

# The Circumferential Femoroplasty: An All-Arthroscopic Technique for Addressing a Challenging Hip Deformity



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**Abstract:** Femoroacetabular impingement is recognized as a common cause of hip pain. Cam-type femoroacetabular impingement results from abnormal contact between an aspherical femoral head and the acetabular rim during hip range of motion, leading to labral tearing, cartilage damage, and, eventually, osteoarthritis. Arthroscopic correction of this bony deformity has been well described, particularly in the anterolateral quadrant of the femoral neck. Some deformities extend well beyond this quadrant, involving most or all of the circumference of the femoral neck, making arthroscopic decompression a challenge. We present a post-less, all-arthroscopic technique for performing a circumferential cam decompression using 3-dimensional preoperative planning software and interactive fluoroscopy-integrated computer vision interface.

**F**emoroacetabular impingement (FAI) is a common cause of hip pain and disability in young adults.<sup>1</sup> Cam-type FAI is caused by an abnormal contact between the head–neck junction of the femur and the rim of the acetabulum during hip flexion and rotation.<sup>2</sup> Cam morphology is characterized by a bony prominence of the anterolateral femoral head–neck junction.<sup>3</sup> Untreated, cam impingement can cause labral

tearing, acetabular chondrolabral junction injury, and eventually, osteoarthritis.<sup>1,3,4</sup>

The goal of surgical intervention is the alleviation of mechanical impingement, which occurs during range of motion. Early corrections of cam lesions were performed using surgical hip dislocation, but the trend has more recently moved toward arthroscopic techniques, which have demonstrated an excellent ability to restore femoral

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head–neck offset,<sup>5</sup> and produce at least equivalent clinical outcomes.<sup>6</sup> The goal of arthroscopic femoroplasty is the reshaping of the femoral head–neck junction to restore the spherical shape of the femoral head.

Both cam over- and under-resection can potentially lead to negative consequences. Over-resection has been shown to increase the risk of femoral neck fractures,<sup>7</sup> correlate with poor outcomes, and increase the risk of conversion to total hip arthroplasty.<sup>8</sup> Under-resection is a risk factor for revision hip arthroscopy, as the underlying pathologic mechanics have not been addressed.<sup>9</sup> Performance of an adequate femoroplasty is technically demanding with mastery of a steep learning curve.<sup>10</sup> This becomes even more challenging in a deformity affecting the circumference of the femoral head–neck junction. We present a postless, all-arthroscopic surgical technique for performance of a circumferential femoroplasty. Advantages, risks, and limitations are noted in [Table 1](#).

### Patient Evaluation, Imaging, and Surgical Indications

This study was performed in accordance with the ethical standards in the 1964 Declaration of Helsinki. This study was carried out in accordance with relevant regulations of the U.S. Health Insurance Portability and Accountability Act. Details that might disclose the identity of the subjects under study have been omitted. This study was approved by the institutional review board (ID: 5276).

A detailed patient history, physical examination, and radiographic analysis were collectively used preoperatively by the senior author (B.G.D.) to evaluate surgical candidates. Gait, range of motion, strength, points of tenderness, and signs of FAI syndrome or mechanical symptoms (snapping, catching, locking) were noted during physical examination.<sup>11</sup>

Radiographic imaging was obtained and evaluated for signs of cam-type and pincer-type morphologies, acetabular dysplasia, and osteoarthritis in all patients using the standing and supine anteroposterior pelvis, modified 45° Dunn lateral, and false-profile views ([Fig 1](#)).<sup>12–15</sup> The alpha angle was determined using the method established by Agricola et al.,<sup>16</sup> and cam-type morphology was defined as an alpha angle >55°.<sup>8</sup>

Evaluations of these images were performed using General Electric Healthcare's Picture Archiving and Communication System (Fairfield, CT). [Fig 1](#) demonstrates a circumferential, cam-type deformity in the left hip, an indication for the present circumferential femoroplasty technique.

