Femoroacetabular Impingement: Radiographic Diagnosis—What the Radiologist Should Know

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OBJECTIVE. The purpose of this article is to show the important radiographic criteria that indicate the two types of femoroacetabular impingement: pincer and cam impingement. In addition, potential pitfalls in pelvic imaging concerning femoroacetabular impingement are shown.

CONCLUSION. Femoroacetabular impingement is a major cause for early "primary" osteoarthritis of the hip. It can easily be recognized on conventional radiographs of the pelvis and the proximal femur.

Femoroacetabular impingement (previously also called "acetabular rim syndrome" [1] or "cervicoacetabular impingement" [2]) is a major cause of early osteoarthritis of the hip, especially in young and active patients [3–6]. It is characterized by an early pathologic contact during hip joint motion between skeletal prominences of the acetabulum and the femur that limits the physiologic hip range of motion, typically flexion and internal rotation. Depending on clinical and radiographic findings, two types of impingement are distinguished (Fig. 1): Pincer impingement is the acetabular cause of femoroacetabular impingement and is characterized by focal or general overcoverage of the femoral head. Cam impingement is the femoral cause of femoroacetabular impingement and is due to an aspherical portion of the femoral head–neck junction (Fig. 2). Most patients (86%) have a combination of both forms of impingement, which is called "mixed pincer and cam impingement," with only a minority (14%) having the pure femoroacetabular impingement forms of either cam or pincer impingement [7].

During sports activities and activities of daily living, repetitive microtrauma of these osseous convexities occur. As a consequence of this recurring irritation, the labrum degenerates [8] and irreversible chondral damage occurs that progresses and results in degenerative disease of the hip joint if the underlying cause of femoroacetabular impingement is not addressed [9, 10].

In the initial phase of this recently described entity, patients with femoroacetabular impingement do not have classic radiographic signs of osteoarthritis such as joint space narrowing, osteophyte formation, subchondral sclerosis, or cyst formation. Thus, this article will familiarize radiologists with this pathophysiologic concept and describe the radiographic findings that are helpful for the correct diagnosis and evaluation before potential surgical treatment of femoroacetabular impingement. In addition, potential pitfalls simulating femoroacetabular impingement are discussed, and some "pearls" for diagnosis are offered.

Clinical Findings

Patients with femoroacetabular impingement are young, usually in their 20s–40s. The estimated prevalence is 10–15% [11]. Patients present with groin pain with hip rotation, in the sitting position, or during or after sports activities. Some patients describe a trochanteric pain radiating in the lateral thigh. Typically, they are aware of their limited hip mobility long before symptoms appear. In the clinical examination, patients with femoroacetabular impingement have a restricted range of motion, particularly flexion and internal rotation [3, 8]. A positive impingement sign is present for anterior femoroacetabular impingement if the forced internal rotation/adduction in 90º of flexion is reproducibly painful, and for posterior impingement with painful forced external rotation in full extension [3, 12] (Fig. 3). The "Drehmann's" sign is positive if there is an unavoidable passive external rotation of the hip while performing a hip flexion [13].

Keywords: bone, femoroacetabular impingement, hip, musculoskeletal imaging, orthopedic surgery, radiography

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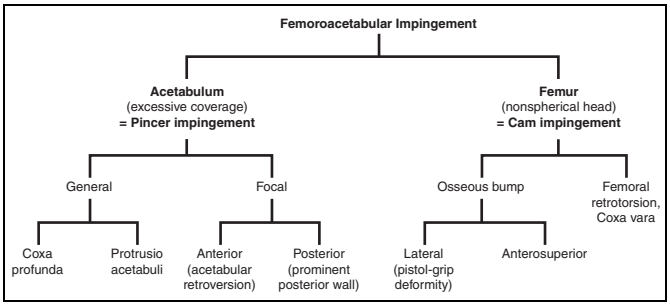

Fig. 1—Flowchart shows classification of types of femoroacetabular impingement.

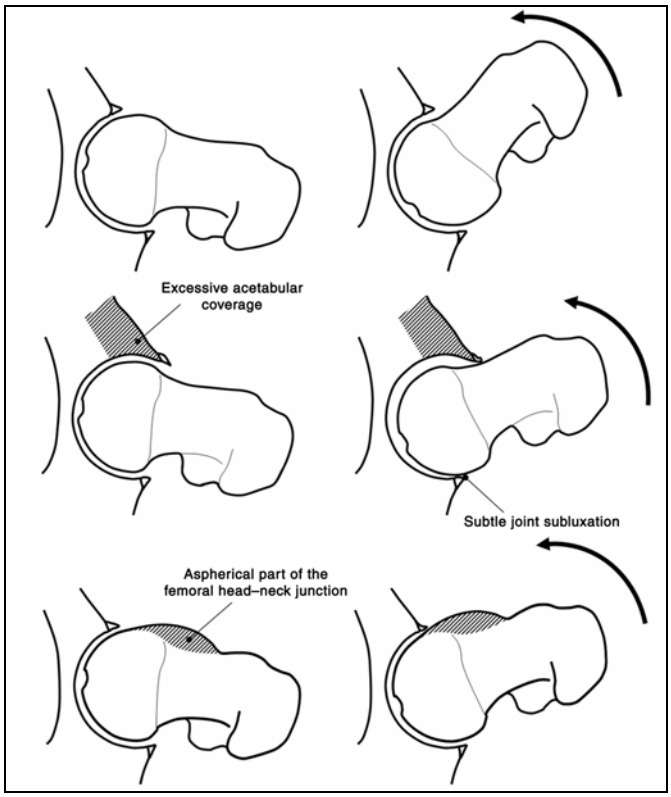

Fig. 2—Normal configuration of hip with sufficient joint clearance allows unrestricted range of motion (*top*). In pincer impingement, excessive acetabular overcoverage leads to early linear contact between femoral head–neck junction and acetabular rim, resulting in labrum degeneration and significant cartilage damage. Posteroinferior portion of joint is damaged (contrecoup) due to subtle subluxations (*center*). In cam impingement, aspherical portion of femoral head–neck junction is jammed into acetabulum (*bottom*).

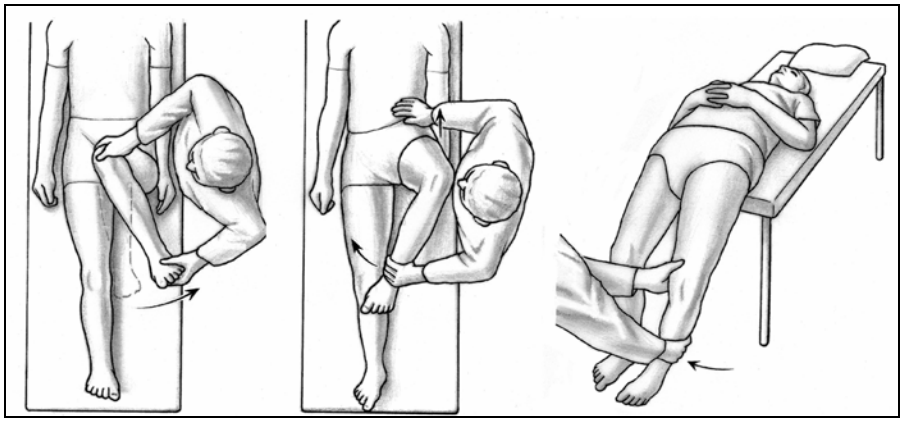

Fig. 3—Clinical tests to assess femoroacetabular impingement. Anterior impingement sign (*left*) is positive, with painful forced internal rotation in 90° of flexion. In extreme forms, there is unavoidable passive external rotation of hip during hip flexion ("Drehmann's" sign, *center*). "Posterior impingement" sign is positive when there is painful forced external rotation in maximal extension (*right*).

