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Safe zones of pin insertion in the pelvis and acetabulum: a cadaver study

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ABSTRACT

Background:

The external fixator is used in emergency stabilization of unstable pelvic fractures; however, its role as a definitive fixation device remains unestablished. The main problem is the risk of injury to surrounding neurovascular structures with no definite safe corridors for pin insertion. The purpose of the current cadaveric study is to outline safe corridors in the pelvis and acetabulum and directions for pin insertion.

Methods:

A cadaver study using two bony and three cadaveric pelves was undertaken. Half pins were inserted in specific demarcated sites and tested for resistance to pullout and safety of nearby neurovascular structures.

Results:

The iliac crest, anterior inferior iliac spine, anterior superior iliac spine, posterior inferior iliac spine, and posterior superior iliac spine, supraacetabular region, ischial tuberosity both triangular and quadrangular areas, anterior column of the acetabulum lateral to the anterior superior iliac spine, and the lateral 1 cm of ala of the sacrum are safe pin insertion sites. While the area 1 cm medial to both the anterior inferior iliac spine and the anterior superior iliac spine, and the rest of the ala of the sacrum is unsafe.

Conclusions:

There are many safe areas for half pin insertion in pelvic and acetabular fractures, while there are other unsafe areas. Adequate knowledge of the safe sites and direction of pin insertion decrease the risks of neurovascular injury and allow a wider use of external fixators in pelvic and acetabular fractures.

Key Words

pelvic, acetabular, hip, pinning, external fixation

Pelvic and acetabular fractures caused by high-energy trauma usually are associated with soft tissues as well as visceral and neurovascular injuries. In such cases, open reduction and internal fixation of these fractures

carries a high risk of complications.¹ The external fixator certainly has a place in the emergency stabilization of unstable pelvic fractures; however, its role as a definitive fixation device remains unestablished.² The main problem associated with pin insertion to fix pelvic and acetabular fractures is the risk of injury to the surrounding neurovascular structures.³ The dense area of the supraacetabular region could be an alternative site to the traditional iliac crest for half pin insertion of external fixators,⁴ but knowledge about the potential anatomic risks of placement of half pins in pelvis still ill-defined.

The aim of the current cadaveric study was to find some answers for these questions. Are there strong areas in bony pelvis where half pins can be inserted? Which areas are safe for pin insertion and allow a good reduction and rigid fixation of some acetabular and pelvic fractures? Is there suggested direction for half pin insertion? Where are the dangerous areas that must be avoided during pin insertion?

MATERIALS AND METHODS

Two bony and three preserved cadaveric pelves were used. One of the cadaver specimens was composed of a hemipelvis and the upper part of the thigh, the other two were hemipelves and complete lower limb. The external fixation set used included 5-mm half pins, 3.2-mm drill bit, and power drill.

The bony specimens were examined to show the best sites for half pins insertion. The following sites were demarcated: anterior superior iliac spine (ASIS), anterior inferior iliac spine (AIIS), posterior superior iliac spine (PSIS), posterior inferior iliac spine (PIIS), superior surface of the ala of the sacrum, the supraacetabular region around the acetabulum, anterior column of the acetabulum, and ischial tuberosity region. Also the iliac crest extending from the ASIS to the PSIS, and the area extending from the ASIS to the AIIS.

The cadaver specimens were dissected to expose the vital and important structures including the femoral sheath with its contents, branches of the femoral nerve anteriorly, sciatic nerve and sacral plexus posteriorly, and the fifth lumbar nerve that enter the pelvis along the superior surface of the medial one third of the ala of the sacrum, and the other structures that emerge from the greater and the lesser sciatic notch. The pelvic visceral structures included the urinary bladder, prostate in male and urethra in female, which are related to pubis anteriorly, and the rectum, which is related to the sacrum and the ischial tuberosity posteriorly.

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To study the possible directions of pin insertion, half pins were inserted in the demarcated sites on the bony pelvis. The direction of insertion of half pins in the ASIS was from superior to inferior, and in the PSIS it was posterior superior to anterior inferior away from the sacral foramina. In the PIIS, the direction of pin insertion was from posterior to anterior (Figure 1). The insertion of half pins in the supraacetabular region was performed 2 cm above the acetabulum and the iliac wing. The direction for insertion of pins in the anterior column of the acetabulum was from anterior to posterior (Figure 2). Pin insertion in the ischial tuberosity was below the level of the ischial spine in a vertical and divergent manner (Figure 3). In the ala of the sacrum one half pin was inserted in the lateral 1 cm superior-medial to

inferior-lateral in the area between the sacroiliac joint and the sacral foramina (Figure 4).