Patients were instructed to attempt nonsurgical treatment (supervised physical therapy, activity modification, anti-inflammatory medications, and therapeutic ultrasound-guided injections) for a minimum of 3 months. If all nonsurgical treatments failed, patients with cam or mixed-type FAI (alpha angle >55°), and patients with cam lesion under-resections from previous hip arthroscopy, were recommended for surgery by the senior author (B.G.D.). Patients with alpha angle <55°, evidence of cam lesion over-resection from previous hip arthroscopy, femoral neck stress reaction, or end-stage osteoarthritis, were contraindicated for arthroscopic circumferential femoroplasty.<sup>17</sup>

Although outside the scope of the present article, magnetic resonance arthrography (1.5 Tesla) also was used to identify labral tears or chondral damage, and to assess any other extra- and intra-articular pathology present. Preoperative three-dimensional (3-D) morphological analysis tool (HipMap Analysis; Stryker, Mahwah, NJ) was utilized to aid in the visualization of the complex deformity.

### Step-by-Step Surgical Technique (With Video Illustration)

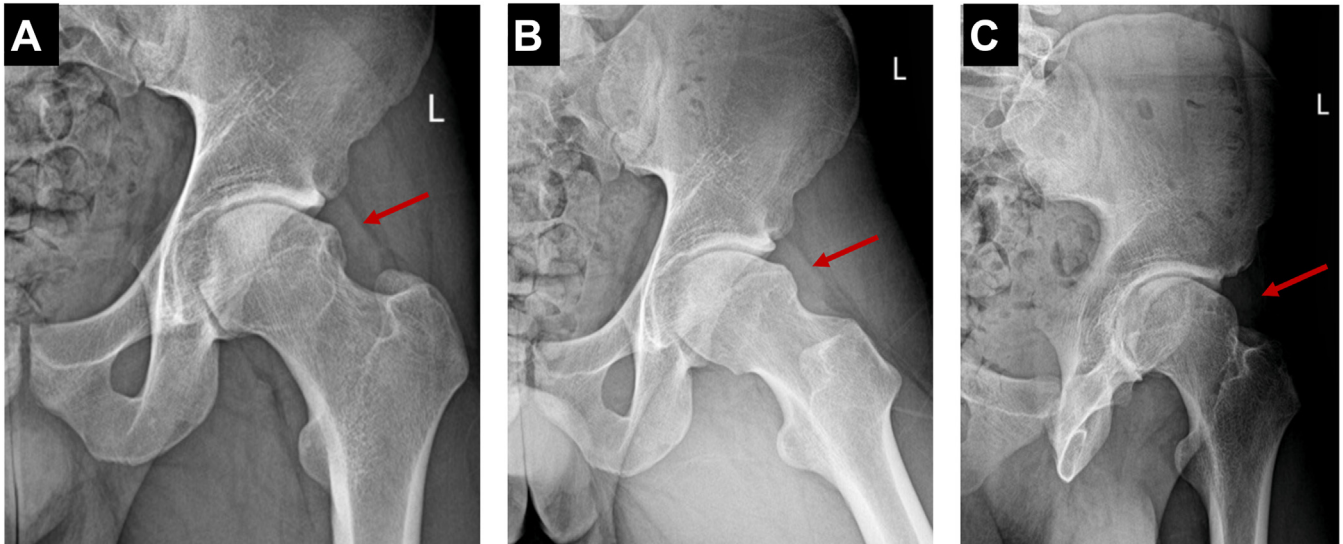
Technique [Video 1](#) describes the circumferential femoroplasty technique in detail.

#### Part A. Patient Preparation, Positioning, and Portal Placement

The patient is placed in a modified supine position on a traction table (Supine Hip Positioning System; Smith & Nephew, Andover, MA) atop a high-friction pink pad (Pink Hip Kit; Smith & Nephew), in approximately 8° to 10° of Trendelenburg inclination. This obviates the need for a perineal post. The feet are well padded, the operative limb is positioned in neutral adduction and rotation, and the nonoperative limb is positioned in 30° of abduction ([Fig 2](#)). The patient is then induced under general anesthesia with good muscle relaxation.

**Table 1.** Advantages, Risks, and Limitations for Arthroscopic Circumferential Femoroplasty

Advantages	Risks	Limitations
<ul style="list-style-type: none"> <li>• Labral “suction seal” maintained</li> <li>• Improved hip range of motion</li> <li>• Most accurate technique for femoral osteoplasty</li> <li>• Ability to access difficult cam deformity</li> <li>• Does not require special instrumentation or perineal post</li> </ul>	<ul style="list-style-type: none"> <li>• Abdominal extravasation</li> <li>• Femoral neck fracture</li> <li>• Increased fluoroscopic radiation exposure</li> <li>• Injury to femoral head vasculature</li> </ul>	<ul style="list-style-type: none"> <li>• Technically demanding procedure requiring steep learning curve</li> <li>• Availability of C-arm technician</li> <li>• Trained surgical team</li> </ul>



**Fig 1.** Preoperative standing and supine radiographs of the left hip taken from the (A) anteroposterior pelvis, (B) modified 45° Dunn lateral, and (C) false-profile views depicting a circumferential, cam-type deformity with preoperative alpha angle  $>55^\circ$  (red arrows).

