Perpendicular Iliac Screw Placement for Reinforcement of Spinopelvic Stabilization

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Abstract: Iliac fixation is indicated to provide spinopelvic stabilization in select cases of long segment thoracolumbar spine fusion, spinal osteotomy/realignment, trauma, and instability caused by tumor or infection. Traditional iliac fixation with iliac screws or S2 alar/iliac (S2AI) screws may provide inadequate fixation in select clinical scenarios, such as severely compromised bone quality or spinopelvic dissociation. The purpose of this article is to describe the perpendicular iliac screw technique with ipsilateral iliac crest screw plus S2AI fixation. The technique may be applied for select individuals in cases of 3-column osteotomy in the lower lumbar spine, spinopelvic dissociation (caused by trauma, neoplasm, or Charcot arthropathy), and failure of previous iliac fixation and when anatomic constraints limit standard iliac screw or S2AI screw placement. [Orthopedics. 2016; 39(6):e1209-e1212.]

Sacropelvic screw fixation in spinal surgery is commonly used for patients undergoing correction of spinal deformity, with additional applications in spinal trauma, tumor, infection, and degenerative conditions. Current techniques to enhance spinopelvic stabilization include multiple rod constructs, bicortical S1 pedicle screws, traditional iliac screws, S2 alar/iliac (S2AI) screws, and anterior interbody supports. Iliac screw fixation improves construct stability and lumbosacral fusion rate. However, traditional iliac screws are associated with high rates of symptomatic hardware prominence, skin breakdown, and the need for implant removal. The S2AI screw trajectory was developed to allow placement of long, large diameter iliac screws with the screw heads situated below the level of the posterior superior iliac spine. Compared with standard iliac screws, placement of an S2AI screw requires less soft tissue dissection. There is also less offset of the polyaxial head relative to that of the S1 pedicle screw, allowing for simplified seating of the rod. Recent data suggest a decreased complication rate with S2AI screws compared with traditional iliac screws. Despite their respective advantages, traditional iliac screws and S2AI screws can fail. Screw fracture, pullout, and loosening are particularly problematic in cases of coronal deformity correction. Tsuchiya et al reported on a series of 67 patients with bilateral iliac screws; 34.3% of patients required screw removal for symptomatic screw prominence with 7 cases of screw breakage and 29 iliac screws showing halo formations.格尔 et al reported a 35% implant failure rate in 20 patients treated with S2AI screws due to screw head/shaft disengagement and screw pullout.

The majority of patients requiring iliac fixation can be reliably treated with traditional iliac or S2AI screws. Supplemental pelvic instrumentation may become necessary in cases...
of severely compromised bone quality, lumbopelvic dissociation, and anatomic anomalies, which limit the ability to place standard iliac or S2AI screws. The authors describe an iliac fixation technique that enhances pelvic fixation and may prevent failure of a lumbopelvic construct by placing 2 ipsilateral iliac screws in a perpendicular orientation.

**Surgical Technique**

Preoperative planning should take into consideration the iliac crest screw construct with review of computed tomography scans or magnetic resonance imaging of the patient’s sacropelvic anatomy. Screws up to 10.5 mm in diameter and more than 100 mm in length may be placed in the iliac crest trajectory if anatomy allows. Selection of the diameter and material of the rods is at the discretion of the operating surgeon. Availability of numerous screw width and length options, in addition to a full complement of offset and side-to-side connectors, is mandatory.

Segmental fixation is performed using polyaxial screw fixation in the lumbar spine, with the addition of S1 screws, preferably with bicortical purchase for improved fixation. S2 alar/iliac screws are placed bilaterally, when possible. The starting point for the iliac crest pathway is in the posterior ilium, just lateral to the S3 segment, directly distal and in line medially/laterally with the S2AI starting point (Figure 1A). The screw is then directed cranially into the ilium, perpendicular to the S2AI screw pathway within the plane of the posterior ilium (Figures 1B-1C). A small notch can be created to help the screw tulip sit properly to allow polyaxial capability and to easily cannulate the cancellous bone of the iliac crest.