Conventional Radiographic Imaging Technique

The role of imaging in femoroacetabular impingement is to evaluate the hip for abnormalities associated with impingement and to exclude arthritis, avascular necrosis, or other joint problems on radiographs. MRI or MR arthrography can then be used to confirm or exclude labral tears, cartilage damage, and other pathologic signs of internal hip derangement if impingement is suspected. Alternatively, radiography is then usually followed by MRI for cartilage and labral disorders and a 3D understanding of the bone anatomy.

Standard conventional radiographic imaging for femoroacetabular impingement includes two radiographs (Fig. 4): an anteroposterior pelvic view and an axial cross-table view of the proximal femur [3]. An alternative to the axial view, a Dunn/Rippstein view, preferably in 45° of flexion, can be obtained to reveal pathomorphologies of the anterior femoral head–neck junction [14]. For the anteroposterior pelvic radiograph, the patient is in the supine position with the legs 15° internally rotated to compensate for femoral antetorsion and to provide better visualization of the contour of the lateral femoral head–neck junction [15]. The film-focus distance is 1.2 m; the central beam is directed to the midpoint between a line connecting both anterosuperior iliac spines and the superior border of the symphysis (Fig. 4), which can easily and reproducibly be palpated by the radiology technician [16, 17]. Accordingly, the cross-table view of the proximal femur is taken with the leg internally rotated, with a film-focus distance of 1.2 m, and with the central beam directed to the inguinal fold [18]. If these prerequisites of correct positioning of the patient and accurate radiographic technique are not fulfilled, the radiographs must be interpreted with caution.

A faux profile of Lequesne and de Sèze [19] may be used for quantification of anterior overcoverage but is rarely indicated for femoroacetabular impingement because it does not show the relationship between the anterior and the posterior acetabular rims. Rather, it is used to assess the posteroinferior part of the hip joint to detect the so-called contrecoup lesions in pincer impingement described later.

To determine accurately the individual pelvic tilt of a patient, a strong lateral view of the pelvis can be obtained (Fig. 5B). Correct interpretation of pelvic tilt is crucial for accurate description and radiographic assessment of individual hip parameters. A neutral tilt is

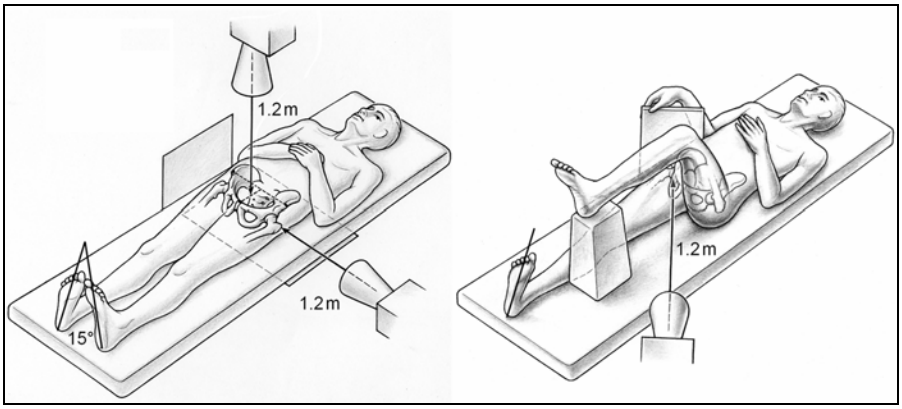

Fig. 4—Correct setting for anteroposterior and strong lateral (*left*) pelvic radiography. Cross-table axial radiograph of hip (*right*) is needed to visualize anatomy of anterior femoral head–neck junction, which is not visible on anteroposterior pelvic radiograph.

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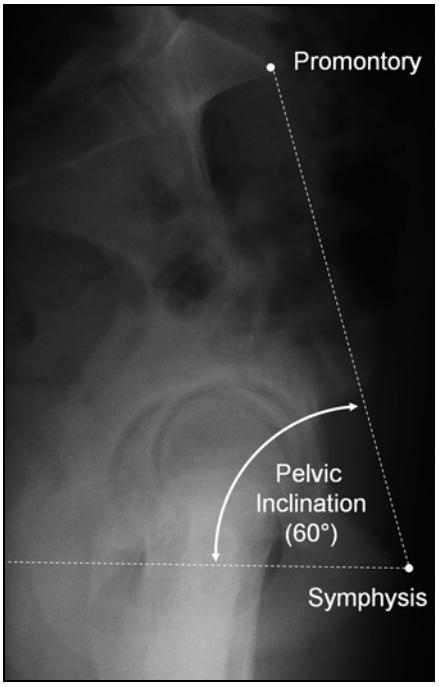

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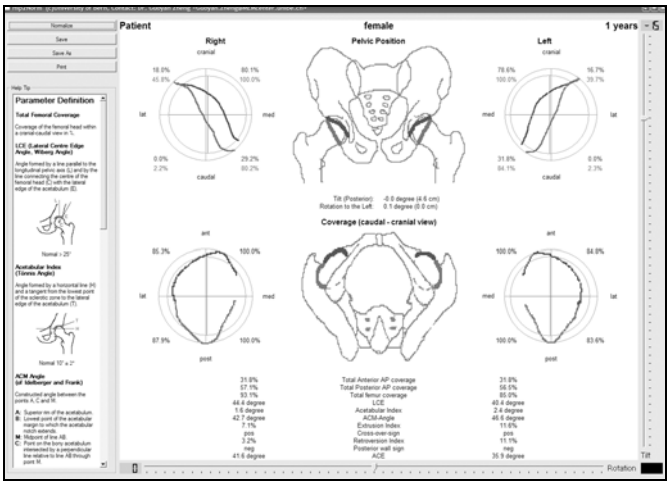


C

Fig. 5—27-year-old woman.
A, Bilateral "cross-over" sign is visible on this anteroposterior pelvic radiograph that is analyzed with specifically developed software Hip^{2}Norm (University of Bern, Switzerland) for tilt and rotation correction of parameters of pelvic radiographs [17].
B, Strong lateral view shows pelvic inclination of 75°, representing anterior tilt of 15° in relation to neutral inclination of 60° [20].
C, Computerized virtual correction to neutral hip morphology.

defined with a pelvic inclination angle of 60°, which includes a horizontal line and a line connecting the upper border of the symphysis and the sacral promontory [20] (Fig. 5).

The use of gonadal shielding is not particularly recommended for the initial assessment of the hip because it impedes correct interpretation of the individual tilt and rotation described later.

Pincer Impingement

Pincer impingement is more common in middle-aged women, occurring at an average age of 40 years, and can occur with various

TABLE 1: Characteristics of the Two Types of Femoroacetabular Impingement

Criteria	Pincer Impingement	Cam Impingement
Cause	Focal or general overcoverage	Aspherical head
Mechanism	Linear contact between overcovering rim and head–neck junction	Jamming of aspherical head portion into acetabulum
Sex distribution (M:F)	1:3	14:1
Average age (range) (y)	40 (40–57)	32 (21–51)
Typical location of cartilage damage	Circumferential with contrecoup	11- to 3-o'clock position
Average depth of cartilage damage (mm)	4	11
Associated disorders	Bladder extrophy	Slipped capital femoral epiphysis
	Proximal femoral focal deficiency	Legg-Calvé-Perthes disease
	Posttraumatic dysplasia	Posttraumatic retrotorsion of femoral head
	Chronic residual dysplasia of acetabulum	Coxa vara
	Legg-Calvé-Perthes disease	Pistol-grip deformity
	Slipped capital femoral epiphysis	Head-tilt deformity
	After acetabular reorientation procedures	Post-slip deformity
	Idiopathic retroversion	Femoral retroversion
		Growth abnormality of femoral epiphysis
Radiographic signs on anteroposterior radiographs	Coxa profunda	Pistol-grip deformity
	Protrusio acetabuli	CCD angle < 125°
	Focal acetabular retroversion (figure-8 configuration)	Horizontal growth plate sign
	Lateral center edge angle > 39°	
	Reduced extrusion index	
	Acetabular index ≤ 0°	
	Posterior wall sign	
Radiographic signs on cross-table radiographs	Linear indentation sign	Alpha angle > 50°
		Femoral head–neck offset < 8 mm
		Offset ratio < 0.18
		Femoral retrotorsion
Secondary changes	Herniation pits	
	Ossification of labrum	
	Appositional bone sign	
	Os acetabuli	
	Posterior inferior joint space loss (on faux profile in pincer hips)	
	Late: classic signs of osteoarthritis	

Note—CCD = centrum collum diaphyseal angle.

disorders (Table 1). Pincer impingement is the result of overcoverage of the hip and can lead to osteoarthritis [21]. Pincer impingement is also the result of a linear contact between the acetabular rim and the femoral head–neck junction due to general or focal acetabular overcoverage (Fig. 2). In contrast to cam impingement, cartilage damage of the acetabular cartilage is restricted in pincer hips to a small thin strip near the labrum that is more circumferentially located [7].

