Technical Note

Intraoperative Fluoroscopy for Evaluation of Bony Resection During Arthroscopic Management of Femoroacetabular Impingement in the Supine Position

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Abstract: There is a steep learning curve regarding many aspects of arthroscopic management of femoroacetabular impingement. One of the concerns with regard to this approach is verification of appropriate bony resection for cam- and pincer-type pathology. Dynamic assessment and direct visualization of bony resection are the primary means of evaluating appropriate resection. Intraoperative fluoroscopy, however, can be a helpful adjunct when performing the rim resection or femoral resection osteoplasty. We describe a predictable and reproducible fluoroscopic method for performing and verifying appropriate bony resection of pincer and cam lesions in an attempt to help minimize the risk of under- and over-resection. Key Words: Hip arthroscopy—Femoroacetabular impingement—Fluoroscopy.

Femoroacetabular impingement (FAI) has been treated by open surgical dislocation, limited open approaches, and all-arthroscopic techniques.\textsuperscript{1-11} Open surgical dislocation allows for complete visualization of the femoral head-neck junction and acetabular rim for resection and dynamic evaluation throughout the entire range of motion. Limited open approaches allow for direct visualization of the anterolateral femoral head-neck junction, with limited evaluation of the acetabular rim. All-arthroscopic techniques allow for evaluation of the anteroinferior to posterosuperior femoral head-neck junction and the majority of the acetabular rim. During arthroscopy, the femoral head and acetabular rim are not visualized in 3 dimensions and instead are visualized regionally through multiple portals. This regional assessment can make evaluation of the bony pathology and subsequent resection difficult. Potential complications related to improper orientation and poor visualization include inaccurate resection, under-resection, over-resection, or a combination thereof.\textsuperscript{12-16} We propose a reproducible intraoperative fluoroscopic evaluation before, during, and after bony resection for management of cam- and pincer-type pathology as an adjunct to direct assessment during arthroscopic management of FAI.

PREOPERATIVE EVALUATION

The patient is placed supine on the fracture table with generous padding of bony prominences and the use of a well-padded perineal post. The nonoperative leg is placed in maximal abduction and external rotation. The operative leg is placed in neutral abduction, 0° to 10° of hip flexion, and maximal internal rotation. The anterior-superior iliac spines are identified, and the bed is rotated...
in the axial plane, or “air planed” (typically to the operative side), to have the anterior-superior iliac spines parallel to the floor and/or ceiling. This helps to place the pelvis in a neutral position. A fluoroscope is then introduced at a 45° angle between the legs, and an anteroposterior (AP) view of the operative hip is obtained with slight traction (Fig 1). Trendelenburg or reverse Trendelenburg positioning of the patient is used to replicate a well-centered preoperative AP pelvis view of the patient with respect to the level of the acetabular crossover sign, when present, and the relation between the ilioischial line and tear drop (Fig 1). The preoperative pelvis should have symmetric obturator foramina, and the tip of the coccyx should be centered over the symphysis with 0 to 3 cm between these 2 structures so that acetabular version can be properly evaluated. The fluoroscopy machine can be moved to the tip of the coccyx and symphysis to further verify appropriate pelvic orientation.

After the fluoroscopic image replicates the preoperative AP pelvis view, the femoral head-neck junction is assessed with an “around-the-world” fluoroscopic evaluation. The AP image with the hip and knee in extension allows for evaluation of the superior and inferior head-neck junction (Fig 2). AP images of the femur are obtained with the hip in maximal internal rotation (Fig 3), neutral rotation (Fig 4), and maximal external rotation (Fig 5). Hip rotation is obtained by rotating the foot of the operative leg. Next, the hip and knee are flexed to approximately 40° to evaluate the anterior and posterior head-neck junction (Fig 2). Lateral images of the proximal femur are obtained in

**Figure 1.** The radiographic profile of the operative hip (left hip) is reproduced by comparing the (A) intraoperative fluoroscopic AP view with a properly aligned (B) preoperative AP pelvis view. Specific attention is paid to the level and degree of acetabular crossover (with the posterior wall represented by a solid line and the anterior wall represented by a dashed line) and the relation between the tear drop and ilioischial line (horizontal line) on both images.