The hip joint is accessed through the anterolateral, modified mid-anterior, and distal anterolateral accessory, portals using a 70° arthroscope. The technique for atraumatic hip joint access has been previously described in

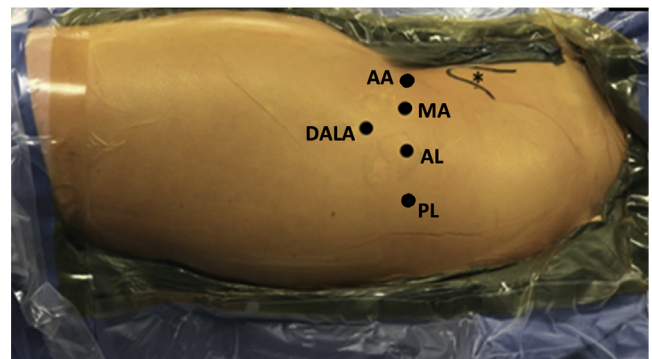
detail.<sup>18</sup> A posterolateral portal is established following diagnostic arthroscopy should the need for labral reconstruction arise. An accessory anterior portal is established if access to the posteromedial or posterior femoral neck are required for femoroplasty (Fig 3).

### Part B. Capsulotomy, Diagnostic Arthroscopy, Central Compartment Management

An interportal capsulotomy is performed between the anterolateral and mid-anterior (MA) portals and diagnostic arthroscopy is carried out. Central compartment pathology is diagnosed and treated accordingly.<sup>19,20</sup> In this case, the labrum was not of sufficient quality to re-repair and an allograft reconstruction was performed using a modification of the previously described “knotless pull-through technique” (Fig 4).<sup>21</sup>

