Technical Note

Capsular Management of the Hip During Arthroscopic Acetabular Chondral Resurfacing: Pearls, Pitfalls, and Optimal Surgical Technique

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Abstract: Treatment of hip joint chondral damage is a well-recognized aspect of the arthroscopic management of femoroacetabular impingement syndrome. Hip chondral resurfacing has evolved from microfracture to different forms of cartilage grafting, all with variable long-term outcomes. Recent literature has focused on techniques using different cartilage sources (native and synthetic products) that are available for clinicians to choose from during hip arthroscopy. None of the published reports on cartilage grafts have commented on hip joint capsular management as part of the procedure. This is likely because of the increased difficulty of capsular closure in the dry arthroscopic environment required for graft stabilization. However, potential iatrogenic hip instability induced by an unrepaired interportal capsulotomy can be detrimental to the existing joint architecture and possibly to the cartilage graft. This article presents a step-by-step approach, including tips and pearls, for capsular closure during arthroscopic acetabular chondral resurfacing with BioCartilage (Arthrex, Naples, FL). This method is a safe and reproducible way to close the joint capsule during chondral resurfacing in patients undergoing hip preservation that can potentially enhance the chances of a successful outcome.

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The arthroscopic management of focal chondral lesions of the hip has evolved in an attempt to alleviate symptoms and mitigate progressive chondrolabral damage while treating femoroacetabular impingement syndrome (FAIS).[1-3] This evolution has included abrasion chondroplasty,[4] microfracture,[5] fibrin adhesive for partly detached acetabular cartilage flaps,[6] mononuclear cell concentrate with platelet-rich plasma,[7] various types of autologous cartilage grafts,[8-13] and synthetic matrix substances,[14,15] among other hip preservation techniques. In earlier reports, the underlying surgical principles consistently aimed at debriding the loose cartilage fragments from the defect bed and creating stable margins.[16] The bleeding subchondral bone from microfracture holes in the defect bed helped release bone marrow mesenchymal stem cells and pertinent growth factors. This resulted in fibrocartilage filling the defect, with a potential for symptomatic relief.[5,16] However, the long-term efficacy of this surgical technique remains in question.[17,18]

The current literature on arthroscopic chondral resurfacing focused on using native hip joint cartilage[8-13] has shown promising mid-term outcomes.[9,13] This was accomplished either in the same sitting during arthroscopic treatment of FAIS or in a staged manner with cultured autologous chondrocytes. Recent reports have chosen to use readily available synthetic products such as BioCartilage (Arthrex, Naples, FL) as a viable alternative.[19-26] BioCartilage is a synthetic cartilage graft that supplies the much-needed matrix substances such as proteoglycans, type II collagen, and relevant growth factors.[27] This synthetic scaffold, when mixed with autologous blood solutions such as bone marrow aspirate concentrate (BMAC) or conditioned leukocyte-reduced platelet-rich plasma, is known to enhance chondrogenesis in the microfracture defect bed, resembling articular cartilage.[19-26] However, the optimal technique and protocol for construct adherence and clot stability are yet to be established.[28]

None of these published reports on hip arthroscopic cartilage resurfacing have mentioned any details of capsular management as part of the procedure.[6,8,10-13,22] The cartilage graft requires a dry arthroscopic environment to stabilize at the end of the procedure, and with existing methods,[22] this step has precluded proper visualization and handling of the hip joint capsulotomy. This article presents a step-by-step approach, including tips and pearls, for capsular management during arthroscopic acetabular chondral resurfacing with BioCartilage. This method is a safe and reproducible way to close the joint capsule during chondral resurfacing in patients undergoing arthroscopic hip preservation surgery.

Indications, Patient Evaluation, and Imaging

The hip pain significantly limits the patient's activities of daily living and is unresponsive to conservative treatment. Clinical examination findings are positive for hip impingement. Radiographically, there is a large cam morphology in the hip with an alpha angle of 76° (Fig 1A). The hip is graded as Tönnis grade 1 owing to evidence of subchondral cysts. A magnetic resonance arthrogram (SAG PD) image depicting a large subchondral acetabular cyst is shown in Figure 1B.

Surgical Technique

Patient Preparation and Positioning

After induction of general anesthesia, the patient is placed in the modified supine position on a traction extension table (Smith & Nephew, Andover, MA) with a well-padded peroneal post, the genitalia protected, and the feet well secured.[29] The hip and the contralateral iliac crest are prepared and draped in usual sterile fashion. Traction is applied to the hip under fluoroscopy.