**Figure 2.** Our preferred terminology used to describe the direction of reference in relation to the operative anatomy for a left hip in the AP orientation (the hip is in slight flexion, neutral rotation, and neutral abduction) and lateral orientation (the hip and knee are flexed to 40°, with neutral rotation).
FIGURE 3. (A) Intraoperative positioning of left hip in extension with maximal internal rotation reproducing AP radiograph for evaluation of superior and inferior head-neck junction and acetabular version. (B) The intraoperative fluoroscopic image before resection with the hip in extension and maximal internal rotation shows the crossover sign (with the posterior wall represented by a solid line and the anterior wall represented by a dashed line) as indicated by the anterior wall crossing lateral to the posterior wall. (C) The intraoperative fluoroscopic image after resection with the hip in the same position confirms bony resection and absence of the crossover sign (with the posterior wall represented by a solid line and the anterior wall represented by a dashed line). Nitinol guidewires (asterisks) are left in place to allow for re-establishment of portals if necessary.

FIGURE 4. (A) The intraoperative fluoroscopic image before resection with the hip in extension and the foot in neutral rotation shows the crossover sign (dashed arrow) as indicated by the anterior wall crossing lateral to the posterior wall and cam impingement (solid arrow). (B) The intraoperative fluoroscopic image after resection with the hip in the same position confirms the absence of the crossover sign (dashed arrow) and presence of improved head-neck offset (solid arrow).
maximal internal rotation (Fig 6), neutral rotation (Fig 7), and maximal external rotation (Fig 8). The neutral image is similar to the modified Dunn view. Cam lesions noted anteriorly on the lateral view indicate anterolateral asphericity, whereas cam lesions seen superiorly on the AP view indicate superior extension. Finally, the fluoroscopy machine is rotated under the operative leg to obtain a cross-table lateral view for additional evaluation of the head-neck junction and femoral neck version with the knee in neutral rotation (Fig 9).

Once the intraoperative fluoroscopic evaluation has been performed, the surgeon can correlate the images with the preoperative templating from previously obtained plain radiographs and computed tomography scans (Tables 1 and 2).

**SURGICAL PROCEDURE**

Our technique for arthroscopic management of FAI has been previously described. Traction is applied, and typically 2 portals (anterolateral and anterior) are established for arthroscopic management of FAI. A spinal needle is placed in the posterolateral portal for outflow. The central compartment is first inspected, and the labrum, acetabular rim, and labrochondral junction are evaluated to confirm the suspected pathologic forces. Preoperative and intraoperative radiographic findings need to be correlated with the encountered arthroscopic pathology when one is making decisions about the management of any bony abnormalities (Tables 1 and 2).
FIGURE 7. (A) Intraoperative positioning of the left hip in flexion with neutral rotation reproducing the lateral radiograph of the femur for evaluation of the anterior and posterior femoral head-neck junction. (B) The intraoperative fluoroscopic image before resection with the hip in flexion and neutral rotation shows cam impingement (arrow). (C) The intraoperative fluoroscopic image after resection with the hip in the same position confirms improved head-neck offset (arrow).

FIGURE 8. (A) The intraoperative fluoroscopic image before resection with the hip in flexion and maximal external rotation shows cam impingement (arrow). (B) The intraoperative fluoroscopic image after resection in the same position confirms improved head-neck offset (arrow).
Pincer Resection

