Image-Based Techniques for Percutaneous Iliosacral Screw Start-Site Localization

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Abstract

Despite the routine use of iliosacral screws for the treatment of a variety of pelvic fractures, the technique is demanding, and complications are well described. This article describes a novel image-based technique for accurately identifying and reproducing the appropriate placement of iliosacral screws. Using the stab-incision technique presented here allows for more accurate landmark identification and safer placement of implants.

Iliosacral (SI) screws remain the standard of care for the vast majority of posterior pelvic ring disruptions.[1,2] However, despite their routine use, the procedure remains technically demanding with repeated cases of aberrant screw placement and complications.[3,4] Sacral morphology is extremely variable within a patient population and affects accurate placement and trajectory of percutaneous screws.[5] Classically, it is taught that the external starting position/landmark is at an intersection point of the greater trochanter and the anterior superior iliac spine (ASIS). While this "one size fits all" approach will certainly help to coordinate a start position, it is our experience that multiple stab incisions are necessary to find the optimal start site. To our knowledge, the most common image-based technique used to guide start-point localization and placement of SI screws begins with drawing a virtual sacrum on the patient's side, guided by the lateral image.[5] This article provides a novel image-based technique to be used with, or as a replacement for, the traditional technique.

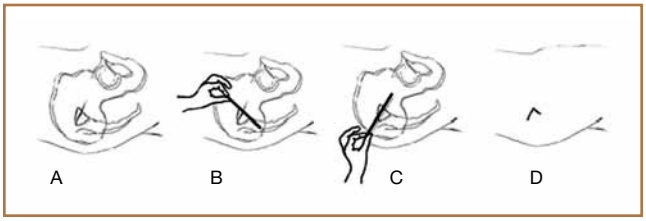
Techniques

The patient is brought to the operating room and placed supine on a radiolucent operating table. If the closed reduction of the pelvic ring is successful or can be achieved via anterior manipulation/traction, posterior percutaneous pinning is planned. Either a rolled towel or a bag of saline is used as a bolster and placed midline underneath the sacrum and lumbar spine to help "bump" the pelvis and improve the range of motion for the surgeon's drill. The patient is brought to the edge of the table when possible (ie, a posterior ring injury requiring fixation from only 1 side) to further enhance drill motion. If bilateral screws are planned, surgeons must be careful not to position 1 side at the expense of screw placement on the contralateral side. Nitrous-based anesthetic agents are avoided, because they may collect in the bowel and obscure good radiographic visualization. Arms are placed perpendicular to the body to facilitate the inlet view. Pre-preparation anteroposterior pelvis, inlet, and outlet views are obtained to assure ability to accurately and safely assess landmarks on all projections, and to mark the C-arm position and angles. This process helps decrease "useless" radiographs obtained during the procedure. Acceptable inlet radiographs show the anterior cortex of the S1 body superimposed on the S2 body. Acceptable outlet radiographs show the superior pubic symphysis at the level of the S2 foramen and visualization of the S1/S2 sacral foramen.[6] The patient is then prepared in the standard fashion. Reduction maneuvers are performed and, if acceptable alignment is achieved, posterior percutaneous screw placement begins.

Technique 1

To our knowledge, the most common image-based technique used to guide start-point localization and placement of SI screws begins with drawing a virtual sacrum on the patient's side using the lateral image. The fluoroscopic machine is set up in a lateral position.[5] A free guide wire is superimposed upon the iliac cortical density and anterior sacral slope, which

Figure 1. (A) Lateral fluoroscopy image is taken. A perfect lateral is one in which the greater sciatic notch and femoral heads align. (B) A free guide wire, which is superimposed upon the anterior sacral slope, is marked on the skin. (C) A free guide wire is superimposed upon the iliac cortical density and marked on the skin. (D) Final markings on the skin provide reference for start point and corrections.



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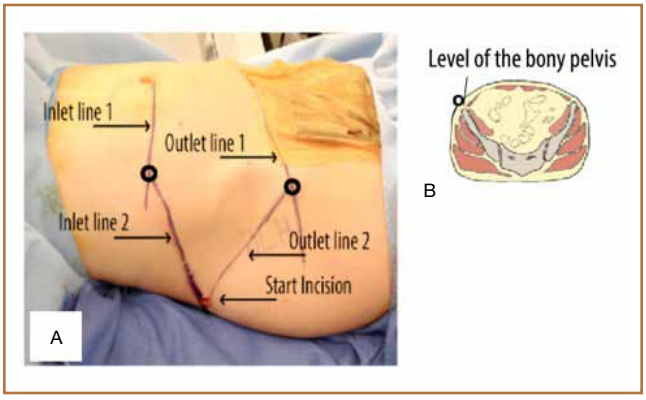

Figure 2. (A) Intraoperative photograph of skin markings. Circles (o) represent intersection point between line 1 and line 2. Intersection point(s) should occur as the skin vertically slopes at the level of the bony pelvis. (B) Cross section showing the location of the intersection point(s) at the level of the bony pelvis and the vertical slope of the skin.

