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Operative Techniques in
Orthopaedics

CAM Impingement: Surgical Management

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CAM-type femoroacetabular impingement is increasingly recognized as a source of activity-limiting symptom and a contributor to degenerative hip disease. Hip arthroscopy is an effective treatment option for repairing the resulting acetabular chondrolabral junction injury and reshaping the pathologic bony morphology to limit further joint degeneration. Recent randomized controlled trials have confirmed the advantages of surgical management of femoroacetabular impingement with hip arthroscopy over conservative management. Standard technique utilizes 3 portals, anterolateral, mid-anterior, and distal anterolateral accessory. Interportal capsulotomy allows access to the central compartment to resect a concomitant pincer lesion, refixate a torn labrum, and treat articular cartilage injury. The mid-anterior portal is used for arthroscopic visualization, while suture anchors are placed through the distal anterolateral accessory portal and the anterolateral portal is a working portal. T-capsulotomy provides extensile exposure of the entire CAM lesion, and viewing from the mid-anterior portal further improves arthroscopic visualization. Fluoroscopy is essential for intraoperative mapping of the CAM lesion and to confirm appropriate resection. Capsular closure is performed routinely to repair both the T-capsulotomy and the interportal capsulotomy. This review provides a comprehensive description of the surgical technique for CAM impingement, as well as the postoperative rehabilitation and outcomes.

KEYWORDS Femoroacetabular impingement, CAM, hip arthroscopy, femoroplasty, osteochondroplasty, labral repair

Introduction

Hip arthroscopy for femoroacetabular impingement (FAI) is rapidly expanding.[7] The CAM type structural abnormality is present in the majority of surgically indicated cases of FAI.[1] CAM deformity is characterized by an abnormally shaped femoral head with a loss of head-neck offset that results in abnormal contact between the anterolateral neck and acetabulum. This results in injury to the adjacent labrum and chondrolabral junction, and ultimately articular cartilage degeneration and osteoarthritis.[3] Recognition of FAI and its consequences, as well as advances in arthroscopic techniques, has led to earlier diagnosis and treatment to both address the chondrolabral injury and prevent further joint degeneration. Arthroscopic management provides a minimally-invasive approach to access the hip joint and correct the underlying FAI. The purpose of this review is to provide a comprehensive description of the arthroscopic management of CAM-type FAI, including utilizing a mid-anterior viewing technique for improved arthroscopic visualization.

Diagnosis

Clinical evaluation is the first point of emphasis for effective management. The history and physical exam are first used to begin to differentiate between intra-articular and extra-articular hip pathology, and also lumbar spine, sacroiliac joint, and intrapelvic conditions. Patients presenting with hip pain concerning for FAI are evaluated radiographically with 3 views: anteroposterior pelvis, Dunn lateral, and false profile of the affected hip. The abnormal bony morphology is defined on the plain films. Magnetic resonance imaging is used to rule out other soft tissue causes of pain, such as tumors, and evaluate the cartilage and labral injury. Computed tomography with 3-dimensional reconstruction can be used to assist the

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surgeon in better understanding the deformity during preoperative planning. FAI syndrome is diagnosed when the patient's clinical symptoms correlate with the radiographic findings of FAI, and the bony abnormality is classified as CAM, pincer, or combined.

Indications

Presence of cam deformity has been well-documented in symptomatic and asymptomatic athletic populations. Determination of appropriate surgical indications is key to effective management of the patient with suspected cam type femoroacetabular impingement. A conclusive diagnosis of FAI syndrome must be made and other pathologies should be ruled out. The presence of degenerative changes and acetabular dysplasia must be carefully considered. Typically, patients are initially treated with rest, activity modification, and physical therapy. A recent prospective cohort study reported that 70% of patients initially managed with rest, activity modification, and physical therapy achieved significant improvements in hip outcome scores at 2 years and did not require surgical management.[9] An additional 12% of patients improved after intra-articular corticosteroid injection for a total of 82% of patients not requiring surgical management.

