A Three-View Radiographic Approach to Femoroacetabular Impingement

Publish date: September 7, 2018
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Author’s Disclosure Statement: The author reports no actual or potential conflict of interest in relation to this article.

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Take-Home Points

- FAI is a frequently unrecognized cause of hip pain in adolescents and young adults.
- Understanding the potential sites of impingement and the specific radiographs to visualize these sites can help avoid unnecessary imaging and delayed diagnosis.
- A simple radiographic approach consisting of a standing AP view of the pelvis, a cross-table lateral view, and a false profile view is often a sufficient screening tool.
- While we tend to classify FAI into cam and pincer osseous bumps, alterations in hip dynamics can result in functional impingement even in the absence of the osseous bumps.
- Advanced imaging is reserved for patients who have failed conservative management or are considering surgical intervention.

The prevalence of femoroacetabular impingement (FAI) in the general population is estimated at 23.1%. While FAI is often bilateral, patients usually present with unilateral symptoms. Young, highly active individuals are most commonly affected. Despite significant improvement in our understanding of FAI in recent years, it remains a poorly recognized cause of hip pain among orthopedic providers. Clohisy and colleagues found that the average time to diagnosis was 3.1 years (range, 3-15 years) and the average number of providers seen before correct diagnosis was 4.2 (range, 1-16) with nearly half those providers being orthopedic specialists. This is likely attributed to limited training and lack of appropriate imaging. Multiple comprehensive radiographic approaches have been described, including plain films, computed tomography, and magnetic resonance imaging. The objective of this article is to present a simple 3-view plain film approach for young adults with hip pain. While history and physical examination remain key to FAI diagnosis, a basic knowledge of the common sites of impingement with appropriate radiographic views to visualize these sites may help eliminate unnecessary imaging.
and delayed diagnosis.

**Standing Anteroposterior View of the Pelvis**

An anteroposterior (AP) view of the pelvis, as opposed to an AP view of the hip, is an important first radiograph in the evaluation of young patients presenting with hip pain. Not only does it permit visualization of the contralateral hip for comparison, but it also allows more accurate measurements of several radiographic parameters (Table). An AP view of the hip often gives the false impression of global over coverage, such as coxa profunda and protrusio acetabuli (Figures 1A, 1B), and may overestimate the amount of acetabular anteversion.

A good quality radiograph is important for accurate assessment. The X-ray beam should be perpendicular to the coronal plane of the pelvis. Neutral rotation of the pelvis is a prerequisite and can be confirmed by the presence of symmetric obturator foramina, iliac wings, and coccyx vertically in line with the pubic symphysis. Deviations from this configuration can significantly affect the ability to accurately assess the acetabular version. This is because the rotational profile of the acetabulum is sensitive to pelvic rotation.

While the AP view of the pelvis can be obtained in either supine or standing positions, the standing position is recommended. A supine view tends to increase the likelihood of finding a crossover sign that often disappears in the standing position (Figures 2A, 2B). This is attributed to the posterior tilt of the pelvis in the sagittal plane with standing, which functionally increases acetabular anteversion, eliminating the crossover sign. In contrast, a crossover sign that persists in the standing position combined with other abnormal radiographic parameters, such as a negative Tonnis angle and/or increased lateral center edge angle, are concerning for pincer-type FAI (Figures 3A, 3B). An isolated crossover sign may be a normal variant in young asymptomatic patients and is not a reliable indicator of acetabular retroversion.

In addition to assessing the acetabular coverage and version (Figures 1A, 1B, 3A, 3B, and 4A, 4B), the AP view of the pelvis can provide valuable information regarding the proximal femur. One should pay attention to the sphericity of the head (pistol grip cam lesions are most obvious on this view), congruency between the femoral head and the acetabulum, femoral offset, and neck-shaft angle. While we tend to traditionally classify FAI into cam and pincer osseous bumps, alterations in hip dynamics (i.e., coxa vara and coxa breva) can result in functional impingement even in the absence of the osseous bumps.

