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Single Incision Posteromedial to Ventrolateral (PML) Surgical Technique for Minimally Invasive Sacroiliac Joint Fusion

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Summary of Background Data: Sacroiliac joint fusion transfixing procedures place implants across 3 bone cortices. The most studied trajectory is lateral to medial. While the safety and effectiveness of this trajectory have been well documented, concerns of vascular injury involving the branches of the SGA over the lateral ilium have been raised. In heavier patients, a straight lateral-to-medial trajectory frequently requires traversing through a significant amount of soft tissue. While the posterolateral transfixing trajectory decreases the amount of soft tissue dissection, concerns of inferior patient outcomes and biomechanical stability have been published. Herein, we describe a new transfixing procedure for SIJ fusion with implants starting on the dorsal sacrum with a posteromedial to ventrolateral (sacro-alar iliac) implant trajectory.

Methods: A case video of posteriomedial to ventrolateral SIJ fusion demonstrates the operative technique and is accompanied by a step-by-step description of this technique. Four cases are presented.

Conclusions: The posteromedial to ventrolateral operative trajectory allows for minimally invasive bilateral SIJ fusion through a single incision with minimal tissue disruption and avoids branches of the superior gluteal artery.

Key Words: minimally invasive, sacroiliac joint, sacroiliac joint fusion, technique, posteromedial SI joint fusion

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Sacroiliac (SI) joint dysfunction is a common source of back pain. Moreover, sacroiliac joint pain after lumbar fusion has been reported in up to 33% of patients.[1] The greater the number of motion segments included in the lumbosacral fusion, the greater the incidence of SI joint pain or degeneration.[2] SI joint fusion is a well-accepted treatment for chronic SIJ pain refractory to nonsurgical treatment.[3–5] Historically performed by spine-trained surgeons, interventional physicians have begun to adopt various procedures for fusing the SI joint.

Minimally invasive surgical (MIS) approaches for a SI joint fusion were popularized in the 2000s.[6–8] These procedures involve placing specially designed fusion implants across the SI joint with a lateral to medial (iliosacral) trajectory and evolved from techniques developed by trauma surgeons for treating SI joint disruptions and fractures of the pelvis.[9] MIS SIJ fusion procedures that include placement of implants across multiple bone cortices and the SI joint are described as transfixing or transverse procedures.

An alternative procedure for MIS SI joint fusion, described as intra-articular or in line, has recently been popularized by interventional physicians. This procedure describes placement of structural bone allograft or metallic devices into (intra-articular) or in line with the SI joint to stabilize and fuse the SI joint. Additional implant variations include implants placed in line with the SI joint that span the SI joint, engaging the ilium and sacrum with pontoons or devices placed into the SI joint that have device elements that engage with the lateral cortex of the sacrum and/or the medial cortex of the ilium. These trajectories and bone products have been popularized by the interventional physician community in an effort to perform MIS SIJ fusion using a procedure that requires less soft tissue dissection and with an implant placement strategy that avoids risk to the vasculature of the lateral pelvic area.[10]

MIS SIJ fusion with transfixing/transverse procedures, where implants pass through the ilium cross the joint space and anchor within the sacrum, is currently considered the gold standard treatment. SIJ fusion using a transfixing approach may be achieved with implants placed direct lateral to medial or with implants placed posterolateral to ventromedial. The safety and effectiveness of lateral SIJF is supported by > 130 published articles, including 2 randomized controlled trials, numerous multicenter single-arm series, prospective clinical and radiographic outcomes to 5 years, and cadaver and FEA model biomechanical studies.[3,11–14] The lateral approach is quite straightforward with clear views of the implant employing pelvic imaging that is familiar and easily understood. Complications with the lateral approach primarily relate to suboptimal implant placement, including violation of the S1 or S2 neuroforamen and L5 nerve impingement secondary to implant placement that violates the osseous envelope of the sacrum with the tip of the implant cephalad or ventral to the sacral cortex.[11,15–17] Excessive bleeding, likely due to injury to lateral branches of the superior gluteal artery (SGA) has also been reported. In a large meta-analysis, the rate of symptomatic implant malposition was 0.43%, and bleeding requiring intervention was reported at 0.04%.[3] Case series have corroborated the rates of vascular injury reported from company-sponsored trials, with an incidence of 0.6%–1.2%.[18,19] Sacral dysmorphism has been suggested as a potential factor leading to increased rate of SGA branches in the target trajectory for laterally placed implants. However, the literature is conflicting.[20,21]

