Review

Acetabular Fractures: Easier Classification with a Systematic Approach

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Fractures of the acetabulum have varied fracture lines traversing complex three-dimensional anatomy that makes them difficult to describe. It is tempting to dictate that "a complex fracture of the acetabulum is noted" and move on to other images. Unfortunately, this notation conveys almost no information to the orthopedic surgeon who treats the patient. The surgeon must decide between conservative and surgical treatment and, if surgery is indicated, what surgical approach will best access the fracture to reduce and internally fix it. To provide value-added service, radiologists must interpret and describe acetabular fractures using high-quality radiographs and CT scans, reviewed together when possible.

Acetabular fractures are almost universally classified by the method described by Judet et al. [1] and Letournel [2]. This classification is the first step in surgical decision making. For inexperienced observers, this classification is complicated; to use the classification one must understand acetabular anatomy and correlate it to radiographic anatomy. We have found that approaching the interpretation of anteroposterior and Judet oblique radiographs along with CT scans in a systematic way facilitates classification of acetabular fractures. For each case, the observer answers several questions leading to accurate classification; with regular use of this system, acetabular fracture classification becomes less daunting than initially perceived.

In this article, we present a discussion of the anatomy and radiographic appearance of the acetabulum, the classification of Judet et al. [1] and Letournel [2] for acetabular fractures, and how to use anteroposterior and oblique radiographs as well as CT scans to classify these fractures. We stress that this is not a comprehensive discussion of acetabular fractures but rather a method to facilitate classification by those who are not expert at evaluating these fractures. A number of excellent chapters [1, 3–7] and textbooks [2, 8] provide a more detailed description of the location, classification, and subclassification of the many possible patterns of complex fracture lines.

Acetabular Anatomy

The acetabulum is made up of two columns and two walls, each termed anterior or posterior [1, 2]. The walls stabilize the hip joint in the anterior and posterior directions. The anterior wall is smaller in size than the posterior wall and is rarely fractured, whereas the posterior wall is large and is commonly fractured [2, 9]. The anterior and posterior columns are unequal in size; the anterior column is larger than the posterior column [1]. The column orientation resembles the lowercase Greek letter lambda (λ), with the longer limb of the letter representing the anterior column and the smaller limb the posterior column (Fig. 1). Both columns are connected to the axial skeleton via a strut of bone, called the sciatic buttress, that extends from the sacroiliac joint lateral and inferior to meet with the two columns above the greater sciatic notch [1, 2]. Functionally, this strut transfers forces from weight-bearing to the axial skeleton.

Although most discussions of acetabular anatomy center on the columns and walls, the iliac wing and the obturator ring are additional important structures in the setting of acetabular fractures [1, 3–6]. The anterior column extends above the dome into the iliac wing, and fracture lines disrupting the iliac

Fig. 1.—Orientation of acetabular columns. Diagram of left acetabulum viewed from outside shows anterior column (*arrowheads*) to be larger than posterior column (*large arrows*). Note that both columns support horseshoe-shaped articular surface. Diagram of inside view of left acetabulum shows that sciatic buttress (*small arrows*) connects both columns to axial skeleton through sacroiliac joint. (Reprinted with permission from [2])

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wing indicate an anterior column component to the fracture pattern. The obturator ring is bounded superiorly by the inferior aspect of the quadrilateral plate, posteriorly by the anterior portion of the ischium, anteriorly by the inferior pubic ramus, and inferiorly by the junction of the ischium to the pubis. Only certain fracture types involve the obturator ring. Accurate determination of whether fractures involve either the iliac wing or the obturator ring (although not directly part of the acetabulum) provides important clues for classifying fractures.

Radiographic Examination

The standard radiographic examination for a suspected acetabular fracture consists of an anteroposterior radiograph and two oblique views termed "Judet views" (Fig. 2). These oblique radiographs are taken with the patient turned 45° and are called right and left posterior oblique views. A common problem with the oblique views is that the patient is underrotated, because of pain or lack of cooperation, resulting in radiographs labeled as 45° oblique views that are actually exposed with the patient rotated 30° or even less. To determine the amount of rotation, the position of the coccyx relative to the femoral head is noted. On a well-positioned Judet oblique (45°) view, the tip of the coccyx projects over the femoral head [2]. When oblique radiography is performed, it is important that the patient is turned and that the film remains perpendicular to the X-ray beam. Radiographing a supine patient with an angled tube results in significant distortion. Volume-rendered images from CT scans can be displayed to resemble the oblique views [10, 11]; however, to our knowledge, no study has determined whether these projections are of sufficient quality to replace radiography.

While radiologists use the terms right and left posterior oblique to describe the supine oblique views, orthopedic surgeons call these images the obturator and iliac oblique views. In a patient with a fracture of the right acetabulum, the right posterior oblique view shows the right iliac wing *en face* and obscures the obturator ring. Orthopedists call this view the iliac oblique view. The left posterior oblique view shows the obturator ring to advantage and is called the obturator oblique view. These terms are side specific for a given patient; in a patient with a left acetabular fracture, the views described above would be reversed. This nomenclature is potentially confusing in the setting of bilateral fractures. Radiologists should be familiar with these terms because they improve

