Technical Note

Two-Tiered Resection of Cam Lesions in Hip Femoroacetabular Impingement: Optimizing Femoral Head Sphericity

Lucas Haase, M.D., Erwin Secretov, M.D., Grant Nelson, M.D., Yazdan Raji, M.D., Mikhail Alexeev, M.D., and Michael Salata, M.D.

Abstract: Hip arthroscopy is one of the most rapidly growing fields in orthopaedic surgery. One of the most frequent pathologies treated with hip arthroscopy remains femoroacetabular impingement, which is addressed by labral repair and femoral osteoplasty. The most commonly cited reason for failure of arthroscopic treatment of femoroacetabular impingement is under-resection of the cam lesion. Surgeons frequently use evaluations of preoperative images, intraoperative fluoroscopy, and dynamic range of motion to ensure adequate resection. In this article, we describe a reproducible and standardized technique to assist in appropriate resection. This is achieved by a 2-tiered resection technique: Tier 1 aims to set the depth of resection and restore the head-neck offset. Tier 2 then matches the depth of the resection set by tier 1 and allows for retention of appropriate transition of the proximal convexity to the distal concavity seen in more ideally shaped femoral heads. With this technique, we offer a tool to avoid under-resection in the area of maximal conflict while simultaneously minimizing the risk of proximal over-resection and thus compromising the fluid seal dynamics of the joint in deeper flexion angles.

Hip arthroscopy is a technically challenging procedure owing to the unique anatomy of the hip including the bony constraints and thick soft-tissue envelope, which initially limited its use.[1] With recent advancements in surgical instrumentation and an improved understanding of disease processes, the use of hip arthroscopy is growing rapidly, with the number of procedures performed increasing nearly 600% from 2006 to 2014 and 85% from 2011 to 2018.[2,3] The current indications for hip arthroscopy include lavage of a septic joint, removal of loose bodies, repair of symptomatic labral tears, and osteoplasty for femoroacetabular impingement (FAI).[2,4]

FAI is the result of abnormal bony morphology of the proximal femur and acetabulum leading to pathologic contact and shearing of the acetabular labrum and articular cartilage, which is caused by cam morphology of the femoral head-neck junction, pincer morphology of the acetabulum, or a combination of both.[5] Arthroscopic techniques such as femoral osteoplasty for cam lesions and rim trimming of pincer lesions have been developed to restore the normal anatomy with the goal of preventing further damage.[6]

Despite continued advances, failure rates after primary hip arthroscopy as high as 13.2% to 15.1% are reported, leading to rates of revision hip arthroscopy between 3.8% and 4.5%.[7-9] The most commonly reported reason for revision hip arthroscopy in the setting of FAI is inadequate bony resection.[1,10,11] Common strategies to combat under-resection include careful analysis of preoperative images, use of intraoperative fluoroscopy, and evaluation of dynamic range of motion.[12-14] With this technique, we offer a tool to avoid under-resection with a simple, reproducible approach to ensure consistent cam resection to achieve the appropriate head-neck offset (Fig 1).

From University Hospitals of Cleveland, Cleveland, Ohio, U.S.A. (L.H., E.S., G.N., Y.R., M.A., M.S.); and Sentara Healthcare, Harrisonburg, Virginia, U.S.A. (E.S.).

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Address correspondence to Lucas Haase, M.D., University Hospitals of Cleveland, 11100 Euclid Ave, Cleveland, OH 44106, U.S.A. E-mail: lucas.haase@uhhospitals.org

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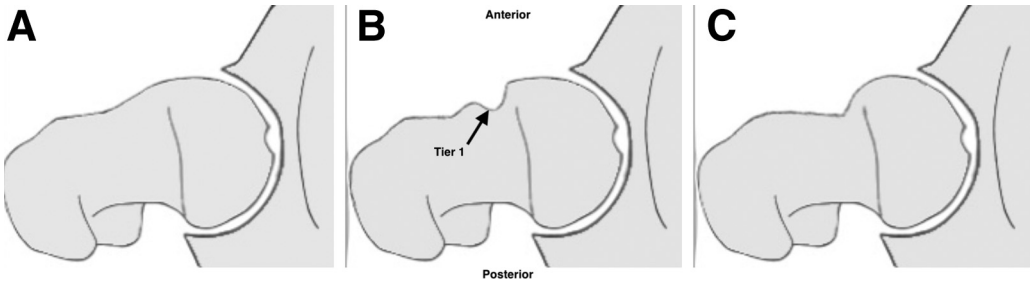