The posterolateral variation of the transfixing/transverse procedure was developed to reduce the amount of soft tissue dissection required to place implants across the SIJ. Implants placed in this trajectory are placed with a starting position on the lateral ilium near the posterior superior iliac spine (PSIS), traverse the ilium and the SI joint, and are then anchored in the sacral ala.[22] While seemingly straightforward, this trajectory presents technical challenges and is likely both biologically and biomechanically disadvantaged.

Technical challenges are related to the obliquity of the approach, proximity of major vascular structures in the pelvis, and poor bone quality. During initial pin placement, the marked obliquity of the angle of bone engagement may result in skiving off the bone during initial bone access. Major neurovascular structures are located just anterior to the sacrum, directly in line with implant trajectory. Thus, penetration of the anterior sacral cortex has potentially fatal consequences. To date there is minimal prospective data supporting the safety of the posterolateral approach. Complaint reporting mechanisms such as the FDA Manufacturer and User Facility Device Experience (MAUDE) database (https://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfMAUDE/search.cfm) should not be used to infer a low rate of adverse events/patient injury. Finally, implants placed with a posterolateral trajectory are anchored in the sacral ala. Sacral alar bone density is poor in healthy patients, and is markedly decreased in patients with osteoporosis.[23–25]

The posterolateral trajectory is biomechanically disadvantaged. In this trajectory, implants are oblique to the primary axis of joint motion. Biomechanical studies have demonstrated that implants placed in this oblique-to-rotational axis position provide lower stability compared with a direct lateral approach.[26] This may be due to the fact that rather than a direct compression across the articular portion of the SI joint, implants in this trajectory cross the dorsal ligamentous portion of the SI joint. The surfaces of the sacrum and ilium are typically separated by 10–15mm in this area; joint compression impossible with this trajectory. Moreover, ligamentous tissue is avascular and not conducive to bone formation, limiting the possibility of joint fusion.

Finally, in a large meta-analysis reporting on the 2 variations of the transfixing procedure and the intra-articular/in line procedure, posterolateral transfixing had lower functional improvements compared with lateral transfixing (ODI improvement of 6.8 points vs. 25.9 points for lateral).[3] Thus the posterolateral variation of the transfixing procedure does not provide an ideal solution to address concerns with the lateral approach.

Sacroiliac joint pain and degeneration are common occurrences after lumbar spinal fusion. Weighted averages from a large meta-analysis (n = 3363 patients, n = 21 studies) report a 38% rate of SIJ degeneration and 24% rate of SIJ pain after lumbar arthrodesis.[1] This is not surprising given our knowledge of the downstream biomechanical consequences of lumbar fusion. Arthrodesis at L5-S1 increases the load on the SIJ by 52%, and this more than triples to 168% when fusing L4-S1.[27,28]

In recent years, S2AI spinopelvic fixation has become an increasing popular adjunct to spinal instrumentation as surgeons attempt to reduce L5-S1 pseudarthrosis rates, mitigate rod fractures, proactively address SIJ-related pain, and provide a firm foundation for long deformity constructs.[29,30] Indeed, biomechanical studies show low rates of mechanical failure with S2AI fixation when used in lumbopelvic surgery.[31] Adding a second point of fixation across the SI joint with a second implant fixed to the longitudinal rods or with an SI joint fusion implant that is not connected to the spinal instrumentation demonstrates additional biomechanical benefits and may provide clinical benefit as well.[32] Early results from a prospective multicenter international randomized control trial show that placement of 2 implants, one screw and one triangular titanium fusion implant, can be safely placed through the SAI corridor.[33]

