Technique Report

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The crest-pillar-column method for percutaneous fixation of the posterior column using a curved intramedullary device: surgical technique

Grayson A. Domingue, MD*, Christian V. DeMaio, MD, John Michael Yingling, DO

Abstract Treatment of posterior column fractures can be treated with open reduction internal fixation via plate osteosynthesis or with screw fixation. Due to common fracture planes and fixation trajectories, traditional anterograde posterior column screw fixation requires an open approach to access the starting point on the inner table. Retrograde posterior column implantation requires a start point in areas that are difficult to drape and access with familiar patient positioning and confident sterility. The advent of curved intramedullary implants allows implantation in nonlinear osseous fixation pathways. This technical paper describes a novel minimally invasive approach to placing a curved intramedullary implant within the posterior column from the readily identifiable iliac tubercle via the gluteal pillar ("Crest-Pillar-Column" technique).

Keywords: fragility fractures, acetabulum, pelvis, percutaneous

1. Introduction

Percutaneous methods of fixation for acetabular and pelvic ring fractures continue to transform orthopaedic trauma care.[1–6] Gay et al[7] first described percutaneous screw fixation of the anterior column under computed tomography (CT) guidance over 30 years ago. With high-quality imaging modalities increasingly utilized in the workup of the trauma patient, Bishop and Routt[8] described several bony corridors to treat pelvic and acetabular fractures with less extensile surgical exposures.

In this way, the pelvis permits passage of straight percutaneous screws through described bony corridors.[8] A curved intramedullary (IM) implant can navigate undescribed native corridors. Indications for a curved IM implant include patients with sacral dysmorphism, prior implants obstructing the pathway of a straight screw, or anterior pelvic ring fractures.[9] As such, Miller et al described the use of the Curvafix implant for fragility fractures of the pelvis (FFP), in turn facilitating fixation, less pain in this patient population, and earlier mobilization by crossing multiple columns of bone with larger diameter and length implants through curved intraosseous pathways.[9,10]

Fragility fractures are distinct from high energy pelvic and acetabulum fractures. Rommens' and Hofmann's classification system for fragility fractures of the pelvis divides FFPs into anterior only, nondisplaced posterior, and displaced posterior injuries that follow a common history of subclinical trauma, incomplete healing, and common locations of low bone density within the sacral ala.[11] Fragility fractures of the acetabulum (FFA) also differ from those in a younger, healthier cohort, showing more anterior column involvement, quadrilateral plate or posterior wall comminution, and possible femoral head injury or posterior hip dislocation.[12,13]

Biomechanically, a curved intramedullary implant differs from traditional screw fixation in several ways. Typically, a screw provides fixation through friction spanning both sides of a fracture, and in percutaneous fixation of the acetabulum, screws act as rods of fixation, which are limited by the diameters and lengths of the known bony corridors of the pelvis.[8] As a result, screws may not possess ideal dimensions to resist stress and shear forces applied by the patient postoperatively, thus leading to failure by screw back-out or breakage. In addition, to prevent rotation around the screw, multiple screws would need to be used, whereas the nonlinear shape of the Curvafix implant precludes this mechanism of failure.[14] This is not to mention that cannulated screws, which are commonly used percutaneously in acetabulum fixation, have been shown to have lower load-to-failure compared with noncannulated screws.[15,16] A curved, flexible intramedullary implant that can be stiffened after placement offers the surgeon the ability to achieve fixation over larger lengths and diameters in percutaneous surgery of the acetabulum, as demonstrated by Zakariaee et al[10] in their study of CT scans of the pelvis in healthy subjects describing constriction points and minimum radii of curvature across the osseous fixation pathways of the pelvis.

Bone quality of patients with FFA may correlate with overall health, as they may not tolerate the systemic burden of large extensile surgical approaches and extended time under anesthesia.[12,17] Like fragility fractures of the pelvis and geriatric hip

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The study was deemed exempt from Institutional Review Board and Animal Use Committee Review.