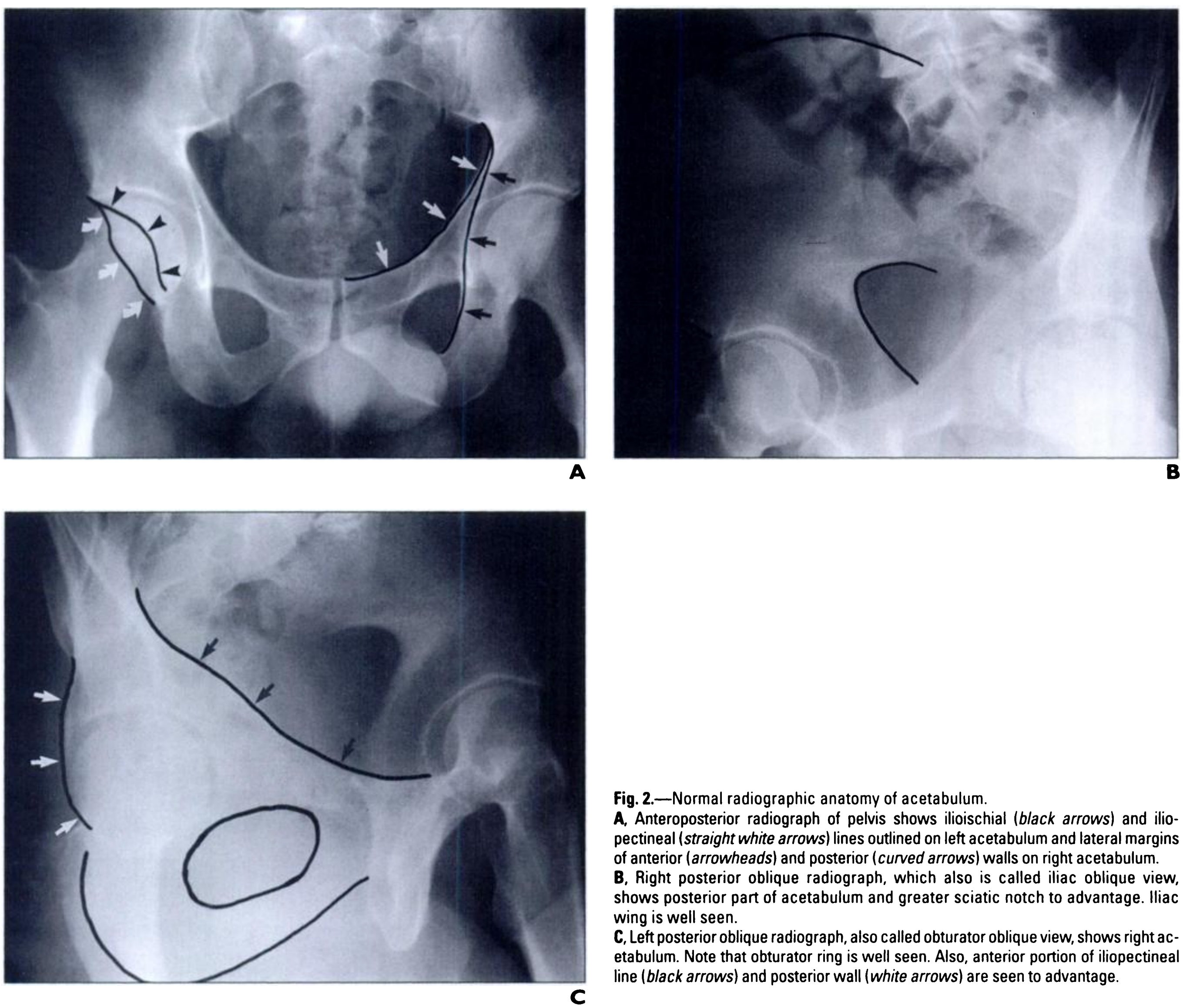


Fig. 2.—Normal radiographic anatomy of acetabulum.
A, Anteroposterior radiograph of pelvis shows ilioischial (*black arrows*) and iliopectineal (*straight white arrows*) lines outlined on left acetabulum and lateral margins of anterior (*arrowheads*) and posterior (*curved arrows*) walls on right acetabulum.
B, Right posterior oblique radiograph, which also is called iliac oblique view, shows posterior part of acetabulum and greater sciatic notch to advantage. Iliac wing is well seen.
C, Left posterior oblique radiograph, also called obturator oblique view, shows right acetabulum. Note that obturator ring is well seen. Also, anterior portion of iliopectineal line (*black arrows*) and posterior wall (*white arrows*) are seen to advantage.

communication with the referring surgeon and they also emphasize that certain structures are best visualized on each of the oblique views.

Radiographic Anatomy

The radiographic anatomy of both the normal and the fractured acetabulum has been described [1, 2, 12, 13]. Judet et al. and Letournel [1, 2] extensively studied the relationship between acetabular anatomy and the radiographic appearance of the pelvis and acetabulum on anteroposterior and oblique radiographs. Several structures on the anteroposterior radiograph are important for fracture classification [1, 14]. These structures include the iliopectineal line (occasionally called the iliopubic line), the ilioischial line, and the margins of the anterior and posterior walls (Fig. 2). The obturator ring is visible on this view but is better examined on the obturator oblique view. The cotyloid notch is visible as is the subchondral arc above the acetabular dome. The iliac wing is viewed obliquely on the anteroposterior view and is better shown on the iliac oblique view.

The iliopectineal line runs from the superior margin of the greater sciatic notch, extending anterior to follow the pelvic brim along the superior pubic ramus to the symphysis pubis. Most of this line follows structures of the anterior part of the pelvis, including the anterior column. The ilioischial line runs from the greater sciatic notch vertically past the cotyloid notch, superimposing on the lateral side of the teardrop, extending inferior to the level of the obturator ring. This line follows posterior pelvic structures, including the posterior column and the posterior part of the quadrilateral plate. The edges of the posterior and anterior walls are visible and represent the lateral edges of these structures. The anterior wall can be difficult to see on the anteroposterior view and is better visualized on the iliac oblique view. The posterior wall is usually visible on the anteroposterior view, and nonvisualization is a sign of a displaced posterior wall fracture. However, the posterior wall is best examined on the obturator oblique view.

The iliac oblique view shows the iliac wing *en face* (Fig. 2), and it is therefore the best view for detecting fractures that extend proximally into the iliac wing (this observation is important for classification). The iliac oblique view also shows the greater sciatic notch and posterior column to advantage, facilitating examination of fractures that extend into this region [1, 8, 14]. The edge of the anterior wall can be seen on this view, especially with steeper degrees of rotation. The obturator ring is poorly seen on this view.

The obturator oblique view (Fig. 2) shows four structures to advantage: the obturator ring; the posterior wall; the lower portion of the anterior column; and, if present, the spur sign [1, 8, 14]. Obturator ring fractures can occur in several places, usually the inferior portion of the ring at the ischiopubic junction or the anterior and superior portion of the ring at the puboacetabular junction. With some acetabular fracture types, the ring is intact. Posterior wall fractures often will be posteriorly and possibly superiorly displaced and are often best seen on this view. Fractures of the lower iliac wing (anterior column) will be visible above the dome. The iliac wing is viewed in tangent, and most fractures of the iliac wing are better seen on the iliac oblique view. However, some fractures of the iliac wing are very difficult to see because of overpenetrated film, overlying bowel gas, or superimposed fracture fragments. In this setting, the obturator oblique view may show discontinuity of the cortices of the iliac wing and be a clue to the presence of a subtle fracture.

CT

CT is useful for examining patients with acetabular fractures [14–20]. It detects intraarticular fragments and shows articular discontinuity better than radiography does [4, 21, 22]. Rotation of fragments also can be difficult to assess by radiography and may be better examined with CT. This information is useful for planning maneuvers to reduce the articular surface intraoperatively [8].

The CT appearances of the fracture types of the Letournel and Judet classification have been described [6, 9, 14, 16, 21]. For column-type fractures, the main fracture plane on CT is from medial to lateral, producing a horizontal fracture on the CT image. Transverse-type fractures have an anteroposterior fracture line that is vertical on the CT image, and wall fractures have an oblique fracture orientation (Fig. 3).

When performing acetabular CT, scan parameters are different than for trauma CT of the abdomen and pelvis. Scanning should begin at the iliac crest and continue through the ischial tuberosities, extending beyond the symphysis pubis. Scanning with thin slices through the articular surface improves detection of nondisplaced fractures and leads to better reconstructions than if thicker slices are used. We typically use 5-mm-thick slices obtained from the iliac crest to 1 cm above the acetabular dome with 3-mm slices for the remainder of the study through the ischial tuberosities, but significant interinstitutional variation exists in actual scan parameters. Helical technique is recommended if available because it allows faster examination times and decreased motion artifact [23]. Slices can be reconstructed from the volumetric data set at any interslice increment, regardless of slice thickness. Slice overlap decreases partial volume-averaging effects and improves the quality of two- and three-dimensional reconstructions [23]. However, if a patient is large and X-ray tube capacity limits amperage when using helical technique to a level that has unacceptable noise, then conventional scanning with overlapping slices is preferred.

Three-dimensional reconstructions are helpful for surgical planning [10, 11, 18]. These images are particularly helpful for surgeons or radiologists who are less experienced in the interpretation of the radiographs and even for experienced observers in the setting of more complex fracture patterns. Preoperative assessment of predominant fracture orientation may direct lag screw or malleable plate placement, and displacement or rotation of fragments may alter reduction methods. Techniques that improve fracture visualization include disarticulating the ipsilateral hip (by region-of-interest subtraction) and reconstructing only the fractured hemipelvis.