Fig 1. Artistic rendering of the 2-tiered resection of a right hip as seen from the Dunn lateral view. (A) Pre-resection view of the cam lesion. (B) Creation of the tier 1 resection, in which the depth of resection is set to re-create the appropriate head-neck offset. This is performed 1.5 burr lengths distal to the articular cartilage margin. (C) Completion of the tier 2 resection, which resects the cam lesion distal to tier 1 to the same depth and re-creates the sphericity of the femoral head.

Technique

Preoperative Examination

The patient history is reviewed for symptoms consistent with FAI, including hip pain radiating to the groin exacerbated by physical activity and prolonged sitting.[12] Hip range of motion is tested, and a flexion–adduction–internal rotation (FADIR) impingement test is conducted by placing the hip in 90° of flexion, adduction, and internal rotation. A positive test result is indicated by groin pain suggesting impingement of the femoral neck on the anterior rim of the acetabulum.[15,16]

All patients are evaluated with plain radiographs including a weight-bearing anteroposterior radiograph of the pelvis, as well as a false-profile view and a 45° Dunn lateral view of the affected hip. From the Dunn lateral view, the alpha angle, as validated by Barton et al.,[17] is calculated to determine whether a cam lesion is present. Additional attention is directed toward evaluation of the head-neck offset and bony morphology of the proximal femur, as well as acetabular coverage and orientation. For patients with suspected symptomatic FAI, conservative treatment is attempted with physical therapy, nonsteroidal anti-inflammatory drugs, and in some cases, corticosteroid injections.[18] If these measures fail, magnetic resonance imaging is obtained to assess the integrity of the labrum and status of the articular cartilage.

From the Dunn lateral view, a preoperative template is created using a picture archiving and communication system (Healthcare Server IDS7; Sectra Medical). The template begins at the physeal scar, creating a rounded head to match the beta angle and removing the remaining cam distally (Fig 2).

Positioning and Equipment

The patient is placed in the supine position on a post-free hip distraction table (Pivot Guardian Distraction System; Stryker) with a friction pad. The patient's range of motion is again assessed for hip flexion, abduction, and extension. The patient's feet are then placed in well-padded traction boots, and the bony prominences are padded. A timeout is performed to confirm the correct patient, procedure, and surgical site. Traction is applied, and adequate distraction is confirmed with fluoroscopy. The patient is prepared and draped in a sterile fashion, and a marking pen is used to outline the greater tuberosity, anterior superior iliac spine, and approximate incision sites of the anterolateral (AL), midanterior (MA), and distal anterolateral (DAL) portals (Fig 3).

