

EXHIBIT 1014

Anatomic Considerations for Posterior Approach to the Sacroiliac Joint

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Study Design. This anatomic study describes a new intraosseous, posterior approach to the sacroiliac joint.

Objectives. To define a transosseous approach to the sacroiliac joint in which a triangular bony window is raised on the posterosuperior aspect of the ilium that provides improved access to the sacroiliac joint for posterior fusion.

Summary of Background Data. A posterior approach to the sacroiliac joint has been widely used for debridement of infectious diseases and for fusion. Most conventional approaches to the sacroiliac joint are intraosseous, and there is a relative lack of information on transiliac approaches.

Methods. The projection of the sacroiliac joint on the outer table of the ilium and the thickness of the posterior ilium forming part of the sacroiliac joint were determined in 15 cadaveric pelvises. A right angle, triangular bony window was raised from the posterior ilium to investigate the suitability of a transiliac approach in performing sacroiliac debridement and arthrodesis. A horizontal reference line 3–3.5 cm in length was drawn between a point 1 cm anterosuperior to the posteroinferior iliac spine and a point 1.5 cm superior to the superior border of the greater sciatic notch. A vertical reference line was extended superiorly for 2–2.5 cm perpendicular to and beginning at the anterior end of the horizontal reference line. The oblique arm of the right triangle was created by joining the superior end of the vertical reference line to the posterior end of the horizontal line.

Results. Thirty percent to fifty percent of the articular surface of the iliac bone was removed with this triangular segment of bone, and a corresponding area of the sacral articular surface was visualized directly. It was possible to remove the rest of the articular cartilage with angled curettes in all specimens.

Conclusions. This approach facilitates improved access to the sacroiliac joint for debridement and arthrodesis with minimal soft tissue dissection and iliac bone resection. [Key words: anatomy, fusion, sacroiliac joint, surgical approach] *Spine* 1996;21:2709–2712

internal fixation of the posterosacroiliac complex.^{10,11,13,14} The posterior approach has been widely used for management of infectious or inflammatory diseases and instability of the sacroiliac joint by debridement and fusion of sacroiliac (SI) joint.^{2,9,16} Previously described techniques require considerable dissection, however, and removal of the articular surfaces from the sacrum and ilium may be incomplete. In the present study, the authors describe a modified posterior approach to the sacroiliac joint through a triangular bony window on the posterosuperior aspect of the ilium, which requires minimal dissection and provides improved access to the joint surfaces.

Materials and Methods

Fifteen adult pelvises stripped of all soft tissues were obtained from the Department of Anatomy, Medical College of Ohio, Toledo, OH, for the first part of the study. The mean age of the pelvises was 63 years (range, 32–78 years). The articular surface of the ilium was divided into anterior and posterior halves, and its thickness was measured at the upper, middle, and lower third levels with a caliper accurate to within 1 mm. The longitudinal axis of the lower limb then was drawn on the inner table of posterior ilium, and the distance from this line to the inferior margin of the posteroinferior iliac spine (PIIS) and to the superior margin of the greater sciatic notch was measured.

A right angle, triangular bony window was marked on the outer table of the ilium as follows. A point was marked 1 cm anterior and superior to the inferior border of PIIS, and another point 1.5 cm superior to the superior border of the greater sciatic notch was chosen. A line was drawn joining these two points, corresponding with the longitudinal axis of the inferior limb. Next, a vertical line was drawn beginning at the anterior end of the first line and extending superiorly and perpendicularly for 2–2.5 cm. A third oblique line was drawn connecting the first two lines, thus completing a right triangle (Figure 1). The area thus marked on the relatively thinner posterosuperior quadrant of the ilium then was removed with an osteotome or an electric saw, which exposed the corresponding sacral articular surface. The cartilage lining the iliac and sacral articular surfaces then was removed thoroughly with the angled curettes. The SI joint then was disarticulated, and denuded iliac and sacral articular surfaces were examined. The articular surface removed from the ilium with the triangular bony window also was measured with a square centimeter, transparent grid; this measurement was expressed as a percentage of the total iliac articular surface.

Several previous studies have described the surgical anatomy and the techniques of open or closed reduction and

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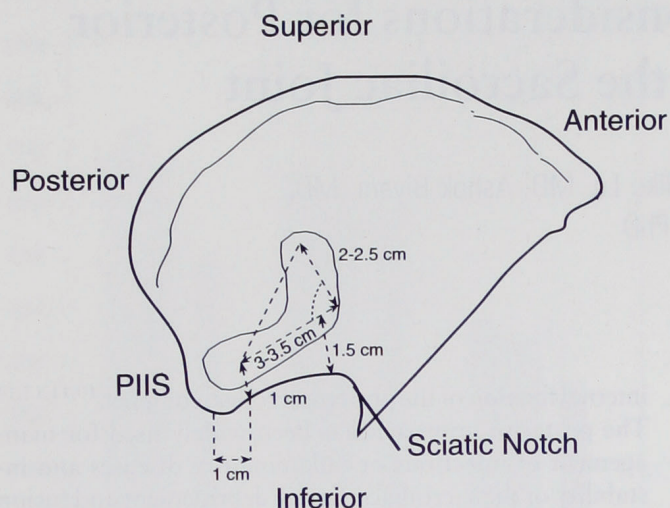


Figure 1. Diagrammatic illustration of a right triangle on the outer table of the posterior ilium.