Fluoroscopic imaging should be used to confirm correct placement of all implants. In addition to anteroposterior and lateral radiographs, oblique pelvic radiographs assessing the teardrop (posterior superior iliac spine to the anterior inferior iliac spine corridor) can be used to analyze the iliac crest screw in addition to S2AI screws. The iliac crest screws should be parallel and opposing to the S2AI screw on the teardrop view (Figure 2). Intraoperative computed tomography or 3-dimensional fluoroscopy may also assist to ensure the screws are contained within bone.

The first step in rod contouring involves use of tube benders to create a 60° to 90° angle at the distal end of the titanium rod to allow seating of the rod into the S2AI and iliac crest screws (Figure 3). The 2 main rods are then cut to appropriate length and contoured using standard technique. As always, care is taken to avoid sharp, angular bends in the main section of each rod to minimize stress risers and reduce the risk of rod fracture. The sharp bend between the iliac crest and S2AI screws is acceptable because of the lack of a spinal motion segment between the 2 and the minimal risk of rod breakage at that location. Use of an offset connector for the iliac crest screw is another option if direct rod placement is too challenging. After the rods are seated into the polyaxial heads, set screws are placed and final tightened.

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**Figure 1:** Posterior view of the pelvis showing the trajectories of the S2 alar/iliac (S2AI) (red) and the iliac crest (green) (Adapted from Piersol GA. Human Anatomy. Philadelphia, PA: J. B. Lippincott Company; 1908. Retrieved from http://etc.usf.edu/clipart/53000/53067/53067_pelvis.htm). (A) Coronal view of the cadaver model showing S2AI (blue probe) and iliac crest (blue and yellow probe) starting points and trajectories (B). Oblique view of the cadaver model showing the trajectories of the S2AI and iliac crest screws (C).

**Figure 2:** Anteroposterior fluoroscopic image of the cadaver model showing positioning of the S2 alar/iliac (S2AI) and the iliac crest (A). Lateral fluoroscopic image of the cadaver model showing perpendicular S2AI and iliac crest screws (B). Teardrop fluoroscopic image showing placement of the iliac crest screw through the teardrop and cranially into the iliac wing (yellow line: iliac crest trajectory; blue line: S2AI trajectory; red dots: teardrop corridor) (C).

**Figure 3:** Tube benders facilitating 80° to 90° bend in distal aspect of the spinal rod.
**Cadaver Model/ Biomechanical Testing**

A male cadaver lumbo-pelvic spine was prepared for spinal and pelvic instrumentation. Using anatomic landmarks as described by Chang et al., an S2AI screw of 8.5-mm diameter and 90-mm length was placed on each side of midline. Bilateral iliac crest screws of the same dimensions (8.5-mm diameter; 90-mm length) were then inserted according to the described technique. Bilateral L4 and L5 and bicortical S1 pedicle screws were placed and radiographs were obtained to ensure accurate screw placement. Rods were then contoured and seated followed by final tightening of the set screws (Figure 4).

The rods were then removed and axial pullout testing was performed for each S2AI and iliac crest screw individually. The mean pullout load was 2467.5 N for the S2AI screws and 1103 N for the iliac crest screws. These loads compare favorably with those of unaugmented lumbar pedicle screws, which have a mean axial pullout of 488.5 N.11

**Clinical Case**

A 34-year-old man presented with back pain and spinal instability 11 years following an American Spinal Injury Association A thoracic spinal cord injury. He had undergone T10 corpectomy and a T4 to L4 posterior spinal arthrodesis. For the past decade, he had lived independently and was active in wheelchair sports. Current radiographs revealed severe destruction of the L4 vertebral body and lumbo-pelvic dissociation due to Charcot spinal arthropathy. Computed tomography-guided biopsy of the L4 lesion yielded negative results.