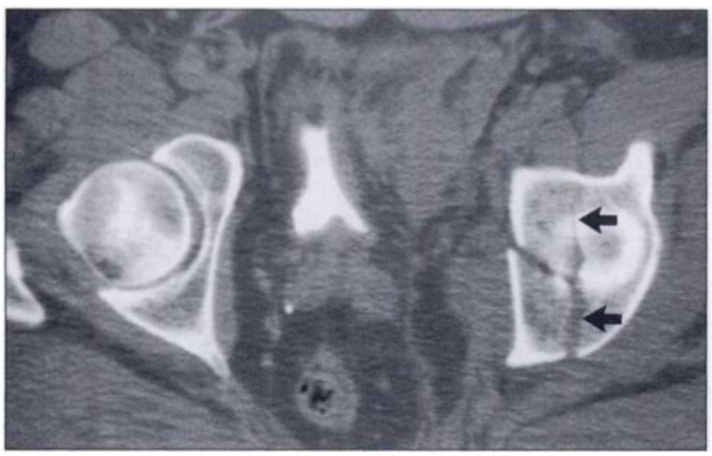
The fracture classification described by Judet et al. [1] and Letournel [2] was developed from radiographic observations, and some authors suggest that the role of CT for fracture classification is limited [2, 8, 14]. They recommend CT only to collect ancillary information such as fracture comminution, fragment rotation, articular impaction, or femoral head injuries [7]. We believe that CT complements the radiographic series for examining and classifying these fractures (Fig. 3). Optimally, both the radiographic series and the CT scan are available for review together when determining fracture type. Subtle fractures may be overlooked with both CT and radiography; using both procedures while classifying fractures may lead to fewer errors and better interobserver agreement. CT also may serve as a partial substitute for suboptimal oblique radiography.

Fracture Classification System of Judet and Letournel

The system developed by Judet et al. [1] and Letournel [2] is a morphologic classification based on observations from radiography using anteroposterior and oblique radiographs (Judet views). This classification is important for several reasons. First, it is the universally accepted system for communicat-

A

Fig. 3.—CT of main acetabular fracture planes.
A, CT scan of 29-year-old man with anterior column fracture of right acetabulum shows horizontal, or coronal, orientation to fracture plane.
B, CT scan of 34-year-old man with T-shaped fracture shows main fracture plane, mildly comminuted, running from front to back, resulting in vertically oriented radiolucency (*arrows*).
C, CT scan of 36-year-old man with posterior wall fracture of left acetabulum shows oblique orientation of main fracture plane (*arrows*).



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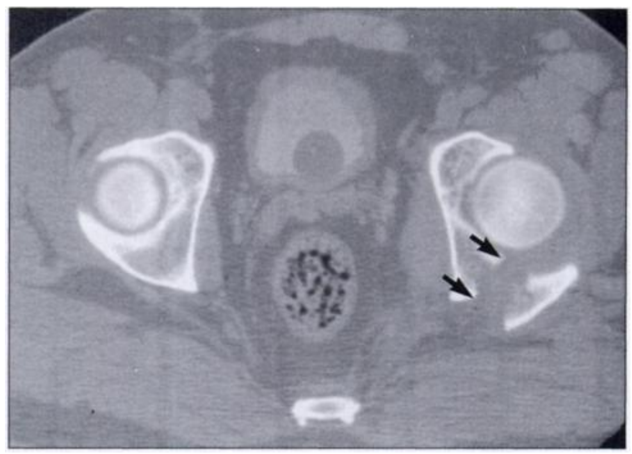


C

ing acetabular fracture information, accepted internationally [24]. Second, it guides the surgical approach for reduction [25–27]. Third, it provides an elegant anatomic framework for describing these fractures [1, 2]. However, limitations to this system exist. An ideal classification typically proceeds from simple to complex injuries [28], but the fracture types in the classification of Judet et al. [1] and Letournel [2] do not relate either to complexity or directly to prognosis. In addition, the interobserver and intraobserver agreement of this system has not been widely tested, and on the basis of experience with other complex classification systems [28], this system may have low interobserver agreement. Finally, some acetabular fractures are difficult or confusing to classify, such as the anterior column with posterior hemitransverse fracture or the extended varieties of posterior wall fractures that resemble column fractures. Fortunately, the extremely difficult cases are uncommon and for most fractures accurate classification should be possible.

In the classification of Judet et al. [1] and Letournel [2], fractures are divided into elementary and associated patterns. The elementary fractures consist of a single main fracture line, whereas associated fractures involve combinations of elementary fractures [1, 2]. The elementary fractures include anterior wall, posterior wall, anterior column, posterior column, and transverse fractures. The associated fractures include both-column, T-shaped, transverse with posterior wall, posterior column with posterior wall, and anterior column with posterior hemitransverse fractures.

Using this fracture classification can be daunting, and rote memorization of the 10 patterns is difficult. Rather than thinking in terms of elementary and associated fractures, another way to organize the 10 fracture types is to divide them into those that are predominantly column-type fractures, transverse-type fractures, or wall-type fractures. Learning the imaging features that differentiate these groups is easier than memorizing the 10 patterns [9, 29] (Fig. 4). To further simplify the task of classifying these fractures, the fact that the relative frequencies of fracture types differ [1, 2, 5, 9, 30, 31] means that certain fracture patterns are encountered more commonly than others. In our experience, the three most common fractures are the both-column, transverse with posterior wall, and elementary posterior wall fractures, representing each of the three main fracture types. These three fracture types accounted for 66% of all acetabular fractures examined at our institution [9]. The next two most common types are the T-shaped and transverse fractures. If these five fracture types are combined, they represented 90% of all acetabular fractures. Therefore, although 10 fracture types exist in the Judet and Letournel classification, learning five of them will cover 90% of cases.