Surgical management is offered to those patients who fail to achieve desired function and activity with nonoperative management. Two recent randomized controlled trials investigated operative versus nonoperative management for femoroacetabular impingement syndrome and showed better clinical outcomes with operative management.[4,8] The UK FASHIoN trial published in 2018 randomized 348 patients to hip arthroscopy or personalized physical therapy, and found better patient-reported hip specific outcome scores at 1-year follow up in the operative group.[4] Another multicenter trial published in 2019 randomized 222 patients to either arthroscopic surgery or a physical therapy program and similarly found better hip outcome scores for activities of daily living at 8-month follow up with arthroscopic surgery.[8]

Surgical Technique

Patient positioning and setup is important in the arthroscopic management of FAI. Although both lateral and supine positioning can be used, supine positioning is beneficial for its ease of setup and the familiarity with positioning similar to a standard fracture distraction table. Hip arthroscopy specific distraction tables are increasingly common, but regardless of table type, it is important for the feet and perineal post to be well padded to avoid iatrogenic nerve injury. Gentle countertraction is applied to the contralateral limb for stability of the pelvis on the perineal post. Traction is applied to the operative limb with the hip in 30° of abduction, and then adducted to neutral to allow the perineal post to exert a lateralizing force to aid in distraction. Fluoroscopy is used to confirm adequate distraction is achieved with the minimal amount of force required. More recently, hip distraction without a perineal post has been proposed to decreased the incidence of groin-related problems, such as pudendal nerve palsies.[6] In this technique, a specialized high-friction pad is placed on the table, and the table is placed in 20° of Trendelenburg. Traction is applied to the operative limb with the hip in 30° of abduction, while an assistant stabilizes the pelvis on the table as needed. After distraction is achieved, the table can be leveled. With either method, 10 mm of joint space widening on the anteroposterior fluoroscopic view is adequate, and this is usually obtained with 25 to 50 pounds of force. An air arthrogram can be performed with the spinal needle to release the intra-articular vacuum seal and reduce the total force necessary for hip distraction.

Accurate portal placement is the next key step for safe access to the hip joint and appropriate visualization.[11] Portal placement options are discussed previously in this text. Three portals are standard for the arthroscopic management of CAM impingement: anterolateral, mid-anterior, and distal anterolateral accessory portals. Multiple hip arthroscopy access kits are available providing appropriately sized spinal needles and guidewires to assist with access. The anterolateral portal is established first approximately 1 cm superior and 1 cm anterior to the anterosuperior corner of the greater trochanter. The spinal needle enters the joint as close to the femoral head as possible without causing iatrogenic chondral injury in order to minimize the risk of labral penetration. Fluoroscopic guidance is used. A guidewire is then placed through the spinal needle to the acetabular fossa, and again placement is confirmed with fluoroscopy. Next, a small diameter cannula with trocar is placed over the guidewire, and the guidewire is backed out partially as the cannula enters to joint to avoid breakage of the guidewire in the joint. A 70° arthroscope is placed into the cannula, and dry arthroscopic visualization of the central compartment can be performed.

The mid-anterior portal is placed next under direct arthroscopic and fluoroscopic visualization. The traditional anterior portal, in line with the anterior superior iliac spine lies in close proximity to the lateral femoral cutaneous nerve just 15 mm away.[11] Use of the more distal and laterally placed mid-anterior portal significantly decreases the risk to the nerve. Spinal needle is again used to localize this portal, and direct arthroscopic visualization should confirm the needle enters the joint in the triangular space viewed medially between the femoral head and anterosuperior labrum. Interportal capsulotomy is made with an arthroscopic blade to connect these 2 portals and allow instrument access and mobility throughout the central compartment. One may need to interchange arthroscope and arthroscopic blade between the 2 portals to fully complete the capsulotomy. Standard diagnostic arthroscopy is then performed to visualize the entire labrum, articular cartilage of the femoral head and acetabulum, ligamentum teres, and capsule. Viewing from both the anterolateral portal and the anterior portal provides a comprehensive view of the central compartment. Mid-anterior viewing especially provides excellent visualization of the superior labrum and posterior to 9 o'clock (Fig. 1). The third portal, the distal anterolateral accessory portal, is typically made after capsulotomy and is located