As SI joint fusion placing multiple implants across the SI joint in a sacroalar iliac trajectory fusion has been shown to be a safe adjunct to spinal fusion, it is natural to evaluate this technique as a stand-alone (independent of spinal instrumentation) method of stabilizing and fusing the SI joint. There are several advantages to this variation of the transfixing procedure. First, the depth of the soft tissues in this trajectory is markedly less than the soft tissues encountered with the lateral procedure variation. Second, this trajectory avoids the vasculature that may be encountered with a lateral approach. Third, it allows bilateral SI joint fusion through a single midline incision, with the surgeon remaining on one side of the patient. However, it is not without risk. Imaging is essential to avoid a ventral breach of the ilium. Herein, we describe the technique of posteromedial to ventrolateral lateral (SAI) fusion of the SI joint and present 4 cases where this technique was used successfully.

SURGICAL TECHNIQUE

The procedure described herein is demonstrated in the accompanying video, Supplemental Digital Content 1, http://links.lww.com/CLINSPINE/A389. The procedure is performed with the patient in the prone position on a radiolucent table. Bolsters are placed under the chest, and pelvis, to maintain a neutral position of spine and hips and to decrease intra-abdominal pressure. Clear and accurate imaging is essential for safe and optimal implant placement. Before making the initial incision, obtain clear pelvic inlet, outlet, teardrop, and lateral views.

Guidance for Imaging

True Lateral

A true lateral view shows sciatic notches and iliac cortical densities (alar lines) to be superimposed.

Teardrop View

Begin in the AP view. The teardrop view is oblique in 2 planes. From the AP view, the image intensifier should be tilted cranially, ~20–40 degrees, oblique relative to midline.

Pelvic Inlet View

Begin with an AP image. Then tilt the image intensifier caudally ~20–30 degrees until the sacral promontory and the S1 and S2 vestigial disc overlap, appearing as a single line.

Pelvic Outlet View

Begin from AP and tilt the image intensifier cranially ~30–40 degrees until the S1 and S2 neuroforamen are well visualized.

Incision and Needle Placement

- Standard prep and drape are performed allowing access to the lower lumbar spine and dorsal sacrum.
- Begin the procedure in the outlet view. Place a guide pin on the skin transverse to the long axis of the patient. Make a small transverse skin mark in the midline at the level of the S2 neuroforamen. Make a second transverse mark in the midline at the level of the S1 neuroforamen.
- Make a 1–1.5 cm incision through the skin in the midline connecting the 2 transverse skin marks. Take care to avoid cutting the supraspinous ligament.
- Place an 11-gauge Jamshidi needle with a bevel tip through the incision, entering the fascia just off midline on the operative side.
- Advance the needle until the tip is positioned on the dorsal sacrum at the level of the S2 body in line with the lateral margin of the S1 and S2 neuroforamen (Fig. 1). A slightly more medial starting point ensures that the implant fully engages the sacrum before transfixing the joint. The needle tip should be oriented so that the bevel is pointing down (as viewed on the inlet view) to facilitate engagement with the dorsal sacral cortex and minimize skiving. The needle is typically positioned at an angle 45 degrees from horizontal and is aiming inferolateral towards the caudal third of the teardrop. In this trajectory the needle will be pointing towards the greater trochanter of the proximal femur, which is easily palpated in almost all patients. The trajectory is inferolateral (about 45 degrees posterior to anterior and about 45 degrees cephalad to caudal).
- Dock the needle into the dorsal sacrum and advance it ~1 cm into bone.
- Confirm needle trajectory on the teardrop, the inlet view and the outlet views. On the teardrop view, the needle should be aimed at the inferior third of the teardrop (Fig. 2). On the inlet view, the needle trajectory should be above the pelvic brim and positioned such that it will bisect the articular sacroiliac joint. Oblique the inlet view by 10–15-degree away from the operative side to align the Image intensifier with the articular SI joint to clearly visualize the articular SI joint. On the lateral view the needle trajectory should be just above the sciatic notch.
- Under the inlet view, advance the Jamshidi needle by applying axial force with a gentle clockwise/counterclockwise rotation of the needle. Assess the trajectory of the needle under the inlet and teardrop views. When the needle tip is at the level of the SI joint, you will feel the increased resistance as the needle contacts the dense cortex of the medial ilium. At this point, the needle should be rotated 180 degrees so the bevel tip is aimed upward. This will facilitate entry of the needle into the ilium and minimize medial/ventral needle skiving.
- Confirm needle position and trajectory on the inlet, teardrop, and lateral views.
- Return to the inlet view and continue to advance needle until it is well set (at least 30 mm) into the ilium.