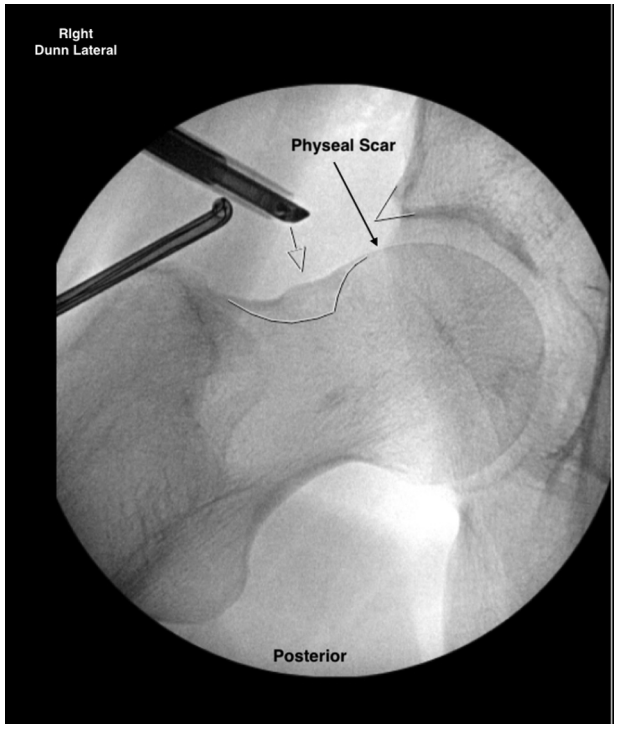

Fig 2. Radiographic imaging of the preoperative template drawn from the Dunn lateral view of a right hip, which is used in the surgical suite to guide resection. The outline shows the plan for resection to begin at the physeal scar, proximally countering to re-create the sphericity of the femoral head as well as to match the alpha angle to the beta angle, which is analogous to the alpha angle performed on the posterior aspect.

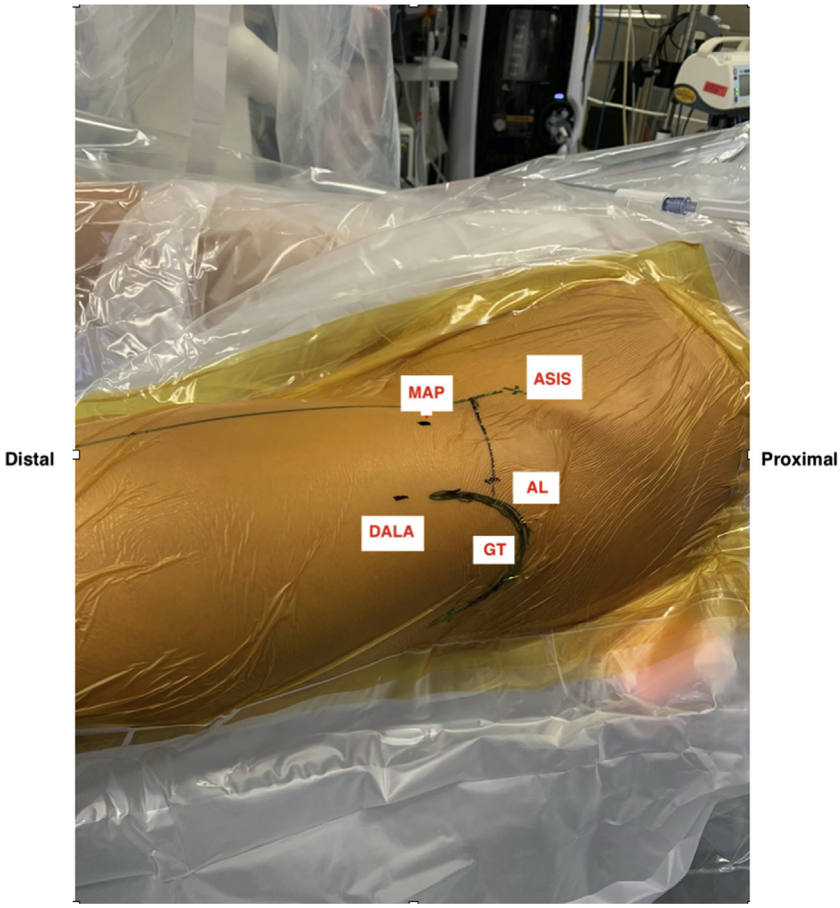

Fig 3. Clinical photograph of the surface landmarks and preoperative markings of the portals to be used during cam resection. This photograph is taken laterally of the left hip with the patient supine on a post-free hip distraction table. The bony landmarks of the anterior superior iliac spine (ASIS) and the greater trochanter (GT) are used as references to create the anterolateral portal (AL), distal anterolateral portal (DALA), and midanterior portal (MAP).

