Systematic Approach to the Interpretation of Pelvis and Hip Radiographs: How to Avoid Common Diagnostic Errors Through a Checklist Approach

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After participating in this activity, the diagnostic radiologist will be better able to identify the anatomical landmarks of the pelvis and hip on radiography, and become familiar with a systematic approach to the radiographic interpretation of the hip and pelvis using a checklist approach.

Key Words: Pelvis and Hip Anatomy, Radiographic Checklist

Radiography of the pelvis and hip is a commonly ordered examination in daily clinical practice. Therefore, it is important for diagnostic radiologists to be proficient with its interpretation. The objective of this article is to present a simple but thorough method for accurate radiographic evaluation of the pelvis and hip.

With the advent of cross-sectional imaging, a shift in residency training from radiography to CT and MR imaging has occurred; and as a result, the art of radiographic interpretation has suffered dramatically. However, the initial imaging examination for the evaluation of hip or pelvic pain should be radiography. In addition to the complex anatomy of the pelvis and hip, subtle imaging findings often indicating significant pathology can be challenging to the veteran radiologist and even more perplexing to the novice radiologist given the paradigm shift in radiology residency education.

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Common views of the pelvis and proximal femur include the AP projection of the pelvis, anterior and posterior 45-degree oblique (Judet) projections of the pelvis, AP projection of the hip, and frog-leg lateral or straight lateral (Dan Miller) projection of the hip. More specific views of the hip and pelvis to include pelvic inlet and outlet (Ferguson) views may be obtained depending on the clinical presentation. Each projection has advantages for visualization of the complex pelvic anatomy. For example, the posterior column of the pelvis is best visualized on the Judet view; the sacroiliac joints are best appreciated on the pelvic outlet view; and the anterior and posterior aspects of the femoral neck are best seen on the frog-leg lateral view.\(^1\)\(^3\)
The complex anatomy of the pelvis derives from the symmetric fusion of 3 pelvic bones: the ilium, ischium, and pubis at the acetabulum (Figure 1). Initially, the 3 pelvic bones are connected by a Y-shaped growth plate, the triradiate cartilage, which fuses at approximately 14 to 16 years of age. Anteriorly, the right and left pubis, composed of a body and superior and inferior pubic rami, articulate at the pubic symphysis. Posteriorly, the body of the ilium articulates with the sacrum forming the sacroiliac joints, which are composed of a synovial component at the lower one third and a syndesmotic component at the upper two thirds of the joint. Key components of the ilium include the iliac crest and the anterior inferior and anterior superior iliac spines. The ischium, which forms the posterior border of the acetabulum, also is composed of a body and 2 rami. Spines arising from the ischium and ilium form the greater and lesser sciatic notches posteriorly. The obturator foramen, which is anterior, is formed by the fusion of the superior and inferior pubic rami and the inferior ischial ramus.

Initially, the 3 pelvic bones are connected at the acetabulum by the triradiate cartilage, which fuses at approximately age 14 to 16 years.

The proximal femur, which can be divided into the femoral head, femoral neck, trochanters, and femoral shaft, articulates with the pelvis at the acetabulum. Normal angulation of the femoral head is approximately 125 to 135 degrees with respect to the long axis of the femoral shaft, with approximately 25 to 30 degrees of anteversion. The femoral neck, composed of the subcapital, transcervical, and basicervical segments, has characteristic compressive (vertically oriented) and tensile (arc-shaped) trabeculae. The intertrochanteric line (anterior) and the intertrochanteric crest (posterior) mark the transition between the femoral neck and the shaft. From the fusion of the 3 pelvic bones and articulation of the femur with the pelvis, several distinct radiographic lines, rings, and arcs are formed and are essential to the analysis of pelvic radiographs. Table 1 outlines the basic checklist approach for the evaluation of pelvic and hip radiographs.

In the absence of trauma, an avulsion injury of the pelvis or proximal femur in an adult should raise concern of an underlying bone neoplasm.
Although often obscured by bowel gas or bowel contents, the sacral foraminal lines representing the superior margin of the sacral foramina should be continuous, symmetric, and smooth. The superior 2 to 3 sacral foraminal lines should be visible if not obscured by bowel gas or bowel contents and any disruption or irregularity may represent subtle clues to traumatic or insufficiency fractures. Alternatively, the absence of a sacral foraminal line may indicate a destructive process (Figure 3). Likewise, the acetabular roof or supra-acetabular line should be symmetric, continuous, and smooth. The supra-acetabular line is typically thicker laterally than medially because of weight-bearing. Absence or disruption of the sharp supra-acetabular line is a reliable indicator of a disease process involving the acetabulum (Figure 4).
Whenever a fracture in either the pelvic or obturator ring is detected, a second pelvic fracture or a diastasis of either the sacroiliac joint or symphysis pubis must be excluded.

