Recent Trends In Management Of Acetabular Bone Defects In Revision Total Hip Arthroplasty

An essay

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APPLIED SURGICAL ANATOMY OF THE ACETABULUM

THE ACETABULUM

It is an approximately hemispherical cavity on the lateral aspect of the hip bone; it is directed laterally, downwards and forwards [8].

The acetabulum faces distally at an angle of 40 degrees to the horizontal plane and is directed anteriorly at an angle of 25 degree to the sagittal plane [9].

THE COLUMN CONCEPT OF THE ACETABULUM

The three elements of the hip bone contribute to the acetabulum formation in human meeting at a Y shaped Cartilage forming their epiphyseal junction. This epiphysis closes after puberty. The united upper limbs of the Y epiphysis are represented on the hip bone by heaping up of bone at the iliopubic eminence anteriorly and at the point of meeting of ilium and ischium posteriorly. The posterior mark reaches approximately to one third of the way down to greater sciatic notch. The stem of the Y is vertical and passes through the acetabular notch to the obturator foramen *(Fig. 1a, b)*[10].

At first sight the acetabulum appears to be contained within an arch. The limbs of the arch are posterior (or ilio-ischial), and anterior (or ilio-pubic). For a better understanding of the pathological anatomy of the acetabular defects, we must alter somewhat this basic concept of the architecture. It is better to regard the acetabulum as being contained within the open arms of an inverted Y *(Fig. 1c)* [11].

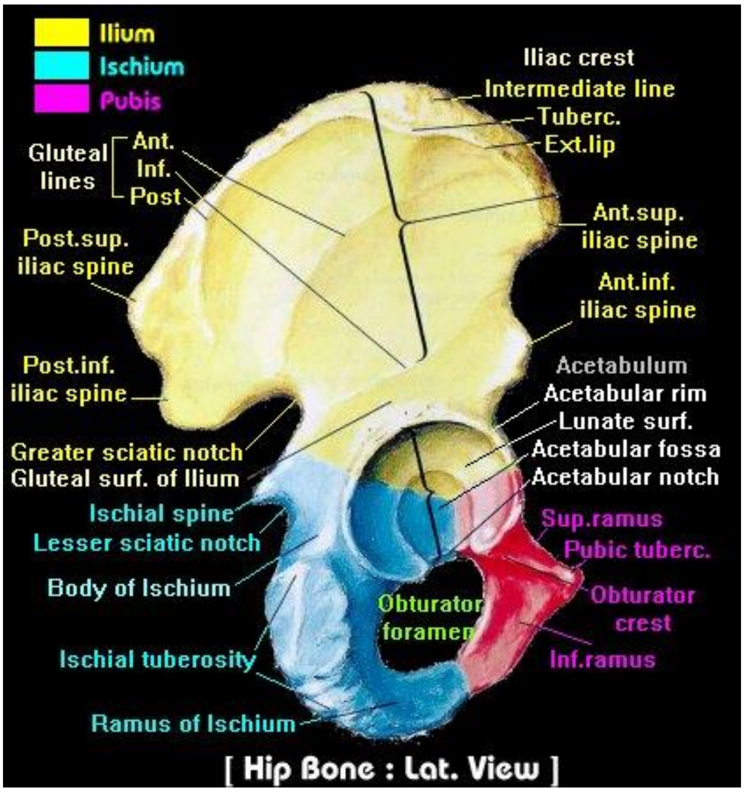


Figure 1a: External surface of the right hip bone(12).