Once the decision has been made to manage the bony impingement, we first address the pincer lesion. Different techniques for management of the labrum associated with pincer impingement have been described. We prefer to preserve the labrum whenever possible. We routinely perform a labral takedown and reattachment to the acetabular rim for pincer lesions extending to or beyond the 12-o’clock position. A bur is then introduced through the anterior portal with the arthroscope in the anterolateral portal. The bur is placed on the anterior rim, and a fluoroscopic image is used to verify placement at or just distal to the site of the anterior wall crossing the posterior wall (Fig 10A). It should be re-emphasized that fluoroscopic/radiographic findings need to be correlated with arthroscopic findings (Table 1). After verification of pincer pathology, the bur is used to resect the prominent anterior rim (Fig 10B). Fluoroscopy will show removal of the prominent anterior wall (crossover sign), and the bur is then moved up the acetabulum from anteroinferior to superior to verify that the anterior wall lies medial to the posterior wall and that the 2 walls converge but do not cross superiorly. There should be a smooth transition from inferior to superior. Once the anterior prominence is resected, the arthroscope is placed into the anterior portal and a bur is introduced through the anterolateral

**Figure 9.** (A) Intraoperative positioning to obtain a cross-table lateral image with the left hip in extension. (B) The intraoperative cross-table lateral fluoroscopic image before resection shows cam impingement (arrow). (C) The intraoperative cross-table lateral fluoroscopic image after resection confirms improved head-neck offset (arrow).
portal. The superior area of rim resection is then completed. The goal should be to leave a lateral center-edge angle of at least 25°. The labrum is repaired with suture anchors after completion of the rim resection.

### Cam Resection

Once the rim resection is completed, the hip is flexed to approximately 40° and the peripheral head-neck junction is identified. Cam-type impingement, when present, is then treated with a femoral resection osteoplasty.\(^3-6,8-11,19,20\) The inferior-medial synovial fold is at about the 5:30 position for a right hip, and this is typically the most inferior extent of cam lesions. A fluoroscopic image is taken, and the medial extent of the resection follows a line that begins at the inferior head-neck junction and runs roughly perpendicular to the superolateral synovial fold.

### Acetabular Coverage

Acetabular coverage can be difficult to determine intraoperatively with the hip in traction, and intermittent release of traction during rim resection allows for a better evaluation of acetabular coverage. A posterolateral portal can be formally established when more posterior areas of acetabular rim resection are required (i.e., posterior labral ossification in the presence of coxa profunda).

### Arthroscopic Management of Protrusio Acetabuli

Arthroscopic management of protrusio acetabuli should be undertaken with caution because the amount of rim resection and subsequent dynamic evaluation can be difficult with an arthroscopic approach.

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### Table 1. Pincer Resection: Pearls and Pitfalls

Preoperative 3-dimensional computed tomography is invaluable to evaluate acetabular version, as well as the location of os acetabuli and rim fractures, and can help template anterior and/or posterior rim resection. If imaging studies show pincer-type pathology but intraoperative findings do not confirm the pathology, bony resection is not clearly indicated.

If a crossover sign is associated with acetabular retroversion and superior and posterior acetabular deficiency/dysplasia, anterior rim resection should be avoided because this can lead to global acetabular structural instability.

If bony resection is not appreciated on intraoperative fluoroscopic imaging despite attempts at appropriate positioning, then further resection should be guided by direct arthroscopic visualization, dynamic testing for impingement, and preoperative radiographic templating. When significant superior-lateral rim resection is planned, the proposed rim resection should be drawn on a well-aligned preoperative radiograph that can be correlated with intraoperative fluoroscopy. Superior rim resection is generally minimal except in cases of labral ossification typically associated with coxa profunda.

Acetabular coverage can be difficult to determine intraoperatively with the hip in traction, and intermittent release of traction during rim resection allows for a better evaluation of acetabular coverage. A posterolateral portal can be formally established when more posterior areas of acetabular rim resection are required (i.e., posterior labral ossification in the presence of coxa profunda). Arthroscopic management of protrusio acetabuli should be undertaken with caution because the amount of rim resection and subsequent dynamic evaluation can be difficult with an arthroscopic approach.