Guide Pin Placement

- Remove the stylet and place a guide pin through the needle. The pin should extend beyond the tip of the needle, and you should palpate a firm end point in the ilium as the pin contacts the lateral cortex of the ilium. A soft end point may indicate that the guide pin has violated the lateral iliac cortex and needle repositioning is required.
- On the inlet view, confirm that the needle and guide pin do not violate the ventral cortex. The tip of the Jamshidi needle and the guide pin must remain within the iliac teardrop or just lateral to the teardrop.
- If the tip of the needle and the tip of the pin are medial to the teardrop on the teardrop view, this indicates that the needle is not across the SI joint.

Implant Placement

- If using a self-drilling and self-tapping implant, the implant can typically be placed without additional bone preparation.
- In patients with hard bone, or in instances where advancing the implant requires significant force, the bone channel can be prepared by drilling and tapping. Remove the Jamshidi needle leaving the pin in place

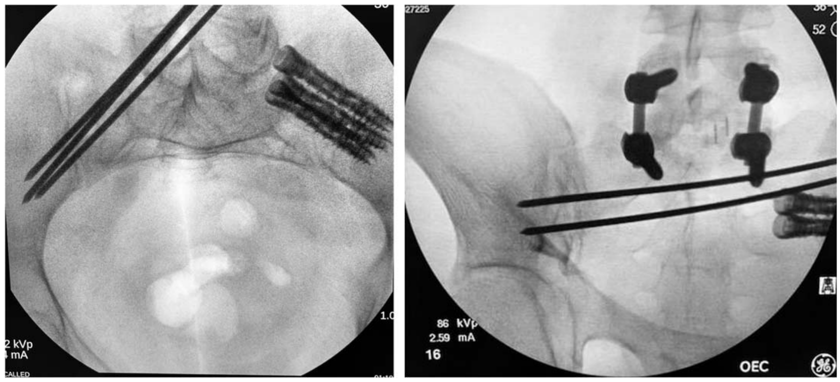

FIGURE 1. Inlet (A) and outlet (B) views of needle placement across the SI joint. full color online

positioned across the SI joint.

- Determine implant length by measuring the amount of the pin that is engaged in bone using a depth gauge. The selected implant should be at least 60–70 mm in length. Anything shorter will likely not adequately engage both the sacrum and the ilium in this trajectory. The typical depth of the sacrum from the dorsal cortex to the sacroiliac joint is 40 mm.
- The selected implant is then inserted over the pin confirming the pin remains in place until the implant is advanced well across the SI joint. The pin is removed, and the implant is advanced to final depth using 2-finger tightening, taking care to avoid countersinking the implant.
- Obtain final imaging in the pelvic inlet, outlet, teardrop, and lateral views. The procedural steps are then be repeated for additional implant placement (Fig. 3).
- Place a second guide pin using a parallel pin guide or place the Jamshidi needle freehand. A third implant is optional depending on the bone corridor.
- Sequential steps are visible in Figure 4.

PEARLS AND PITFALLS

Pearls

This transfixing approach:

- avoids major neural and vascular structures,
- minimizes the amount of soft tissue in the implant path,
- allows for bilateral implant placement through a single incision, without the surgeon moving to the other side of the table,
- and may be used as an adjunct to sacroalar iliac spinopelvic fixation in spinal deformity surgeries.

This approach may be biomechanically advantaged as:

- it allows for placement of longer implants that are anchored between the inner and outer cortical tables of the ilium,
- the implants cross the articular portion of the SI joint crossing the dense subchondral bone, and
- the implants cross the articular portion of the SI joint where the articular surfaces are closely approximated.

Pitfalls

- Clear imaging is essential. Failure to obtain quality imaging may result in suboptimal implant placement.
- The Teardrop view may not be familiar to all physicians wanting to use this approach.
- Ventral breach of the ilium is possible.
- Care must be taken to avoid the nerve roots exiting the sacral neuroforamina.
- There may be a steeper learning curve for physicians not trained in placing implants in a sacroalar iliac trajectory.