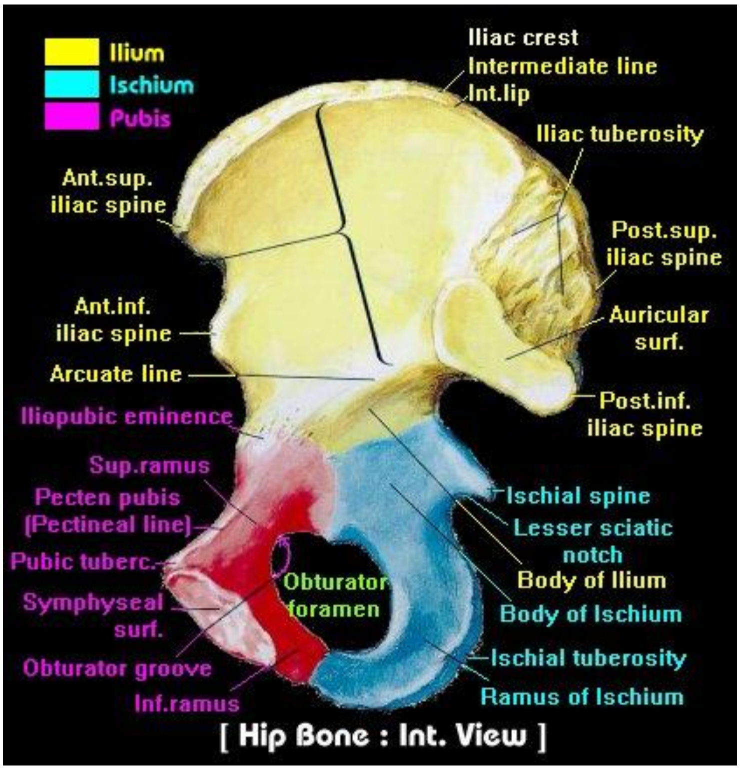


Figure 1b: Internal surface of the hip bone(12) .

It is formed by a posterior column, the ilio-ischial component, and an anterior column, which is much longer and extends from the anterior end of the iliac crest to the pubic symphysis; the upper end of the posterior column is attached to the posterior aspect of the anterior column, a little above its mid-level *(Fig. 1c)*(13).