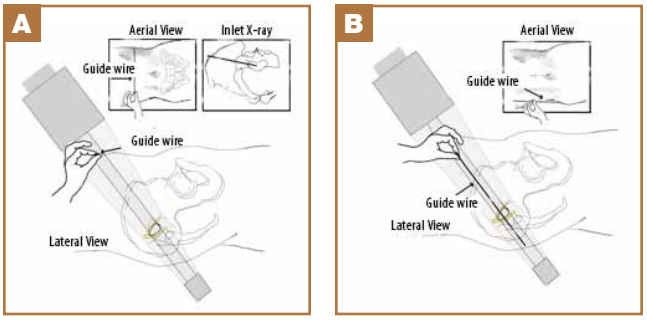

Figure 3. (A) A guide wire is placed over the skin and an inlet radiograph is taken. Once the desired trajectory of the screw is found, a guide wire is used to trace a line on the stomach (inlet line 1). (B) Inlet line 2 is drawn by placing a guide wire on the side of the patient's body in parallel fashion to the fluoroscopic beam in the sagittal plane (lateral view). It should be positioned so that it intersects with inlet line 1 at the level of the bony pelvis. This is also the point where the skin slopes vertically (see Figure 4).

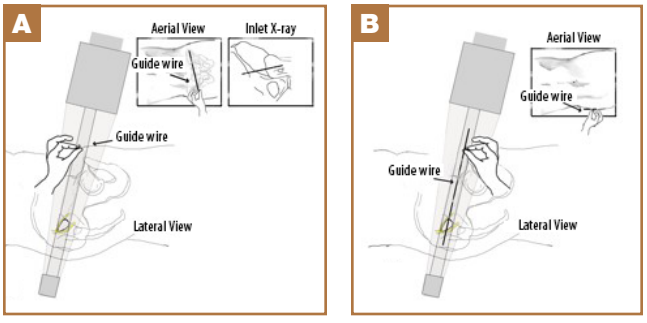

Figure 4. (A) A guide wire is placed over the skin and an outlet radiograph is taken. Once the desired trajectory of the screw is found, the guide wire is used to trace a line on the stomach (outlet line 1). (B) Outlet line 2 is drawn by placing a guide wire on the side of the patient's body in parallel fashion to the fluoroscopic beam in sagittal plane (lateral view). It should be positioned so that it intersects with inlet line 1 at the level of the bony pelvis. This is also the point where the skin slopes vertically (see Figure 2).

is marked on the skin (**Figure 1**). The superior portion of S1, as well as the posterior sacral slope, can be marked as well. This process has outlined the sacrum and provides an external landmark for the "safe zone" for screw placement. The operation proceeds in the standard fashion using inlet, outlet, and lateral radiographs. However, the externally drawn sacrum can aid as a reference during guide-pin placement.

Technique 2

This technique takes into account bone anatomy and soft-tissue coverage. It is helpful to think of the abdomen/pelvis as a box. The anterior abdomen represents the top of the box and the lateral buttock represents the side of the box. The corner of the imaginary box is where the abdomen begins to slope down and transitions laterally to become the buttock. This will be referenced as the "down-sloping point" and typically corresponds to the level of the iliac crest (**Figure 2**).

To begin, a standard cannulated screw guide wire is placed flush on the skin of the abdomen. An inlet fluoroscopy image is taken with the guide pin on the abdomen. Imagine that the resulting image represents the planned screw trajectory (**Figure 3A**). When the position of the guide wire is deemed adequate, a line is marked on the abdomen, using a pen, directly adjacent to the guide wire. This line represents inlet line 1 (**Figure 2**). The line must continue laterally until the down-sloping point. The sagittal angle of the imaginary inlet fluoroscopic beam is noted, and a guide wire is placed in the same sagittal orientation flush with the skin on the lateral buttock (**Figure 3B**). The guide wire must be placed so that it intersects with the first line at the down-sloping point. The skin on the lateral aspect of buttock is marked with a second line, which represents inlet line 2 (**Figure 2**).

The same process is repeated using an outlet view to create outlet lines 1 and 2 (**Figures 4A, 4B**). At this point there are 4 lines drawn on the patient (**Figure 2**). A stab incision is made at the intersection of the 2 lines drawn on the lateral buttock; this represents the skin start point, labeled "start incision" (**Figure 2**). The procedure continues in standard fashion.