Ten embalmed cadavers were dissected in the second part of the study to confirm the efficacy and to evaluate the safety of the modified technique of posterior approach to the SI joint through a right angle, triangular window in the posterosuperior part of the iliac bone. The mean age of the cadavers was 56 years (range, 29–78 years).

Each cadaver was placed in a prone position. An incision was made beginning at the level of the posterosuperior iliac spine (PSIS) and extending distally to the midpoint between the PSIS and the PIIS. The incision then continued laterally and distally for 5 cm (Figure 2). The superficial fascia and the aponeurosis covering the gluteus medius muscles were incised along the line of the skin incision. Sharp dissection then was performed to detach the origin of the gluteus maximus from the posterior ilium. The gluteal musculature was reflected further laterally by subperiosteal elevation, and the superior border of the greater sciatic notch was identified. One or two Steinmann

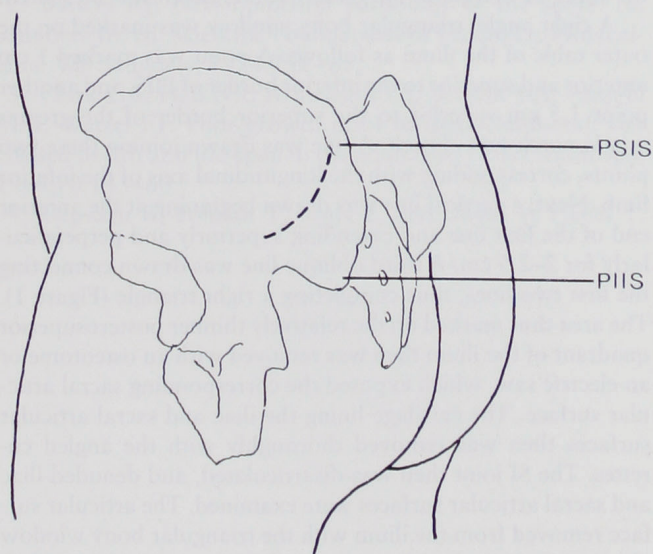


Figure 2. The skin incision starts from the posterosuperior iliac spine and continues laterally and distally for 5 cm.



Figure 3. The superior gluteal artery is located below and lateral to the bony window of the ilium (arrow).

pins (Zimmer, Warsaw, IN) then were inserted in the ilium to retract the gluteus maximus laterally and distally; care was taken not to damage the superior, gluteal, neurovascular bundle. The posterior superficial surface of ilium between the PSIS above and the superior border of the greater sciatic notch below thus were exposed (Figure 3).

A right angle, triangular bony window then was raised from the posterior ilium in the manner previously described (Figure 4). The articular cartilage from the sacral and iliac surfaces was removed with angled curettes. The joint then was disarticulated, and the amount of iliac articular cartilage removed with the triangular bony window and from the iliac and sacral surfaces after curetting were examined.

Results

The thickness of anterior articular portion of the ilium was 2.2 ± 0.4 cm in the upper third, 1.9 ± 0.3 cm in the middle third, and 1.1 ± 0.4 cm in the lower third, and the thickness of the posterior articular portion of the ilium was 1.1 ± 0.1 cm in the upper third, 1.2 ± 0.2 cm in the middle third, and 0.8 ± 0.3 cm in the lower third. This difference between the thickness of the anterior and posterior halves of articular surface of the ilium was statistically significant ($P < 0.001$) using paired *t* test.

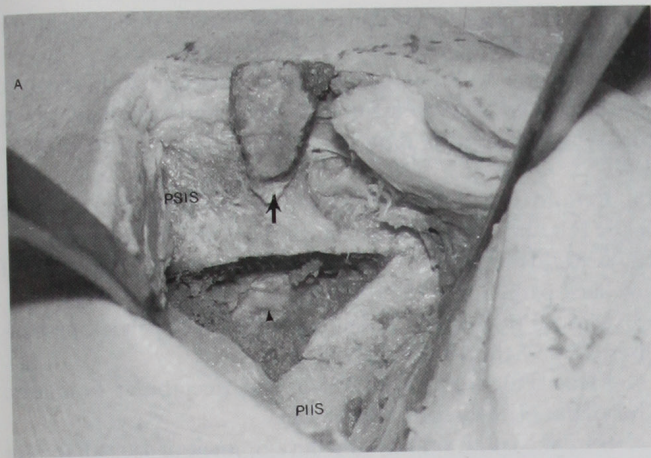


Figure 4. A right angle, triangular bony window is made on the posterior ilium between the posterosuperior iliac spine and the posteroinferior iliac spine. A full-thickness bone flap is removed from the ilium (arrow), and the posterior and superior part of sacroiliac joint cartilage is exposed (arrow head).