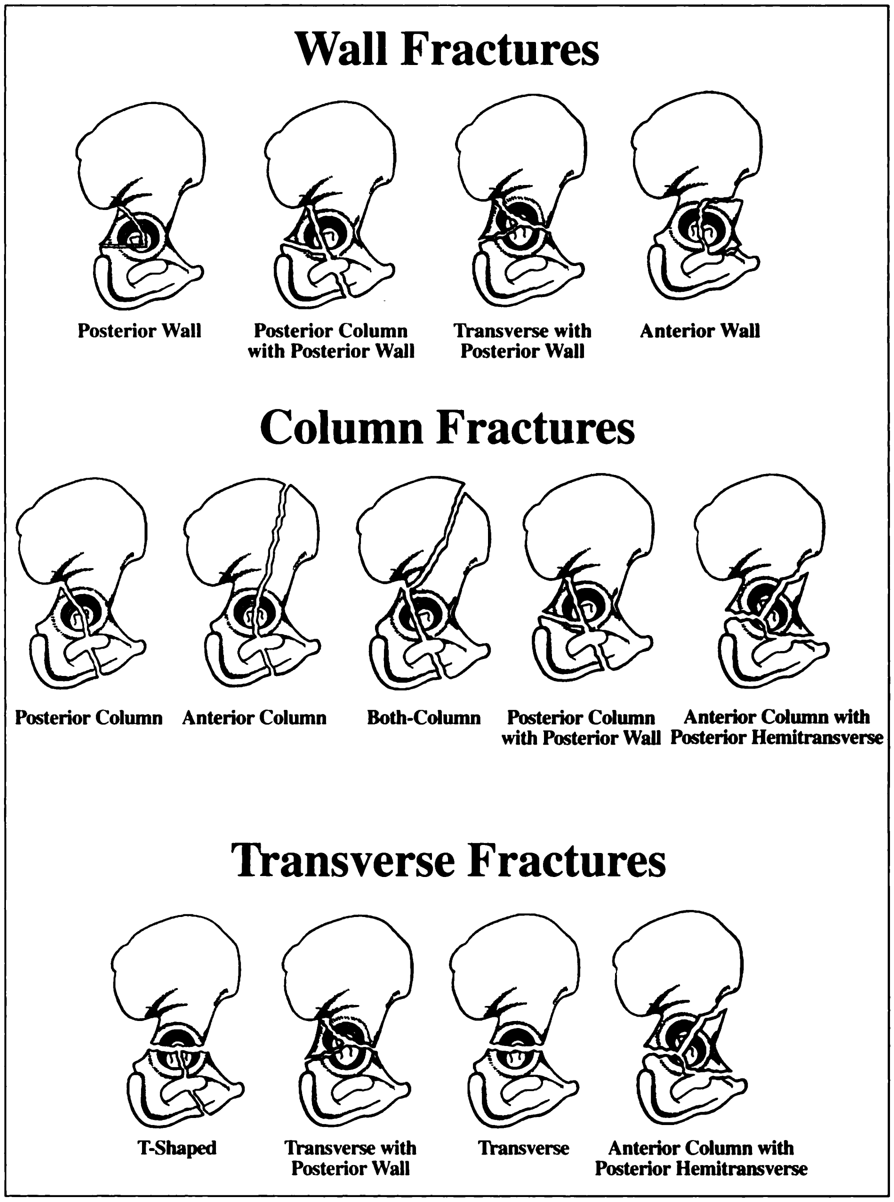


Fig. 4.—Grouped types of acetabular fractures. Classification of Judet et al. [1] and Letournel [2] can be organized into fracture types that are wall fractures, column fractures, and transverse fractures. Note overlap because some fractures fit into more than one group.

Wall Fractures

Fractures that involve acetabular walls are common; fracture of the posterior wall is seen with two of the five most common fracture types. Because this type of fracture is so common and occurs in combination with other patterns, a thorough understanding of the typical appearance of these fractures is necessary. These fractures disrupt the lips of the acetabulum without breaking either column. Isolated fractures of the walls generally do not involve the obturator ring or iliac wing and do not disrupt the ilioischial or iliopectineal lines (Fig. 5). They have an oblique orientation on CT scans.

Fractures of the posterior wall are visible on anteroposterior and obturator oblique radiographs. On the anteroposterior view, disruption of the edge of the posterior wall can be identified. Posterior dislocation or subluxation of the femoral head can be present and, when seen, is a clue to the presence of a posterior wall fracture. Subluxation can be subtle, and loss of superior joint space is a clue to posterior subluxation. The size and displacement of the wall fragment are often difficult to assess on the anteroposterior view and are better appreciated on the obturator oblique view. In some cases, although the anteroposterior view shows absence of the edge for the posterior wall, this finding can be surprisingly easy to overlook, especially if the oblique views are not available at the time of interpretation.

Posterior wall fractures can vary in size and position, from small fractures along the inferior wall to fractures of the entire posterior wall that extend above the dome [1, 2]. This variability of fracture size and location means that posterior wall fractures will have variable radiographic appearances. For example, "typical" posterior wall fractures do not extend far enough posteriorly to involve the sciatic notch or into the quadrilateral plate. A more severe type of posterior wall fracture, called an extended posterior wall fracture, can extend to involve the sciatic notch or the quadrilateral plate or both. If the sciatic notch is disrupted, this fracture can resemble the posterior column fracture, but wall fractures do not disrupt the obturator ring; this feature differentiates posterior column from extended posterior wall fractures [1, 2].

Posterior wall fractures should be examined with CT because the fracture is obvious on CT and the exact anatomy of the fracture is defined more easily than on radiography. CT shows the oblique orientation of the fracture plane and provides the best method to assess the amount of wall involved in the fracture (Fig. 3). Size of the wall fragment is important for predicting posterior stability of the hip [20] and correlates with altered force distribution in the hip [32]. Based on studies of cadavers, if more than 40% of the posterior wall is fractured, the risk of posterior instability is increased significantly [20]. CT also aids in the assessment of comminution and associated impaction, both of which relate to prognosis [33]. When evaluating CT scans for posterior wall fractures, remember that transverse fracture patterns extend posteriorly and interrupt the posterior wall; however, in this case the posterior wall is not a free fragment and should not be misinterpreted as a wall type of fracture.

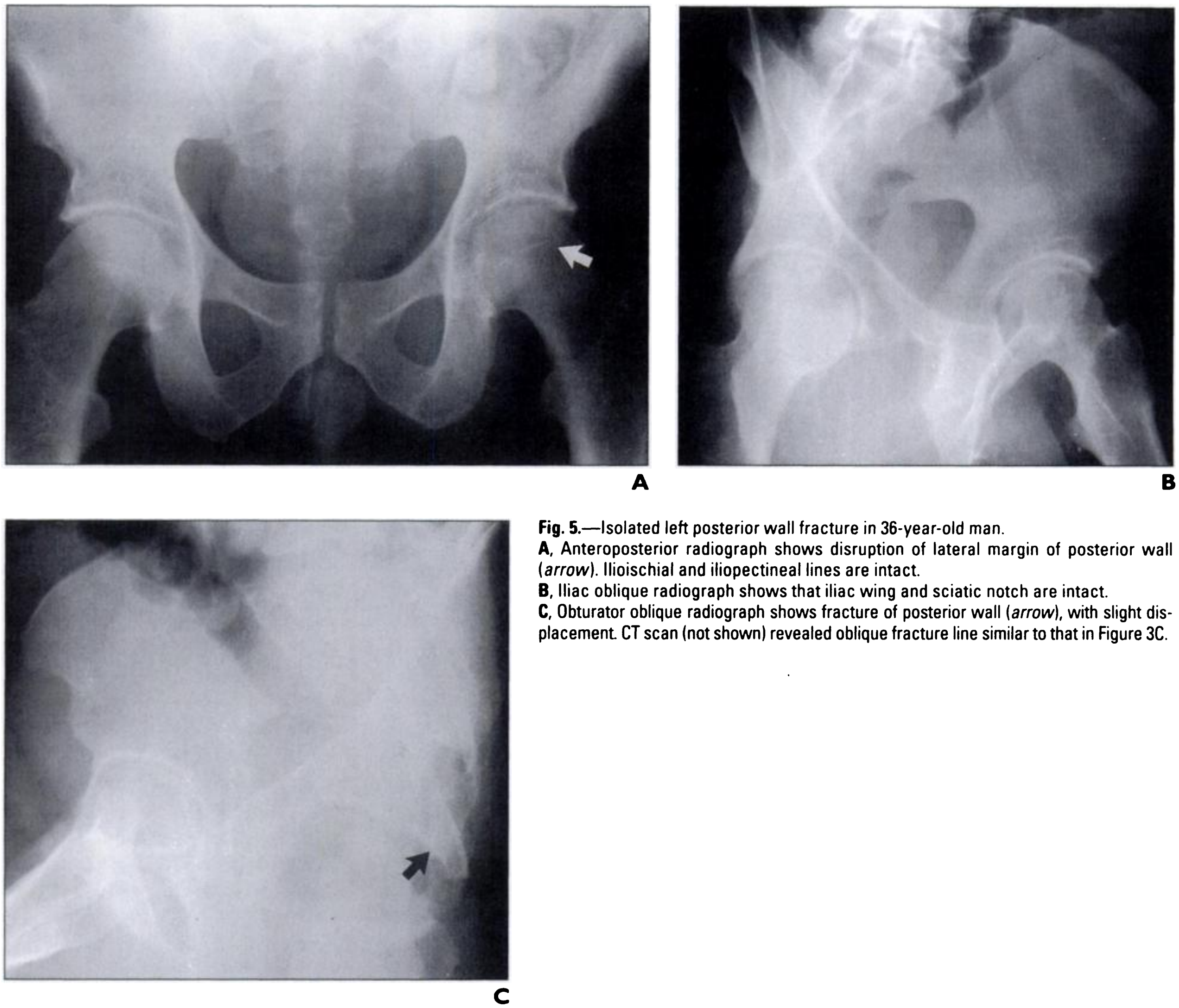


Fig. 5.—Isolated left posterior wall fracture in 36-year-old man.
A, Anteroposterior radiograph shows disruption of lateral margin of posterior wall (*arrow*). Ilioischial and iliopectineal lines are intact.
B, Iliac oblique radiograph shows that iliac wing and sciatic notch are intact.
C, Obturator oblique radiograph shows fracture of posterior wall (*arrow*), with slight displacement. CT scan (not shown) revealed oblique fracture line similar to that in Figure 3C.