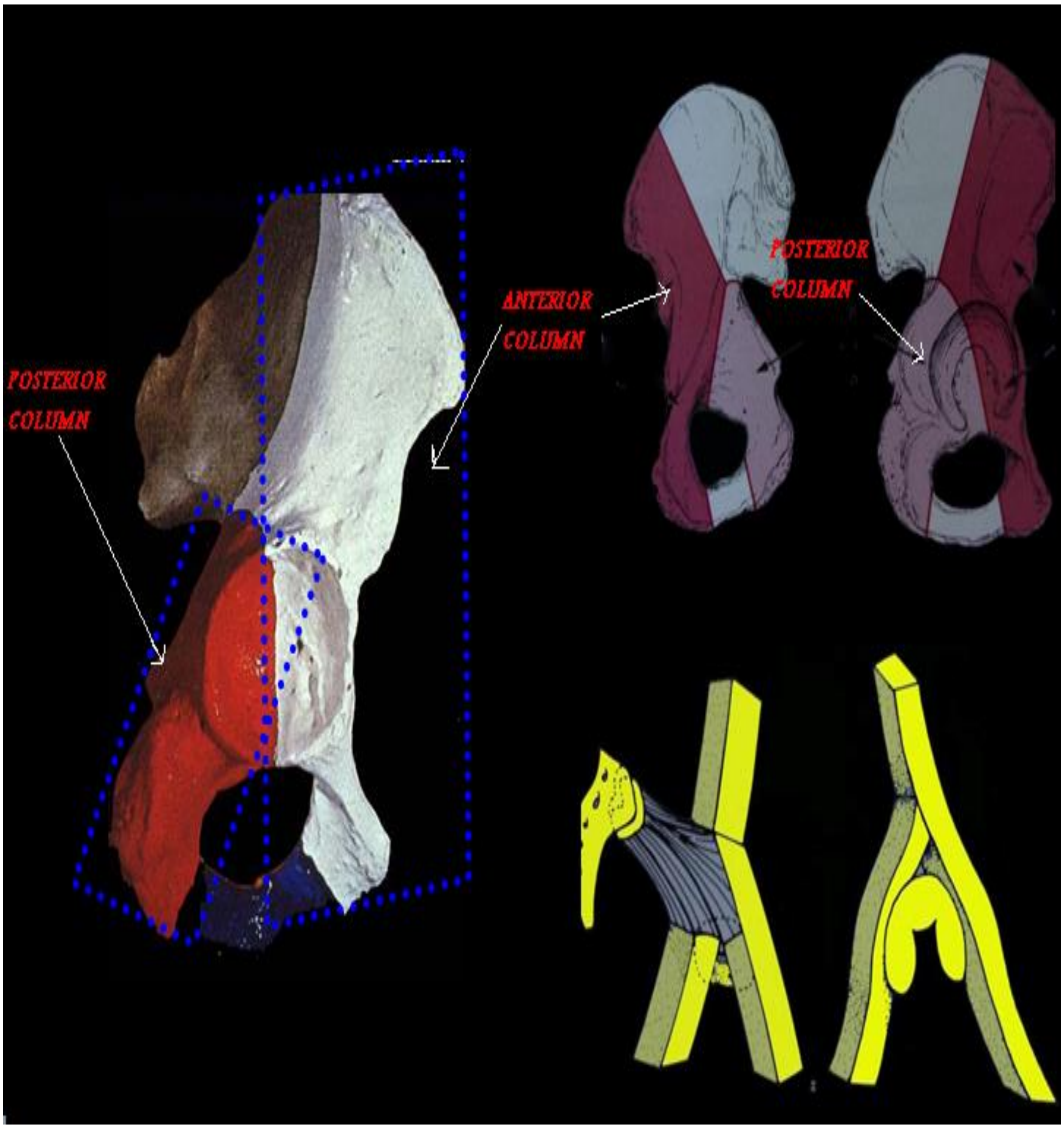


Figure 1c:

A- Schematic of the intrapelvic view of the pelvic bone demonstrating the anterior and posterior columns.

B- Schematic of the extrapelvic view of the pelvic bone demonstrating the anterior and posterior columns (13).

An anatomical and radiographic study was undertaken to determine the safest zones in the acetabulum for the transacetabular placement of screws during uncemented acetabular arthroplasty. To avoid injury to intrapelvic structures, which are not visible to the surgeon during placement of the screws. [14]

The acetabular-quadrant system provides the surgeon with a simple intraoperative guide to the safe transacetabular placement of screws during primary and revision acetabular arthroplasty.

The acetabular quadrants are formed by extending a line from the anterior superior iliac spine through the center of the acetabulum, resulting in anterior and posterior halves (Fig. 2, Line A). A second line drawn perpendicular to Line A at the center of the acetabulum forms superior and inferior acetabular halves (Fig. 2, Line B). The four quadrantsformed by the intersection of Lines A and B are the anterior superior quadrant, the anterior inferior quadrant, the posterior superior quadrant, and the posterior inferior quadrant. A constant relationship was found to exist between specific acetabular quadrants and specific intrapelvic structures. [14] .

Screws originating from the anterior superior quadrant were found to lie near the external iliac artery (Figs. 3-A, 3-B, and 3-C) and vein (Figs. 4-A, 4-B, and 4-C). However,because of the more medial position of the vein with respect to the artery and the paucity of interposed tissue along the pelvic brim, the external iliac vein was more in danger of injury than was the artery (Figs. 4-D).

Screws originating from the anterior inferior quadrant were directed toward the obturator nerve and vascular structures (Figs. 3-A, 3-C, 4-A, 4-B). This was most evident at the superolateral aspect of the obturator foramen, where the nerve, artery, and vein exit the true pelvis through the obturator canal.

Screws placed in the center of the acetabulum at the intersection of Lines A and B (polar position) exited the pelvis through the quadrilateral surface and were near the obturator nerve, artery, and vein (Figs. 3-A through). The obturator internus muscle provided minimum interposition of tissue along the quadrilateral surface and was often sparse and insufficient. This situation was worsened by the thin plate of bone opposite the polar position of the acetabulum. Screws as short as fifteen millimeters that were located around the polar position of the acetabulum were found to endanger the obturator nerve and vessels.

Screws placed in the posterior quadrants can be directed toward the sciatic nerve and inferior gluteal vessel but are directed away from the external iliac vessels and obturator vessels and nerve. Screws longer than twenty millimeters that are inserted along the rim of the posterior column are near the sciatic nerve along its extrapelvic portion. These screws are palpated by placing the finger around the brim of the acetabulum during insertion; screws of the proper size can easily be placed while the sciatic nerve is avoided. (14).

Screws that are located centrally in the posterior superior quadrant (Fig. 4-A) may be directed toward the superior gluteal nerve, artery, and vein as they exit the pelvis through the greater sciatic notch. However, , the bone depth in the central zone of the posterior superior quadrant was always more than twenty-five millimeters.