General Acetabular Overcoverage

Normally, general acetabular overcoverage is correlated with the radiologic depth of the acetabular fossa. A normal hip appears on an anteroposterior pelvic radiograph with the acetabular fossa line lying laterally to the ilioischial line (Fig. 6). A coxa profunda is defined with the floor of the fossa acetabuli touching or overlapping the ilioischial line medially (Fig. 7). Protrusio acetabuli occurs when the femoral head is overlapping the ilioischial line medially (Fig. 8). Both forms relate to an increased depth of the acetabuli; however, at this stage no clear information exists that the two entities are a continuation of each other.

Generally, a deep acetabulum is associated with excessive acetabular coverage that can be quantified with the lateral center edge angle or the acetabular index [22]. The lateral center edge angle is the angle formed by a vertical line and a line connecting the femoral head center with the lateral edge of the acetabulum. A normal lateral center edge angle varies between 25º (which defines a dysplasia) [23] and 39º (which is an indicator for acetabular overcoverage) [24]. The acetabular index is the angle formed by a horizontal line and a line connecting the medial point of the sclerotic zone with the lateral center of the acetabulum. In hips with coxa profunda or protrusio acetabuli, the acetabular index (also called "acetabular roof angle") is typically 0º or even negative.

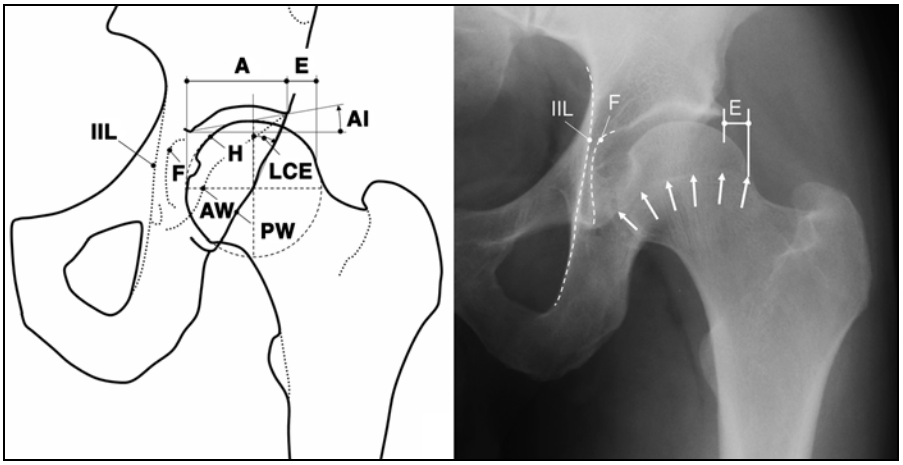


Fig. 6—Schematic (*left*) and radiographic (*right*) appearances of normal hip (detailed view of anteroposterior pelvic radiograph) in 35-year-old man. Acetabular fossa (F) is lateral to ilioischial line (IIL). Acetabular index (AI) is positive, and femoral head (H) is not entirely covered by acetabulum (E). Projected anterior wall (AW) lies medially to posterior wall (PW), which typically runs more or less through center of femoral head. Extrusion index (E / [A + E]) is approximately 25%. Lateral center edge (LCE) angle is 25–39°. Epiphyseal scar lies in femoral head circle (*arrows*). A = covered portion of femoral head, E = uncovered portion of femoral head.

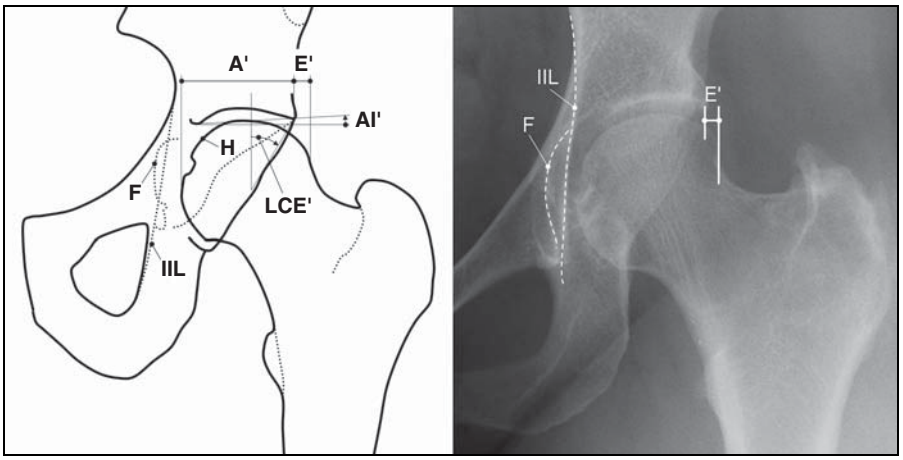


Fig. 7—Schematic (*left*) and radiographic (*right*) presentations of coxa profunda (detailed view of anteroposterior pelvic radiograph) in 29-year-old woman. Acetabular fossa (F) is touching or overlapping ilioischial line (IIL). Femoral head (H) is more covered, resulting in decreased femoral head extrusion index (E / [A + E]), neutral acetabular index (AI'), and increased lateral center edge (LCE') angle. A' = covered portion of the femoral head, E' = uncovered portion of the femoral head.

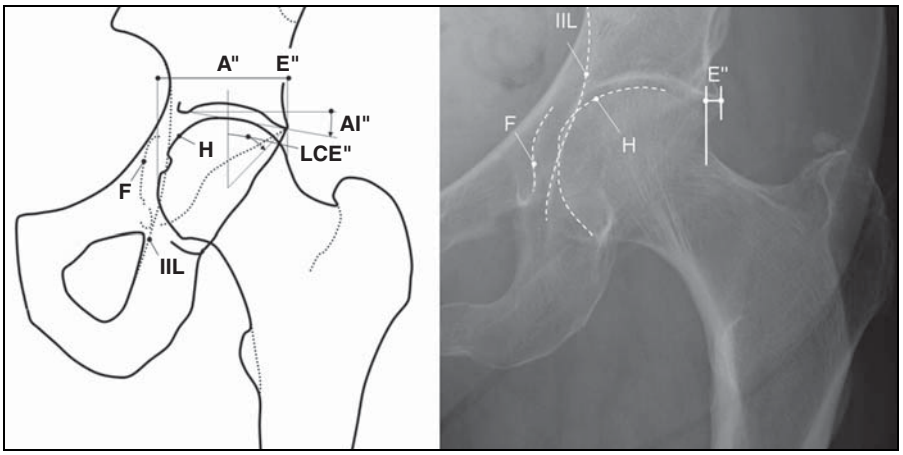


Fig. 8—Schematic (*left*) and radiographic (*right*) presentations of protrusio acetabuli (detailed view of anteroposterior pelvic radiograph) in 42-year-old woman. Femoral head line (H) is crossing ilioischial line (IIL). As a consequence, femoral head extrusion index (E / [A + E]) is zero or even negative, acetabular index (AI") is negative, and lateral center edge (LCE") angle increases. F = acetabular fossa. A" = covered portion of femoral head, E" = uncovered portion of femoral head.