Anterior wall fractures are uncommon [1, 2, 9, 30, 31, 34] and can be difficult to detect. On the anteroposterior view, a crack in the edge of the anterior wall or disruption of the iliopectineal line at the puboacetabular junction, just medial to the acetabulum, may be seen. This junction is best seen on the obturator oblique view, and this radiograph should be carefully studied if an anterior wall fracture is suspected.

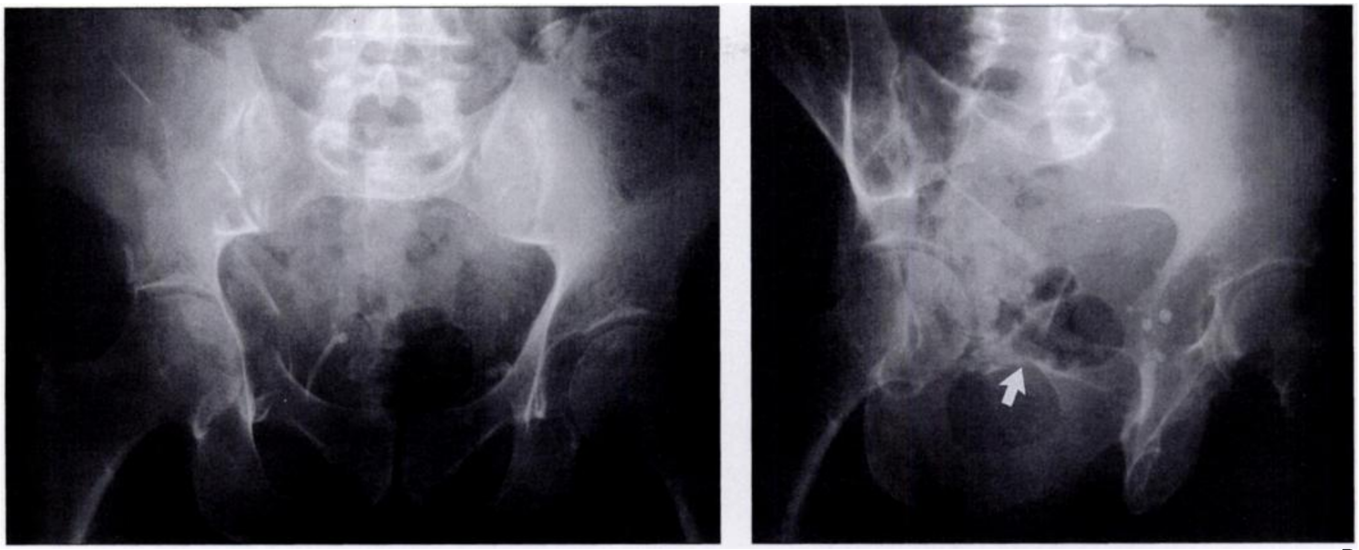
Column Fractures

Five fractures involve the columns: the elementary anterior and posterior column fractures, the associated posterior column with posterior wall fracture, the common both-column fracture, and the uncommon anterior column with posterior hemitransverse fracture. Conceptually, when a column pattern of fracture occurs, the acetabulum is disrupted with a more or less vertical fracture line and the acetabulum is broken into front and back pieces [2, 4, 6, 16]. Depending on the fracture type, one or both of the pieces will be isolated from the axial skeleton, fractured from the sciatic buttress.

The radiographic features of column fractures follow which columns are broken. If the anterior column is fractured, the iliopectineal line is disrupted and a fracture will extend a variable distance above the dome into the iliac wing (Fig. 6). We use the term "iliac wing" to represent all of the ilium above the acetabular dome to simplify discussion but recognize that this term is not entirely correct anatomically. If the posterior column is fractured, the ilioischial line will be disrupted. Because nearly all column fractures extend down into the obturator ring, detection of the obturator ring fractures is important. In the setting of acetabular fracture, if the obturator ring is broken, then the patient has either a column-type fracture or a T-shaped fracture. Most obturator ring fractures occur at the inferior portion of the ring, the ischiopubic junction—a finding that is especially true of posterior column and both-column fractures. However, the ring fracture can occur high in the ring, adjacent to the radiographic teardrop; anterior column fractures often have this pattern.

CT scans of column pattern fractures show a medial to lateral (horizontal) fracture line, above the acetabulum into the iliac wing in the case of anterior column fractures and at the level of the dome and inferior for posterior column fractures. CT also reveals the spur sign, a pathognomic sign of a both-column fracture.

Isolated anterior column fractures are relatively uncommon, but the major features of fracture line into the ilium are variable, ranging from just above the dome of the acetabu-



A B

Fig. 6.—34-year-old man with anterior column fracture.
A, Anteroposterior radiograph shows disruption of iliopectineal line; ilioischial line is intact. Subtle overlapping density is noted in iliac wing because of superimposed fracture fragments.
B, Obturator oblique radiograph shows disruption of obturator ring (*arrow*) better than anteroposterior view.
C, Iliac oblique radiograph shows extensive fracture into iliac wing. Posterior column is intact to inferior sacroiliac joint (*arrows*). Anterior column fracture fragment is unusually large.

C

lum through the iliac crest [2]. When the fracture extends only a short distance into the ilium, the fracture may resemble an anterior wall fracture. The anterior wall fracture can be differentiated from a low anterior column fracture because the latter fracture extends into the obturator ring. The obturator ring fracture may be at the puboacetabular junction or extend distal to the superior pubic ramus. The associated anterior column with posterior hemitransverse fracture is uncommon. A fracture line extends above the acetabulum into the ilium, characteristic of anterior column fractures. In addition, a transverse component extends from front to back through the acetabulum.

The elementary posterior column fracture and the associated posterior column with posterior wall fractures also are uncommon. When the posterior column breaks, the ischial portion of the acetabulum is isolated from the sciatic buttress [1, 2]. The obturator ring fracture, which is always present, typically extends from the cotyloid notch to the ischiopubic junction.

The most prevalent type of column fracture is the both-column fracture [1, 2, 5, 9, 30, 31] (Fig. 7). It has the radiographic and CT features of both the anterior column and posterior column fractures. In addition, when both the anterior and posterior columns fracture, no intact support exists between the acetabular articular surface and the axial skeleton through the sacroiliac joint. The acetabulum is free-floating and can be displaced medially into the pelvis [1, 2, 30, 31]. If medial displacement occurs, the sciatic buttress from the sacroiliac joint remains in normal position and can be seen as a shard of bone posterior to the displaced column fragments on the obturator view. When seen, this shard of bone is called the spur sign and is pathognomic of a both-column fracture [1, 2] (Fig. 7). CT can reveal the spur as well as a triangular-shaped shard of bone extending inferior and lateral from the sacroiliac joint, discontinuous from the articular surface. However, not all both-column fractures will have a spur sign; only those with medial displacement of the acetabular fragments will have a spur sign. With or without medial displacement, careful inspection of CT scans of patients with both-column fractures will show that the strut of bone from the sacroiliac joint ends without reaching the articular surface, which is free-floating. This feature allows separation of both-column fractures from comminuted T-shaped fractures [9, 29] (Fig. 8).