Screws that are located centrally in the posterior inferior quadrant (Figs. 4-A and 4-D) are directed toward the inferior gluteal and internal pudendal nerves and vessels. These structures are rarely endangered, due to surrounding intrapelvic tissue and their distance from the posterior column. The deeper bone depths in the central zones of the posterior inferior quadrant also afford decreased risk of damage to vessels or nerves caused by screws. (14) .

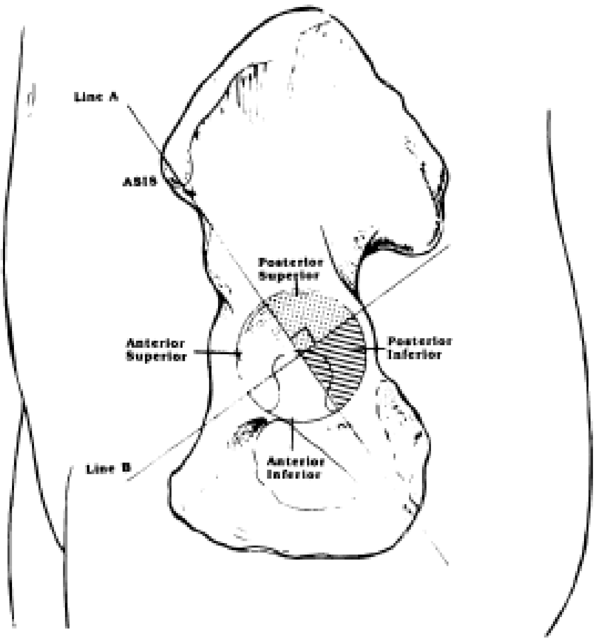


Fig2

The acetabular-quadrant system. The quadrants are formed by the intersection of Lines A and B . Line A extends from the anterior superior iliac spine (ASIS) through the center of the acetabulum to the posterior aspect of the fovea, dividing the acetabulum in half. Line B is drawn perpendicular to Line A at the mid-point of the acetabulum, dividing it into four quadrants: the anterior superior quadrant, the anterior inferior quadrant, the posterior superior quadrant, and the posterior inferior quadrant. (14)