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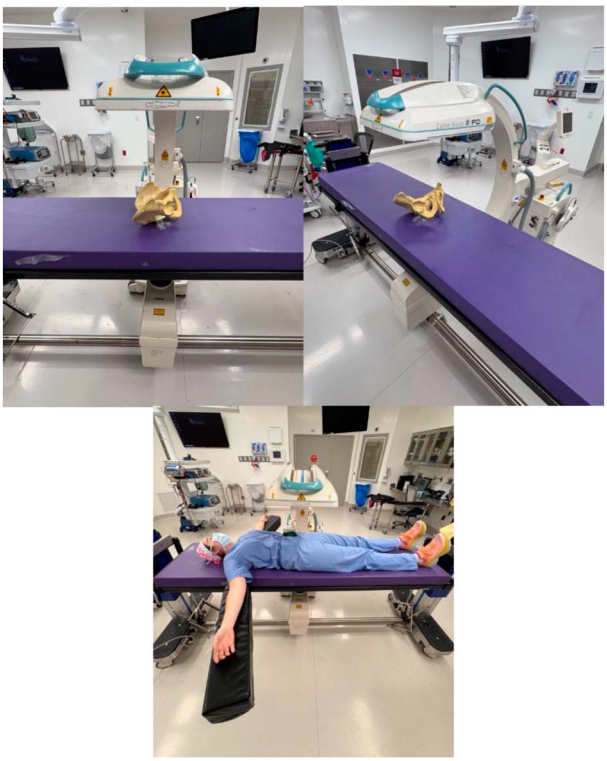

Figure 1. Example AP imaging patient position and fluoroscopy position.

fractures, the goal is early ambulation to mitigate the post-operative complications associated with trauma and stasis, including, but not limited to, venous thromboembolism, pressure ulcers, urinary tract infections, and pneumonia. The current iteration of this implant functions similarly to an intramedullary rod promoting load-sharing stability and secondary, indirect, or type 2 bone healing, and its indications and application near articular surfaces should align with this presumed function. Using a curved intramedullary implant thus allows for a minimally invasive implantation while also supporting early weight bearing.[9] This technique gives orthopaedic trauma surgeons an additional option that may decrease associated surgical insult and

Figure 2. Example iliac oblique imaging patient position and fluoroscopy position.

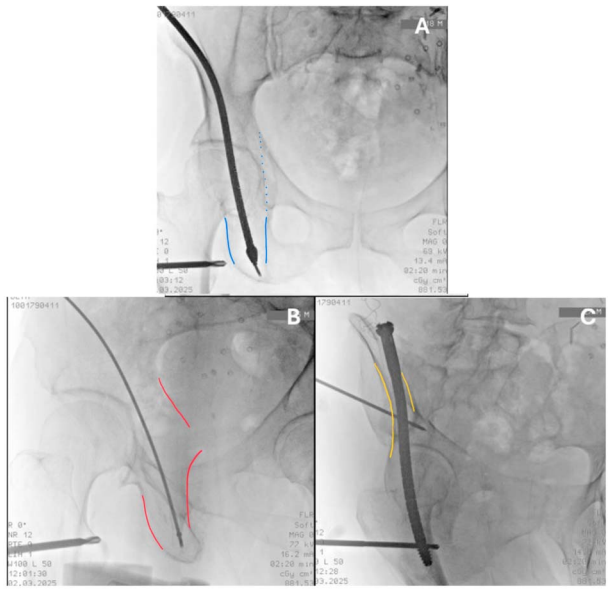

Figure 3. A–C, Fluoroscopic AP view, which can be used to assess the medial and lateral margins of the posterior column (A). Iliac oblique view used to assess the anterior and posterior margins of the posterior column (B). Obturator oblique outlet view, demonstrating the corridor of the gluteal pillar and lateral cortex adjacent to the posterior horn of the acetabulum and ischial tuberosity (C).