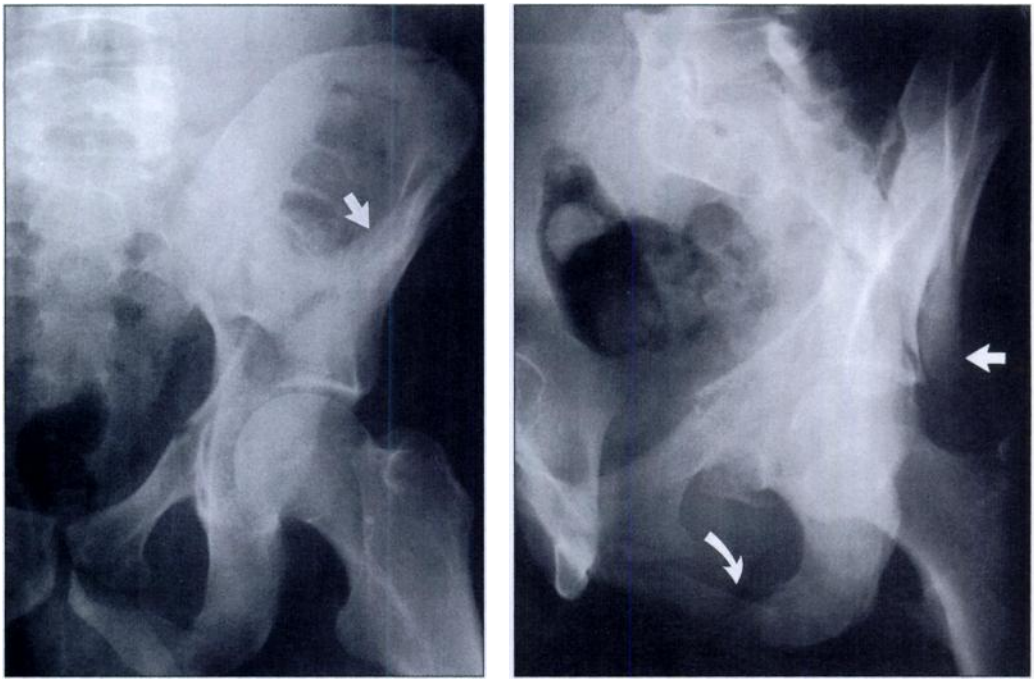


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Fig. 7.—22-year-old man with both-column fracture.
A, Anteroposterior radiograph reveals disruption of iliopectineal and ilioischial lines; fracture line also extends above acetabulum into iliac wing (*arrow*). Obturator ring also is disrupted.
B, Obturator oblique radiograph reveals typical fracture of obturator ring at ischiopubic junction (*curved arrow*). Spur sign also is present (*arrow*), which is pathognomic for both-column fractures.
C, Fracture into iliac wing is difficult to see on iliac oblique radiograph; film is overpenetrated.

Transverse Fractures

The transverse-type fractures include the elementary transverse, transverse with posterior wall (Fig. 9), and T-shaped fractures (Fig. 10). These fractures are common and share characteristic imaging features that allow them to be distinguished from other patterns. With transverse-type fractures, the main fracture plane runs through the acetabulum from the back to the front of the pelvis, dividing the acetabulum into top and bottom halves [1–3, 6]. An anteroposterior radiograph will show disruption of both the ilioischial and iliopectineal lines, and oblique views show that the fracture line crosses both the anterior and posterior columns. On CT, transverse-type fractures show an anteroposterior (vertical) fracture plane, which differentiates these fractures from the medial to lateral fracture plane seen with column fractures and the oblique plane present with wall fractures [2, 4, 6, 16].

In the setting of the elementary transverse fracture, the obturator ring is intact, and the inferior portion of the acetabulum moves as a unit and is connected from anterior to posterior. With the T-shaped fracture, the superior fragment above the fracture line is similar to an elementary transverse fracture, but the obturator ring is disrupted and the inferior portion of the

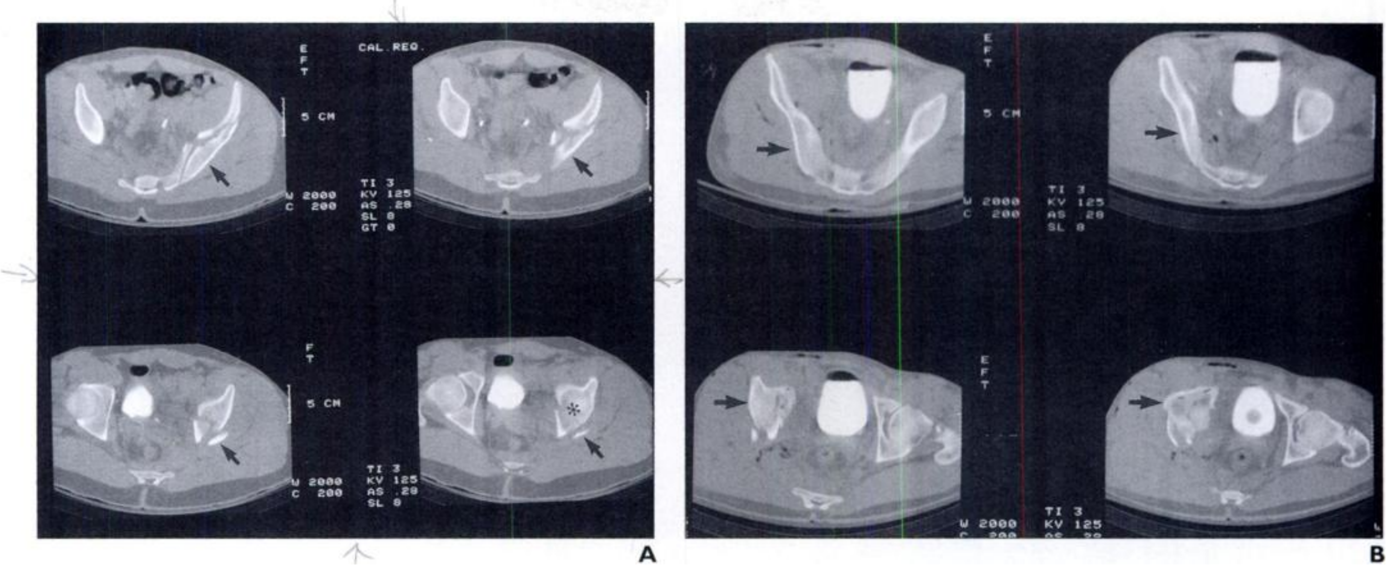

Fig. 8.—CT to differentiate T-shaped fracture from both-column fracture.
A, Slices from CT scan of 19-year-old man with left both-column fracture. Iliac bone that abuts sacroiliac joint (*arrows*) ends at small spur, and weight-bearing portion of acetabulum (*asterisk*) is separate from spur. Spur sign is indicated by CT appearance, which is characteristic of both-column fracture.
B, Slices from CT scan of 17-year-old man with T-shaped fracture. From level of acetabular dome (lower right image), intact strut of bone can be traced back to sacroiliac joint (*arrows*). Appearance is characteristic of transverse type of fracture, which includes T-shaped fracture.

acetabulum is fractured into anterior and posterior pieces (Fig. 10). This distinction is important because both lower fragments may not be reducible from a standard incision and may require a modified surgical approach [4, 5]. If a transverse fracture is detected, look for a posterior wall fracture on the obturator oblique view because this association is common (Fig. 9). Remember that a transverse-type fracture traverses the posterior wall, and a separate posterior wall fracture may or may not be found.