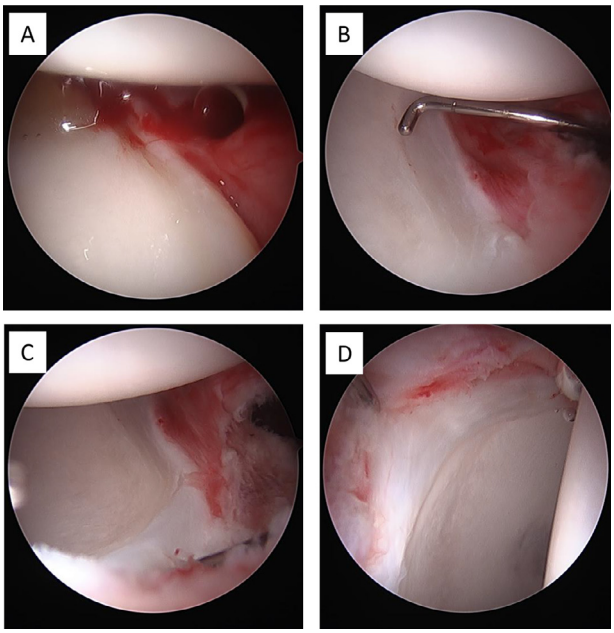

Figure 1 Excellent visualization from the mid-anterior portal in a right hip viewing back at the anterolateral cannula (A), probe down to 10 o'clock posteriorly (B), posterosuperior labrum from 10 o'clock to 12 o'clock (C), and anterosuperior labrum (D).

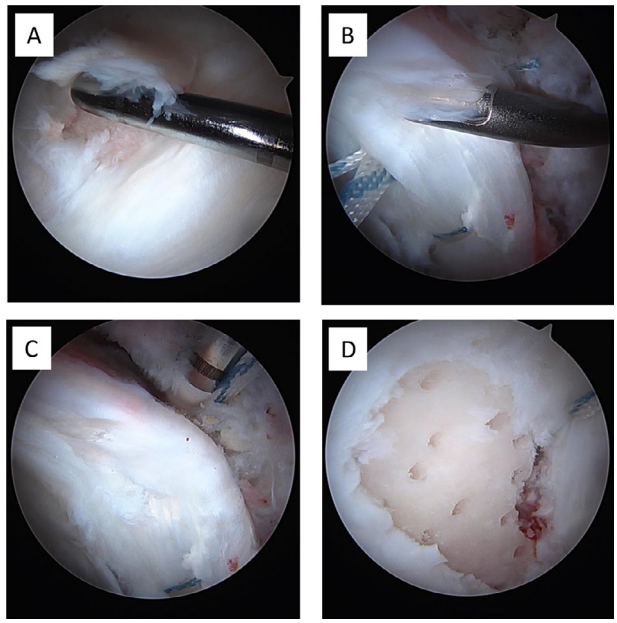

Figure 2 Typical chondrolabral junction injury with articular cartilage delamination seen in CAM impingement viewing from mid-anterior portal in a left hip (A). Mid-anterior portal view showing labral refixation suture passage from anterolateral portal (B). Suture anchor placement anterosuperior at 12 o'clock from the distal anterolateral accessory portal (C). Microfracture is performed for the articular cartilage defect (D).

4-5 cm distal and 1 cm anterior to the anterolateral portal. A switching stick can be used and should enter between the 2 existing portals at a shallower angle in preparation for suture anchor placement.