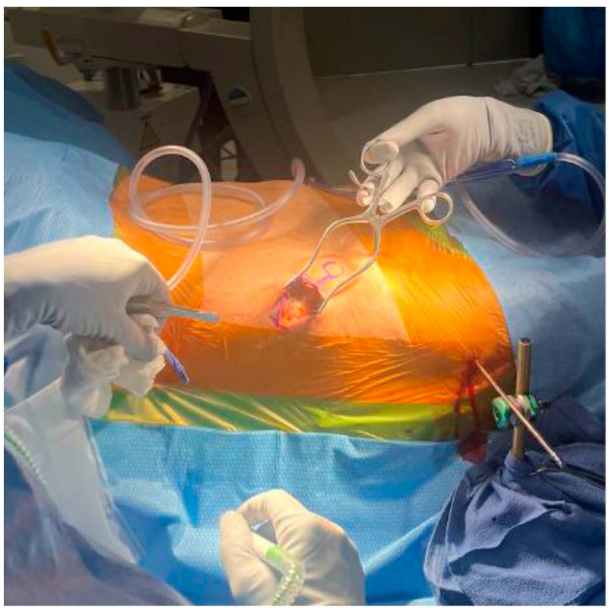

Figure 4. Exposure for starting point.

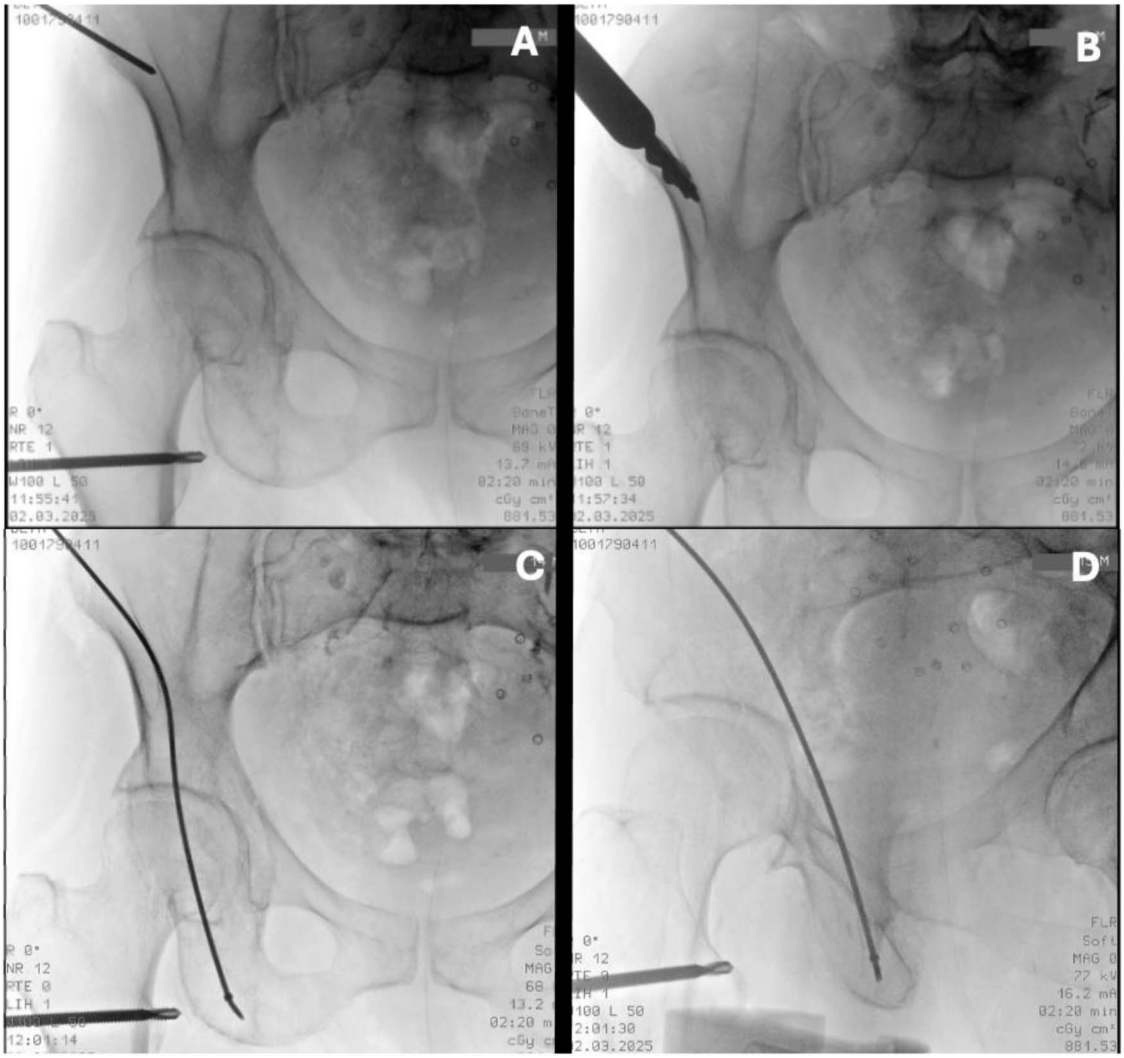

Figure 5. A–D, Intraoperative fluoroscopic imaging illustrating start point on AP imaging (A), application of entry reamer (B), advancing the flexible guide wire to the posterior column (C), and visualized on AP and iliac oblique imaging (D).

afford more confidence in early weight bearing in the treatment of posterior column fractures.

1.1. Radiographic Assessment

In the radiographic evaluation of the pelvis and acetabulum, orthopaedic practitioners typically utilize anterior-posterior (AP), inlet, outlet, and Judet radiographs. In the acute and high-energy setting, it is standard to include a CT scan of the pelvis as a part of the workup. Although not always implemented in low-energy settings, CT scan can aid in the evaluation of insufficiency fractures. Multiple classification systems have arisen over recent years to describe insufficiency fractures of the pelvis such as OF-Pelvis,[18] AOSpine sacral classification,[19] and one described by Bakker et al.[20] The most commonly used classification, however, is described by Rommens et al, which has proven useful for guiding treatment based on grouping these fractures into one of 4 types based on imaging findings.[11] Magnetic resonance imaging is useful in the evaluation of the occult nondisplaced fractures of the posterior pelvis and acetabulum due to its sensitivity to marrow abnormalities surrounding the fracture line.[18–21] For the purposes of this technique report, informed consent was obtained for the included radiographs and intraoperative photographs.

2. Technique

The patient is placed in the supine position on a radiolucent table (Figs. 1 and 2). Minimize material (sheets, bedding, etc.) between the patient and fluoroscopic imaging machine as this may decrease the ability to visualize the osseous corridors radiographically in this frequently osteopenic and osteoporotic population. A sacral bump is rarely warranted because the ability of the curved implant and relatively anterior starting position overcome its benefit. The arms are placed out to the side, perpendicular to the body, if able, to maximize one's ability to obtain hyper-inlet fluoroscopic views, if necessary. If the fracture pattern requires a reduction or approach that would benefit from relaxation of the iliopsoas muscle of the operative hip, flex the ipsilateral hip and knee over a triangle or stack of blankets to shorten the muscle belly with the leg

