Technical Note

Arthroscopic Femoral Osteochondroplasty for Cam-type Femoroacetabular Impingement: Cortical—Cancellous Sclerotic Boundary Guides Resection Depth

Alexander J. Mortensen, B.S., Ian Duensing, M.D., and Stephen K. Aoki, M.D.

Abstract: Hip arthroscopy and femoral osteochondroplasty are commonly used in the treatment of femoroacetabular impingement (FAI). Determining the correct resection depth of the femoral head—neck cam lesion intraoperatively can be challenging. Both inadequate resection and over-resection may result in complications, underlying the importance of using a consistent and accurate technique when resecting and reshaping the proximal femur. Osseous resection to a depth of the subchondral cortical—cancellous bone margin in individuals with FAI has been shown to restore proximal femoral anatomy to within submillimeter differences when compared with control subjects without FAI. This bony boundary may be used as an intraoperative guide to consistently achieve appropriate resection depth. The sclerotic margin indicating the extent of the cam-type deformity can be evaluated with preoperative radiographs and recreated fluoroscopically, giving the surgeon a reliable intraoperative template. In addition, changes in clinical appearance during arthroscopy, particularly identification of the underlying trabecular structure at the cortical—cancellous border during resection, provides a visible, reliable intraoperative guide to resection depth.

Introduction (With Video Illustration)

Cam-type femoroacetabular impingement (FAI) most commonly occurs in the anterosuperior region of the femoral head—neck junction[1] and, although location is consistent, the specific morphometry of lesions vary. That is, the areal extent and depth of each cam lesion is unique. One of the challenges faced by surgeons is determining the appropriate depth of resection intraoperatively during femoral osteoplasty (Video 1). Inadequate resection results in residual impingement and is the most common indication for revision surgery in patients with cam-type FAI.[2] However, over-resection also can lead to complications, such as iatrogenic femoral neck fracture or loss of stability by disruption of the congruity of the femoral head and acetabular labrum.[3,4] The technique described in this paper is based on previously published data that demonstrated resection of sclerotic bone to the cortical—cancellous junction provides an objective method in determining resection depth within the cam lesion, thereby restoring proximal femoral anatomy.[5] The referenced study used 3-dimensional reconstructions of the proximal femur generated from computed tomography images of an asymptomatic screened control group and a symptomatic cam-type FAI group. Mean proximal femur shapes representative of each group were created and used to define the average areal region of the lesion. Simulated resection of subchondral cortical bone was performed in the FAI group using the sclerotic margin as a guide for resection depth. The mean shapes of each group were compared, revealing submillimeter differences in the resection area, quantitatively establishing the cortical—cancellous border as a reliable guide to determine resection depth.[5]

Routine and reproducible preoperative imaging is paramount. Specifically, various pelvic and hip specific radiographs are obtained to characterize the morphology

From the School of Medicine (A.J.M.) and Department of Orthopaedic Surgery (I.D., S.K.A.), University of Utah, Salt Lake City, Utah, U.S.A.

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Address correspondence to Stephen K. Aoki, M.D., Department of Orthopaedic Surgery, 590 Wakara Way, Salt Lake City, UT 84108. E-mail: stephen.aoki@hsc.utah.edu

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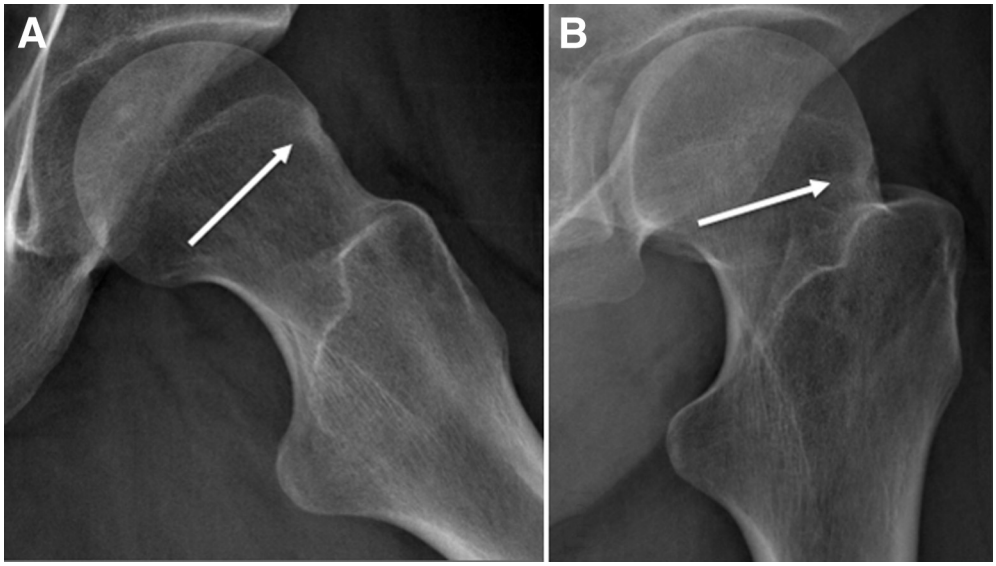