CAM impingement routinely causes damage to anterosuperior acetabular articular cartilage and chondrolabral junction.[1] This damage in the central compartment is identified and addressed (Fig. 2). Typically, this will require labral refixation, and any concomitant pincer lesion will be managed first. The extent of pincer impingement is identified with direct arthroscopic visualization and correlated with fluoroscopy. The plane between the labrum and capsule above the acetabular rim is developed with arthroscopic shaver and electrocautery. The pincer lesion is exposed up to the cartilage junction, and a burr is used to resect the excess bone. The labrum is then refixed to the acetabular rim using a series of suture anchors. Knotless suture anchor technology is readily available and preferred by the senior author for the ease of insertion and to avoid suture knots which may increase the risk of capsular adhesions or abrasion to the femoral head. Sutures are passed through the labrum in a labral base fixation technique to limit suture material directly abutting the femoral head, or in a looped simple suture fashion depending on the quality of labral tissue and the specific situation.[2] A suture anchor is drilled and placed at the edge of the acetabulum ensuring not to violate the articular cartilage surface. The location of the labral tear dictates which portals are used for visualization and instrumentation. For the most anterior suture anchors, 3 o'clock to 2 o'clock, the arthroscope is placed in the anterolateral portal and the suture anchor is drilled and placed through the mid-anterior portal. For the remaining suture anchor placement from 2 o'clock to 9 o'clock, the mid-anterior portal provides excellent visualization and the distal anterolateral accessory portal is used for drilling and suture anchor placement. Both direct arthroscopic visualization of the central compartment and fluoroscopy are used to confirm there is no cartilage violation and suture anchor placement is solidly in bone.

After labral repair and any pincer resection are complete, the arthroscope is moved from the central compartment to the peripheral compartment and traction is released. Arthroscopic visualization is used to confirm the labral refixation has resulted in appropriate restoration of the labral suction seal (Fig. 3A-B). A typical CAM lesions will occur along the anterolateral head-neck junction and be best viewed with the hip in 45° of flexion. The arthroscope is placed in the mid-anterior portal for optimal visualization of the head-neck junction down to the base of the femoral neck. An arthroscopic blade is then brought in through the distal anterolateral accessory portal, and a T-capsulotomy is made in line with the neck and over the affected anterolateral region of the CAM lesion (Fig. 3C-D). Careful planning and placement of the T-capsulotomy is important to allow for later capsular closure. 1-2 sutures can be passed through the lateral capsular flap and brought out the anterolateral portal for retraction of the capsular flap to add in visualization and instrumentation or resection of the CAM lesion. Visualization and resection of the entire CAM lesion can be one of the most challenging aspects of hip arthroscopy procedures. This method of viewing from the mid-anterior portal, performing a T-capsulotomy, and using a retraction suture from the anterolateral portal can successfully improve the surgeon's ability to accomplish the surgical goals (Fig. 4).[12] Fluoroscopy is

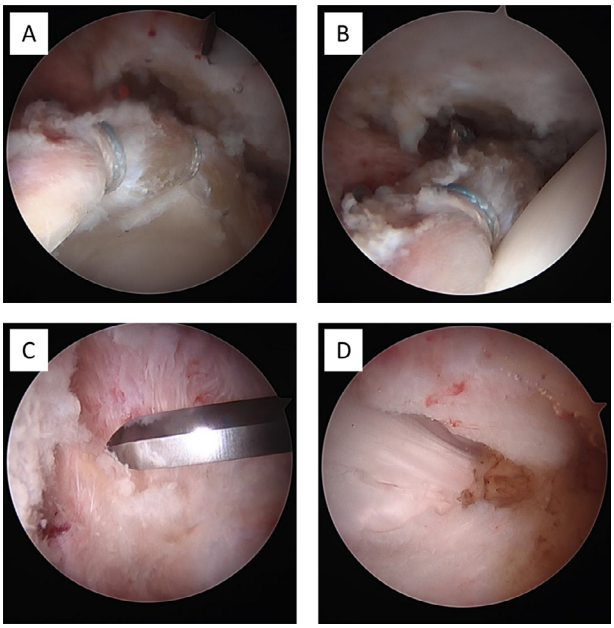

Figure 3 Peripheral compartment access. Labral repair is completed (A). Traction removed and confirm suction seal restored (B). T-capsulotomy made with arthroscopic blade in distal anterolateral accessory portal (C, D).