Labral Repair

A standard AL portal is created under fluoroscopic guidance. A 70° arthroscope is inserted, and an MA portal is established using direct visualization. A capsulotomy is performed using an arthroscopic scalpel, followed by a diagnostic arthroscopy to evaluate the integrity of the labrum and chondral surfaces. The labrum is isolated from the proximal capsule, and a plane is developed to expose the acetabular rim. By use of a shaver (4.2-mm HPS Great White Shaver Blade [Pre-bent Concave]; ConMed Linvatec), an acetabuloplasty is performed until a bed of bleeding bone is exposed and resected as indicated by the preoperative plan if pincer impingement is present. The labrum is then repaired with a series of anchors (1.4-mm Pivot Nanotack TT Suture Anchor with 1.2-mm XBraid; Stryker) from posterior to anterior placed from the DAL portal and secured using a standard arthroscopic half-hitch knot technique with either a base refixation technique or looped suture configuration as dictated by labral quality. Once the surgeon is satisfied with the repair, traction is removed and the hip is reduced to evaluate the suction seal.

Resection of Cam Lesion

Resection of the cam lesion is begun with the hip in 30° of flexion and neutral rotation. The distal capsular flap is freed from soft-tissue adhesions to provide mobility. Retention sutures are placed in the distal capsule through the DAL portal and tensioned with an external clamp to optimize exposure without the need for a T-capsulotomy. Direct visualization is used to delineate the articular cartilage margin. The physeal scar is identified under fluoroscopy, indicating the most proximal extent of the resection (Fig 4). Electrocautery (Arthrowand Multivac 50 XL; Smith & Nephew) is used to remove all residual soft tissue distal to the physeal scar for better visualization of the cam lesion.

Using a burr (5.5-mm HPS Pre-bent Spherical Burr; ConMed Linvatec) in the MA portal, the surgeon begins the 2-tiered resection by first placing the burr 1.5 burr lengths distal to the articular cartilage margin. The location of the proximal tier is often noted to begin just a few millimeters proximal to the insertion of the lateral retinacular vessels, which serve as reliable intraoperative landmarks. The tier 1 resection is performed to re-create the native offset and overall depth of resection using fluoroscopy (Fig 5). As the first tier of the resection is deepened to the appropriate depth of offset, the proximal head-neck junction is contoured to achieve sphericity of the femoral head, which minimizes proximal over-resection and maintains the normal transition from convexity to concavity. Gradual deepening of the tier 1 resection in conjunction with

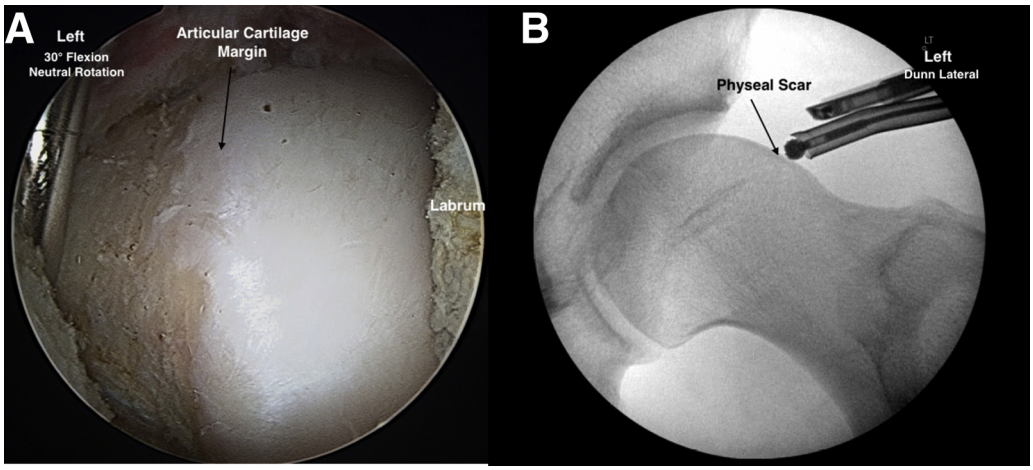

Fig 4. (A) Arthroscopic view of the articular cartilage margin as seen from the distal anterolateral portal with the left hip in 30° of flexion and neutral rotation. The identification of the articular cartilage margin is used as a reference for the tier 1 resection. The tier 1 resection is begun roughly 1.5 burr lengths distal to this margin. (B) Fluoroscopic imaging taken with a 45° Dunn lateral view. This image is used prior to beginning cam resection to confirm the location of the proximal femoral physeal scar. This will be used as the proximal extent of the osteoplasty. In this image, the arthroscopic burr is positioned on the physeal scar.

occasional contouring of the femoral head allows for excellent control of femoral head sphericity while minimizing contouring difficulties that may be encountered if the transition between the proximal femoral head and the initial tier 1 resection is too abrupt.