Another parameter for quantification of femoral coverage is the femoral head extrusion index, which defines the percentage of femoral head that is uncovered when a horizontal line is drawn parallel to the interteardrop line [25]. A normal extrusion index is less than 25% [26]; however, to our knowledge no study has defined a minimum extrusion.

A pitfall: Formation of a pseudodeep acetabulum can be produced on an anteroposterior radiograph that is centered over the hip (Fig. 9). Because of this centering error, these radiographs are not useful for reliable diagnosis of a deep acetabulum.

Focal Acetabular Overcoverage

Focal overcoverage can occur in the anterior or the posterior part of the acetabulum. Anterior

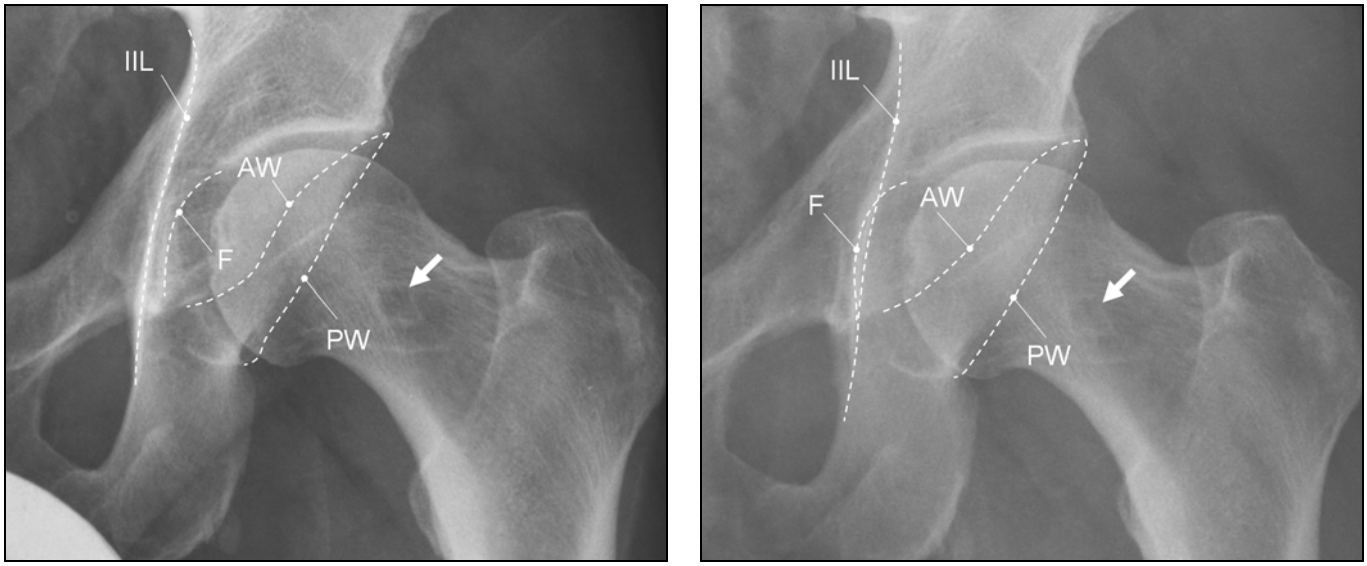


Fig. 9—Influence of direction of center of X-ray beam on appearance of acetabular depth in 22-year-old man. Arrows show herniation pit caused by cam type of femoroacetabular impingement. IIL = ilioischial line, AW = anterior wall, PW = posterior wall, F = fossa.
A, Section of anteroposterior pelvic radiograph shows regular acetabular configuration with acetabular fossa lying lateral to ilioischial line.
B, Hip radiograph centered over hip shows apparent coxa profunda. In addition, version of acetabulum seems to be larger with anterior wall being projected more medially.

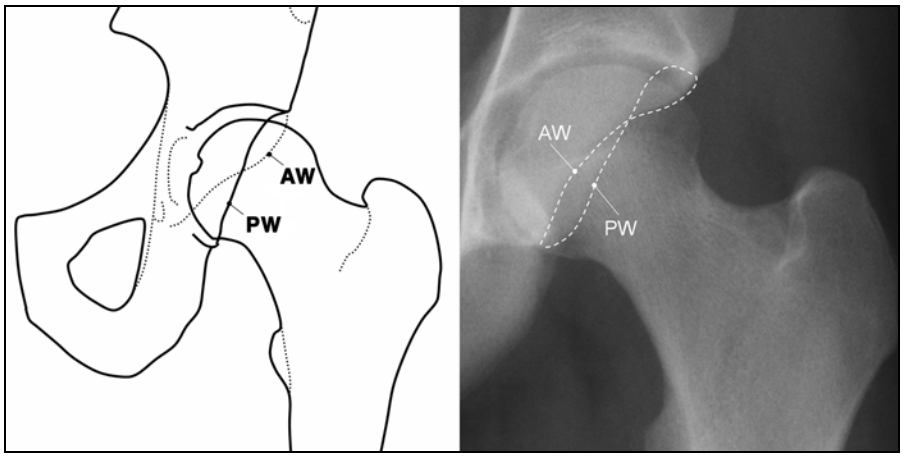


Fig. 10—Schematic (*left*) and radiographic (*right*) presentations of focal anterior overcoverage of hip in 29-year-old woman. Acetabular retroversion is defined as anterior wall (AW) being more lateral than posterior wall (PW), whereas in normal hip anterior wall lies more medially. This cranial acetabular retroversion can also be described by figure-8 configuration.

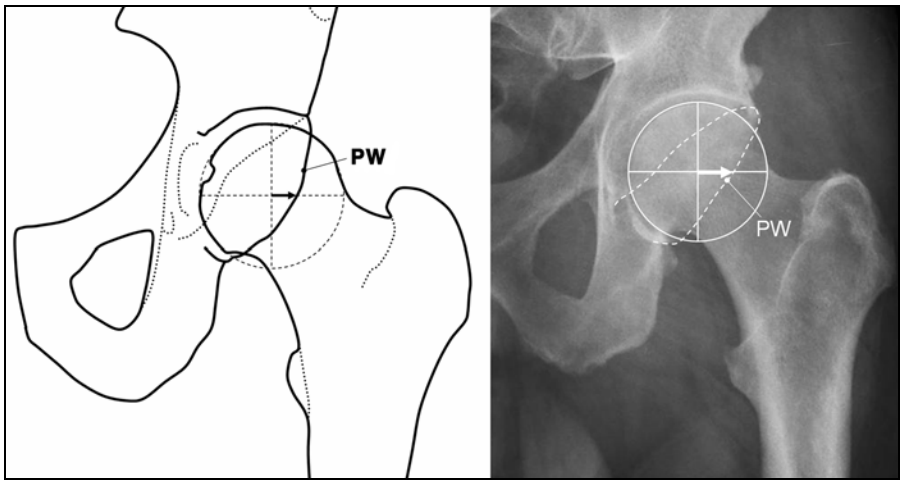


Fig. 11—Schematic (*left*) and radiographic (*right*) presentations of too-prominent posterior wall (PW) show posterior wall line running laterally to femoral head center in 30-year-old man.