The iliopectineal line formed by the superomedial linear bony ridge of the superior pubic ramus in continuation with the arcuate line of the ilium serves as the anterior border of the anterior column. Conditions affecting the anterior column such as Paget disease or idiopathic hyperphosphatasia may result in thickening of the iliopectineal line, whereas other pathologic processes may result in discontinuity or destruction of the line. The ilioischial line, which defines the posterior column of the pelvis, extends along the medial border of the ischium inferiorly to the ischial tuberosity. Fractures and osseous lesions (e.g., fibrous dysplasia) of the posterior column will result in discontinuity or deviation of this typically smooth line. Of note, the iliopectineal and ilioischial lines are best appreciated on the Judet views.

The teardrop or radiographic U is a projectional phenomenon secondary to the summation of shadows of the medial acetabular wall. Bone lesions or osteomyelitis may destroy the teardrop (Figure 7). Radiographically, the teardrop distance is being measured from the lateral edge of the teardrop to the femoral head, and this distance should be bilaterally symmetric and measure less than 1 cm. Asymmetry of the teardrop distance greater than 2 mm may provide subtle clues about an underlying pathologic process. Differential considerations for widening of the teardrop distance include hip joint effusion, developmental dysplasia of the hip with superior and lateral subluxation of femoral head, intra-articular body from recent hip fracture dislocation, or intra-articular mass. The anterior lip of the acetabulum can be located by following the superior pubic ramus laterally and superiorly, whereas the posterior lip of the acetabulum can be located by following the inferior pubic ramus laterally and superiorly. Normally, the anterior lip of the acetabulum is located medial to the posterior lip of the acetabulum.

Figure 5. This AP view of the pelvis reveals absence of the right iliopectineal line (arrow) and supra-acetabular line due to a lytic osseous lesion with associated soft-tissue mass. The right proximal femur also is involved.

Figure 6. This AP view of the pelvis shows thickening of the left ilioischial line (thin arrow) secondary to fibrous dysplasia of the left ischial tuberosity (thick arrow). Note a second focus of fibrous dysplasia in the right intertrochanteric region (check mark).

Figure 7. This AP view of the pelvis demonstrates loss of the right teardrop or radiographic U (thick arrow) secondary to aneurysmal bone cyst. Note normal left teardrop (thin arrow).
Radiographically, the teardrop distance is measured from the lateral edge of the teardrop to the femoral head and normally should measure less than 1 cm.

The line of Klein is drawn along the long axis of the superior aspect of the femoral neck and normally intersects the proximal femoral epiphysis. In the setting of slipped capital femoral epiphysis (SCFE), the normal relationship of the line of Klein will be lost (Figure 8). Likewise, the smooth curvilinear line connecting the medial aspect of the femoral neck with the undersurface of the superior pubic ramus forms the Shenton arc. Disruption of the Shenton arc may be secondary to hip dislocation, femoral neck fracture, or chronic developmental dysplasia of the hip with superior and lateral subluxation of the femoral head (Figure 9).

At the femoroacetabular joint, horizontal (Hilgenreiner line) and perpendicular (Perkins line) lines define the 4 quadrants of the joint in which the femoral head should reside in the lower inner quadrant. The Hilgenreiner line connects the triradiate cartilages, and Perkins line extends vertically through the lateral edge of the acetabulum and perpendicular to the Hilgenreiner line (see Figure 1).
are some of the most difficult findings on radiography even for the experienced radiologist.

The pubic symphysis should be less than 5 mm in width and may be widened in traumatic symphyseal diastasis, bladder exstrophy, or septic arthritis. Widening greater than 10 mm in males and 15 mm in females suggests instability. With widening greater than 25 mm, associated sacroiliac joint diastasis is expected (Figure 10). Interestingly, in the third trimester of pregnancy, pubic symphysis mobility increases up to 8 to 12 mm.

No discussion of the pelvis would be complete without a discussion of the soft tissues and joint spaces. The subtle findings associated with soft-tissue masses and joint diseases

The line of Klein is drawn along the long axis of the superior aspect of the femoral neck on the frog-leg lateral view of the hip and normally intersects the proximal femoral epiphysis.

**Figure 12.** A: This AP view of the pelvis shows displacement of the left gluteal fat stripe superiorly (thick arrow) in the setting of a left hip joint effusion in comparison with the normal right gluteal fat stripe (thin arrow). The left arrowhead denotes the inferior extent of the hip joint capsule. B: This coronal T1 MR image of the pelvis shows displacement of the left gluteal fat stripe superiorly (thick arrow) in the setting of a left hip joint effusion in comparison with the normal, nondisplaced right gluteal fat stripe (thin arrow). The left arrowhead denotes the inferior extent of the hip joint capsule. C: Coronal STIR MR image of the pelvis shows distension of the left hip joint (arrows) by a large left hip joint effusion.
The normal sacroiliac joints should be 2 to 4 mm in width. Widening of the sacroiliac joints may be seen in the setting of septic sacroiliitis (Figure 11) and traumatic diastasis. The cortical margins of the sacroiliac joint also should be thin and continuous without sclerosis or erosions. Although beyond the extent of this article, the femoroacetabular joints are involved in numerous infectious, neoplastic, and degenerative processes. It should always be remembered that an infectious process will affect both sides of the hip joint with disruption of the cortical lines of the femoral head, acetabular roof, or teardrop.