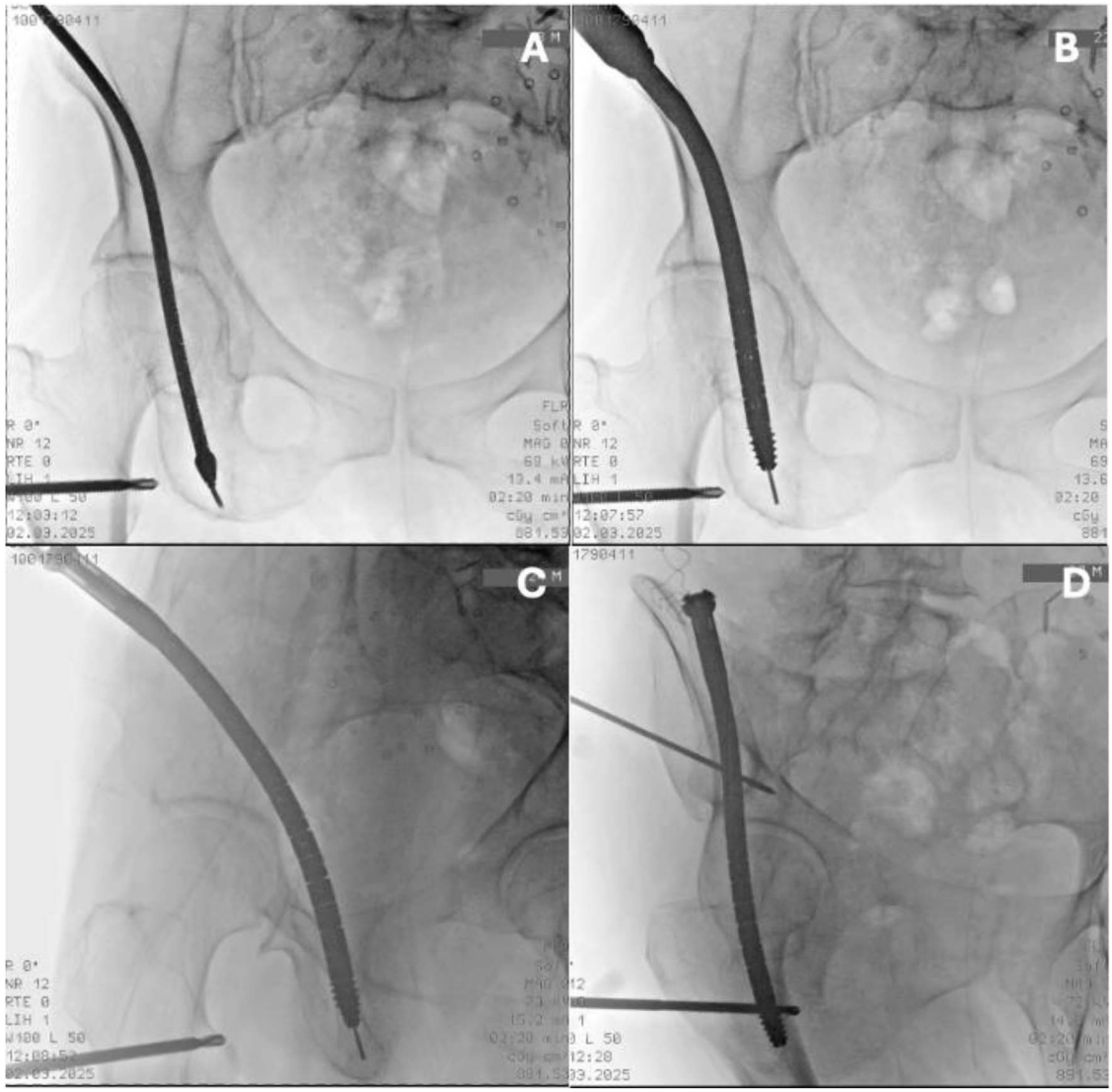

Figure 6. A–D, Application of reamer (A), application of curved intramedullary implant on AP (B), iliac oblique (C), and obturator oblique outlet (D) intraoperative fluoroscopy. The start point for anterior column fixation is also noted.