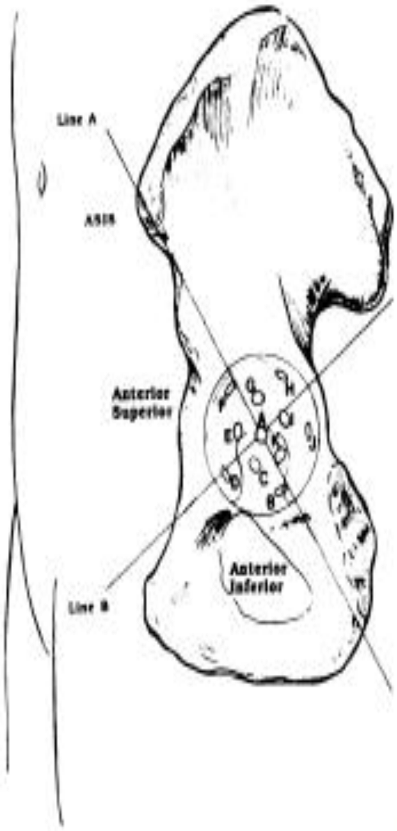


FIG. 3-A

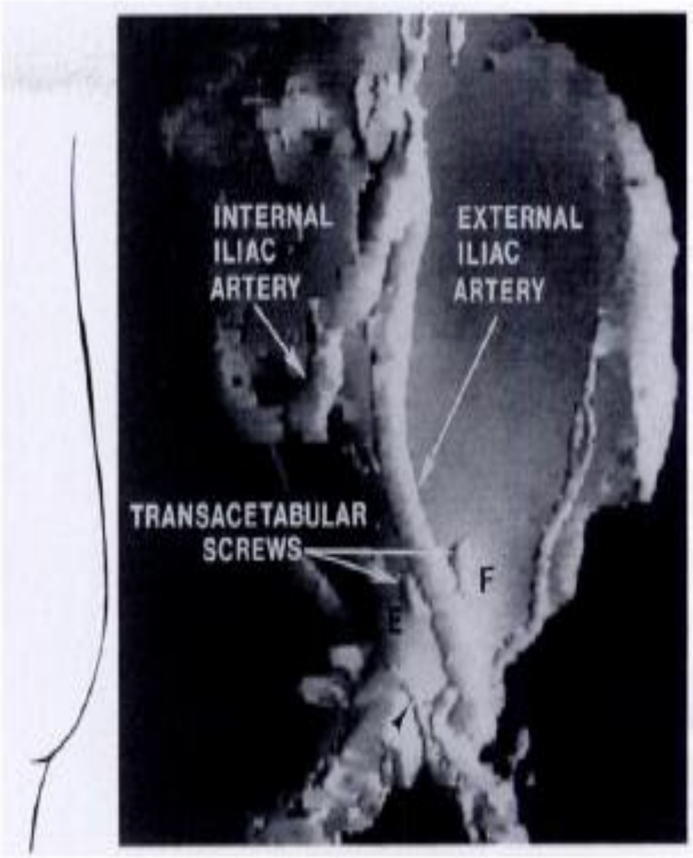


FIG. 3-B

***Figs. 3-A.**: Schematic drawing showing the acetabular origin of the screws (labeled A through K). ASIS = anterior superior iliac spine.*

***Fig. 3-B:** Three-dimensional reconstruction of a computed tomographic scan, showing the position of the screws (E and F) and their relationship to the external iliac artery. The acetabular origin of these screws is the anterior superior quadrant (Fig. 3-A).* [14]**.**

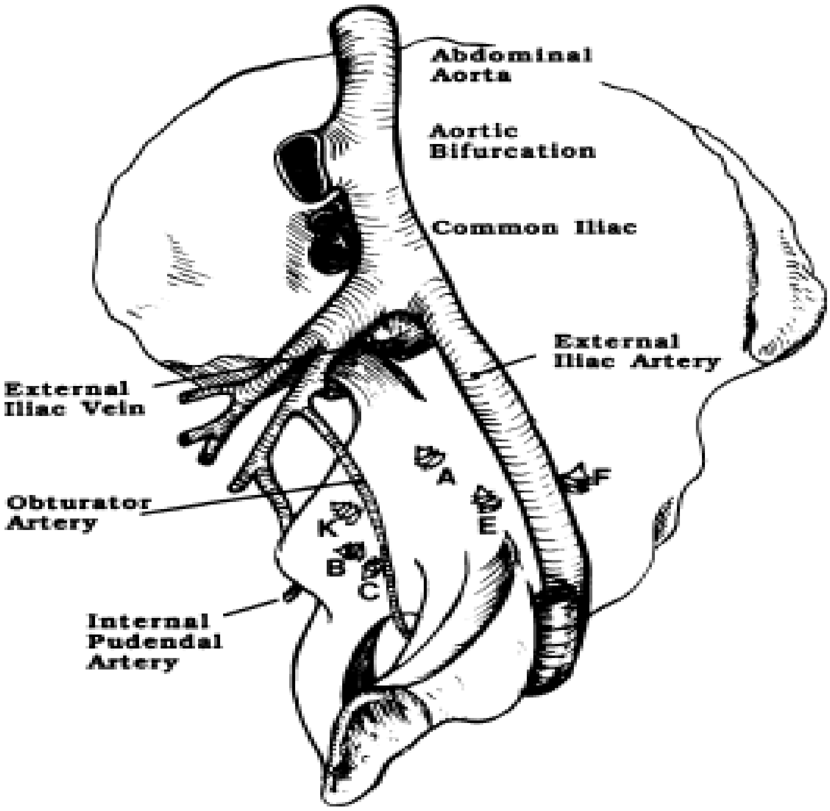
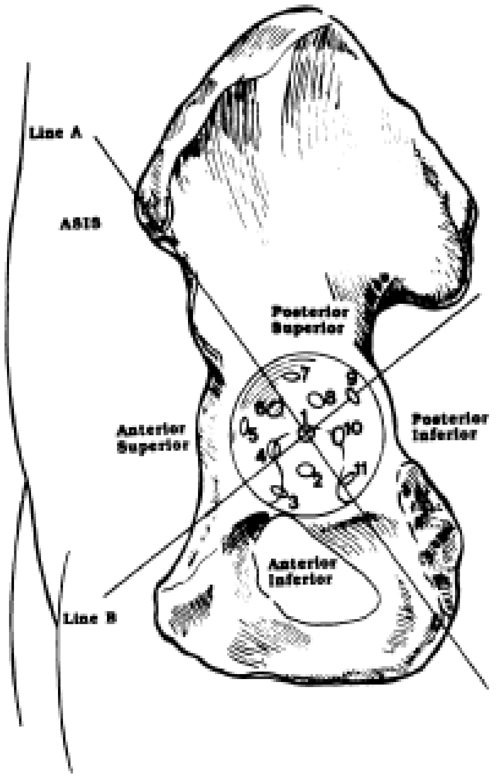