T-type fractures can be comminuted and resemble a both-column fracture. One important distinction between these two fractures allows proper classification. The both-column fracture separates both the anterior and posterior columns from the axial skeleton (allowing the possibility of the spur sign). With T-type fractures, the top half of the fracture, including the attached acetabular dome and articular surface, connects to the axial skeleton via the sciatic buttress. If an intact strut of bone can be traced from the sacroiliac joint to the articular surface of the dome of the acetabulum, then the patient has a comminuted T-type fracture. If the strut ends before the articular surface, which is free-floating, the patient has a both-column fracture [2, 9, 29] (Fig. 8).

Systematic Approach to Interpretation

Our experience has been that systematically approaching radiographic evaluation with a checklist of fracture features allows us to apply the classification of Judet et al. [1] and Letournel [2] more easily [9]. We use this systematic approach to initially decide what main subgroup the fracture best fits and to determine whether a column, wall, or transverse fracture is present or whether features from two subgroups are present. We then further classify the fracture within the subgroup into one of the 10 fracture types.

When looking for fracture lines, use of the terms "anterior column" and "posterior column" often leads to confusion in trying to classify the fracture. For example, a transverse fracture that runs from front to back through the acetabulum will cause disruption of both the ilioischial and iliopubic lines; using the terms "anterior column" and "posterior column" during fracture description may result in this fracture being classified incorrectly as a both-column fracture. A better approach is to reserve the terms "anterior column" and "posterior column" for fracture classification and use the terms "front part" and "back part" of the acetabulum for fracture description. If the ilioischial line is disrupted the posterior part of the acetabulum is fractured, and if the iliopectineal line is disrupted the anterior part of the acetabulum is fractured.

When studying the radiographic series (anteroposterior and obliques) and CT scan of a patient with an acetabular fracture, eight observations allow most fracture types to be accurately classified (Table 1). Table 2 summarizes the findings of these eight observations for each of the 10 fractures types in the classification of Judet et al. [1] and Letournel [2].

Determining the status of the obturator ring is important for subsequent fracture typing. If the obturator ring is broken, then the fracture is either a column type of fracture or a T-shaped fracture (Figs. 6, 7, 10). The usual location for obturator ring fractures is inferior, at the ischiopubic junction, but anterior column patterns will involve the anterior part of the ring, at the puboacetabular junction or superior pubic ramus. To see the inferior ring fractures on CT, scan parameters must include scanning all the way through the ischial tuberosities. Obturator ring fractures can be subtle and may be visible on radiography but not on CT and vice versa.

Radiographically, the status of the obturator ring is best examined on the obturator oblique view. On CT, follow the images of the inferior acetabulum to determine if a fracture line is extending into the ring through the bottom of the acetabulum.

The second and third questions assess whether fracture lines are present in the front and back of the acetabulum. The best view for seeing the iliopectineal line is the anteroposterior radiograph. A disruption of the iliopectineal line indicates a fracture line traversing the anterior portion of the pelvis. Confirmation of the anterior fracture line should be sought on the obturator oblique view, which shows the inferior portion of the line (the region of the superior pubic ramus) to advantage. After assessing the iliopectineal line, the ilioischial line should be examined, again from the greater sciatic notch, past the radiographic teardrop into the ischium. Disruption of the ilioischial line indi-

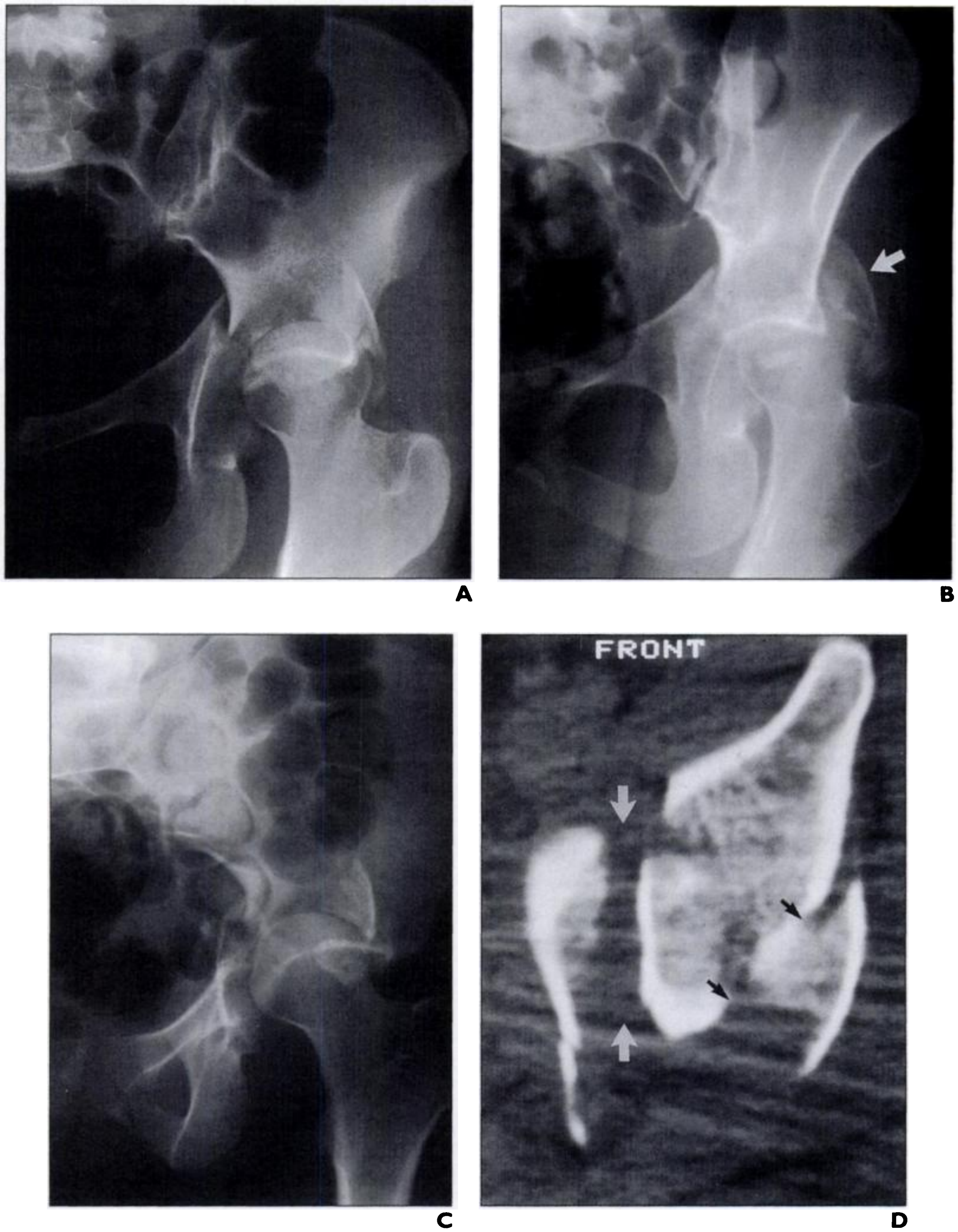

Fig. 9.—31-year-old woman with transverse with posterior wall fracture.
A, Anteroposterior radiograph reveals disruption of iliopectineal and ilioischial lines; lateral margin of posterior wall is absent and femoral head is posteriorly dislocated.
B, Obturator oblique radiograph (underrotated because of patient discomfort) shows posterior wall fragment (*arrow*) to advantage. Obturator ring is intact, which distinguishes this fracture from T-shaped or column fractures.
C, Iliac oblique radiograph reveals intact iliac wing. Posterior wall fragment is seen through wing; femoral dislocation is again noted.
D, CT scan reveals vertical radiolucent line representing transverse part of fracture (*white arrows*). Oblique fracture line (*black arrows*) is posterior wall fracture.

cates a fracture traversing the posterior part of the pelvis. This interpretation should be confirmed on the iliac oblique view by searching for fracture lines traversing the posterior pelvis. Many fractures that disrupt these lines cause discontinuity near the level of the greater sciatic notch, and these fractures can be overlooked if special attention is not paid to this area.