Fig 1. Preoperative routine radiographs for evaluation of cam-type FAI. (A) Frog-leg lateral view of the left hip. The arrow indicates the sclerotic thickening of the subchondral cortical bone in the anterosuperior aspect of the femoral head–neck junction indicating the cam-type deformity. (B) Modified false-profile view of the left hip. Again, the arrow indicates the sclerotic cortical bone thickening of the cam-type deformity.

of the cam lesion (Fig 1, Video 1).[6] Radiographically, the lesion can be identified by the sclerotic appearance of the subchondral cortical bone located at the anterosuperior femoral neck.[7] These preoperative images are recreated during surgery by means of fluoroscopy and, coupled with direct visualization of the surface changes during resection, can be effectively used to follow the progression of the bony resection.[8] In this article, we describe our technique of using the aforementioned imaging and visual assessment during femoral osteoplasty, which ultimately provides a resection that is both complete and tailored to the specific anatomy of the individual.

Surgical Technique

Patient Positioning and Gaining Access to Hip

The patient is placed in the supine position on a post-free Pivot Guardian Distraction System table (Stryker, Kalamazoo, MI). Access to the hip is obtained through an anterolateral portal located slightly anterior and superior to the greater trochanter and is established with fluoroscopic assistance.[9] Next, the modified anterior portal is established using direct visualization through the anterolateral portal.

Interportal Capsulotomy

After access is obtained, an interportal capsulotomy is created by connecting the anterolateral and modified anterior portals. The interportal capsulotomy is made parallel to the acetabular rim, leaving sufficient acetabular-sided capsule (~1 cm) to aide in capsular closure at the conclusion of the case. Extracapsular fat is removed using a radiofrequency ablation device (SERFAS 90°; Stryker Medical, Kalamazoo, MI) to provide optimized visualization throughout the procedure. Removing extracapsular fat will also aid in capsular closure at the end of the case.

Central Compartment Pathology

While the hip is in traction, the central hip compartment is evaluated. All intra-articular, acetabular, and labral pathology is addressed. Traction is then released and attention is turned to the peripheral hip compartment.

Fig 2. Intraoperative fluoroscopy of the patient's left hip in external rotation and abduction in attempt to recreate the frog-leg lateral view. The arrow indicates the trough created through the sclerotic cortical bone down to the underlying cancellous bone.