FIG. 3-C

Fig. 3-C. *Schematic diagram showing the location of excessively long screws* ***on*** *the quadrilateral intrapelvic surface relative to the iliac arterial system.Screws E and F are near the external iliac artery; their acetabular origin is the anterior superior quadrant* ***(Fig. 3-A)****.over-penetration during drilling, tapping,* [14]**.**



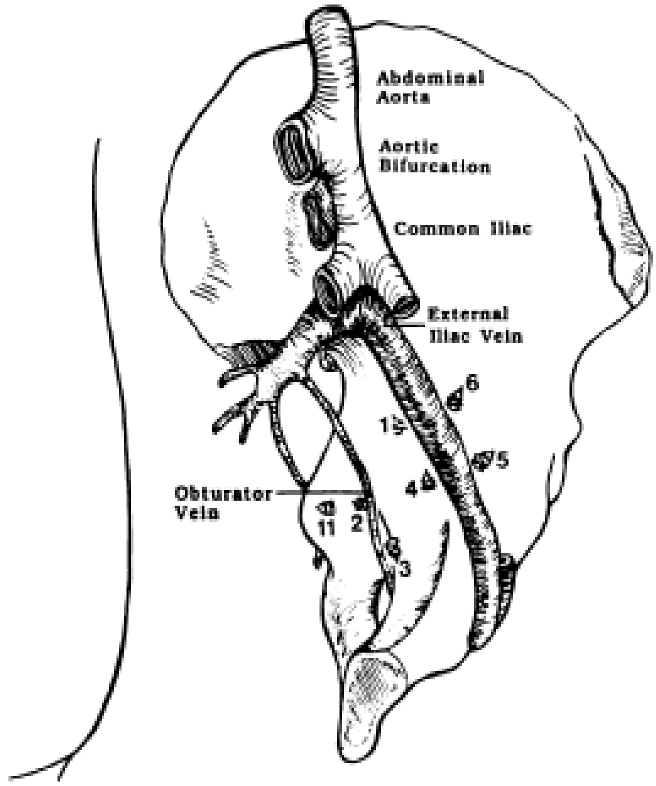
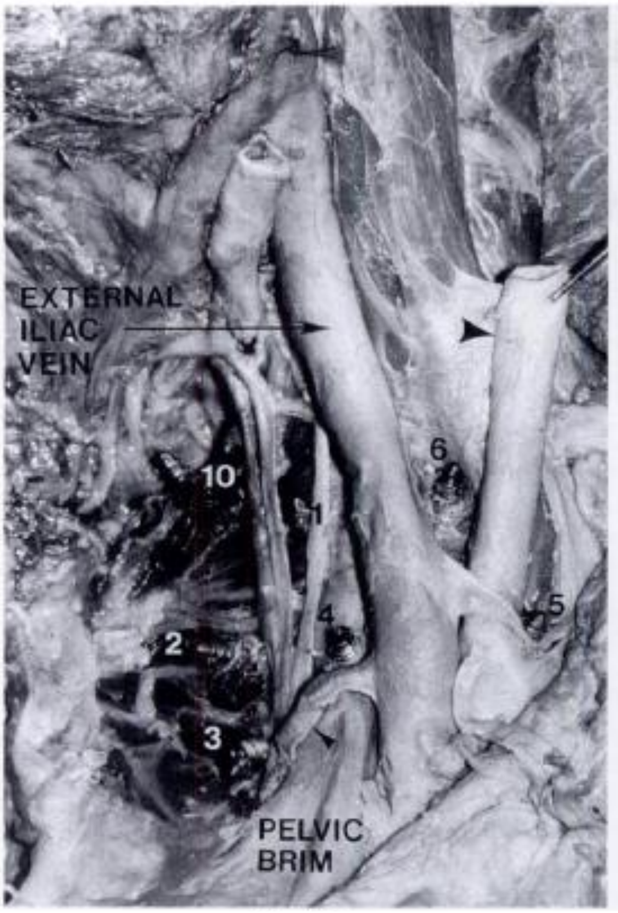