The mean longitudinal axis of the inferior limb of the SI joint was 1.2 ± 0.2 cm superior to the inferior margin of the PIIS and 1.7 ± 0.3 cm superior to the inferior margin of the greater sciatic notch (Figure 5).

Thirty percent to fifty percent of the cartilage surface of the ilium was removed with the triangular bony window, and a corresponding area of the sacral articular surface was visualized in the trough that was created (Figure 4). Almost all of the joint surface could be denuded in all specimens using angled curettes. The surgical approach and the marking and elevation of the triangular bony window over the posterosuperior ilium were performed in all cadavers with no difficulty.

Discussion

Structural abnormalities, infections, metabolic and inflammatory diseases, and degenerative joint disease of

the SI joint may require surgical intervention.^{1,3,6,8,12} A standard posterior approach most commonly is used, which provides limited access to the sacroiliac joint surfaces.⁷ There are very few previous studies, to the authors' knowledge, that describe a posterior approach to the SI joint through an iliac bony window.

The projection of the SI joint on the outer table of the posterior ilium has been described previously.¹⁷ The mean length of the superior and inferior limbs of the sacroiliac joint in that study was 4.4 ± 0.4 cm and 5.6 ± 0.9 cm, respectively; the mean length of the longitudinal axes of the superior and inferior limbs was 3.3 and 4.2 cm, respectively. The width of each limb averaged 2.0 cm, and the mean angle formed by the intersection of the longitudinal axes was $93 \pm 8^\circ$. In the present study, the authors found that the mean longitudinal axis of inferior limb of the SI joint was 1.2 ± 0.2 cm superior to the inferior margin of the PIIS and 1.7 ± 0.3 cm superior to the inferior margin of the greater sciatic notch (Figure 5). These morphometric data facilitate accurate determination of the location of the SI joint on the outer table of the ilium.

The SI joint is usually described as "L-shaped," with the long arm directed caudally and the short arm directed cranially. Alternatively, the two arms may be of equal length. The joint may be "V-shaped," with varying angles between two arms. The short arm may be absent, and the surface may resemble either a rectangle, triangle, or an intermediate form.^{4,15} Bowen et al⁵ reported that the joint was always auricular or "C-shaped."

The present anatomic study shows that the SI joint surfaces project a right triangle, and the posterosuperior portion of the ilium is only half as thick as the anteroinferior portion. Therefore, making a right angled, triangular bony window through the thinner posterosuperior portion of the iliac bone is more effective. The curette should be directed anteriorly and inferiorly from the iliac window, and the articular surface should be thoroughly denuded to ensure fusion. The advantages of this technique include smaller skin incision, less soft tissue dissection, and minimal bony resection through the thinner portion of iliac bone, thus decreasing blood loss. The interosseous ligaments are not damaged because the approach to the SI joint is transosseous, and almost all articular cartilage can be removed. The risk of postoperative instability and pseudarthrosis, therefore, should be theoretically reduced.

Accurate localization of the bony window in the iliac crest away from the greater sciatic notch is important to avoid laceration of the superior, gluteal, neurovascular bundle. Laceration of the superior gluteal artery may allow retraction of its bleeding end into the pelvis, making clamping or ligation difficult. Superior gluteal denervation may lead to loss of hip abductor function.

A posterior transiliac approach to the SI joint is simple to perform through a small incision and requires less soft tissue dissection. It removes 30–50% of the iliac articu-

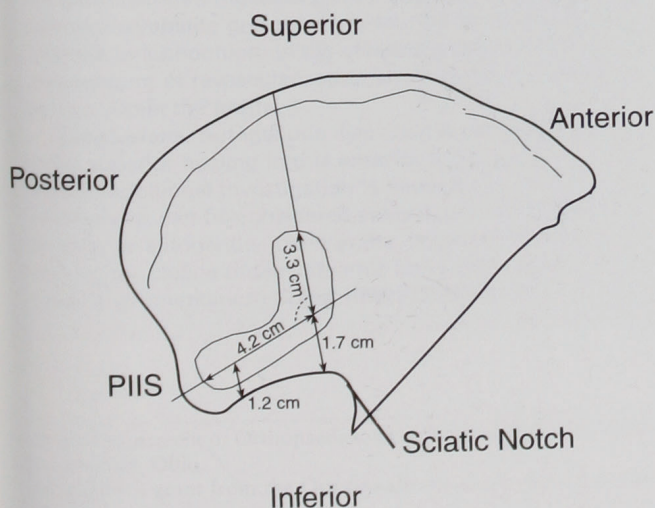


Figure 5. Schematic representation of the projection of sacroiliac joint. The average values characterized in previous studies and in the present study are represented in the drawing.

lar surface and facilitates direct visualization of the corresponding sacral articular surface. Almost all remaining sacral and iliac articular cartilage can be removed with the angled curettes. After removal of the articular cartilage, cancellous bone may be harvested from the adjacent iliac crest to fill in the joint space. The bony window that is removed may be anatomically oriented to its original position and tamped back into the trough at the end of the procedure.

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