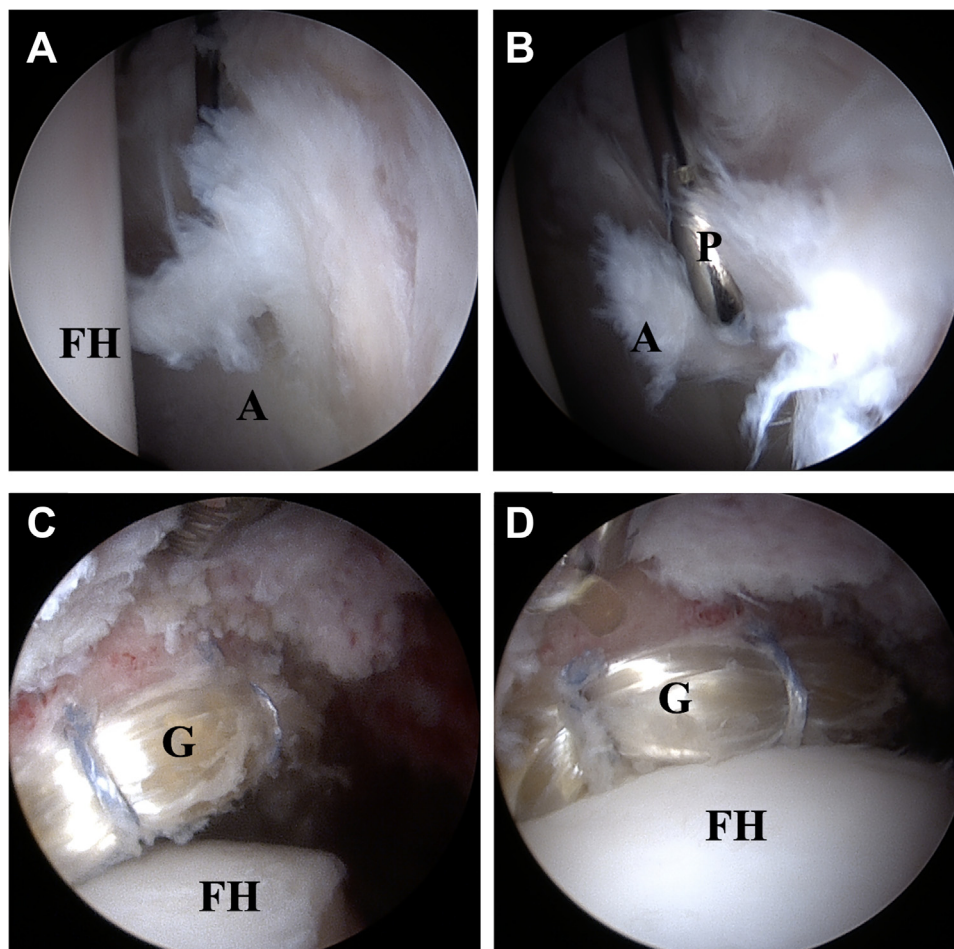


**Fig 2.** The patient is placed in the modified supine position on a traction table on top of a high-friction pink pad. The left hip is shown, with patient’s head to the right and feet to the left. The feet are well padded, and the operative limb is in neutral adduction and rotation and the non-operative limb is in 30° of abduction. The C-arm is positioned over the patient.



**Fig 3.** The patient is placed in the modified supine position, and the anterior inferior iliac spine is marked (\*). The left hip is shown, with patient’s head to the right and feet to the left. The 5 portals used are identified: anterolateral (AL), mid-anterior (MA), distal anterolateral accessory (DALA), posterolateral (PL), and accessory anterior portal (AA).





**Fig 4.** Intraoperative images during diagnostic arthroscopy and labral assessment depicting settings that indicated labral reconstruction (A-D). The patient is placed in the modified supine position. The labrum is visualized with a 70° arthroscope from the anterolateral portal. Probe (P) is coming from the mid-anterior portal, and the femoral head (FH) and acetabulum (A) are identified. (A-B) Labral tear evidenced in a left hip with a complex circumferential labral defect and nonviable tissue. In this setting, labral reconstruction is indicated. Additionally, acetabular labrum articular disruption (ALAD) grade 3/4 is found during intraoperative assessment. (C) View of posterior tibialis tendon allograft used for labral reconstruction in the left hip. (D) Traction is released to restore the labral suction seal.

### Part C. Circumferential Femoroplasty Setup Within the Peripheral Compartment

#### Circumferential Femoroplasty Technique

Performance of a circumferential femoroplasty requires several leg positions to access different portions of the femoral neck. Clockface values of the femoral neck are based on a study by Ross et al.<sup>22</sup> Femoroplasty is then performed using a 5.5-mm round burr in a stepwise manner starting with the anterolateral zone then progressing to the anteromedial, lateral, and posterolateral zones. The technique to adequately access and image the neck positions from 9:30 to 3:30 has been published in detail by Lall et al.<sup>17</sup> and is beyond the scope of this article.

