Percutaneous iliac screw placement: description of a new minimally invasive technique

MICHAEL Y. WANG, M.D.,1 STEVEN C. LUDWIG, M.D.,2 D. GREG ANDERSON, M.D.,3 AND PRAVEEN V. MUMMANENI, M.D.4

1Department of Neurological Surgery, University of Miami Miller School of Medicine, Lois Pope LIFE Center, Miami, Florida; 2Department of Orthopedic Surgery, University of Maryland, Baltimore, Maryland; 3Department of Orthopaedic Surgery, Thomas Jefferson University, Philadelphia, Pennsylvania; and 4Department of Neurological Surgery, University of California at San Francisco, California

Minimally invasive spinal instrumentation techniques have evolved tremendously over the past decade. Although there have been numerous reports of lumbar instrumentation performed via a percutaneous or minimal incisional route, to date there have been no reports of minimally invasive iliac screw placement.

A method was developed for accurate placement of minimally invasive iliac screw placement based on a modification of currently available percutaneous lumbar instrumentation techniques. The method involves fluoroscopically guided insertion of a cannula-based screw system, and this technique was successful applied to treat an L-5 burst fracture with L-4 to iliac spinal stabilization via a minimally invasive approach.

This report demonstrates the feasibility of percutaneous iliac screw instrumentation. However, future studies will be needed to validate the safety and efficacy of this approach. (DOI: 10.3171/FOC/2008/25/8/E17)

KEY WORDS • iliac fixation • lumbar spine • minimally invasive technique • spinal fracture • spinal instrumentation • spinal trauma

Pelvic fixation is an important tool in the armamentarium of the modern spinal surgeon. Because the human pelvis contains a significant cancellous bone space bordered by inner and outer cortical walls, screws or bolts of a significant diameter and length can be placed safely for spinal stabilization. Furthermore, these screws extend anterior to the spine in the sagittal plane and lateral to it in the coronal plane. Thus, these rigid iliac anchor points are useful for long instrumentation constructs, sagittal and coronal deformity corrections, stabilization of low sacropelvic instability, and instances in which sacral pedicle screws may be prone to failure due to the larger moment forces and higher pseudarthrosis rates found regionally.

Since the original description of Galveston spinal fixation to the pelvis by Allen and Ferguson, numerous variations of the original technique have been developed. The original method involved bilateral stainless steel rod placement into the cancellous bone of the ilium. This provided significant resistance to axially directed forces for cases of spinal deformity. Later iterations included the use of plates to span the sacrum and ilium as an additional anchoring point. Contemporary spinal surgeons now favor the placement of large bone (7–9-mm-diameter) screws or bolts ranging from 60 to 80 mm in length into the cancellous bone of the ilium bilaterally, cross-connected bilaterally. These are frequently supplemented with pedicle screws in the first sacral vertebra as an additional orthogonal anchoring point. These constructs have thus been used in settings requiring significant resistance to hardware loosening or pullout, such as in cases involving significant local instability, spinal deformity, long-segment fixation, or osteoporotic bone (Table 1).

Although the placement of iliac screws has become widely accepted, sufficient lateral muscular dissection over the posterior superior iliac spine is typically necessary to expose the screw entry points. Pain secondary to iliac screw placement can be attributed to hardware prominence, disruption of the sacroiliac joint, and screw loosening. However, local soft-tissue destruction and muscular devitalization may also play a role.

Other regional percutaneous pelvic fixation techniques have already been described, most notably with iliosacral screws for sacropelvic fractures. Whereas some reports
have indicated that the technique can be applied safely,\textsuperscript{13,14,23} the proximity of the spinal canal, nerve roots, and pelvic vessels can result in significant complications,\textsuperscript{15} leading some authors to conclude that the procedure may be more safely performed with image-based navigation.\textsuperscript{17,18} A previous report by Sciubba, et al.\textsuperscript{16} described percutaneous placement of a transiliac sacroplasty in combination with a methylmethacrylate sacroplasty for an insufficiency fracture. This sacropelvic fixation method was used based on the rationale that rigid spinal implants would be needed in addition to the vertebroplasty to produce an adequate clinical response and was achieved without complications in a minimally invasive fashion.

We describe here a technique of percutaneous iliac screw placement. This method allows for the insertion of screws or bolts of a length and caliper similar to those used for open surgeries, with the potential to reduce soft-tissue trauma, blood loss, and local postoperative pain.