Fascial planes created by the interface of fat with adjacent soft tissues are of particular importance in the evaluation of pelvic radiographs. These fascial planes include the gluteal fat stripe, which parallels the superior aspect of the femoral neck on the AP radiograph and depicts the fat plane between the gluteus minimus tendon and the ischiofemoral ligament. In the setting of a hip joint effusion, the gluteal fat stripe will be displaced superiorly (Figure 12). Inferior to the iliopsoas tendon, the iliopsoas fat stripe, which also may be displaced in a hip joint effusion, can be identified. The obturator internus fat stripe, which can be seen paralleling the iliopectineal line, is formed by the fat adjacent to the obturator internus muscle. In the setting of trauma, the obturator internus fat stripe may be displaced by a hematoma; otherwise, subtle displacement of the obturator internus fat stripe may be seen in the setting of an extraosseous soft-tissue mass arising from the acetabulum (Figure 13). Although other fascial planes may be evident on pelvic radiographs, the above-mentioned fascial planes represent those most commonly associated with pelvic pathologic processes.

**Conclusion**

The anatomy of the pelvis and hip is complex. Therefore, a systematic approach to the radiographic interpretation is essential. A checklist of the common anatomical landmarks in the pelvis and hip aids in the interpretation of hip and pelvis radiography. This CME activity emphasizes that abnormal, asymmetric, or absent appearance of any of these anatomic structures may provide a clue to underlying pathology and guide the diagnostic radiologist in further imaging workup.

**References**

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1. All of the following are radiographic findings on an AP radiograph of the pelvis consistent with possible osteolytic metastatic disease, except
   A. destruction of an ilioischial line
   B. destruction of multiple sacral foraminal lines
   C. thickening of an iliopectineal line
   D. destruction of a supra-acetabular line
   E. avulsion of a femoral lesser trochanter in a nontraumatized adult

2. An afebrile 14-year-old boy presents with worsening pain in his left hip. A frog-leg lateral view of the pelvis reveals an abnormal left line of Klein and subtle widening of the left femoral physis. The most likely diagnosis is
   A. left slipped capital femoral epiphysis
   B. left hip joint effusion
   C. stress fracture of the left femoral neck
   D. septic arthritis of the left hip
   E. fracture of the left acetabulum

3. According to the authors, which of the following is/are important parts of the systematic approach of the radiographic evaluation of the pelvis and hips?
   A. Intact teardrop or radiographic U
   B. Sacroiliac joint width of 2 to 4 mm
   C. Intact iliopectineal line
   D. Intact supra-acetabular line
   E. All of the above

4. All of the following conditions may cause disruption of the Shenton arc on an AP radiograph of the pelvis, except
   A. hip dislocation
   B. nondisplaced acetabular fracture
   C. femoral neck fracture
   D. chronic developmental dysplasia of the hip with superior and lateral subluxation of the femoral head

5. After severe injury to the pelvis of a 35-year-old man, the width of the symphysis pubis on an AP radiograph of the pelvis is greater than 25 mm. What other pelvic injury should the radiologist suspect?
   A. Posterior dislocation of a hip
   B. Anterior dislocation of a hip
   C. Comminuted fracture of the sacrum
   D. Sacroiliac joint diastasis
   E. Femoral neck fracture

6. All of the following are differential considerations for widening of the teardrop distance, except
   A. hip joint effusion
   B. developmental dysplasia of the hip
   C. intra-articular body from recent fracture dislocation of the hip
   D. intra-articular hip mass
   E. osteoarthritis of the hip

7. On an AP radiograph of the pelvis, sacral foraminal lines represent
   A. inferior margin of the sacral foramina
   B. superior margin of the sacral foramina
   C. lateral margin of the sacral foramina
   D. medial margin of the sacral foramina

8. After a motor vehicle accident, a 25-year-old man complains of left-sided pelvic pain. His AP radiograph of the pelvis reveals a DuVerney fracture. The location of the fracture is
   A. iliac wing
   B. sacrum
   C. pubis
   D. ischiium
   E. femoral neck

9. Which one of the following imaging examinations should be performed initially for the evaluation of hip or pelvic pain?
   A. CT
   B. MRI
   C. Bone scintigraphy
   D. Radiography
   E. Ultrasound

10. Which one of the following radiographic projections is the best to visualize the posterior column of the pelvis?
    A. Pelvic outlet view
    B. AP projection
    C. Judet view
    D. Dan Miller projection of hip
    E. Pelvic inlet view