Surgical treatment consisted of posterior L4 vertebractomy, anterior column reconstruction, lumbopelvic instrumentation, and circumferential arthrodesis. Fixation points distal to the spondylectomy level consisted of bilateral L5 pedicle screws, bicortical S1 pedicle screws, and S2AI screws. Because of compromised bone quality, high patient activity demand, and the limited number of distal fixation points, iliac crest screws were inserted as additional pelvic anchors. A 4-rod construct was assembled to complete the instrumentation and lumbopelvic reconstruction (Figure 5).

At last follow-up 6 months postoperatively, there was no evidence of hardware failure or loosening and the patient had resumed full activity.

**Discussion**

Although spinopelvic fixation is routinely used for maintaining sagittal and coronal balance in long fusions for spinal deformity,13,12 existing methods of iliac fixation may be inadequate in the setting of compromised bone quality or complete lumbo-pelvic dissociation.13 Additionally, iliac screws are often associated with symptomatic hardware necessitating removal,2 and high failure rates of S2AI screws have been reported.4 The iliac crest screw provides enhanced fixation to the pelvis in a perpendicular trajectory to the S2AI screw in cases where maximal pelvic fixation is necessary.

This study had several limitations. This was a preliminary study, examining only 1 clinical patient and 1 cadaver, and bone mineral density was not measured in either. Although further biomechanical testing and clinical follow-up is necessary to confirm and quantify the increased fixation strength provided by this novel screw trajectory, the theoretical advantage of the iliac crest screw technique is based on the perpendicular trajectory of the 2 ipsilateral iliac screws. Although some surgeons advocate 2 ipsilateral iliac screws placed into the teardrop corridor to confer additional fixation (Figure 6), there is potential benefit to placing screws in a perpendicular trajectory. The iliac crest screw pathway resists force along an orthogonal vector to the S2AI screw trajectory and may provide greater resistance to pullout and screw loosening.

The iliac crest screw trajectory may be used with or without S2AI screws. Although iliac crest screws alone should not be relied on for pelvic fixation, they are not dependent...
on S2AI fixation. Depending on patient anatomy, iliac crest screws may be paired with traditional iliac screw trajectory fixation or sacral alar screws, although side-to-side or outrigger rod constructs may be necessary to provide segmental fixation. Sacral iliac fusion can be performed as well, if desirable.

There are several potential disadvantages to this technique. There is the necessity for a slightly increased incision length to reach the S3 starting point, and the distal sacral and iliac crest anatomy may be less familiar to some surgeons. Additionally, inner table and outer table penetration is a possible complication of this technique. Banno et al. found that 18.8% of iliac screws penetrate the inner or outer table. It is possible that iliac crest screws, with their cranial trajectory, will have higher rates of penetration. As noted by Banno et al., however, whether this complication is clinically significant remains uncertain.

Other considerations when placing iliac crest screws include rod bending and satellite incisions. Rod bending to a 90° angle may be necessary, and can easily be accomplished with tube benders. The risk of rod fracture between the S2AI and iliac crest screws should be low because of the lack of significant motion between these segments. Although modern polyaxial head technology should allow set screw insertion through the primary incision, a satellite stab incision may be necessary for placement and final tightening of the iliac crest set screw. The length of the incision and potential need for a satellite incision should be taken into consideration when draping the patient.

**CONCLUSION**

The iliac crest/S2AI percutaneous screw fixation technique provides a sturdier pelvic attachment compared with standard iliac fixation. Two ipsilateral iliac screws placed in a perpendicular orientation theoretically reduce the risk of lumbopelvic fixation failure. This construct is most useful in patients with compromised bone quality and lumbopelvic dissociation from trauma, tumor, infection, or Charcot arthropathy. Additional clinical and biomechanical studies are necessary to investigate the efficacy and safety of the technique.

**REFERENCES**