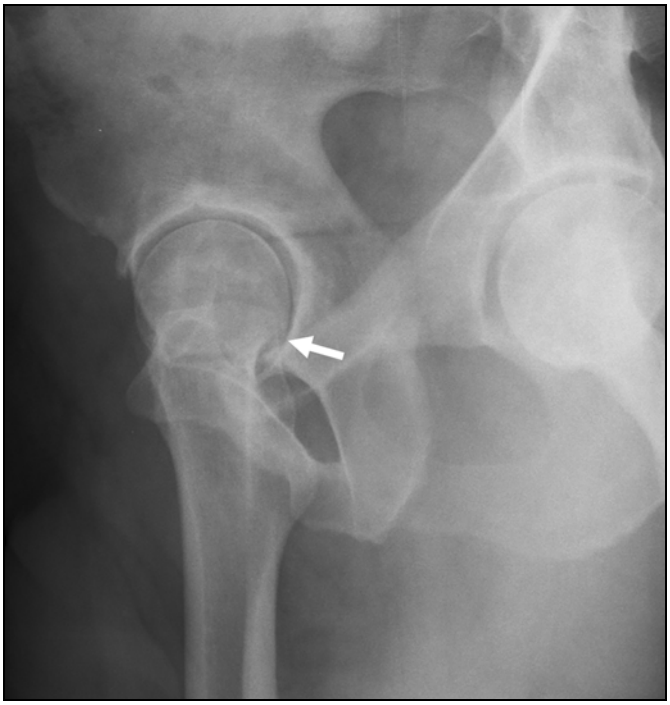
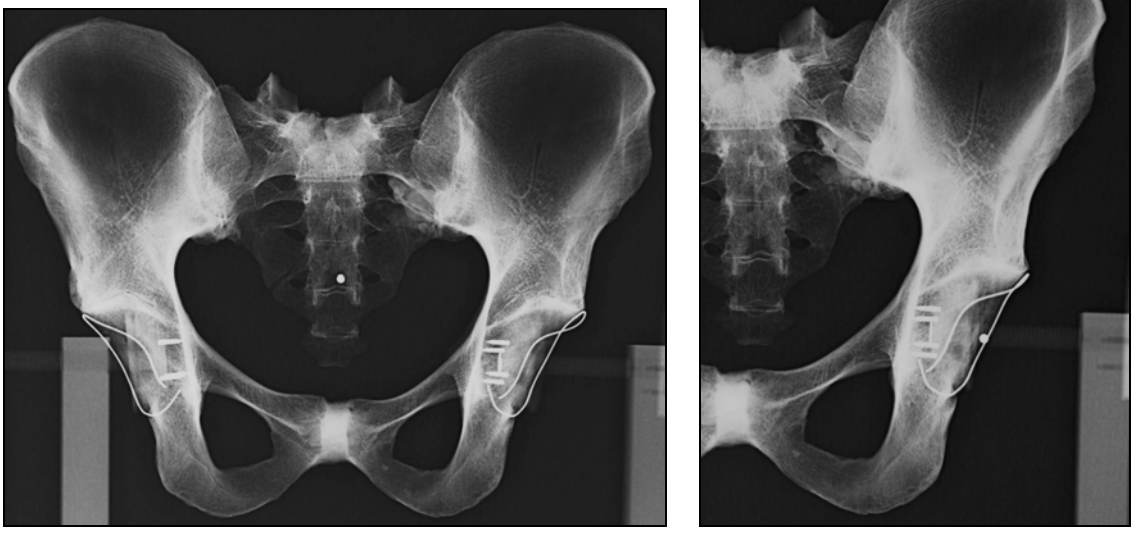


Fig. 12—Faux profile of 25-year-old man with pincer impingement shows posteroinferior joint space narrowing (*arrow*) as result of recurrent subluxations, which is unfavorable prognostic sign.

overcoverage is called "cranial acetabular retroversion" or "anterior focal acetabular retroversion" and causes anterior femoroacetabular impingement that can be reproduced clinically with painful flexion and internal rotation. By carefully tracing the anterior and posterior acetabular rims, different acetabular configurations can be identified. A normal acetabulum is anteverted and has the anterior rim line projected medially to the posterior wall line [16, 27–29] (Fig. 6). A focal overcoverage of the anterosuperior acetabulum causes a cranially retroverted acetabulum. This is defined with the anterior rim line being lateral to the posterior rim in the cranial part of the acetabulum and crossing the latter in the distal part of the acetabulum. This figure-8 configuration is called the "cross-over" sign (Fig. 10).

To distinguish between a too-prominent anterior wall and a deficient posterior wall, the posterior wall must be depicted in more detail. Therefore, the "posterior wall" sign was introduced as an indicator for a prominent posterior wall. This can cause posterior impingement with reproducible pain in hip extension and external rotation (Fig. 3). In a normal hip, the visible outline of the posterior rim descends approximately through the center point of the femoral head (Fig. 6). If the posterior line lies laterally to the femoral center, a more prominent posterior wall is present (Fig. 11). In contrast, a deficient posterior wall has the posterior rim medial to the femoral head center. A deficient posterior wall is often correlated with acetabular retroversion or dysplasia [27]; an excessive posterior wall can often be seen in hips with coxa profunda or protrusio acetabuli but can also occur as an isolated entity. Acetabular retroversion can also be caused by acetabular reorientation procedures if the configuration of the acetabular rims is not taken into consideration [30, 31].

This persistent abutment in the anterior part of the joint can lead to a slight subluxation posteroinferiorly. The increased pressure between the posteroinferior acetabulum and the posteromedial aspect of the femoral head can cause chondral damage to the posteroinferior part of the acetabulum as a contrecoup lesion, which occurs in approximately one third of pincer cases [3, 7, 32]. The resulting loss of joint space can be visualized on a faux profile and is a bad prognostic sign (Fig. 12).



A **B**

Fig. 13—Retroversion sign can be missed if central X-ray beam is not directed correctly. **A,** In this cadaveric pelvis with wire marking acetabular rims, cranial acetabular retroversion is visible on left side on anteroposterior pelvic radiograph. Center of X-ray beam is marked with radiopaque marker. **B,** On anteroposterior hip view, retroversion sign disappears.