If only the iliopectineal line is disrupted, then the patient likely has an anterior column fracture (Fig. 6). If only the ilioischial line is disrupted, the patient could have a posterior column fracture, an extended posterior wall fracture, or the associated posterior column with posterior wall fracture. If both lines are disrupted, then the fracture involves both the front and back parts of the pelvis. Therefore, the fracture is a transverse-type fracture, including T-shaped (Fig. 10), transverse, transverse with posterior wall (Fig. 9), or anterior column with posterior hemitransverse fractures; or a both-column fracture (Fig. 7).

The next question to be answered is whether a fracture extends into the iliac wing above the acetabulum. The iliac wing fracture can be seen on the anteroposterior view, but overlying bowel gas often obscures the fracture. One sign on the anteroposterior view is the double density sign, present when the two pieces of iliac wing overlap slightly, resulting in a linear area of increased radiodensity. The better view for detecting anterior column fractures is the iliac oblique view, which shows the iliac wing *en face*. Overlapping cortices of the iliac wing fracture may be appreciated on the obturator oblique view. Iliac wing fractures are detected easily and reliably with acetabular CT; in our experience, CT is more reliable for detecting iliac wing fractures than radiography. Slices above the dome of the acetabulum will conclusively show the presence or absence of a fracture into the iliac wing. Detecting a fracture of the iliac wing is important for fracture typing; if a fracture extends into the iliac wing, the patient has an anterior column (Fig. 6), anterior column with posterior hemitransverse, or a both-column fracture (Fig. 7). If this fracture line is not present, these fracture patterns are not possible.

The next question to be answered is whether a fracture of the posterior wall is present. Posterior wall fracture can be the only fracture present and is then called an elementary posterior wall fracture (Fig. 5). When a posterior wall fracture is detected, other fractures should be sought because in many cases posterior wall fractures are part of an associated fracture pattern. The most common such pattern is the transverse with posterior wall fracture (Fig. 9), but posterior wall with posterior column fracture also can be seen.

The sixth question combines information obtained by answering the first five questions and stratifying the fracture into one of two general groups. If the fracture breaks the pelvis, through the acetabulum, into top and bottom halves, then the fracture is a transverse type of fracture, including the elementary transverse, transverse with posterior wall (Fig. 9), and T-shaped fractures (Fig. 10). If the fracture divides the pelvis into front and back halves, then the fracture is a column type of fracture, including the elementary anterior and posterior column fractures as well as the both-column fracture (Fig. 7). If the fracture does not divide the pelvis into halves, then posterior and anterior wall fractures are considerations.

The seventh question deals with the detection of a spur sign. The spur is seen on the obturator oblique view and, if present, is pathognomic of a both-column fracture [1, 2] (Fig. 7). The spur also can be detected on CT scans [9, 16, 29] (Fig. 8). Even when no medial displacement is present to cause the spur sign, CT evaluation is important to determine whether the acetabulum is connected to the sacroiliac joint via an intact strut of bone. Understanding the significance of the spur allows the evaluator to search for this finding on CT, even when it is not apparent on radiography. When reviewing the CT scan, start at the sacroiliac joint proximally and follow the iliac wing distally. If this bone is not contiguous with any of the articular surface, the patient has a both-column fracture.

The last question emphasizes that the CT scan is useful for fracture classification and that the main fracture plane seen on CT can be used to stratify fractures into transverse, wall, and column subgroups.

Fig. 10.—T-shaped fracture in 15-year-old boy. Obturator oblique radiograph shows transverse fracture, dividing acetabulum into top and bottom halves. Fracture is present in obturator ring at ischiopubic junction (*straight arrow*), further dividing bottom portion of acetabulum into anterior (*curved arrow*) and posterior (*asterisk*) pieces. This finding differentiates T-shaped fracture from transverse fractures, where obturator ring is intact (see Fig. 9B).

This systematic approach guides the search for important imaging features that are necessary for fracture classification. Answering these questions provides enough information to classify most acetabular fractures. This approach starts with a search for fracture lines and then proceeds to an initial classification of a fracture into one of three main groups. To further classify a fracture, specific imaging features allow differentiation of each fracture into one of the 10 fracture types of Judet et al. [1] and Letournel [2]. Complicated cases may not fit neatly into one of the 10 fracture types, but, fortunately, these fractures are uncommon.

Conclusions

Although 10 fracture types exist in the classification of Judet et al. [1] and Letournel [2], all can be categorized into three subgroups. Certain radiographic features allow separation

TABLE 1 Observations Necessary to Classify Most Acetabular Fractures

Question	Systematic Approach to Acetabular Fractures: Radiographic Observation
1	Is there a fracture of the obturator ring?
2	Is the ilioischial line disrupted?
3	Is the iliopectineal line disrupted?
4	Is the iliac wing above the acetabulum fractured?
5	Is the posterior wall fractured?
6	Does the fracture divide the acetabulum into top and bottom halves or front and back halves?
7	Can an intact strut of bone be followed from the sacroiliac joint to the acetabular articular surface or is a spur sign present?
8	What is the orientation of the major fracture line on CT?

TABLE 2 **Radiographic Features of Acetabular Fracture Types**

Type of Fracture	Obturator Ring Fracture	Ilioischial Line Disrupted	Iliopectineal Line Disrupted	Iliac Wing Fracture	Posterior Wall Fracture	Pelvis into Halves	Spur Sign	CT Fracture Orientation
Both-column	Yes	Yes	Yes	Yes	No	Front and back	Yes	Horizontal
Anterior column	Yes	No	Yes	Yes	No	Front and back	No	Horizontal
Posterior column	Yes	Yes	No	No	No	Front and back	No	Horizontal
Posterior column with posterior wall	Yes	Yes	No	No	Yes	Front and back	No	Horizontal and oblique
T-shaped	Yes	Yes	Yes	No	No	Top and bottom	No	Vertical
Transverse with posterior wall	No	Yes	Yes	No	Yes	Top and bottom	No	Vertical and oblique
Transverse	No	Yes	Yes	No	No	Top and bottom	No	Vertical
Posterior wall	No	Varies	No	No	Yes	No	No	Oblique
Anterior wall	No	No	Yes	No	No	No	No	Oblique
Anterior column with posterior hemitransverse	No	Yes	Yes	Yes	No	Not applicable [a]	No	Not applicable [a]

[a]Several features do not fit the anterior column with posterior hemitransverse fracture type, a combination of column and transverse fracture types.

of these groups. A systematic approach to studying the anteroposterior and oblique radiographs facilitates fracture detection and categorization. Initially grouping fractures into larger categories and then subclassifying a given fracture into one of the 10 types allow classification of most acetabular fractures. CT is a valuable adjunct to radiography in the evaluation of patients with acetabular fractures.

Resisting the temptation to call all acetabular fractures a "complex fracture of the acetabulum" is important. The fracture classification of Judet et al. [1] and Letournel [2] is used universally by surgeons, is required for surgical approaches, and elegantly describes the pathoanatomy of acetabular fractures. If radiologists are to contribute to optimal patient care, they must be familiar with this system and the terminology that surgeons use to describe these fractures.

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