FIGURE 1. (A and B) Frontal and side views of bony pelvic specimen showing half pins inserted in the posterior inferior iliac spine, the posterior superior iliac spine, outer part of the sacrum, and the supraacetabular region. The direction of half pin insertion in the posterior superior iliac spine and the posterior inferior iliac spine is from posterior superior to anterior inferior.

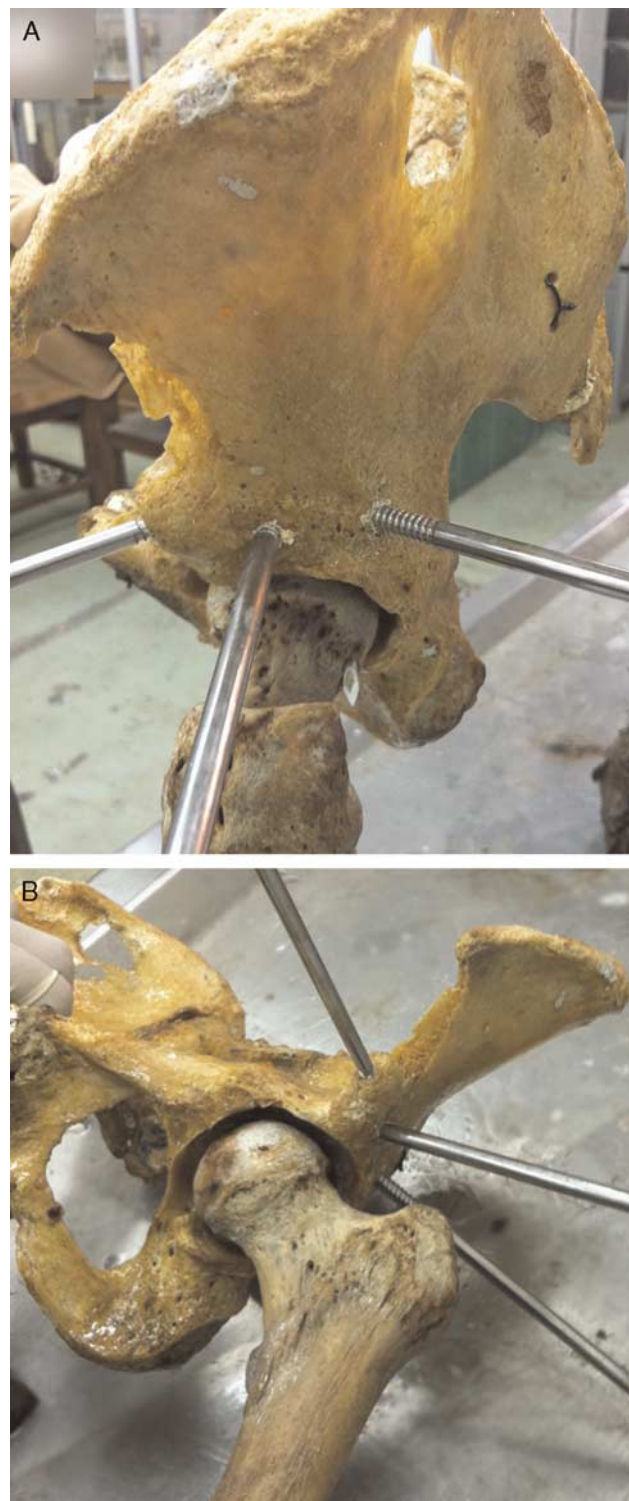


FIGURE 2. (A and B) Frontal and side views of bony pelvic specimen showing half pins inserted in the anterior inferior iliac spine and in the supraacetabular region. The direction of half pin insertion in the anterior inferior iliac spine is from anterior to posterior, whereas in the supraacetabular region is from lateral to medial and posterolateral to anteromedial perpendicular to the acetabulum.