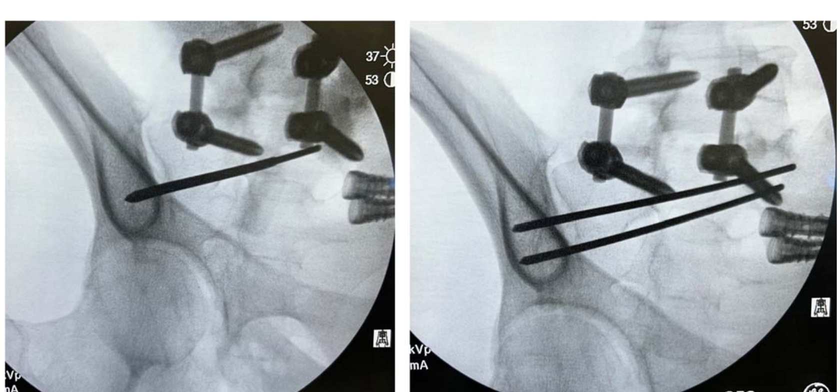

FIGURE 2. Confirm needle trajectory on the teardrop view. full color online

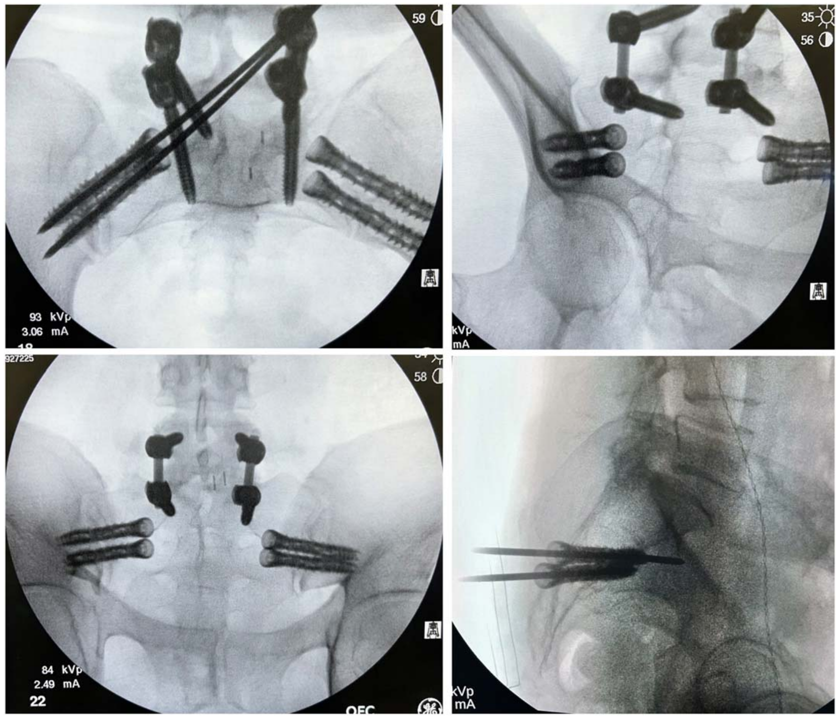

FIGURE 3. Implant placement in the outlet, inlet, teardrop, and lateral views. full color online