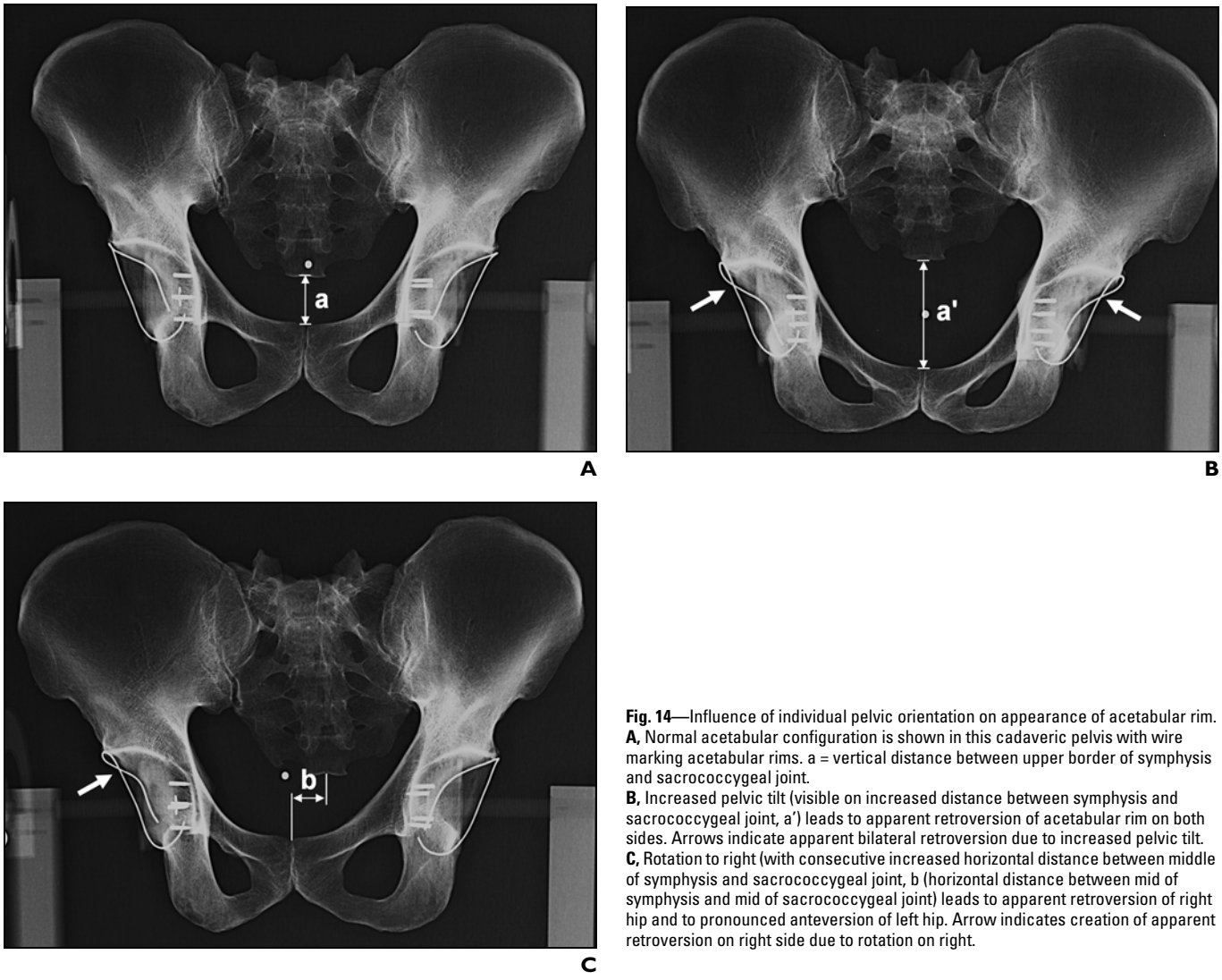


Fig. 14—Influence of individual pelvic orientation on appearance of acetabular rim.
A, Normal acetabular configuration is shown in this cadaveric pelvis with wire marking acetabular rims. a = vertical distance between upper border of symphysis and sacrococcygeal joint.
B, Increased pelvic tilt (visible on increased distance between symphysis and sacrococcygeal joint, a′) leads to apparent retroversion of acetabular rim on both sides. Arrows indicate apparent bilateral retroversion due to increased pelvic tilt.
C, Rotation to right (with consecutive increased horizontal distance between middle of symphysis and sacrococcygeal joint, b (horizontal distance between mid of symphysis and mid of sacrococcygeal joint) leads to apparent retroversion of right hip and to pronounced anteversion of left hip. Arrow indicates creation of apparent retroversion on right side due to rotation on right.

Regarding pitfalls, in certain hips, distinguishing between the two lines of the acetabular rim is difficult. As a helpful guideline, the posterior rim line can always be readily identified when starting from the inferior edge of the acetabulum.

An anteroposterior radiograph centered over the hip is not usable for reliable diagnosis of acetabular retroversion. This projection will imply a discrepancy in the appearance of the acetabular rim compared with a standard pelvic radiograph, on which the anterior rim will be displayed more prominently because it lies closer to the X-ray beam source [17, 29]. Therefore, acetabular version is generally overestimated when interpreting an anteroposterior radiograph centered over the hip. In addition, a cross-over sign can even be missed if only an anteroposterior radiograph of the hip is available (Fig. 13).

The appearance of acetabular morphology depends on the individual pelvic orientation, which can vary considerably in terms of tilt and rotation [33]. Increased pelvic tilt or a rotation to the ipsilateral hip leads to a more pronounced retroversion sign and vice versa [16, 17, 34, 35] (Fig. 14). A neutral pelvic rotation is defined as the tip of the coccyx pointing toward the midpoint of the superior aspect of the symphysis pubis. As a general rule, a neutral pelvic tilt is defined as the distance of 3.2 cm between the upper border of the symphysis and the midportion of the sacrococcygeal joint for men, and 4.7 cm for women [16]. With the help of one additional lateral radiograph, the radiographs of extensively rotated or tilted pelves can be calculated back with recently developed software Hip^{2}Norm (University of Bern, Switzerland) to ensure a tilt and rotation independent of anatomically based interpretation of the acetabular morphologic configuration [17] (Fig. 5). If obtained, the lateral pelvic view must be taken after the anteroposterior projection without motion of the patient and with the central beam directed to the upper tip of the greater trochanter (Fig. 4).

In addition to acetabular pathomorphologies, pincer impingement can also be caused by excessive hip motion in patients in whom no obvious acetabular disorder is present. It occurs typically in hypermobile young women (e.g., ballet dancers).

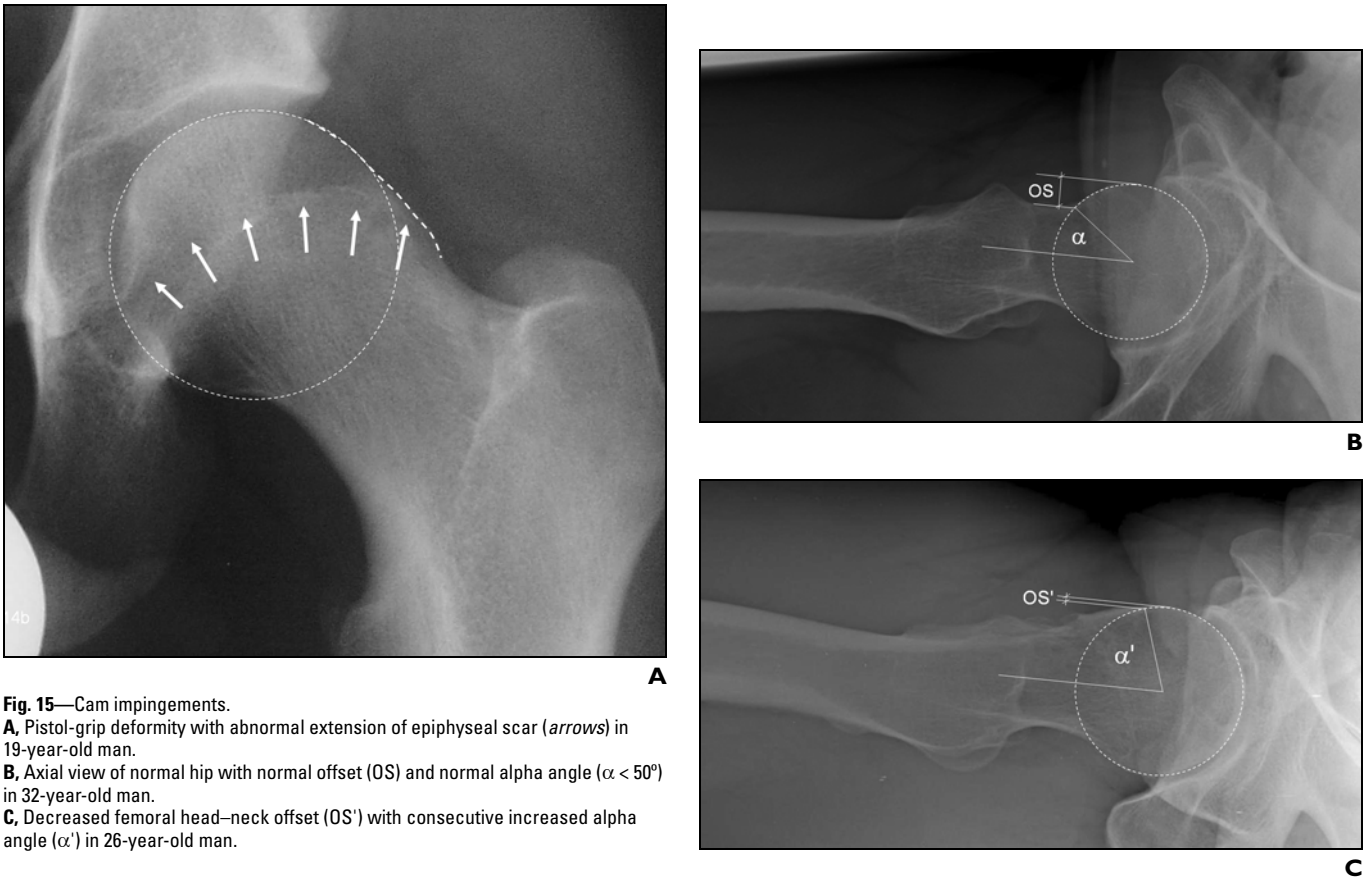


Fig. 15—Cam impingements.
A, Pistol-grip deformity with abnormal extension of epiphyseal scar (*arrows*) in 19-year-old man.
B, Axial view of normal hip with normal offset (OS) and normal alpha angle ($\alpha < 50°$) in 32-year-old man.
C, Decreased femoral head–neck offset (OS') with consecutive increased alpha angle (α') in 26-year-old man.