especially important in localizing the CAM lesion and ensuring adequate resection. Dynamic arthroscopic assessment can also be helpful for visualizing the impingement area. Arching the C-arm over the leg or releasing the foot and rotating the hip are important steps to ensure one appreciates the full extent of the CAM deformity. Intraoperative assessment and findings should confirm the preoperative plan.

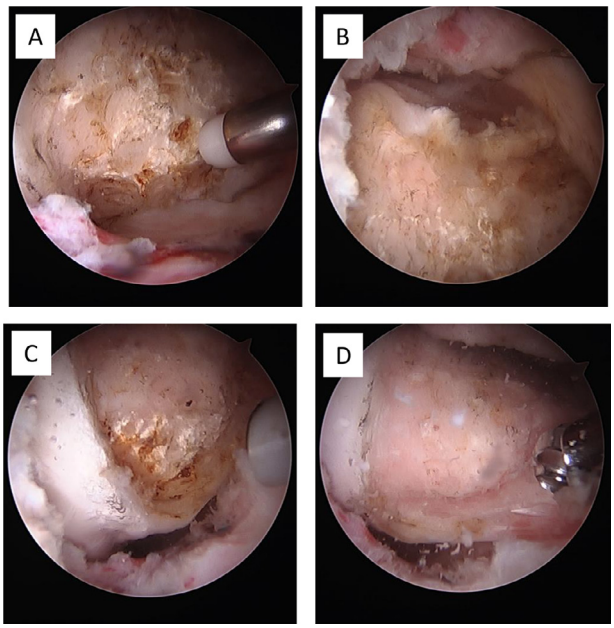

Figure 4 CAM visualization from the mid-anterior viewing portal. Anterolateral CAM lesion is exposed (A). Hip flexion and external rotation exposed medial CAM (B). Hip extension and internal rotation exposed superolateral CAM. Broad view of CAM from mid-anterior portal for arthroscopic resection with burr (D).

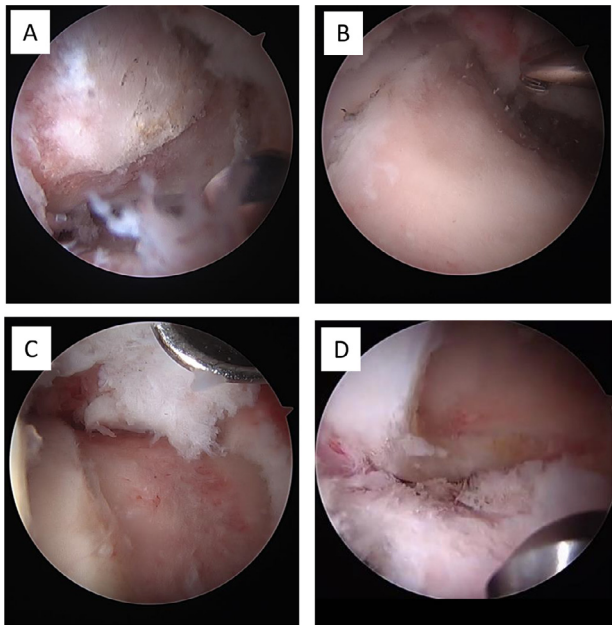

Figure 5 CAM resection: Arthroscopic burr is used to systematically resect the CAM lesion (A), ensuring to resect medially (B), anterolaterally using the distal normal femoral neck as a guide (C), and superolaterally (D).