### Methods

#### Preoperative Preparation

This technique was based on experiences in the cadaveric lab, where it was determined that a minimally invasive method for iliac screw placement could be effectively applied, but would rely heavily on radiographic guidance. Thus, the patient should be positioned so that the pelvis does not overlie the base of the operating table, and care must be taken to ensure that no metallic objects will obscure the appropriate imaging area. In addition, because of the angulation required for fluoroscopy in the sagittal plane, the base of the table must not prevent the fluoroscope from achieving the proper Ferguson view. Alternatively, a radiolucent bed such as a Jackson table can be used.

After preparation of the sterile field, the fluoroscope is brought in for inlet and outlet pelvic views to localize the sciatic notch. This prevents inadvertent injury to the sciatic nerve and its surrounding vessels. For each side of the iliac crest the fluoroscope is angled in the sagittal and coronal planes in the obturator outlet view so that the x-ray beams are approximately parallel to both the inner and outer tables of the ilium (Fig. 1).

#### Cannulation Technique

A small diagonally placed incision is then made overlying the PSIS. A Jamshidi needle is then docked onto the most superficial aspect of the PSIS and “walked” ventromedially, with care not to enter into the sacroiliac joint. The exact starting point along the superoinferior plane of the PSIS can vary according to the specific screw trajectory desired, as multiple paths are acceptable. In this case, the entry point was just beneath the shelf of the ilium underlying the PSIS. A drill can be used to create an osseous depression to better seat the screw or bolt head to minimize hardware prominence.

The Jamshidi needle is then carefully directed under fluoroscopic guidance with tactile feedback to prevent penetration through the cortical walls. Osseous violations are more likely in osteoporotic patients, and a beveled needle tip may be preferable to a diamond tip for this purpose. After engaging 2 cm of bone, the fluoroscope is adjusted to inlet and outlet pelvis views, as well as to the lateral view to confirm the proper needle trajectory and to ensure that the sciatic notch is avoided (Fig. 2). This is followed by readjustment of the fluoroscope to the starting position and engagement of 65–80 mm of ilium.

The Jamshidi needle is then replaced internally with a K-wire and then removed. Cannulated and serially enlarging cancellous screw taps are then placed over the K-wire to the appropriate length (Fig. 3). Because of the large diameter of iliac screws (7–9 mm), after withdrawal of the tap a ball-tipped probe can be used to palpate the internal aspect of the hole thus created with the K-wire still in place. The K-wire thus serves as a continuous guide for the ball-tipped probe (Fig. 4A). Electrophysiological stimulation of the tap can be performed by placing an insulating sheath over the tap shaft by using standard stimulus-evoked electromyography to check for sciatic nerve proximity.

### TABLE 1

\textit{Indications for extension of lumbosacral fusions to the ilium}

1. \textsuperscript{\textdagger} Grade II L5–S1 spondylolisthesis
2. long segment fusions to the sacrum (L-2 or above to S-1)
   a. spinal deformity (scoliosis or kyphosis)
   b. lumbar fractures
   i. trauma
   ii. osteomyelitis
   iii. neoplasm
3. lesions that destroy the sacrum
   a. neoplasm
   b. osteomyelitis
   c. fractures
4. treatment of L5–S1 pseudarthrosis

---

**Fig. 1.** Fluoroscopic view showing both the inner and outer tables of the ilium with a Jamshidi needle directed into the cancellous bone of the pelvis.
Screw Placement and Rod Attachment

Screws can then be unilaterally placed using cannulated large-diameter iliac screws or bolts over the K-wire or by using standard iliac screws passed down the now dilated screw path. The contralateral screw is then placed. Screw extension posts (Viper & Expedium Pedicle screws, DePuy Spine) can be used to assist with rod passage and screw connection in a manner similar to that used for percutaneous or minimally invasive pedicle screw placement (Fig. 4C and D). The extension posts allow for pushing of the rod onto the polyaxial screw head, acting as a guide. This would have been more difficult to accomplish if the next rod connection point was closer to the iliac screw (that is, an S-1 pedicle screw).

Illustrative Case

History and Presentation. This 46-year-old man was involved in a high speed motor vehicle accident, sustaining a burst fracture to the L-5 vertebral body (Fig. 5). He was neurologically intact, with normal sensation and motor strength in the lower extremities. He also had a complex fracture of the left femur. Because of the combination of injuries, the options for management were either an extended period of bedrest or surgical stabilization of the fracture because of the difficulties associated with bracing with a leg extension. The patient elected for surgical stabilization. Based on the severe disruption of L-5, iliac instead of S-1 pedicle screws were used.