Once the appropriate depth of the tier 1 resection is established and confirmed with fluoroscopy, attention is directed to the tier 2 resection of the residual cam lesion. A combination of views is used through the AL portal to achieve full resection: the traditional view perpendicular to the neck, as well as an up-the-neck view, obtained by 90° rotation of the camera such that the view is parallel to the neck directed at the head-neck junction. After cam resection is confirmed via direct visualization and fluoroscopy, attention is directed to the remainder of the neck proximal to tier 1 to ensure appropriate sphericity of the head (Fig 5). The preoperative template is used to guide final resection.

Fluoroscopic views of the hip in flexion—external rotation, flexion—neutral rotation, and extension confirm the adequacy of resection of the cam lesion (Fig 6, Video 1). A dynamic hip examination is then performed under direct visualization to ensure that no residual impingement exists. The capsule is closed using nonabsorbable suture in a horizontal mattress configuration. The portal sites are closed with nylon suture.

Discussion

Hip arthroscopy continues to grow in incidence owing to advances in techniques and surgical equipment. Despite advances, failure rates are still reported to be as

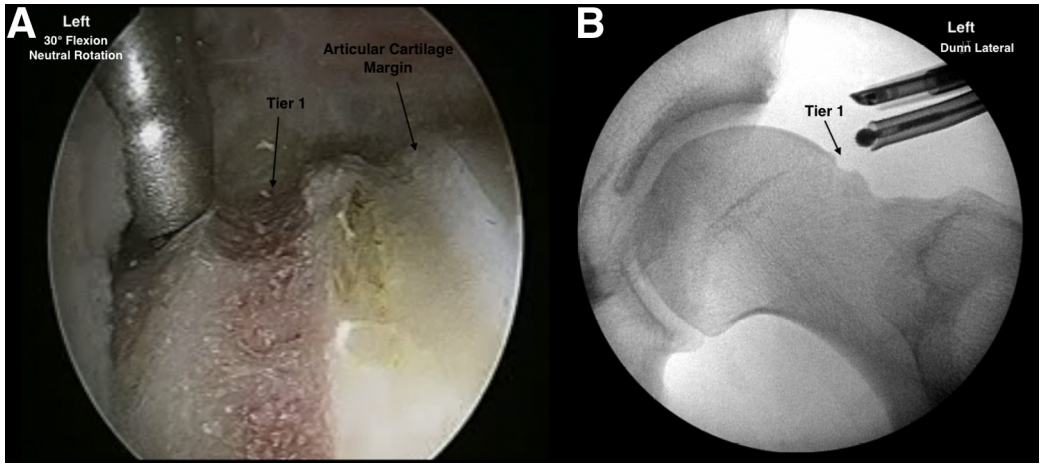

Fig 5. (A) Arthroscopic view after the completion of the tier 1 resection as seen through the distal anterolateral portal with the left hip in 30° of flexion and neutral rotation. This tier creates the depth of resection required to achieve the native head-neck offset. The resection is begun 1.5 burr lengths distal to the articular cartilage margin. (B) Fluoroscopic imaging obtained via a 45° Dunn lateral view after completion of the tier 1 resection to ensure the appropriate depth has been set. The tier 1 resection can be deepened based on imaging to re-create the native offset at the head-neck junction.