FIGURE 4. Sequential steps of the procedure. full color online

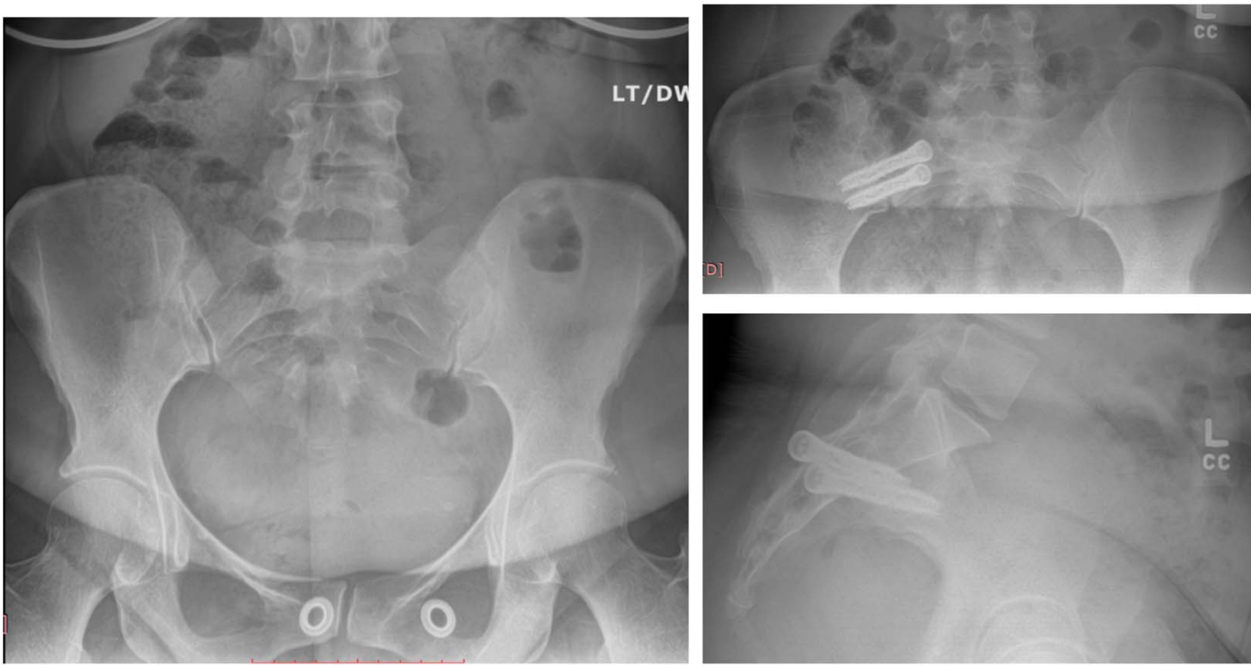

FIGURE 5. Case 1: primary right SI joint fusion. full color online

CASE EXPERIENCE

Patients were diagnosed with SI joint dysfunction if they had a positive response to at least 3 physical provocative maneuvers specific to the SI joint, and experienced at least 75% improvement in pain following a diagnostic injection. After failing conservative measures, discussion of the risks and potential benefits, patients underwent MIS SI joint fusion with implants placed in the posteromedial to ventrolateral trajectory. Blood loss was minimal in all cases. Patients were immediately weight-bearing as tolerated.

Case #1: Primary Right SI Joint Fusion

A 34-year-old Caucasian female presented with severe right-sided lower back, hip, and leg pain, rated as 10 out of 10. Oswestry disability index (ODI) score was 50. Lumbar spine MRI and x-rays were unremarkable. Patient underwent right-sided SIJ fusion with 2 implants in the PML trajectory. At 6 months postoperatively, she reports near complete resolution of her pain (NRS 1) and a 90% reduction in her ODI. X-rays show good implant placement (Fig. 5).

Case #2: Bilateral SIJ Fusion After Previous L2-S1 Fusion

An 81-year-old female, 36.7 BMI presented with severe lower back pain, rated as 10 out of 10, after previous L2-S1 spinal fusion. Her ODI was 54. Lumbar spine MRI showed no evidence of pseudarthrosis or adjacent level disease. Physical exam was positive for 4 SI joint provocative tests. Subsequent diagnostic injections resulted in 75% pain relief.

At 3 months postoperatively, patient reported complete resolution of her SI joint pain. Imaging shows all implants intact (Fig. 6).

FIGURE 6. Case 2: Bilateral SIJ fusion after previous L2-S1 fusion. full color online

CONCLUSIONS

MIS SIJ fusion using a posteromedial to ventrolateral trajectory is a straightforward procedure, allowing bilateral treatment through a single incision. This variation of the transfixing procedure approach avoids the lateral neural and vascular structures at risk during lateral SIJ fusion. This technique is a modification of the sacroalar iliac trajectory used in spinopelvic fixation.

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