Operation. The patient was taken to the operating room where percutaneous pedicle screws were placed at the L-4 and L-5 levels. Iliac bolts measuring 8.0 mm in diameter and 65 mm in length were placed and connected to the pedicle screws after rod contouring. The construct was then cross-linked through a mini-open incision at the L4-5 level (Fig. 6). This was accomplished by passing a curved cross-link holder from one side to the other, allowing the pulling of the link across the midline to establish a bilateral connection, with the central tightener accessed through one of the mini-open incisions. Electrophysiological stimulation of all 6 screw trajectories yielded no electromyographic response at 20 mA, and the patient tolerated the procedure well. The total blood loss was 50 ml, and the patient did not suffer any neurological complications.
Postoperative Course. The patient was subsequently effectively mobilized with external fixation of his left lower extremity and no lumbosacral bracing. He was sent to inpatient rehabilitation and discharged in ambulatory status 10 days later. Plans were made for subsequent planned instrumentation removal following bone healing of the spinal fracture.

Discussion

There has been a proliferation of minimally invasive techniques in spinal surgery in response to the substantial morbidity encountered with open surgical procedures that devitalize soft tissues, result in substantial blood loss, and prolong immobilization. New fixation methods for stabilizing the spinal column from the C-1 to the sacrum have been developed.\textsuperscript{4,8,10–12,21} However, to date there have been no reports of minimally invasive segmental spinal fixation to the ilium.

This report describes the technique for percutaneous screw placement into the ilium. This technique could provide for a significant advantage in the armamentarium of spinal surgeons. Because iliac fixation is typically used for stabilization and not for fusion across the sacroiliac joint, percutaneous stabilization is a rational approach. In many instances sacropelvic fixation devices are removed following definitive fusion of the spinal column, and the minimally invasive approach presents no drawback in this regard.

It remains unclear whether this approach can result in reduced postoperative morbidity. The extent of subperiosteal dissection often used for open iliac screw placement is substantial and may be similar to the problems encountered when harvesting autograft bone from the posterior iliac crest. In numerous reports, posterior iliac crest harvesting was associated with a 15–30\% incidence of new and prolonged local pain at the donor site.\textsuperscript{6,7,19} Whether this minimal access procedure will result in reduced pain, discomfort, and disability thus remains to be proven.

The bony pelvis can vary in thickness and geometry, and the soft tissues, including neural and vascular structures, do not conform to a standard or reliable anatomic arrangement. Thus, minimally invasive screw placement can be more difficult with a potentially higher probability of cortical breach or neurovascular injury. Ultimately, 3D intraoperative imaging has the potential to make percutaneous
Percutaneous iliac screw placement

spinal instrumentation more straightforward, but large clinical studies will be needed to prove safety and efficacy.

A second problem associated with this approach is the difficulties that can be associated with rod/screw articulations. Because of the entry point for iliac screws, a significant amount of rod contouring is typically necessary to connect S-1 pedicle and iliac screws. In our illustrative case, 5 pedicle screws were placed at L-4 and L-5, making the connection much easier because of increased rod length between the 2 fixation points. Ultimately, long-segment spinal reconstructions typically require complex 2-plane rod bends that may render percutaneous rod passage and screw articulation difficult.

Furthermore, iliac bolts are typically supplemented with cross-connections between the left and right side at some or multiple points within the construct to realize their optimal biomechanical pullout and stiffness profiles. In this report’s case illustration a mini-open approach was used to engage both rods to a cross-connector. Ultimately, newly engineered cross-link designs will likely make this a more straightforward endeavor.

Conclusions

Placement of iliac screws via a percutaneously technique is technically feasible. Furthermore, attachment to cephalad segmental fixation is possible with existing minimally invasive spinal instrumentation. However, cadaveric studies and larger clinical studies will be necessary to validate the safety and efficacy of this approach.

Disclosure

This study was not supported by any outside funding sources. Drs. Wang, Ludwig, and Mummaneni are consultants to DePuy Spine.

References


Manuscript submitted April 4, 2008. Accepted April 24, 2008.
Sources of support: none reported.
Address reprint requests to: Michael Y. Wang, M.D., Department of Neurological Surgery, University of Miami Miller School of Medicine, 1095 NW 14th Terrace, D4–6, Lois Pope LIFE Center, Miami, Florida 33136. email: Mwang2@med.miami.edu.