Fig4-A **Fig4-B**

Fig. 4-A: *Schematic diagram showing the acetabular origin of the screws (numbered 1 through 1 1). ASIS = anterior superior iliac spine.*

Fig. 4-B: *Schematic diagram showing the location of the screws on the quadrilateral intrapelvic surface relative to the iliac venous system. Screws 1 , 4, 5, and 6 are near the external iliac vein; their acetabular origin is the anterior superior quadrant (Fig. 4-A). Screws 2 and 3 are near the obturator vein; their acetabular origin is the anterior inferior quadrant (Fig. 4-*A). [14]**.**



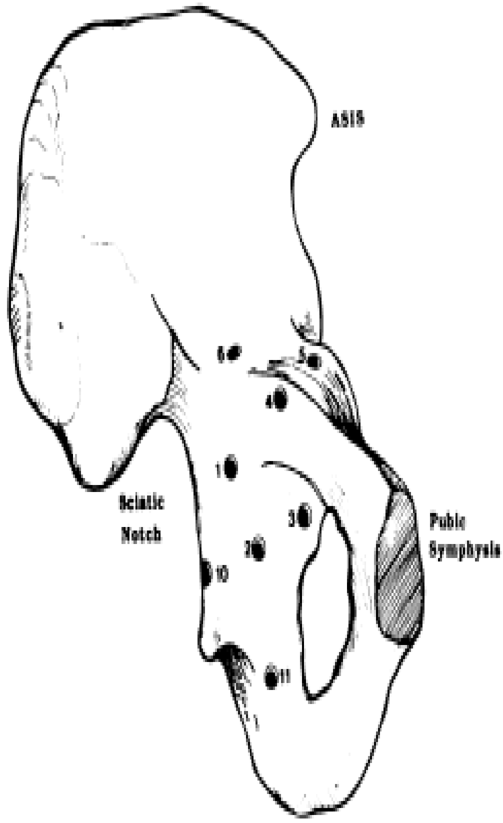


Fig4-C **Fig4-D**

Photograph of a dissection. Screws 1 , 4. 5, and 6 are near the externaliliac vein. An accessory obturator vein (small arrowhead) is shown trayeling across the pelvic brim from the obturator foramen to the external iliac vein. The orientation is the same as in Figure 4-B. Large arrowhead- external iliac artery. (14)**.**	*Schematic diagram showing the quadrilateral intrapelvic surface and the location ofthe screws. The holes are numbered according to their acetabular origin (Fig. 4-A). ASIS = anterior superior iliac spine.*(14)

Understanding the measurements used to create a topographic map of normal periacetabular bone could help surgeons obtain better acetabular fixation and more easily locate the hip center of rotation in complex cases. Additionally, these data could provide the basis for more anatomically driven implant designs such as revision acetabulum components, acetabular reconstructive cages, augments, and pelvic bone fixation plates.

The measurements were made by Viktor Krebs et al, in reference to a line that bisected the ischium 1 cm distal to the posteroinferior acetabular rim (Fig. 5). This allowed angular measurements between the specific landmarks. Owing to its importance for acetabular fixation, the superior quadrant was divided into two subregions by the superior iliac column, S1 and S2. This allowed for more detailed analyses of the size, position, and topography of each region. Angular measurements included: superior angle 1 (S1), the angle between the top of the sciatic notch and the most prominent ridge on the ilium; superior angle 2(S2), the angle between the most prominent ridge on the ilium and the ASIS; posterior angle (P), the angle betweenthe top of the sciatic notch and the line bisecting the ischium; inferior angle (I), the angle between the ischial bisection and the superior pubic ramus; and anterior angle(A), the angle between the ASIS and the superior pubic ramus[15].