internally rotated to ensure the anteversion of the femoral head is not inducing a deformity or displacement of any other fracture lines. Note that this position does place traction on the sciatic nerve.[22] Otherwise, the lower limbs should lie flat with the hips and knees extended, internally rotated, secured, and bony prominences well-padded. It is advantageous to ensure one can obtain proper imaging before draping the patient. Obtain an iliac oblique view to assess the anterior and posterior margins of the posterior column and an AP view to assess the medial and lateral margins of the posterior column (Fig. 3A and B). In addition, an obturator oblique outlet view should be obtained to visualize the corridor of the gluteal pillar and lateral cortex adjacent to the posterior horn of the acetabulum and ischial tuberosity (Fig. 3C).[23] Prepare the skin from the xyphoid process proximally to the base of genitalia distally and as far posterior as possible on either side of the thorax and pelvis, at least further than the mid-axial line of the abdomen. It is the authors' preference to drape with squared-off universal drapes to provide the widest field available but any draping scheme that exposes the same field is acceptable. To aid in reduction, a Schanz pin can be placed percutaneously into the proximal femur to provide a lateralization force to aid in reduction. Palpate the anterior superior iliac spine. In the rare event this landmark is unpalpable due to body habitus or other reason, use the iliac oblique view and a radio-opaque instrument to identify radiographically. Then palpate approximately 3 to 4 fingerbreadths, or about 5 to 7 centimeters, posterior to this landmark, along the iliac crest, to identify the iliac tubercle, the most cranial extent of the gluteal pillar.[8] Incise the skin about 3 centimeters in line with a traditional lateral window interval,[24] centered over the iliac tubercle (Fig. 4). Dissect down to the iliac crest and incise the abdominal fascia far laterally and distally along its insertion to not transect any muscle belly. Further detach the fascia more medially at this level until the inner table is palpable. Detach the least amount of the footprint needed for the desired implant.

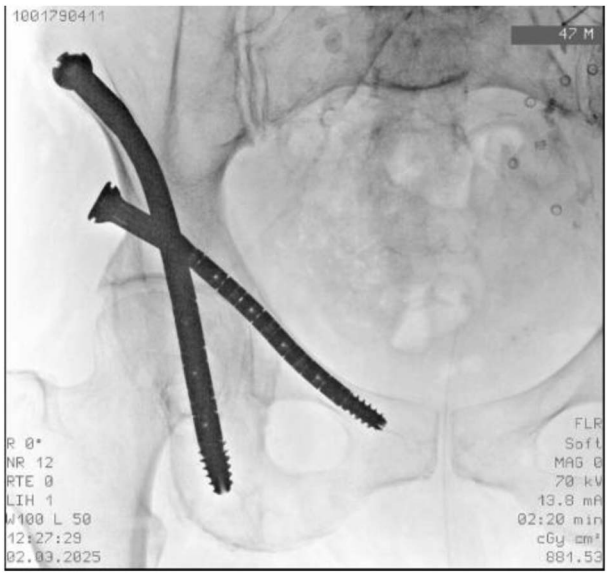

Figure 7. Intraoperative AP fluoroscopy of final fixation.

Extension of the incision and fascial release longitudinally may be needed if using any reduction aides, such as a paddle clamp or spiked pushers, through this same interval, deep to the iliacus muscle. Place the starting guidewire on the iliac tubercle and palpate medially and laterally to ensure the starting point is in the center of the tubercle (Figs. 5 and 6). An obturator oblique outlet view should be obtained to ensure radiographically that the positioning is centered over the gluteal pillar (Fig. 6D). Then, an iliac oblique view should be obtained to ensure general alignment with the posterior column; however, this view is not as critical due to the implant's ability to curve (Fig. 6C). Monitor the insertion of the entry reamer on the obturator oblique outlet view and be sure to ream deep enough to accommodate the length of the straight portion of the curved intramedullary implant. Steer the flexible guidewire through the gluteal pillar into the posterior column using the AP and iliac oblique views to traverse the fracture. In the event the flexible guidewire exits the corridor through a fracture line or insufficient bone, usually at or near the pelvic brim, instrument a paddle clamp or broad surface elevator through this small lateral window to block the wire from exiting the cortex at this level. In some instances where fixation through an intrapelvic approach using plates and screws along the brim and/or quadrilateral surface has been performed prior, this hardware will act to prevent the wire from escaping at this level. Once the wire is at the desired level, confirm intraosseous placement using the AP, iliac oblique, and obturator oblique views. Then, complete the measurement, reaming, and insertion of the implant (Figs. 7 and 8). Postoperatively, patients are weight bearing as tolerated due to the load-sharing quality of fixation afforded by the Curvafix implant.