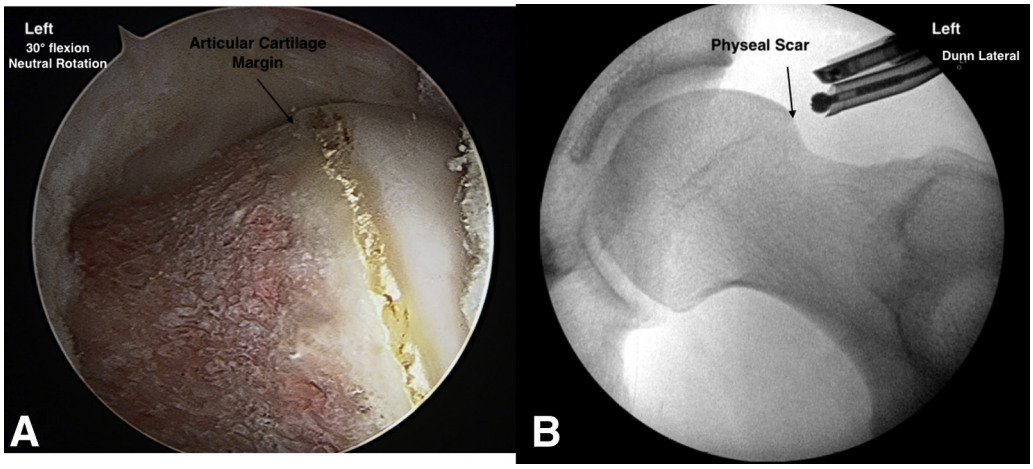

Fig 6. (A) Direct visualization of the completed osteoplasty through the distal anterolateral portal with the left hip in 30° of flexion and neutral rotation. Fluoroscopic imaging, along with evaluation of dynamic hip range of motion under direct visualization, is also used to confirm adequate resection of the cam lesion. (B) Fluoroscopic imaging obtained from a 45° Dunn lateral view of the completed osteoplasty. Direct visualization of the cam during dynamic hip range of motion is used to ensure adequate cam resection.

Table 1. Pearls and Pitfalls for Performing 2-Tiered Resection

Pearls
The technique allows for initial judgment of offset prior to full cam resection.
Maintaining the proximal convexity-to-concavity relation necessitates careful proximal bone removal.
The technique allows for initial restoration of the femoral head-neck offset in the location of maximal impingement and better contouring of proximal bone at the head-neck junction.
Using preoperative imaging and intraoperative fluoroscopy helps to locate the area of maximal impingement.
Changing the leg position and changing the orientation of the fluoroscopy machine to provide a more 3D appreciation of the anatomy aid in creating a successfully contoured head-neck junction in all views.
Use of the operating burr in the reverse setting allows a smooth, consistent resection.
Pitfalls
Too proximal of a start point will prevent re-creation of the round shape of the femoral head.
Overzealous resection of the proximal convexity-concavity position can lead to potential loss of the suction seal in deep flexion, which may alter joint biomechanics.
Not visualizing the osteoplasty in multiple views may not allow for optimal resection or contouring.

3D, 3-dimensional.

Table 2. Risks and Benefits Associated With 2-Tiered Resection Technique

Benefits
Re-creation of a spherical head decreases mechanical impingement in deep flexion.
A systematic approach allows for reproducible results.
Risks
There is a theoretical risk of iatrogenic hip fracture with over-resection due to an aggressive first and second tier depth exceeding 35% of the femoral neck length.
There is potential for under-resection of the posterosuperior extension of the cam deformity if the head-neck junction morphology is not assessed in neutral hip extension.

high as 15%, with reported rates of revision arthroscopy as high as 4.5%, most commonly because of inadequate bony resection of the cam lesion.[1,7-10] We offer a technique that is simple and repeatable to achieve consistent, adequate osteoplasty. The 2-tiered resection offers a systematic approach to cam resection that is now the sole technique used by the senior author (M.S). Although reproducible, this technique remains technically demanding and attention to detail must be maintained throughout to ensure desired results (Table 1). Adherence to preoperative templating, as well as frequent use of fluoroscopy and intraoperative dynamic testing, can guide resection and avoid over-resection. As compared with traditional resection, the 2-tiered resection creates a rounded head with a symmetrical head-neck junction to the beta angle, which provides theoretical benefits in deep flexion (Table 2).