With the arthroscope in the mid-anterior portal, the distal anterolateral accessory portal is used for instrumentation and bony resection. The boundaries of the CAM lesion are marked out as identified by arthroscopic findings and fluoroscopic assessment (Fig. 4). Electrocautery can be used to clear periosteum and fibrocartilage from the CAM lesion to map the proposed resection. A 5.5 mm arthroscopic spherical burr is then used to perform the resection and restore concavity at the head-neck junction (Fig. 5). The CAM lesion bone is resected to create a spherical femoral head and restore the head-neck offset. The normal distal femoral neck is used as a guide for contouring the neck resection. Fluoroscopy is again used to determine the proximal extent of the resection which will often extend proximal to the physeal scar. Controlling hip flexion and rotation is essential to move the operative window and allow full access to the borders of the lesion. Inadequate resection of the CAM lesion still remains a leading cause of persistent pain after hip arthroscopy. Hip flexion and external rotation brings the inferomedial aspect of the femoral neck into view, whereas extension and internal rotation typically exposes the superolateral extent of the head neck junction. When working superolaterally, the retinacular vessels should be direction visualized along the superolateral femoral neck. Caution is observed to ensure adequate resection but also to avoid vascular injury. As described by Larson,[5] 3 views can be taken in both hip extension and 50° of hip flexion with varying rotation to confirm appropriate resection of the CAM lesion. Resection of <30% of the head-neck junction has been recommended to preserve the weight-bearing capacity of the femoral neck.[10]

Capsular closure is performed routinely with #2 absorbable suture (Fig. 6). The T-capsulotomy is first approximated side-to-side with simple, interrupted suture technique. Commercially

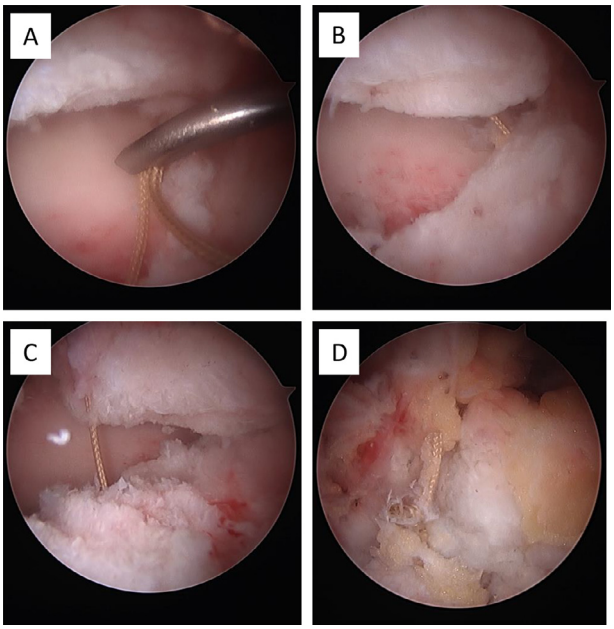

Figure 6 Capsular closure is performed routinely with suture passing device and #2 absorbable suture (A). T-capsulotomy closure starts distal (B), and progresses proximally (C). Interportal capsulotomy is closed last from medial to lateral to complete capsular closure (D).

available arthroscopic suture passing devices can be used to first pass suture through one limb of capsule. A tissue penetrator of suture passing device then pierces the second limb of capsule, and retrieves the suture in an inside-out manner. This is done in serial fashion to securely repair the T-capsulotomy from distal to proximal first. The T split sutures can be easily tied as passed without compromise of placemen to subsequent sutures. The interportal capsulotomy is closed in similar fashion beginning from lateral and progressing medially. These sutures are passed and retrieved through the distal anterolateral portal and then tied collectively at the end. Typically, 4-5 sutures are used for routine capsular closure.