Cam Impingement

Cam impingement is more common in young men, occurring at an average age of 32 years. Cam impingement is the femoral cause of femoroacetabular impingement and is caused by an aspherical shape of the femoral head where the nonspherical portion is jammed into the acetabulum as a result of several known causes or idiopathically [6, 36, 37] (Fig. 2 and Table 1). These osseous bumps lead to a decreased femoral head–neck offset, which is defined by the distance between the widest diameter of the femoral head and the most prominent part of the femoral neck (Fig. 15). The recurrent irritation leads to an abrasion of the acetabular cartilage or its avulsion from the subchondral bone [38]. The cartilage area involved in cam impingement is much larger than pure pincer impingement and may be associated with large areas of cartilage delamination or fissuring. However, in both mechanisms, although there is significant and irreversible prearthritic damage of the cartilage, there is no joint space narrowing because only the quality of the cartilage, and not its diameter, is impaired in the early stage of the disease.

Cam impingement can be caused by an osseous bump on the femoral head–neck junction or by a retroverted femoral neck or head. Osseous bumps are typically located either in the lateral (so-called pistol grip, seen on an anteroposterior pelvic radiograph [Fig. 15A]) or in the anterosuperior (seen on an axial cross-table view of the proximal femur [Figs. 15B and 15C]) portion of the femoral head–neck junction (Figs. 15B and 15C). A pistol-grip deformity is characterized on radiographs by flattening of the usually concave surface of the lateral aspect of the femoral head due to an abnormal extension of the more horizontally oriented femoral epiphysis [39–42] (Fig. 15).

Cam impingement is usually caused by a primary osseous variant of the head–neck junction that is considered to be caused by a growth abnormality of the capital femoral epiphysis [42], but it can also be the result of several known causes, such as a subclinical slipped capital femoral epiphysis [43–45] or Legg-Calvé-Perthes disease [4, 46], or it can occur after femoral neck fractures [2, 47]; it may also be idiopathic (Table 1).

Quantification of the amount of asphericity can be accomplished by the angle α, the femoral offset, or the offset ratio [37]. Angle α is the angle between the femoral neck axis and a line connecting the head center with the point of beginning asphericity of the head–neck contour (Fig. 15). It can be measured on radiographs. An angle exceeding 50º is an indicator of an abnormally shaped femoral head–neck contour.

Another parameter for quantification of cam impingement is the anterior offset, which is defined as the difference in radius between the anterior femoral head and the anterior femoral neck on a cross-table axial view of the proximal femur (Fig. 15). In asymptomatic hips, the anterior offset is 11.6 ± 0.7 mm; hips with cam impingement have a decreased anterior offset of 7.2 ± 0.7 mm [18]. As a general rule for clinical practice, an anterior offset less than 10 mm is a strong indicator for cam impingement. In addition, the so-called offset ratio can be calculated, which is defined as the ratio between the anterior offset and the diameter of the head. The offset ratio is 0.21 ± 0.03 in asymptomatic patients and 0.13 ± 0.05 in hips with cam impingement.

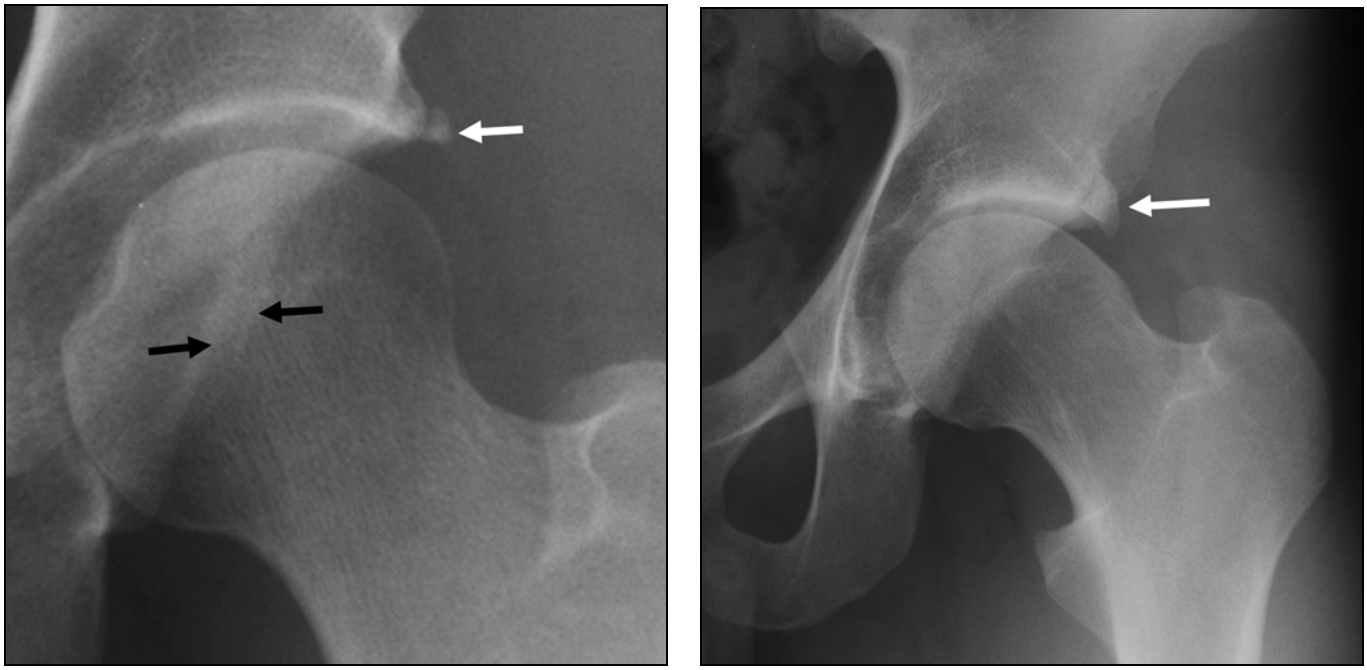


Fig. 16—Secondary radiographic signs of femoroacetabular impingement.
A, Recurrent impingement can lead to ossification of labral basis (*white arrow*) and to osseous apposition of acetabular rim, which is visible as double contour (*black arrows*) in 45-year-old woman.
B, Because of abnormal stress in impinging hips, prominent acetabular bone fragment can even be separated from adjacent bone margin (os acetabuli, *arrow*) in 36-year-old man with pistol-grip deformity.

Another cause for cam impingement is femoral retrotorsion, which can occur as a primary entity [48] or posttraumatically after healed femoral neck fractures [47]. Femoral retrotorsion can be calculated reliably only on CT scans involving the proximal and distal parts of the femur [49]. In addition, a coxa vara (defined by a centrum collum diaphyseal angle [CCD] of less than 125º) has been recognized as a cause of cam impingement [50].

A pitfall: In the initial phase of the disease, these entities are anatomic abnormalities and do not represent classic osteophytes. Classic osteophytes occur in an advanced stage of the disease when the cartilage damage already has taken place. Osteophyte formation can lead to a worsening of femoroacetabular impingement, an increase of the overcoverage for pincer hips, or a further loss of femoral head–neck offset. Through careful evaluation of the radiographs, the original acetabular rim can be identified. Occasionally, on the femoral side at the head–neck junction, a linear indentation may be observed in hips with pincer impingement and a cortical thickening (Fig. 17). In the end stage of pincer impingement, posteroinferior cartilage abrasion occurs, which is the result of the contrecoup lesion during subtle subluxation of the femoral head. This bad prognostic sign is best seen on a faux profile of the hip or, if available, on MRI (Fig. 12).