**Cross-Table Lateral**

A cross-table lateral of the affected hip is another important radiographic adjunct in the evaluation of hip pain in young patients. This view provides AP axial visualization of the hip joint identifying potential pathologies such as anterior cam lesions that may not be apparent on frog-leg lateral radiographs (Figures 5A, 5B and 6A, 6B). The cross-table lateral view can also show posterior impingement and/or joint space narrowing from countercoup lesions associated with pincer-type FAI (Figures 3A, 3B). In addition, the rotational profile of the proximal femur is best assessed in this view (Figure 4B). The challenge with a cross-table lateral, however, is that it is operator-dependent. In circumstances where a good quality cross-table lateral cannot be obtained, we default to a frog-leg lateral to avoid excess radiation exposure.
False Profile View

A false profile view provides a good visualization of the anterosuperior aspect of the acetabulum. It can show anterior acetabular over or under coverage. It may also show sub-spine impingement (Figures 7A, 7B). Sub-spine impingement is characterized by a prominent anterior inferior iliac spine (AIIS) that extends to the level of the anterosuperior acetabular rim. The prominent AIIS can impinge on the femoral head-neck junction during hip flexion. A prominent AIIS has also been shown to give the false impression of a crossover sign. 8

Conclusion

Even to the trained eye, radiographic findings of FAI can be quite subtle and easily missed. A systematic approach when interpreting plain radiographs is important. Radiographic assessment starts with good quality X-rays with the pelvis in neutral rotation. Because of the young age of most patients, radiation exposure should be minimized. An understanding of the potential sites of impingement and the specific radiographs to visualize these sites minimizes radiation exposure and other unnecessary imaging. In our experience, the 3-view radiographic approach presented combined with supportive history and physical examination findings are highly sensitive to identify cases of FAI. Advanced imaging is reserved for patients who have failed conservative management or considering surgical intervention.

Key Info

Figures/Tables

Figures / Tables:

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Figure 1. (A) Anteroposterior (AP) view of the right hip. Note that both the medial aspect of the femoral head (green line) and the medial wall of the acetabulum (yellow line) are medial to the ilioschial line (red line) indicating protrusio acetabuli (PA) and coxa profunda (CP), respectively. (B) A standing AP view of the pelvis in the same patient showing resolution of both the PA and CP previously seen in the AP view of the hip.

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Figure 2. An 18-year-old woman presenting with activity-related left lateral hip and groin pain for 8 months. (A) Supine view showing a crossover sign indicative of possible acetabular retroversion. (B) Standing view showing resolution of the crossover sign as a result of the posterior tilt of the pelvis. Red lines represent the rim of the posterior wall of the acetabulum. Yellow lines represent the rim of the anterior wall of the acetabulum.

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Figure 3. A 67-year-old woman presenting with constant pain in her left buttocks and groin. (A) Anteroposterior view of the pelvis showing increased acetabular retroversion resulting in anterior over coverage (note the crossover sign, increased lateral center edge angle, negative Trendelenburg angle). (B) Cross-table lateral view showing early posterosuperior degenerative changes from contrecoup injury (red circle).

Figure 4. A 29-year-old woman presenting with activity-related right groin pain worse with hyperextension and external rotation. (A) Anteroposterior view of the pelvis showing increased acetabular anteversion resulting in posterior over coverage; note the posterior rim of the acetabulum (red lines) is lateral to the center of the femoral head (yellow dots). (B) Cross-table lateral view showing femoral retroversion (neck angled posteriorly instead of anteriorly).
Figure 5. A 45-year-old female with a 1-year history of activity-related left groin and later hip pain. (A) Anteroposterior view of the pelvis showing no apparent significant radiographic abnormalities. (B) Cross-table lateral showing an anterior cam-type lesion. Notice the loss of concavity at the anterior head-neck junction. Normally, the anterior head-neck offset (ANHO) (distance between the red and yellow lines) should be >10 mm. Another radiographic parameter is that the ANHO ratio (AHNØ divided by the femoral head diameter) is <0.14.

Figure 6. A 29-year-old woman with a 3-month history of activity-related right groin pain. (A) Anteroposterior view of the pelvis showing bilateral anterolateral cam lesion (pistol grip deformity) with loss of concavity at the head-neck junction (red circle). (B) Cross-table lateral view showing decrease of anterior femoral head-neck offset (alpha angle 76°, yellow line).
Table. Summary of Common Radiographic Parameters When Assessing Young Adults with Hip Pain