In conclusion, the 2-tiered resection technique provides a universally approachable guide to adequate cam resection. This may reduce the need for revision surgery owing to inadequate bony resection. However, no prospective or retrospective studies to date have examined the incidence of reoperation when using this technique. Therefore, future investigation is necessary to determine reoperation rates when using the 2-tiered resection.

References

1. Ross JR, Larson CM, Bedi A. Indications for hip arthroscopy. *Sports Health* 2017;9:402-413.
2. Bozic KJ, Chan V, Valone FH III, Feeley BT, Vail TP. Trends in hip arthroscopy utilization in the United States. *J Arthroplasty* 2013;28:140-143 (suppl).
3. Zusmanovich M, Haselman W, Serrano B, Banffy M. The incidence of hip arthroscopy in patients with

femoroacetabular impingement syndrome and labral pathology increased by 85% between 2011 and 2018 in the United States. *Arthroscopy* 2022;38:82-87.
4. Lynch TS, Terry MA, Bedi A, Kelly BT. Hip arthroscopic surgery: Patient evaluation, current indications, and outcomes. *Am J Sports Med* 2013;41:1174-1189.
5. Amanatullah DF, Antkowiak T, Pillay K, et al. Femoroacetabular impingement: Current concepts in diagnosis and treatment. *Orthopedics* 2015;38:185-199.
6. Griffin DR, Dickenson EJ, O'Donnell J, et al. The Warwick Agreement on femoroacetabular impingement syndrome (FAI syndrome): An international consensus statement. *Br J Sports Med* 2016;50:1169-1176.
7. Degen RM, Pan TJ, Chang B, et al. Risk of failure of primary hip arthroscopy—a population-based study. *J Hip Preserv Surg* 2017;4:214-223.
8. Malviya A, Raza A, Jameson S, James P, Reed MR, Partington PF. Complications and survival analyses of hip arthroscopies performed in the national health service in England: A review of 6,395 cases. *Arthroscopy* 2015;31:836-842.
9. Cevallos N, Soriano KKJ, Flores SE, Wong SE, Lansdown DA, Zhang AL. Hip arthroscopy volume and reoperations in a large cross-sectional population: High rate of subsequent revision hip arthroscopy in young patients and total hip arthroplasty in older patients. *Arthroscopy* 2021;37:3445-3454.
10. Sardana V, Philippon MJ, de Sa D, et al. Revision hip arthroscopy indications and outcomes: A systematic review. *Arthroscopy* 2015;31:2047-2055.
11. Shapira J, Kyin C, Go C, et al. Indications and outcomes of secondary hip procedures after failed hip arthroscopy: A systematic review. *Arthroscopy* 2020;36:1992-2007.
12. Casp A, Gwathmey FW. Hip arthroscopy: Common problems and solutions. *Clin Sports Med* 2018;37:245-263.
13. Lall AC, Annin S, Chen JW, et al. Achieving a perfectly spherical femoroplasty: Pearls, pitfalls, and optimal surgical technique. *Arthrosc Tech* 2020;9:e303-e313.
14. Beck EC, Chahla J, Krivicich L, et al. Intraoperative automated radiographic visualization tool allows for higher accuracy of cam lesion resection when used by novice surgeons for arthroscopic femoroplasty: Lowering the learning curve. *Arthroscopy* 2022;38:1156-1163.
15. Tibor LM, Sekiya JK. Differential diagnosis of pain around the hip joint. *Arthroscopy* 2008;24:1407-1421.
16. Wong SE, Cogan CJ, Zhang AL. Physical examination of the hip: Assessment of femoroacetabular impingement, labral pathology, and microinstability [published online February 16, 2022]. *Curr Rev Musculoskelet Med*. doi:10.1007/s12178-022-09745-8.
17. Barton C, Salineros MJ, Rakhra KS, Beaulé PE. Validity of the alpha angle measurement on plain radiographs in the evaluation of cam-type femoroacetabular impingement. *Clin Orthop Relat Res* 2011;469:464-469.
18. Mujahed T, Hassebrock JD, Makovicka JL, et al. Preoperative intra-articular steroid injections as predictors of hip arthroscopy: 2-Year outcomes. *Orthop J Sports Med* 2021;9:23259671211053817.