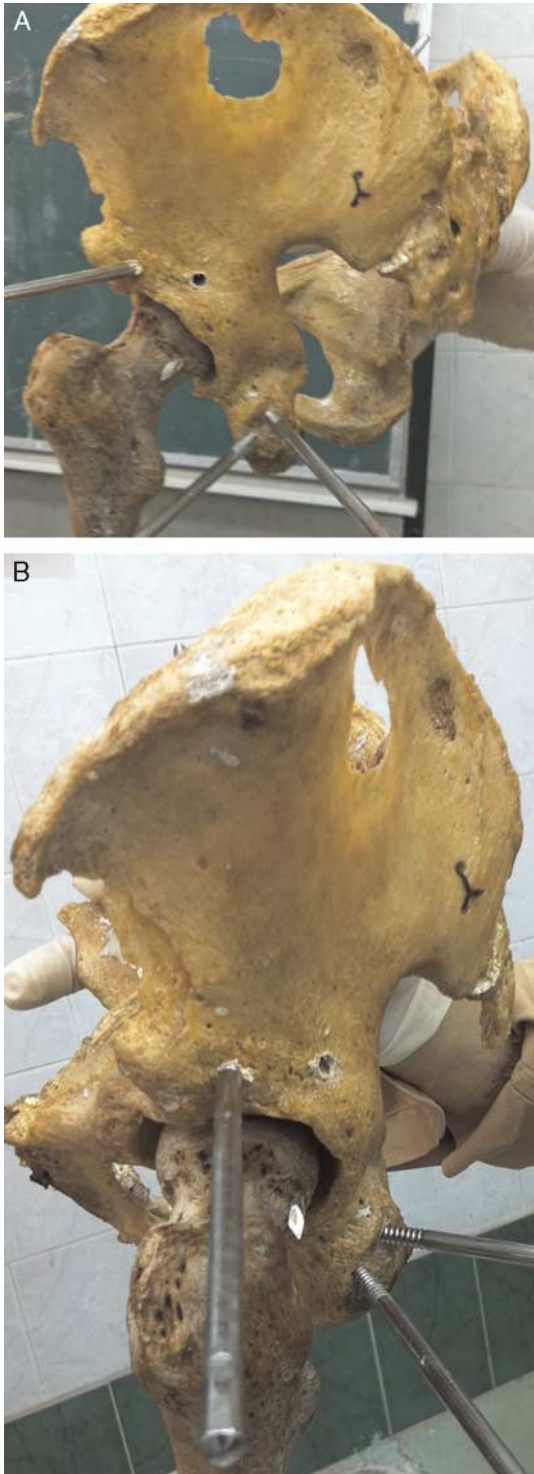


FIGURE 3. (A and B) Frontal and side views of bony pelvic specimen showing half pins inserted in the ischial tuberosity. The direction is from posterior to anterior in the medial part, and from posterolateral and inferior to anteromedial and superior in the lateral part.



FIGURE 4. Bony pelvic specimen showing half pin inserted in the outer part of the sacrum, directed from superomedial to inferolateral.

of about 30N for 3 sec (calibrated by the author on a myometer) until the pin come out. Pull-out force was categorized into three categories (highest strength, lower strength, least strength).

These steps were repeated again in the cadaveric specimens to study the relation of pin insertion sites to the important anatomical structures.

RESULTS

In regard to bone quality and resistance to pull out of pins in both the bony and cadaver specimens using the manual pull-out technique, it was found that the strongest area for pin insertion was the supraacetabular region followed by ischial tuberosity. The AIIS, ASIS, iliac crest along its length, PSIS and PIIS have a pull-out strength less than the supraacetabular and ischial tuberosity regions. The ala of the sacrum was the weakest point.

In regard to the safety of the pin insertion sites on the cadaver specimens (Table 1), we found that AIIS, ASIS, iliac crest, PIIS, PSIS, the supraacetabular region at or above the level of upper border of greater sciatic notch, the anterior column of the acetabulum lateral to the ASIS, and the lateral 1 cm of the ala of the sacrum lateral to the sacral foramina were safe for pin insertion. We also found that insertion of pins in ischial tuberosity region below the level of the ischial spine in both triangular and quadrangular areas was safe.

Based on our study, the best direction of pin insertion in the ASIS and AIIS in the bony pelvis is anterior to posterior. Along the iliac crest the pin insertion was directed vertically perpendicular to iliac wing. The direction of half pin insertion in the supraactabular region was perpendicular to acetabulum and 2cm above the roof of the acetabulum (see Figure 2).