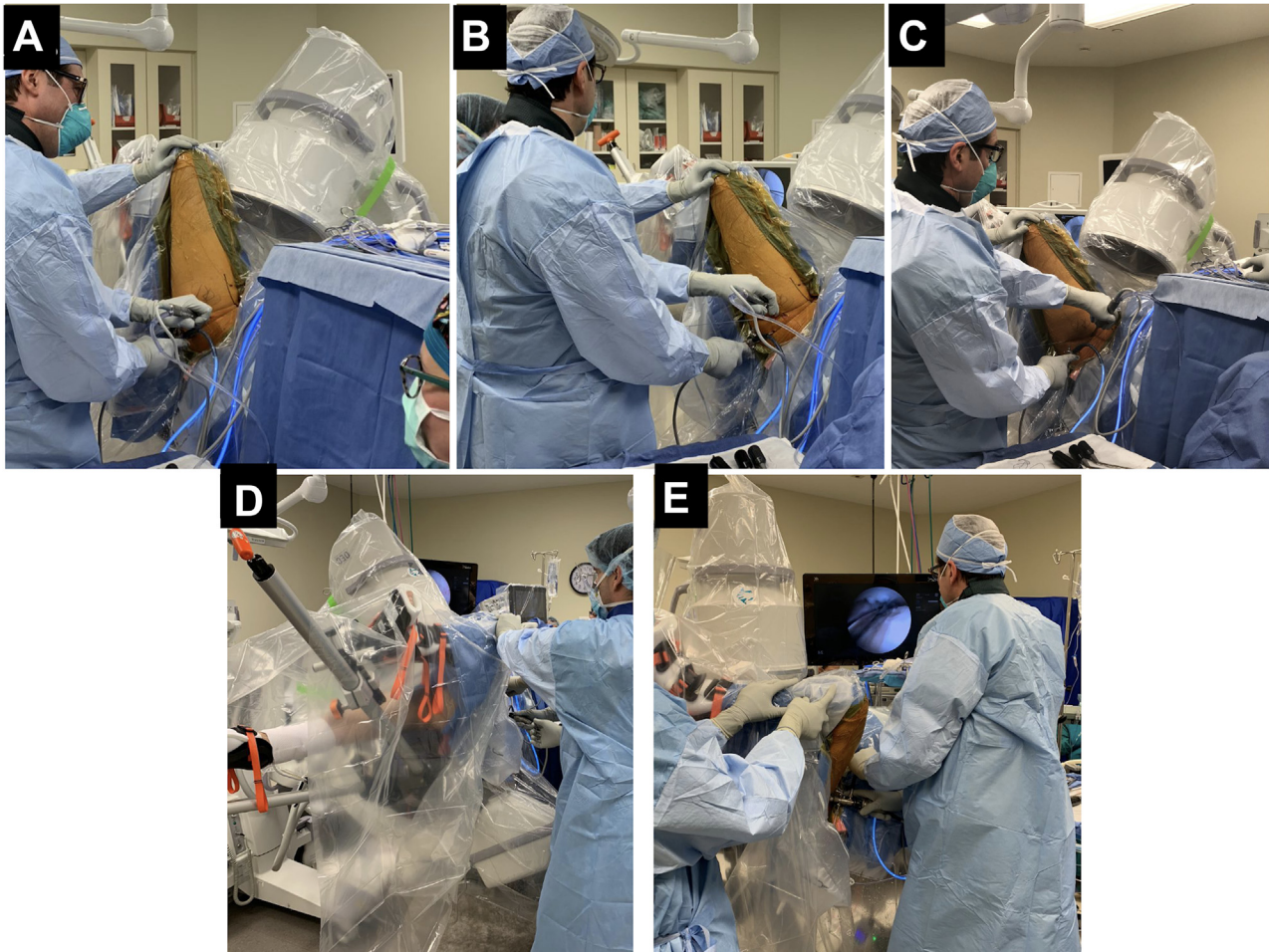
To access to the posteromedial and posterior portions of the femoral neck, an accessory anterior portal is established medial to the MA portal, in line with a tangent drawn distally from the anterior superior iliac spine. This portal allows for better access along the medial femoral neck as the femoroplasty is carried posteriorly.

The operative extremity is then brought into 90° of flexion in neutral abduction. Progressive abduction and external rotation are performed to bring the

posteromedial and posterior femoral neck into the field. Slight adjustments in flexion, abduction, and rotation may be required to bring the bony surface to the burr tip. These leg positions are illustrated in Fig 5. In addition, the arthroscope can be transferred to the posterolateral portal and burr introduced into the anterolateral portal with the leg in full extension and internal rotation, which allows access to the posterolateral femoral neck (Fig 6). Fluoroscopy is used to confirm positions on the femoral neck throughout the procedure (Fig 7). Interactive fluoroscopy-integrated computer vision interface (CVI) (HipCheck, Stryker, Greenwood Village, CO) aided with visualizing the adequacy of bony resection. Video 1 describes details of the circumferential femoroplasty technique.

#### Inspection and Closure

Once the bony resection is deemed adequate, a dynamic examination of the joint and capture of final fluoroscopic images of the operative extremity confirm accurate resection of the cam deformity, restoration of the femoral head–neck offset, and avoidance of over/under-resection.



**Fig 5.** (A) The operative extremity is brought into 90° of flexion in neutral abduction. The hip was progressively moved from flexion and neutral rotation to internal and external rotation positions (A-E). Most notably to achieve adequate decompression of the inferior medial and posterior medial regions, the hip was flexed and externally rotated to allow for the burr to move in this direction.

Any concern for instability, dictated by preoperative physical examination and imaging criteria, necessitates a capsular plication.<sup>23-26</sup> Otherwise, a capsulorrhaphy is performed. In patients with joint stiffness, the capsule may be left unrepaired.