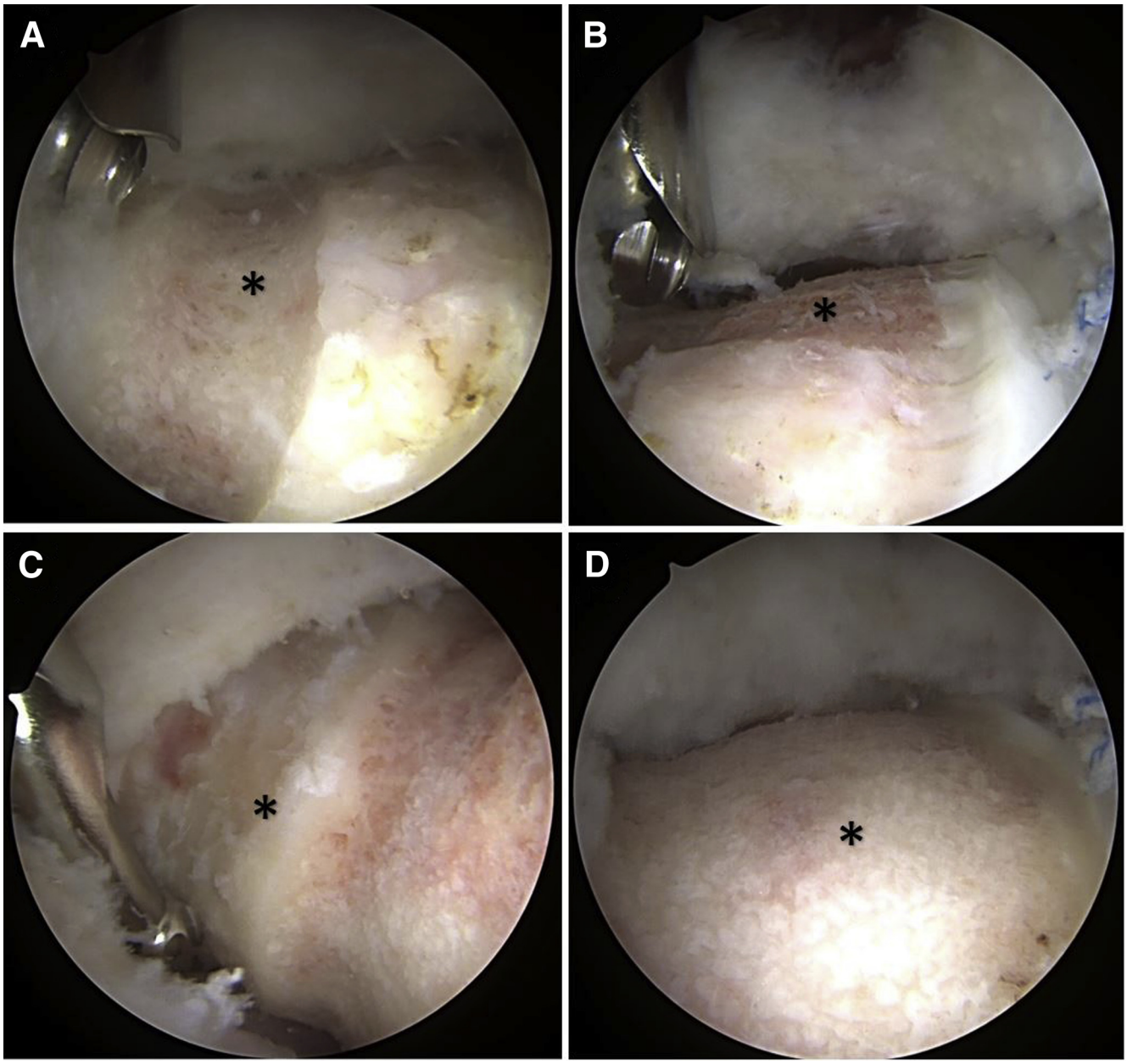

Fig 3. Left-sided hip arthroscopic images viewed from the anterolateral portal showing resection down to the red hue of the cortical—cancellous border. Asterisks indicate the following: (A) Trough created parallel to femoral head—neck junction. (B) Area of resection proximal to trough, working medially to laterally. (C) Sclerotic cortical bone distal to the trough, before resection in this area. (D) Completed femoral osteochondroplasty.

Peripheral Compartment: Identifying and Defining the Cam Lesion

A combination of preoperative radiographs, intraoperative fluoroscopy, and arthroscopic visualization provides multiple modalities to evaluate and define the cam-type deformity. In addition, the cam lesion is dynamically assessed through arthroscopic visualization as the hip joint is internally rotated and flexed. The most common location for the cam-type deformity is the anterosuperior region between 1 and 2 o'clock on the femoral head—neck junction.[1] When using an interportal capsulotomy technique, the superoposterior margin of the cam-type deformity is most easily visualized with the hip in extension and internal rotation, whereas the anteroinferior cam deformity margin is most easily visualized with the hip in 30° to 45° of flexion and in neutral rotation. To allow for comparisons and to monitor progress throughout the procedure, anteroposterior and lateral fluoroscopic images are taken before performing any resection and reshaping. The hip is flexed to 45° to relax the surrounding capsular tissue and provide for a more