The 4 external reference lines serve multiple purposes. First, the lines mark the true lateral start point for the pin at the level of the skin. This contrasts with the standard technique in which bony landmarks are marked on the skin and the surgeon must estimate a point on the skin that will provide an appropriate trajectory to the bony start point on the ilium. Further, the lines can also be used to reorient the cartesian plane so that adjustments can be isolated to a single plane, ensuring movements only alter the position on a single radiographic view (**Figure 5**).

Discussion

Despite the widespread use of percutaneous screw placement for posterior pelvic ring injuries, this remains a technically demanding surgery. Recent data suggest patient pelvic anatomy is extremely varied, especially the sacrum.[7] Further, screw trajectories vary depending on surgical goals, fracture pattern, and

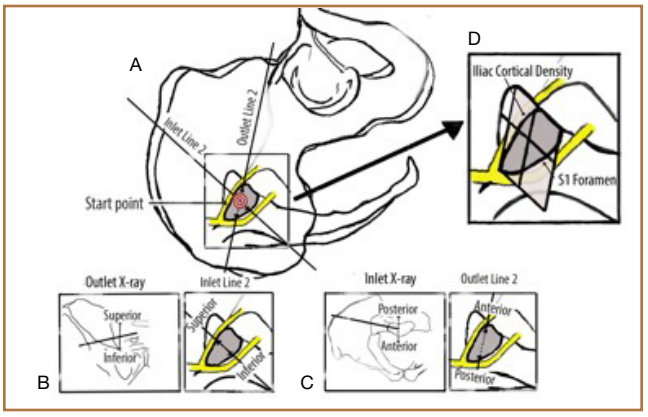

Figure 5. (A) Lateral view of the skin markings crossing at the start point. (B) Superior/inferior correction on the outlet radiograph is done in line with inlet line 2. This ensures no trajectory change in the inlet radiograph. (C) Anterior/posterior correction on the inlet radiograph is done in line with outlet line 2. This ensures no trajectory change in the outlet radiograph. (D) The dark grey area represents the targeted alar bone for the screw. It is inferior and posterior to the iliac cortical density and superior and anterior to the S1 foramina. Using only the inlet and outlet radiographs isolates the start point to the area shaded in light grey. This shows the importance of obtaining a lateral radiograph before crossing the S1 foramina on the outlet radiograph.

number of screws. Taken together, this implies that there is no perfect universal starting site along the external ilium. Therefore, while classic teaching states to begin screw insertion within the vicinity of the intersection of the greater trochanter and the ASIS, it is our experience that this location is often not ideal.

The inlet, outlet, and lateral radiographs are all vital to assess correct trajectory of the guide pin and drill prior to final screw insertion, but the start site remains a critical step to assure a successful surgical outcome. We present 2 techniques, used together or separately, that allow the surgeon to place the initial guide pin more accurately for percutanous iliosacral screws. Though not specifically examined in this study, we think technique 2 has the potential to save operative time and use less fluoroscopic imaging because a lateral image is not required until later in the case. Technique 2 identifies the start point at the level of the skin. This is in contrast to technique 1, which identifies the desired sacral target and requires a surgeon to select a skin start site that will provide an optimal trajectory towards the desired target. Judging trajectory can be difficult, particularly in obese patients, and technique 2 eliminates this extra variable.

It is also important to consider that criteria-based nonorthogonal imaging is required for percutaneous screw placement. In these cases, it is more difficult to judge trajectory corrections because the fluoroscopic beam cannot guide perpendicular corrections as it can in operations that use orthogonal imaging. Adjustments made perpendicular to the fluoroscopic beam will change trajectory in multiple planes.[8] Moreover, because the standard cartesian frame of reference is rotated, understanding the location of the sacrum in space can be especially challenging. When using the first technique, sacral landmarks are delineated, and a virtual sacrum drawn on the patient's exterior helps with orientation. In the second technique, the ideal pin placement is mapped, and the external reference lines guide uniplanar changes. For example, the line drawn co-planar with the inlet view is essentially marking the sacral slope. Therefore, by following this line, uniplanar changes in the cranial and caudal direction are achieved on the outlet view (**Figure 5**). Because this line is also in reference to the already known ideal pin placement, ideal pin placement can be maintained in 1 radiographic projection while changing the start site in the appropriate direction. In a similar fashion, the co-planar line identified on the inlet view can be used on the outlet image to affect uniplanar changes in the anteroposterior direction. This technique effectively minimizes disorientation when placing percutaneous SI screws. This can be particularly beneficial when placing screws in the prone position.

Conclusion

We have shown 2 techniques that are routinely used at our institution to help identify an accurate starting position for percutaneous screw placement in posterior pelvic ring injuries. Even experienced traumatologists can more quickly and accurately identify the correct stab incisions leading to more confidently placed screws. Further, we believe understanding the usage of fluoroscopy and the concepts involved in drawing the lines enhance trainees' comprehension of the complex anatomy of the sacrum.

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