, it is always preferable to have anterior support especially those constructs extending into the dorsal spine. The use of an interbody cage in anterior reconstruction will not only remove stress on posterior instruments but also promotes fusion. The objective of any lumbo-pelvic construct is to prevent failure and increase the stability of construct, whether a single or dual iliac screw (DIS) is adequate depends on clinical situations. DIS when compared with a single iliac screw, DIS is optimum in terms of stability at the caudal part of the spinopelvic construct and offers higher construct stiffness with respect to compression and torsion. DIS can also be performed by MIS fashion which is described by Hasan and Liu [15].

Use of O arm and navigation renders 3D visualization of bony structures, helps in planning the desired trajectory and guiding the screw with real-time multiplanar images eliminating fluoroscopic exposure and determine the suitable entry point of the screw, screw trajectory [7,13] and maximizing screw length and diameter. Utilizing a submuscular or MI approach to the PSIS and sacrum may reduce soft tissue complications avoiding disruption of erector spinae muscle, posterior sacroiliac, and interosseous iliac ligament contributing to lower infection rates and more rapid recovery than the standard open techniques.

Emami et al. [13] and Tsuchiya et al. [14] group reported various wound and hardware-related complications following the open screw technique. Though there are direct no comparative data between open and percutaneous techniques to assess hardware and wound complications, Liu et al. [16] and Wang et al. [17] group reported no wound or hardware related complications in their case series of PIS insertion.

Liu et al. [16] and Wang et al. [17] group performed PIS insertion in 5 and 24 patients respectively using intraoperative fluoroscopy as a key primary tool for image guidance and screw insertion with the removal of cortical bone to accommodate the screw head [17]. In contrast, our technique of freehand MIS iliac screw placement is based on anatomical landmarks which reduce the overall time of radiation exposure with minimal insult to supporting structure of ilium and PSIS and use of navigation would facilitate in planning appropriate and accurate entry points, trajectory, and screw insertion.

Wound closure should always be in a layered fashion and all efforts should be made to close the fascia to avoid hardware prominence especially in the paramedian incision. Ultimately, larger clinical series is required to demonstrate the safety of this technique.

## CONCLUSION

Lumbo-pelvic instrumentation technique has been redefined over the decade. Percutaneous insertion of the iliac screw can safely be performed without bony violation along screw trajectory with limited soft tissue damage offering the same biomechanical stability and overcoming the disadvantages of open iliac screw insertion.

## CONFLICT OF INTEREST

No potential conflict of interest relevant to this article.

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