Postoperative radiographs are shown in Fig 8. Comparisons of preoperative and postoperative 3-dimensional reconstructions (HipMap Analysis; Stryker, Mahwah, NJ) are shown in Fig 9, demonstrating the ability to access all portions of the femoral neck.

### Postoperative Plan

A hinged hip brace is worn and crutches used for 6 weeks postoperatively to restrict hip range of motion from 0° to 90° of flexion and allow for up to 20 lbs of flat-footed weight-bearing. Physical therapy begins 1 day postoperatively. Immediate, active range of motion is encouraged through use of stationary bicycle or continuous passive-motion machine.

### Discussion

This technique allows for the performance of a circumferential femoroplasty using postless patient positioning, commonly used arthroscopic instrumentation, and fluoroscopic guidance. This provides the ability to address rarely seen extensive cam deformities through an all-arthroscopic approach without the need for specialized instrumentation. In addition, dynamic fluoroscopy and the use of CVI allowed for real-time visualization of the extent of resection to avoid the pitfalls of over- and under-resection.

Adequate correction of the bony deformity is paramount to preventing complications and avoiding revision surgery. It has been reported that persistent impingement is the main cause of recurrent FAI symptoms in 95% of patients undergoing a revision hip arthroscopy.<sup>27</sup> It is also well established that the outcomes of revision surgery are inferior to those of primary surgery.<sup>28</sup> Inability to access the harder to reach deformities may limit the surgeons ability to alleviate all





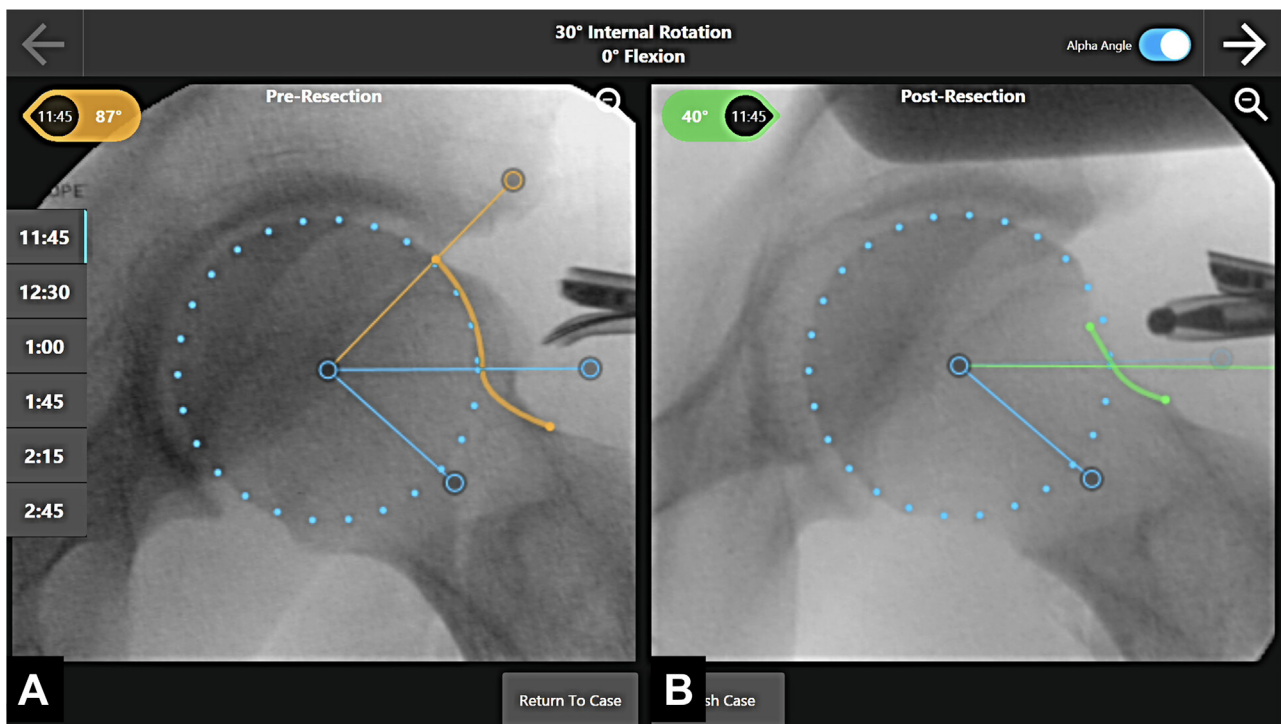
**Fig 6.** Screenshot of a fluoroscopic view used intraoperatively to confirm adequate positioning on the femoral neck throughout circumferential femoroplasty in the left hip.

possible areas of impingement, potentially putting the patient at risk for recurrent symptoms.