The anatomically based topographic maps and cross sections generated by Viktor Krebs et al allowed defining an acceptable range of screw lengths at different positions around the hemisphere when anatomically positioned. The most prominent portion of the ilium was identified visually as the division between the subquadrants S1 and S2 (49°anterior to the sciatic notch). Although the relatively flat surface topography in the S2 subregion appears ideal for superior fixation, the bone thins rapidly as the inner and outer tables converge. Even though the

S1 region has a more complex surface topography, the cross section is thicker, which makes it better suited for implant fixation. This information may help the surgeon position screws and/or plates for optimal fixation. It also is important that implants be designed to match the complex topography of the S1 region, allowing the surgeon to gain fixation in that area [(15)].

The anterior column increases in thickness from 25 to 35 mm in the inferior to superior direction, whereas the posterior column increases from 35 to 45 mm in the superior to inferior direction. The acceptable range of dome and rim screws for a 54-mm acetabular shell ranges from 25 to 50 mm (Fig. 6). [(15)].

Potential design features should focus on maximizing ilium fixation in the S1 region, a high angulation of the superior and posterior acetabulum in the region of the posterior column, flattening of this angulation at the ischial level, screw holes placed to obtain purchase in the widest portion of the ilium (110°) and ischial and pubis screw holes located (100°) apart. [(15)].

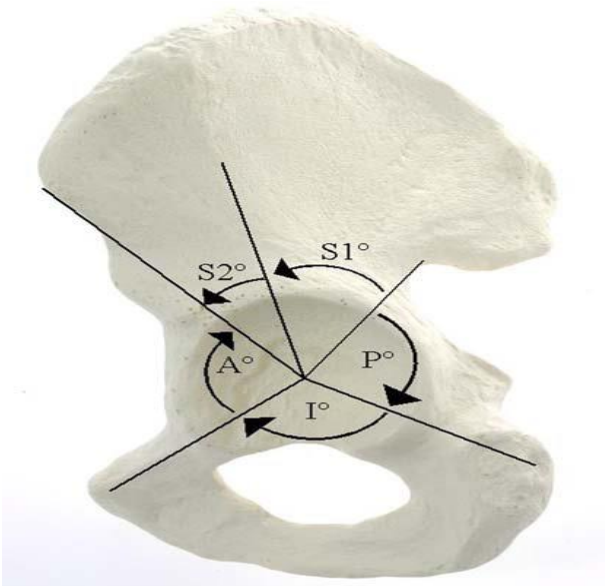


Fig. 5: *A pelvic specimen shows the axes used for angular measurements: S1 = superior angle 1, the angle between the top of the sciatic notch and the most prominent ridge on the ilium; S2 = superior angle 2, the angle between the most prominent ridge on the ilium and the ASIS; P = posterior angle, the angle between the top of the sciatic notch and the line bisecting the ischium; I = inferior angle, the angle between the ischial bisection and the superior pubic ramus; and A = anterior angle, the angle between the ASIS and the superior pubic ramus.* (15)

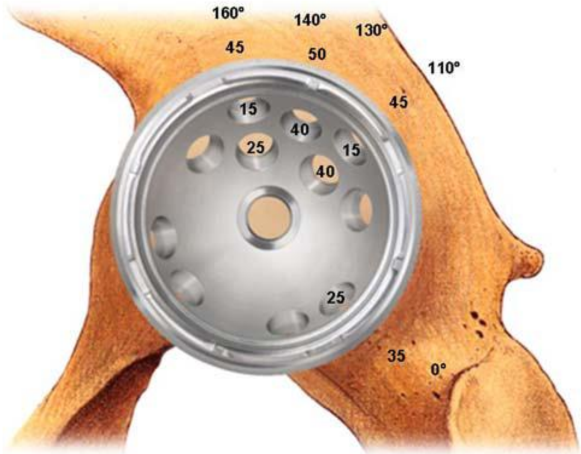


Fig. 6: *The acceptable range of dome and rim screws are shown in aleft hip for a 54-mm acetabular shell. Screw lengths are based on the cross-sectional reconstructions at 0_, 110_, 130_, 140_, and 160_. The screw hole pattern is based on multiple commercially availabl eacetabular shells. All lengths are given in millimeters and a 10-mm safety factor is included.* (15)