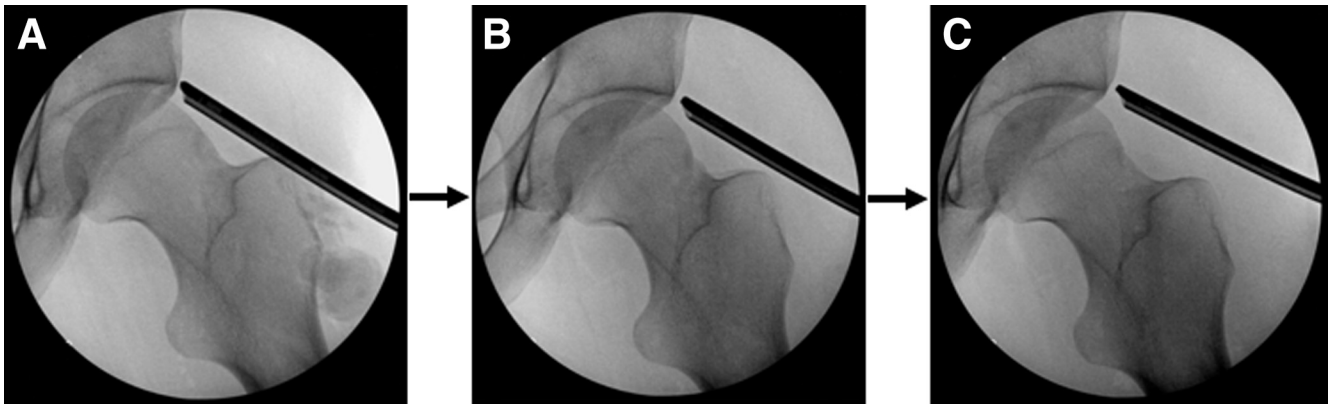

Fig 4. Intraoperative fluoroscopy of the patient's left hip viewing from the medial aspect of the proximal femur. From left to right (A-C) showing progress of femoroplasty performed. (A) Preosteoplasty. (B) Post-trough creation with osteoplasty performed proximal to the trough. (C) Completed resection distal to trough with entirety of cam lesion removed to the depth of the cortical–cancellous bone boundary.

complete visualization of the peripheral compartment. The retinacular vessels are located by identifying the medial and lateral synovial folds. The areal extent of the cam lesion is assessed, and electrocautery is used to remove all soft tissue overlying the cam deformity (Video 1).