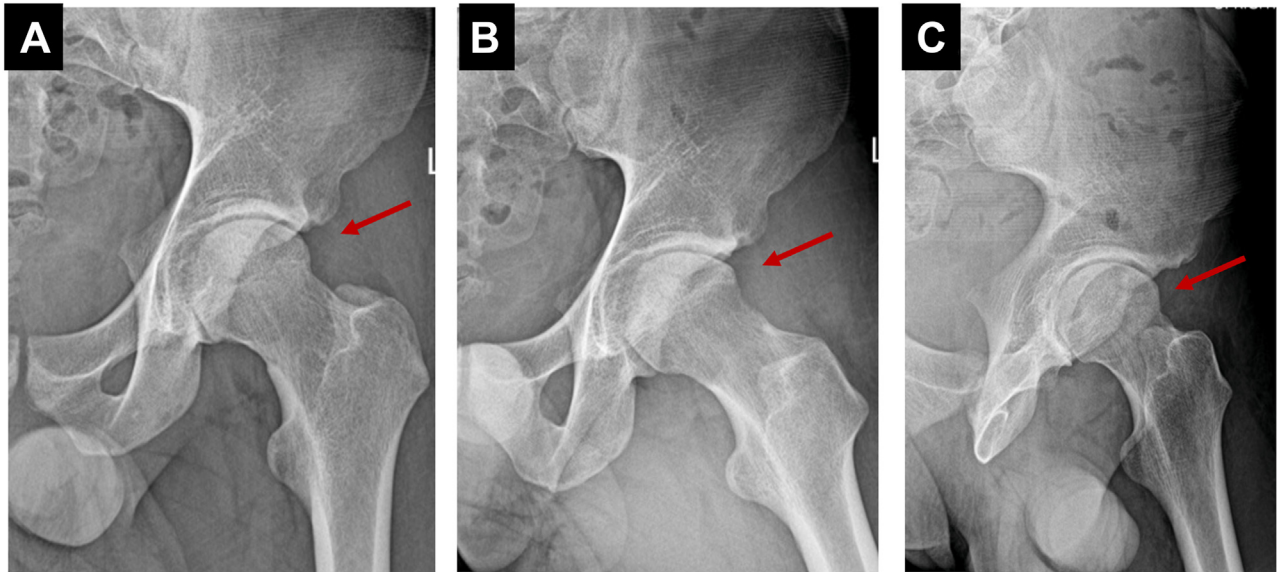
However, there are serious implications for bony over-resection. Mansor et al.<sup>8</sup> compared 3 cohorts (normal resection, under-resection, and over-resection) and found that inferior clinical outcomes occurred more

often in the over-resected group than the under-resected group. The over-resected group also had a greater rate of conversion to total hip arthroplasty than the other two. Any technology to improve the accuracy of femoroplasty is certainly welcome to prevent these complications. CVI-guided femoroplasty was recently validated as a safe and effective way to aid surgeons in performing an accurate proximal femoral cam resection.<sup>29</sup> CVI-guided femoroplasty was used treating this patient due to the complexity of the proximal femoral deformity.

This Technical Note describes a technique for performing a circumferential femoroplasty without the use of specialized instruments. Two previously published techniques address the arthroscopic resection of posterior cam lesions. Matsuda and Hanami<sup>30</sup> described a technique wherein the limb is placed in relative extension and internal rotation and the resection is started laterally then carried posterolaterally, staying proximal to the retinacular vessels. While this technique was adequate for the bony deformity illustrated in their technique article, which was predominately lateral and posterolateral, it would have not addressed the pathology illustrated in our case, which required accessing the medial and posteromedial femoral neck. Ochiai et al.<sup>31</sup> also have recently published a technique article detailing an all-arthroscopic approach for decompressing a posterior cam deformity. Similar to