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### Table 2. Cam Resection: Pearls and Pitfalls

Three-dimensional computed tomography scans are helpful to evaluate the extent of cam lesions and their relation to the lateral retinacular vessels, which can be visualized as perforations at the superolateral head-neck junction on these scans. If imaging studies show cam-type pathology but intraoperative findings do not confirm the pathology, bony resection is not clearly indicated. When recontouring the femoral head-neck junction, the area of resection will typically be seen fluoroscopically by further externally rotating the hip. If bony resection is not appreciated on intraoperative fluoroscopic imaging despite attempts at appropriate positioning, then further resection should be guided by direct arthroscopic visualization, dynamic testing for impingement, and preoperative radiographic templating. The superolateral synovial fold is the site of the superolateral retinacular vessels and should be carefully protected throughout the case and used as a landmark for resection when correlating with preoperative 3-dimensional computed tomography scans. When the hip is brought into extension, further resection of the previously recontoured head-neck junction anteriorly can lead to a resection too far medially when the hip is evaluated in flexion again. It is important to periodically dynamically assess for impingement during the cam resection to avoid over-resection and resultant loss of the labral seal. Symptomatic posterior cam lesions are difficult to address arthroscopically and may be better managed with an open surgical dislocation.
dicular to the femoral neck to the superior head-neck junction (Fig 11). This line should be confirmed by direct arthroscopic visualization of the head-neck junction and is simply a guide. The location of the conflict at the femoral head-neck junction is also evaluated with dynamic assessment showing impingement of the femoral head-neck junction against the acetabular labrum. Once the medial extent of the resection has been outlined with a bur, the surgeon recontours the head-neck junction, working medial to lateral (away from the acetabulum/toward the greater and lesser trochanters). The osseous lesion is gradually removed and tapered to the normal femoral neck laterally with occasional dynamic assessment to avoid over-resection and loss of the labral seal in flexion (Table 2). The femoral resection is continued superiorly, and a fluoroscopic image with the hip in external rotation will show improvement in femoral head-neck sphericity. When the lateral view in external rotation shows improved femoral head-neck offset, which is confirmed by direct arthroscopic visualization, the hip is extended and the foot maximally internally rotated to complete the more superior areas of femoral resection. The bur is placed where the most superior resection has been completed and continued superiorly at the level of the visualized head-neck junction (Fig 12). This will result in a radiograph with improved offset on both AP and lateral views. At this point, a dynamic assessment under direct arthroscopic visualization is performed with hip flexion, internal rotation, external rotation, abduction, and adduction to verify impingement-free range of motion and maintenance of the labral seal. This is followed by a repeat around-the-world fluoroscopic evaluation identical to that performed before the procedure (Figs 3-9). This should show a normal relation of the anterior and posterior
walls of the acetabulum and improved head-neck offset seen on AP and lateral images.

DISCUSSION

Arthroscopic management of FAI continues to evolve, with excellent outcomes reported in the literature at early-term follow-up.3-6,8-11 However, complications such as femoral neck fracture and iatrogenic hip instability have been reported.13,14,16,17,20,21 There is an extremely steep learning curve with respect to making the diagnosis and performing the procedure that even the most experienced hip arthroscopist continues to climb. Under-resection, over-resection, and in some cases both under-resection and over-resection may lead to suboptimal outcomes as a result of residual impingement or the creation of structural instability. It is imperative to use all resources including physical examination findings, preoperative imaging studies, intra-articular anesthetic injections, and intraoperative findings to make the correct diagnosis. Intraoperative findings are the cornerstone with respect to evaluation of the pathologic forces at work, as well as verifying appropriate bony resection and elimination of the conflict. Because of the limitations of arthroscopic visualization, when compared with an open surgical dislocation, we believe that this fluoroscopic technique can help to orient the surgeon, further confirm appropriate bony resection on the acetabulum and femur, and reduce the potential for under- and over-resection. We have used this technique on over 400 patients with the primary diagnosis of FAI and have published our outcomes in this patient population.3,9 We have had no case of femoral neck fracture or iatrogenic hip instability using this fluoroscopic technique as part of an arthroscopic procedure for FAI. This fluoroscopic technique is not meant to replace direct arthroscopic evaluation during the procedure, and the surgeon should not rely on fluoroscopy alone when performing this procedure.

REFERENCES