Postoperative Care

Based on the extent of bone resection and the presence of labral repair, patients are restricted to 20 pounds foot-flat weight-bearing for 2 weeks. Over a three-to-four-month period, a slow progression to full strength and activity occurs. This gradual progression avoids over-activation or aggressive loading of the hip flexors, abductors, and adductors, as these muscle groups are highly susceptible to fatigue and tendinitis postoperatively. A full return to sporting activity is anticipated by 5-6 months, but patients may continue to see improvement in symptoms for up to 1 year postoperatively.

Outcomes

Patient-reported outcomes have demonstrated significant short-term and intermediate-term improvement after arthroscopic management of FAI. Across both sport-specific and generalized quality of life metrics, individuals undergoing arthroscopic management for FAI have demonstrated significant improvement.[13,14] Minkara et al showed a pooled difference of 40 points in the sport subscale of the hip outcome score (HOS-Sport). Significant improvements were also noted in the HOS-ADL subscale, the modified Harris Hip Score, and generalized measures such as the WOMAC and VAS-Pain.[15]

While a majority of individuals improve postoperatively after arthroscopic management of femoroacetabular impingement, the level of improvement can vary depending on a number of factors. Increasing age, longer duration of preoperative symptoms, bipolar chondral damage, and the presence of advanced osteoarthritis have predicted decreased postoperative improvement.[16-19] In addition, structural parameters such as acetabular retroversion and acetabular dysplasia have also been identified as negative predictors of outcome.[20,21] Finally, Krych et al showed that individuals undergoing labral repair showed significantly higher patient-reported outcome scores postoperatively compared to those undergoing labral debridement.[22] These studies illustrate the importance of appropriate patient selection and thorough preoperative discussion with patients regarding expectations prior to surgical correction of FAI.

Complications

Complications after hip arthroscopy are rare. A recent systematic review by Minkara et al showed that the cumulative risk of reoperation after hip arthroscopy was 5.5%. Risk of clinically noted complications was 1.7%.[15] The most commonly reported complication was heterotopic ossification which has been shown to be increased in cases of more extensive bony resection. While heterotopic ossification may be a common radiographic finding postoperatively after hip arthroscopy, the majority of HO is asymptomatic and does not require intervention. Additionally, the use of NSAIDs for HO prophylaxis has significantly diminished the incidence of HO following hip arthroscopy. Bedi et al showed that the overall incidence of HO after hip arthroscopy was 4.7%. Individuals who underwent indomethacin prophylaxis were 4 times less likely to develop HO compared to those who did not. 7/29 (24%) of individuals who developed HO required revision excision.[23] In a double-blind randomized trial, Beckmann et al showed that use of post-operative naproxen for HO prophylaxis reduced the prevalence of radiographic HO from 46% to 4% at 1 year postoperatively.[24]

Other potential complications include fluid extravasation, superficial wound infection, and development of adhesions. Distraction-type injuries around the hip associated with traction can present as neuropraxias of the femoral, sciatic, or peroneal nerves. Compression-type injuries secondary to traction against the perineal post can present as a pudendal nerve palsy or injury to the scrotum or labia major. This is often associated with prolonged traction time and excessive traction force. To prevent these injuries, continuous traction time should be limited to less than 2 hours and traction force

to under 50 pounds. If using a perineal post for distraction, the post should be positioned such that the medial thigh is used as a lever for distraction to avoid excess pressure to the groin crease or genitalia.[25]

Conclusion

Hip arthroscopy is an effective treatment option for CAM impingement. Keys to the surgical technique include adequate visualization, which can be improved with a mid-anterior viewing portal and T-capsulotomy, restoration of the chondrolabral junction and acetabular suction seal, appropriate CAM resection confirmed with thorough fluoroscopic evaluation, and complete capsular closure. Randomized controlled trials have confirmed the superiority of arthroscopic management of CAM impingement FAI when compared to physical therapy and conservative care.

Conflict of Interest

SJM and RTL have nothing to disclose. CSM is a paid consultant for Arthrex, Inc.

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