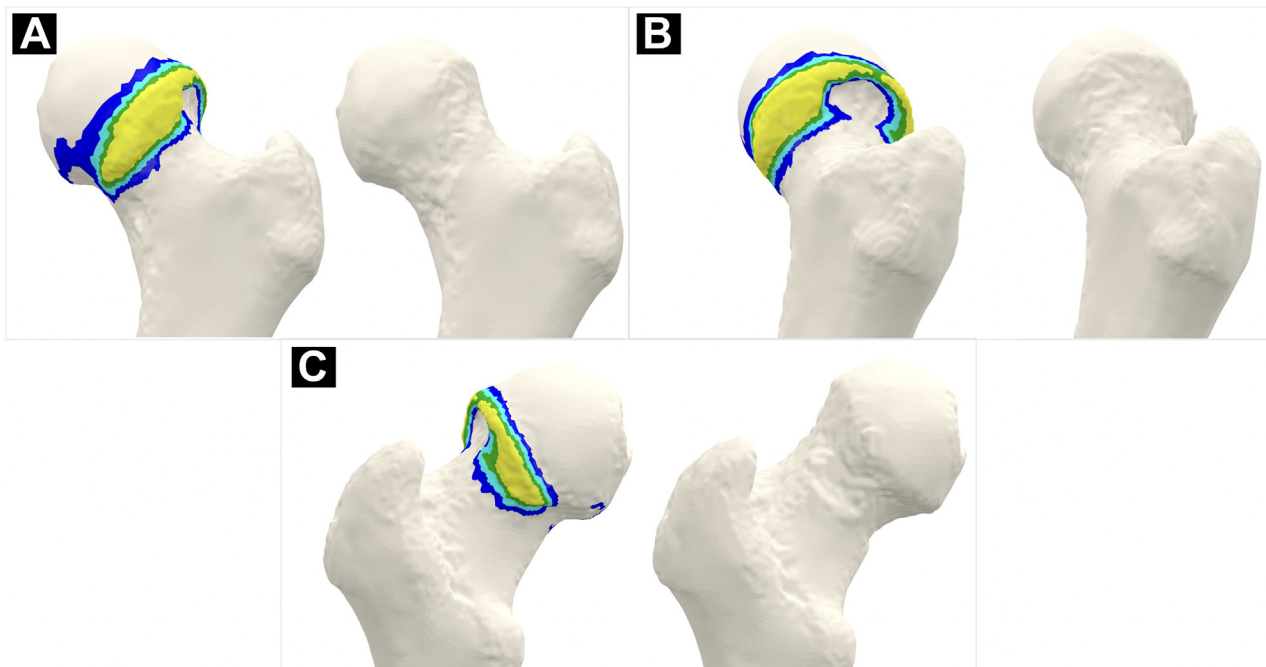
**Fig 7.** Images depicting the interactive fluoroscopy-integrated computer vision interface (HipCheck; Stryker) that aided visualizing the adequacy of bony resection. (A) The left hip is depicted with an alpha angle of 87° (orange) preresection. (B) After circumferential femoroplasty was performed on the left hip, this postresection image depicts an alpha angle of 40° (green).



**Fig 8.** Postoperative standing and supine radiographs of the left hip taken from the (A) anteroposterior pelvis, (B) modified 45° Dunn lateral, and (C) false-profile views depicting adequate resection of the preoperative circumferential, cam-type deformity with postoperative alpha angle  $< 55^\circ$  (red arrows).

our technique, they access the posterior femoral neck medially. Their technique requires the use of pre-bent burrs working through an MA portal. It also requires the foot to be released from the traction boot and positioned in a figure-of-4 position. Our technique can

be performed using a 5.5-mm straight burr, working through an accessory anterior portal, and the foot can be kept in the traction boot with flexion, abduction/adduction, and rotation adjusted through the hip distractor's legs.



**Fig 9.** Images depicting preoperative versus postoperative 3-dimensional reconstructions (HipMap Analysis; Stryker) in a left hip placed in 30° internal rotation and 0° of flexion. Pre- versus postresection images shown in the (A) anterior, (B) lateral, and (C) posterior views demonstrating the ability to access all portions of the femoral neck intraoperatively. The preoperative cam deformity is depicted in color to aid with preoperative planning and intraoperative visualization.

## Conclusions

Arthroscopic femoroplasty is a technically challenging procedure with significant room for error. The difficulty is compounded as the extent of the bony deformity increases. This article provides a straightforward, reproducible technique for addressing circumferential cam deformities using postless positioning, non-specialized instrumentation, an accessory anterior portal.

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