2.1. Limitations

Some limitations in the technique include that it requires curved intramedullary implants, which may be expensive and inaccessible in some facilities. The current iterations of this implant may not allow predictable compression and should rather function to neutralize or bridge fractures.

3. Conclusion

With the use of curved intramedullary implants, this technique discussed posterior column fixation via the iliac tubercle through the gluteal pillar. In the appropriate setting, the "Crest-Pillar-Column" technique can aid orthopaedic surgeons in a minimally invasive or percutaneous treatment of posterior column acetabulum fractures.

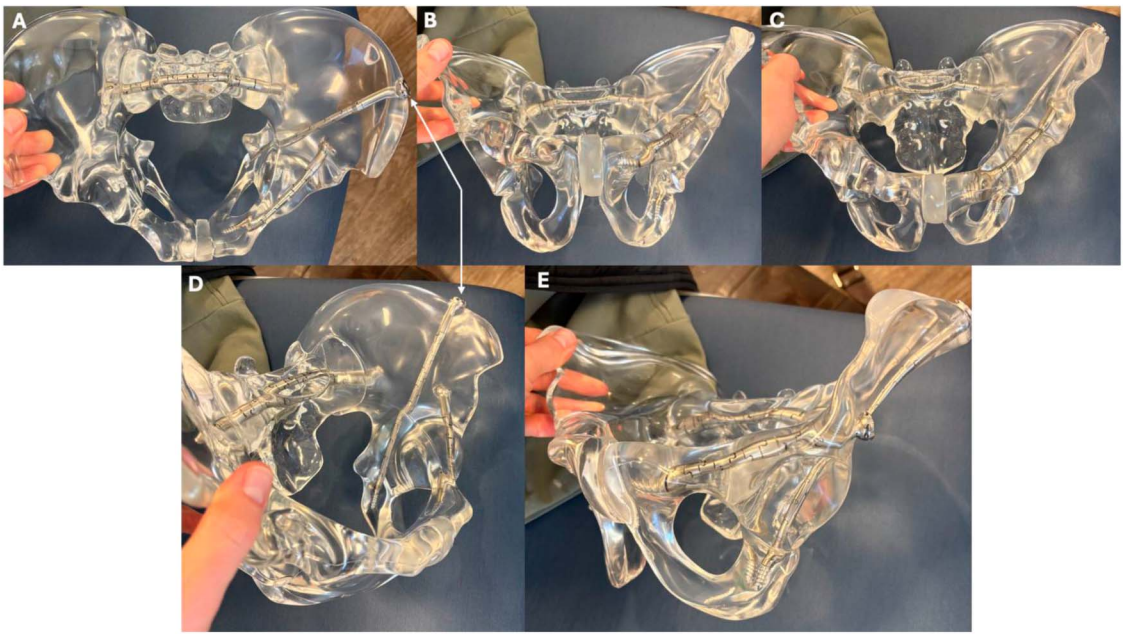

Figure 8. A–E, Pelvis model with Curvafix implants applied to anterior column, posterior column, and upper sacral segment. The start point for percutaneous fixation of the posterior column via iliac tubercle is noted with white arrows.

Data Availability Statement

All data supporting the findings of this study are available in previously published articles, which are cited in the references section of this manuscript.

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