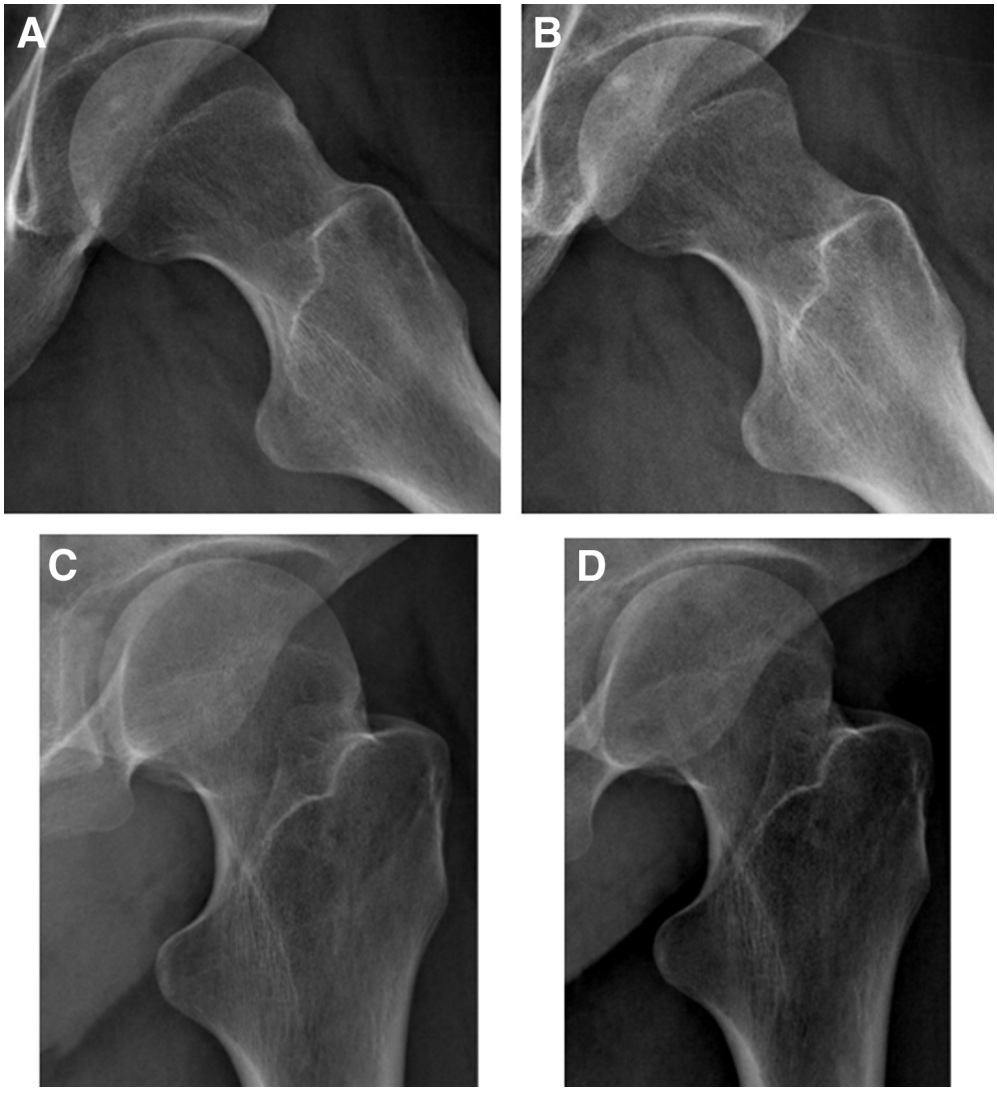

Fig 5. Pre- and postoperative radiographs of the patient's left hip to evaluate change in femoral morphology. Frog-leg lateral view: (A) Preoperative with sclerotic cam lesion present. (B) Postoperative view of cam removal and restoration of femoral head–neck offset. Modified false-profile view: (C) Preoperative with sclerotic cam lesion present. (D) Post-operative view of cam removal with improved femoral head sphericity.

Table 1. Advantages, Risks, and Limitations to Using Sclerotic Cortical–Cancellous Boundary to Guide Resection Depth

Advantages
Helps avoid under- and over-resection of cam lesion and their associated complications.
Accurately restores proximal femoral anatomy while removing sclerotic, impinging bone.
Reliable intraoperative guide, especially useful for hip arthroscopists with less experience.
Real-time feedback specific to the patient's hip morphology is clearly visible to the surgeon.
Minimizes additional operative tooling, advanced imaging, or a 3-dimensional modeling operative plan.
Risks and limitations
The cortical–cancellous boundary provides a limit to the depth of resection, it does not indicate the areal coverage of the cam lesion.
The sclerotic physeal scar region must be noted in younger patients and contoured to the surrounding resection rather than over-resecting this area.
Sclerosis surrounding larger impingement cysts should not be resected in this region.

Subchondral Cortical–Cancellous Bone Margin Used as Guide to Resection Depth

Contouring the proximal femur to a depth between subchondral cortical bone and underlying cancellous bone provides an accurate guide to limit the depth of resection during femoroplasty.[5] Preoperative radiographs are used to visualize the sclerotic cortical–cancellous bone margin (Fig 1, Video 1). Intraoperatively, the cortical–cancellous bone boundary is seen as sclerosis on fluoroscopy and is easily visualized as cortical bone is removed. It is crucial to resect the cam deformity at an appropriate depth to restore femoral anatomy without under- or over-resection. A visual change in both bone structure and color occurs once the boundary between subchondral cortical bone and cancellous bone is reached. At this point, adequate resection depth has been achieved.

First, a trough is created parallel to the head–neck junction and through the cam-deformity to define the depth of femoroplasty. The trough is formed using a 5.5-mm burr (Stryker Medical) down to a depth equal to the thickness of the sclerotic subchondral cortical bone (Fig 2, Video 1). The appropriate femoral head–neck offset is then recreated by resecting the proximal aspect of the cam lesion and contouring from the articular surface to the trough, continuing to use the sclerotic bone to determine resection depth. The remainder of the femoroplasty is completed from the trough moving distally along the femoral neck (Fig 3). Achieving appropriate resection depth throughout the entirety of the cam lesion is accomplished by following the plainly visible cortical–cancellous bone boundary throughout the areal extent of the cam lesion. Of note, it is important for the surgeon to recognize specific anatomic areas of sclerosis that may distort the region of sclerosis. In younger patients, the sclerotic physeal scar may extend deeper than the cam lesion and should not be removed to avoid over-resection. Similarly, sclerosis surrounding impingement cysts should not be removed to prevent over-resection. After complete resection of the cam deformity and before joint irrigation and capsular closure, fluoroscopy shots should be taken circumferentially with respect to the femoral neck to confirm an adequate femoroplasty (Fig 4, Video 1).