Secondary Radiographic Changes in Hips

Unrecognized femoroacetabular impingement leads to recurrent irritation of the acetabular labrum, which is the first structure involved and which is seen in both types of impingement. It leads to a reactive ossification, particularly of the labral basis [8] (Fig. 16). In an advanced stage of the disease, additional reactive bone apposition at the osseous rim leads to further deepening of the acetabulum, thereby increasing the impingement problem, which can also be seen as a double contour of the acetabular rim (Fig. 16). Because of the abnormal stress in impinging hips, the prominent acetabular bone fragment can even be separated from the adjacent bone margin. This os acetabulum is an acetabular rim fracture, presumed to be a stress or impingement fracture, resulting from a constant jamming of the femoral head against the acetabulum [27] (Fig. 16).

Hips with femoroacetabular impingement have a significantly higher prevalence of herniation pits, which are thought to be benign and incidental and the cause of which was not clearly understood [51]. Herniation pits are radiolucencies surrounded by a sclerotic margin that are typically located in the anterior proximal superior quadrant of the femoral neck and occur in some 33% of patients; they range in size from 3 to 15 mm (mean, 5 mm) [52]. This previously described location corresponds well to the typical location where the femoroacetabular impingement occurs. Therefore, hips with these juxtaarticular cysts should be considered a joint at risk for femoroacetabular impingement rather than one with a benign lesion, but herniation pits are not always associated with symptomatic impingement.

General Pearls and Pitfalls of Femoroacetabular Impingement Imaging

Systemic disorders with hip joint involvement may superficially mimic femoroacetabular impingement; these include ankylosing spondylitis, diffuse idiopathic skeletal hyperostosis (DISH), and congenital hip dysplasia. However, these are usually easy to distinguish

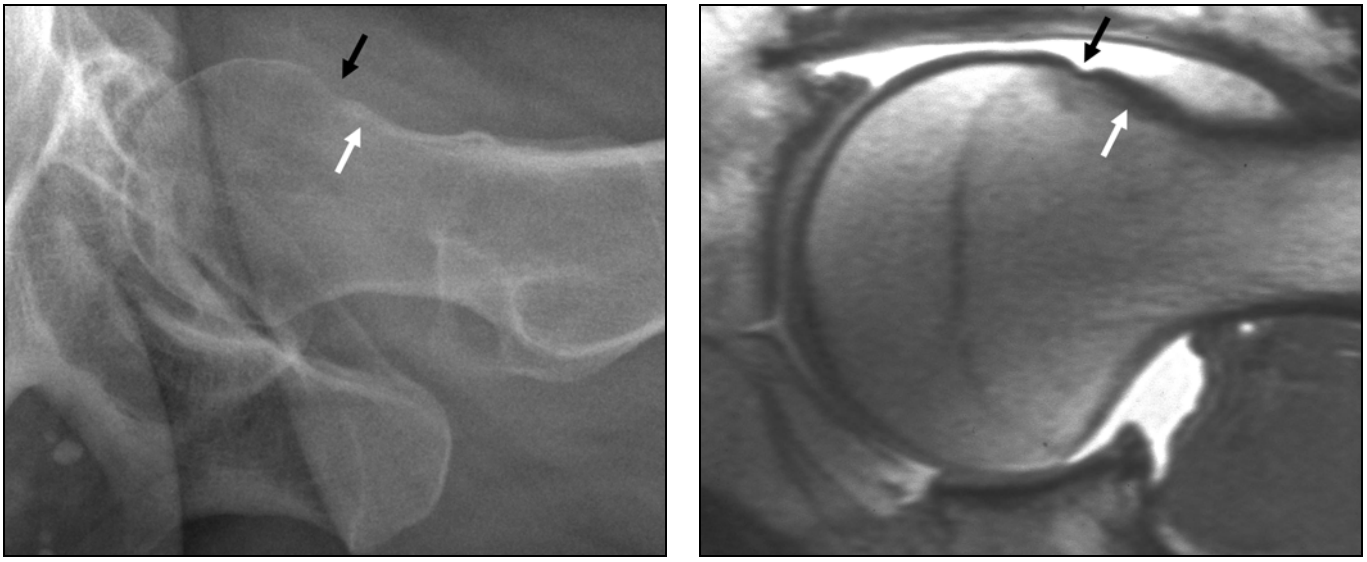


Fig. 17—Pincer hips in 37-year-old woman.
A and **B,** In pincer hips, corresponding linear indentation often occurs on femoral side (*black arrows*) with reactive cortical thickening (*white arrows*), which can be seen on conventional radiograph (**A**) and on MR arthrogram with intraarticular contrast agent (**B**).

from systemic disorders with hip joint involvement by reviewing the sacroiliac joints that will be fused or pathologic with ankylosing spondylitis and other seronegative spondyloarthropathies and the spine for anterior longitudinal ligament calcification with DISH. Congenital hip dysplasia presenting in adulthood is characterized by a lack of acetabular coverage and by lateral proximal femoral head subluxation and is more commonly associated with large labral ganglion [53].

Rarely, patients with femoroacetabular impingement may have additional disorders such as hydroxyapatite deposition in the acetabular labrum; however, this calcification has usually resolved on follow-up radiographs at 6 weeks. More commonly, in the younger adolescent age group, there may be associated enthesopathy of the greater trochanter associated with gluteal tendon overuse, as evident by bone spurring of the greater trochanter.

Femoroacetabular impingement is often bilateral but may present asynchronously. Although symptomatic presentation may be delayed on one side, reviewing both hip joints is recommended. In patients with typical femoroacetabular impingement, radiographic features may be asymptomatic as a result of lack of activity or of being at an early stage in the development of femoroacetabular impingement. Although there are characteristic imaging findings of femoroacetabular impingement, at this stage of knowledge, the gold standard remains the patient's pain and not the imaging findings alone. However, because the prognosis of the hip joint is significantly better if the intraarticular impingement is eliminated as early as possible, surgical reconstruction of the hip joint is recommended as soon as the first symptoms occur [4, 38].

A suboptimal or faulty radiographic technique of the pelvis and hip joint may over- or underestimate or falsely diagnose femoroacetabular impingement. In addition to first reviewing for overall symmetry of the hip joints on the frontal radiograph, in a busy clinical setting with no strong lateral view obtained, brief review of the location of the sacrococcygeal joint in relation to the superior aspect of the symphysis pubis is helpful. If the sacrococcygeal joint is within approximately 3.2 cm of the symphysis for men or 4.7 cm for women, then the pelvic tilt should be largely neutral. Suboptimal technique may be minimized by obtaining radiographs as described in this article or by using a computer-assisted program that corrects for malpositioning [17] (Fig. 5). Accurate angles, measurements, and ratios are also possible with such a tool, as is accurate preoperative planning.

Another way of reviewing the radiographs for femoroacetabular impingement in a busy clinical setting is to use the PACS tool to prescribe a circle, beginning centered on the central point of the femoral head, and to enlarge this circle until the femoral head expansion is met. If there is any bone beyond this circle, then cam impingement is likely. These circles can be drawn on both the frontal and axial radiographs (Fig. 15).

Treatment of Femoroacetabular Impingement

Surgical treatment of femoroacetabular impingement focuses on improving the clearance for hip motion and alleviation of femoral abutment against the acetabular rim. This includes basically the surgical resection of the impinging cause, by trimming the acetabular rim or the femoral head–neck offset either via a surgical hip dislocation [3, 12, 54] or arthroscopically [55], or, rarely, by the reorientation of a retroverted acetabulum via a reversed periacetabular osteotomy [28]. Mid-term results from these procedures are promising [4, 38].

Conclusion

In conclusion, two main forms of femoroacetabular impingement—pincer and cam—occur in young active individuals presenting with hip pain, although most patients will have a combination of both impingement types. The radiographic technique and typical findings have been presented. MRI and MR arthrography are important for further evaluation of the osseous and soft-tissue abnormalities of impingement; these will be presented in a future article.

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