<table>
<thead>
<tr>
<th>Sign</th>
<th>Best Radiographic View</th>
<th>Measurement</th>
<th>Quoted Normal Values</th>
<th>Clinical Relevance of Abnormal Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acetabular depth</td>
<td>AP pelvis</td>
<td>Medial wall of the acetabulum (MWA) relative to the ilioischial line (IIL)</td>
<td>MWA is lateral to IIL</td>
<td>Global overcoverage (ie, coxa profunda)</td>
</tr>
<tr>
<td>Femoral depth</td>
<td>AP pelvis</td>
<td>Medial surface of the femoral head (MFH) relative to the IIL</td>
<td>MFH is lateral and within 10 mm of the IIL</td>
<td>&gt;10 mm may indicate undercoverage (ie, dysplasia)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>MFH medial to IIL may indicate overcoverage (ie, protrusio acetabuli)</td>
</tr>
<tr>
<td>Tonnis angle</td>
<td>AP pelvis</td>
<td>Angle between the weight-bearing surface of the acetabulum and a line parallel to the horizontal axis of the pelvis (eg, inter-teardrop line)</td>
<td>0°-10°</td>
<td>&gt;10° may indicate undercoverage (ie, dysplasia)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0° may indicate overcoverage (ie, pincer-type FAI)</td>
</tr>
<tr>
<td>Lateral center edge angle</td>
<td>AP pelvis</td>
<td>Angle between a line perpendicular to the horizontal axis of the pelvis through the center of the femoral head and a line connecting the center of the femoral head to the lateral most edge of the acetabular weight-bearing surface</td>
<td>25°-40°</td>
<td>&gt;40° may indicate overcoverage (ie, pincer-type FAI) &lt;25° may indicate undercoverage (ie, dysplasia)</td>
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</tr>
<tr>
<td>Crossover sign</td>
<td>AP pelvis</td>
<td>Intersection between the anterior and posterior rims of the acetabulum</td>
<td></td>
<td>Crossover occurs at the lateral most aspect of the acetabular weight-bearing surface. Crossover occurring distal to the lateral most aspect of the acetabular weight-bearing surface may indicate acetabular retroversion</td>
</tr>
<tr>
<td>Femoral neck-shaft angle</td>
<td>AP pelvis</td>
<td>Angle between the femoral shaft and the longitudinal axis of the neck</td>
<td>135° ± 5°</td>
<td>&gt;140° may indicate coxa valga &lt;130° may indicate coxa vara</td>
</tr>
<tr>
<td>Alpha angle</td>
<td>Cross-table lateral</td>
<td>Angle between a line connecting the center of the femoral neck to the center of the femoral head and a line connecting the center of the head to a point on the anterolateral aspect of the head-neck junction where the head sphericity ends</td>
<td>&gt;55°</td>
<td>Decreased head-neck offset (ie, cam-type impingement)</td>
</tr>
<tr>
<td>Anterior head-neck offset</td>
<td>Cross-table lateral</td>
<td>Distance between 2 lines parallel to the longitudinal axis of the femoral neck: 1 line tangent to the anterior most aspect of the neck and 1 line tangent to the anterior surface of the femoral head</td>
<td>&gt;10 mm</td>
<td>Decreased head-neck offset (ie, cam-type impingement)</td>
</tr>
<tr>
<td>Anterior head-neck offset ratio</td>
<td>Cross-table lateral</td>
<td>Anterior head-neck offset divided by the diameter of the femoral head</td>
<td>&gt;0.14</td>
<td>Decreased head-neck offset (ie, cam-type impingement)</td>
</tr>
<tr>
<td>Femoral version</td>
<td>Cross-table lateral</td>
<td>Angle between the longitudinal axis of the femoral neck and the longitudinal axis of the femoral shaft</td>
<td>15° ± 5°</td>
<td>Developmental disorders (eg, dysplasia, slipped capital femoral epiphysis)</td>
</tr>
<tr>
<td>Anterior center edge angle</td>
<td>False profile view</td>
<td>Angle between a vertical line through the center of the femoral head and a line connecting the center of the femoral head to the anterior most edge of the acetabular weight-bearing surface</td>
<td>&gt;20°</td>
<td>Undercoverage (ie, dysplasia)</td>
</tr>
</tbody>
</table>

*Normal values are provided for reference only and should not be solely relied on for diagnosis.*
Abbreviations: AP, anteroposterior; FAI, femoroacetabular impingement.

References


Multimedia
Product Guide

Product Guide

- STRATAFIX™ Symmetric PDS™ Plus Knotless Tissue Control Device
- STRATAFIX™ Spiral Knotless Tissue Control Device
- BioComposite SwiveLock Anchor
- BioComposite SwiveLock C, with White/Black TigerTape™ Loop

Citation