Table 2. Steps of Arthroscopic Osteochondroplasty–cam-type Femoroacetabular Impingement

Choose a capsulotomy approach that allows full visualization of the cam lesion, being careful to maintain the capsular integrity.
Use electrocautery to remove the soft tissue from the cam lesion and identify the full lesion before resection.
Establish depth of resection of the cam lesion by making a trough cut (~8-10 mm away from the head–neck junction) using the sclerotic border to determine depth.
Contour the convex femoral spherical resection down to the trough cut.
Complete the distal resection, tapering the cut down the femoral neck.

Table 3. Pearls and Pitfalls to Using Sclerotic Cortical–Cancellous Boundary to Guide Resection Depth

Pearls
The forward mode of the burr is most efficient for the removal of the sclerotic cortex.
The reverse mode of the burr is used to smoothly contour the osteoplasty and is helpful in preventing over-resection or gouging.
The sclerotic cam lesion is easier to identify and define after removal of the soft tissue by electrocautery.
Capsular retraction stitches may be helpful in visualizing the cam lesion while protecting the capsule from iatrogenic injury from the burr.
Following osteoplasty, perform examination using full dynamic range of motion in combination with arthroscopic and fluoroscopic views to assure osteoplasty is complete.
Fluoroscopy is used in a circumferential manner to assure a complete osteoplasty.
Pitfalls
Use caution not to make a sharp ledge when resecting proximally toward the articular surface of the femoral head because it can compromise the integrity of the suction seal.
If not careful, hip joint subluxation or excessive hip external rotation may result in an osteoplasty reaching too far medially.

Irrigation and Routine Capsular Closure

Following femoroplasty, the hip joint is amply irrigated with saline to remove any remaining bone fragments to minimize a nidus for heterotopic ossification formation. Routine capsular closure is performed using a figure-of-eight watertight closure.[10]

Discussion

Achieving a satisfactory osteoplasty resection depth in the patient with FAI resulting from cam-type impingement remains a challenge for many surgeons.[11] As previously mentioned, under-resection may result in residual impingement, poor patient satisfaction, and is

the most common reason for revision surgery,[2] whereas over-resection also has been implicated in postoperative complications, including iatrogenic fracture or instability from loss of congruency between the femoral head and the acetabular labrum. Atkins et al.[5] quantitatively demonstrated appropriate and reproducible resection depth during osteoplasty through 3-dimensional modeling by using the sclerotic subchondral cortical bone and underlying cancellous bone boundary. The bony pathoanatomy is easily visible both on preoperative radiographs and direct intraoperative assessment during resection. Using this landmark provides the surgeon with both a goal and a limit during osteoplasty to restore femoral head–neck anatomy (Fig 5). Table 1 summarizes the advantages, risks, and limitations of using the sclerotic cortical–cancellous bone margin to guide the depth of resection.

Table 2 outlines the steps of arthroscopic osteochondroplasty in the operative management of cam-type femoroacetabular impingement, including the use of the bone boundary to guide resection. It is imperative to achieve fluoroscopic images that represent and recreate those obtained preoperatively by frequent manipulation of hip position when working through an interportal capsulotomy. This allows for clear visualization of the cam lesion and surrounding anatomy. Hip flexion takes tension off of the anterior capsule, bringing the inferior-most extent of the cam lesion into the visible working space. Gradual extension of the hip from a flexed position allows for visualization of the superior most aspect of the lesion. Ensuring adequate visualization of lesion margins is imperative to visualizing the cortical–cancellous bony boundary in these areas and, ultimately, treating the lesion in its entirety. Additional pearls and pitfalls of our hip arthroscopy technique are provided in Table 3.

In summary, this article provides a detailed technique of using the visible, intraoperative cortical–cancellous bone boundary as a guide to limit the depth of resection during osteochondroplasty of a cam-type deformity in the treatment of FAI. Our technique is supported by a quantitative study which establishes the use of this bony boundary as an effective tool in restoring femoral head–neck anatomy.[5]

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