We found that the quadrangular area extending between the upper border of the greater sciatic notch superiorly, the lateral border of the sacrum medially, the level of the ischial spine inferiorly, and the posterior column of the acetabulum

TABLE 1. Safe zones of half-pin insertion in pelvis and acetabulum		
Safe Zones	Structures at Risk	Direction of Half Pin Insertion
Anterior superior iliac spine	Femoral artery	From anterior superior to posterior inferior
Anterior inferior iliac spine	Femoral nerve	From anterior superior to posterior inferior
	Femoral artery	
	Branches of femoral nerve	
Posterior superior iliac spine	Sacral nerves	From posterior to anterior
Posterior inferior iliac spine		From posterior to anterior
Iliac crest	Sacral nerves	From superior to inferior
Ala of the sacrum	5th lumbar root	From superior to inferior
Supraacetabular region	Sacral nerves	Horizontal parallel to the ground in erect position
Ischial tuberosity	Sciatic nerve	From posterior or postero-lateral to anterior
	Posterior cutaneous nerve of the thigh	
	Inferior gluteal artery	

laterally are unsafe for pin insertion because the sciatic nerve and other structures coming out of greater and lesser sciatic notch were at high risk for injury (Table 2). Also it was found that the area 1 cm medial to the AIIS was unsafe as the branches of the femoral nerve lie medial to AIIS. The area extending from the AIIS to the pubic tubercle was unsafe because the femoral sheath with its contents and lateral cutaneous nerve are present in this area.

The rest of the ala of the sacrum medial to the sacral foramen was unsafe because the sacral nerves and the fifth lumbar nerve are at risk.

DISCUSSION

Several bony landmarks can be palpated subcutaneously during pelvic examination because the ASIS, iliac crest, and PSIS are directly deep to the dimples just superior to the buttocks. Posteriorly, the ischial tuberosity lies in the middle of the buttocks at the level of the gluteal fold. The sacroiliac joint is not palpable and its center is located at the level of the S2 segment of the sacrum.⁵ Other bony landmarks that are not palpable include the greater and lesser sciatic notches, the ischial spine, and the acetabulum.⁶

From the previous anatomic consideration, many areas in the pelvis can be identified and allow percutaneous insertion of half pins. To the authors' knowledge there are no studies evaluating the potential anatomic risks of placement of half-pins in most of these areas except the iliac crest and supraacetabular region. Haidukewych *et al.*⁴ concluded that the percutaneous placement of half-pins into the supraacetabular region can be done safely with fluoroscopic guidance and the use of appropriate soft-tissue sleeves to

TABLE 2. Unsafe zones for half-pin insertion in pelvis and acetabulum	
Unsafe Zones	Structures at Risk
Medial part of ala of the sacrum	Sacral nerves
	5th lumbar root
Area between anterior superior iliac spin and pubic tubercle	Femoral vessels
	Femoral nerve
	Inguinal canal and its contents
The quadrangular area between -Upper border of greater sciatic notch (superior).	Sciatic nerve
-Lateral border of the sacrum (medial).	Superior gluteal nerve and vessels
-Upper border of ischial spine (inferior).	Inferior gluteal nerve and vessels
Posterior column of acetabulum (lateral).	Posterior cutaneous nerve of the thigh
	Internal pudendal nerve and vessels
	Nerve to obturator internus

avoid injury to the lateral femoral cutaneous nerve. To avoid violating the capsule of the hip joint, pins should be at least 20 mm above the hip.⁴ In our study, we inserted a supra-acetabular pin 2cm above the roof of acetabulum in a perpendicular direction to the acetabulum and iliac wing.

Pins for a traditional anterior pelvic external fixator are placed in the iliac wing at the widest portion. A thick zone of bone was identified for pin purchase along the iliac crest about 3 cm posterior to the ASIS, and extending about 7 cm posteriorly.⁷ Solommon *et al.*⁸ used a subcrystal technique by inserting pins from the ASIS in the subcortical bone of the iliac crest and parallel to the crest. An alternative external fixation construct uses one pin in each AIIS aimed toward the thick bone above the greater sciatic notch.⁹

To the authors' knowledge, there is no study demarcating the safe zones in the pelvis posteriorly. The current study showed that the lateral 1 cm of the ala of the sacrum (lateral to the sacral foramen), and both the triangular and quadrangular areas of the ischial tuberosity were safe sites for half pins insertion. The current study also showed that the strongest area for half pin insertion was the supra-acetabular region and the ischial tuberosity. The iliac crest showed lower pin holding strength, while the ala of the sacrum showed the least pin holding strength.

The areas identified as at risk that must be avoided were the area 1 cm medial to both the ASIS and the AIIS, the quadrangular area extending between the upper border of the greater sciatic notch superiorly, the lateral border of the sacrum medially, the ischial spine inferiorly, and the posterior column of the acetabulum laterally because the sciatic nerve and other structures emerge from the greater and lesser sciatic notch.

In summary, there are many safe areas for half-pin insertion in pelvic and acetabular fractures while there are other unsafe areas. Adequate knowledge of the safe sites and direction of pin insertion decreases the risks of neuro-vascular injury and allow a wider use of external fixators in pelvic and acetabular fractures.

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