Fluoroscopy Technique

The C-arm is positioned on the nonoperative side and draped in sterile fashion. A true anteroposterior radiograph of the pelvis is obtained by tilting the C-arm to compensate for the Trendelenburg inclination.[29] Under fluoroscopy, the joint seal is broken, and traction is applied.

Portal Placement

A spinal needle is introduced into the joint under fluoroscopy, and the joint is vented, achieving further distention. The anterolateral portal is created with a No. 11 blade. The spinal needle is reinserted to ensure avoidance of the labrum and femoral head. An over-the-guidewire technique is used to place a 70° arthroscope through the 4.5-mm cannula. This same technique is repeated to place a 5-mm cannula through the mid-anterior (MA) portal. A Beaver blade (BVI Medical, Waltham, MA) is used to perform an interportal capsulotomy, incising the capsule parallel to the acetabular rim to connect the 2 portals. An additional distal anterolateral accessory (DALA) portal is made to provide a better angle for capsular elevation and during capsular closure.

Diagnostic Arthroscopy

Diagnostic arthroscopy of the left hip is then performed, which will confirm the presence of a labral tear (Fig 2A). A grade 4 acetabular labrum articular disruption (ALAD) and (Outerbridge 4)[30] acetabular cartilage lesion, measuring, for example, 3.0 cm^2 in the 12- to 2-o'clock zone, and an adjoining grade 3 (ALAD) and (Outerbridge

grade 3) acetabular cartilage lesion, measuring 1.0 cm^2 in the 2-o'clock to 2:30—clock face zone, can be found (Fig 2 B and C) adjacent to areas of the known subchondral cyst noted on magnetic resonance arthrogram images that is fixated.

Arthroscopic Acetabular Notchplasty, Microfracture, and Subchondral Cyst Decompression

Next, acetabular notch osteophytes are debrided with an arthroscopic shaver (Fig 3). In the area of subchondral cystic degeneration with cartilage damage, a ring curette is used to create sharp margins at the edges of the chondral defect and to denude the subchondral bone of soft tissue (Fig 4 B and C). Then, microfracture of the acetabulum is performed using the MicroFX drill (Stryker, Kalamazoo, MI), creating drill holes 4 mm apart in the bed of the cartilage defect (Fig 4D).[16] A 45° microfracture awl and a curved arthroscopic shaver are used to decompress and excise cystic material from the overlying subchondral cyst under fluoroscopic supervision. By use of arthroscopic suction on the shaver, the debris from the decompressed cyst and microfracture drilling is cleared and bleeding subchondral bone is confirmed with the irrigation stopped (Fig 4E).

Arthroscopic Labral Repair and Femoroplasty

Labral repair is undertaken using the looped stitch technique. A total of 4 anchors (1.8-mm knotless FiberTak; Arthrex) are placed. Excellent refixation of the labrum is achieved in this fashion (Fig 5). Then, the arthroscope and the curved shaver are moved into the peripheral compartment as the traction is released and the hip is flexed to 45°. Next, femoroplasty is performed using a 5.5-mm burr to adequately resect cam impingement under fluoroscopic guidance (Fig 6).[31]

Bone Marrow Harvest and Cartilage Graft Substitute Material Preparation

By use of the Angel BMAC system (Arthrex), the contralateral iliac crest region is accessed for bone marrow harvest. The harvesting cannula is impacted between the inner and outer tables of the iliac crest, and the inner stylus of the cannula is removed. Two 30-mL syringes, pretreated with 5 mL of acid-citrate-dextrose formula A, are secured to the cannula, and bone marrow harvest aspiration is performed to fill both syringes. Once the harvest is complete, both syringes are connected to the Angel system (Fig 7A). The processing time to obtain the concentrate from 60 mL of aspirate is approximately 17 minutes. Next, the cartilage graft compound is prepared on the back table by combining the cell concentrate and the dehydrated scaffold (BioCartilage) in a 1:0.8 scaffold—to—BMAC volume ratio within the mixing syringe until the mixture has the consistency of dry paste. In the meantime, the microfracture site is prepared under traction with irrigation turned off and the joint thoroughly sucked dry of fluid in preparation for graft placement (Fig 4E).

Preparation for Capsular Closure and Suture Management

Before BioCartilage grafting proceeds, the capsulotomy is prepared for anatomic closure by passing 4 sets of No. 1 Vicryl sutures (Ethicon, Somerville, NJ) in an oblique fashion to aid plication (Fig 8). The

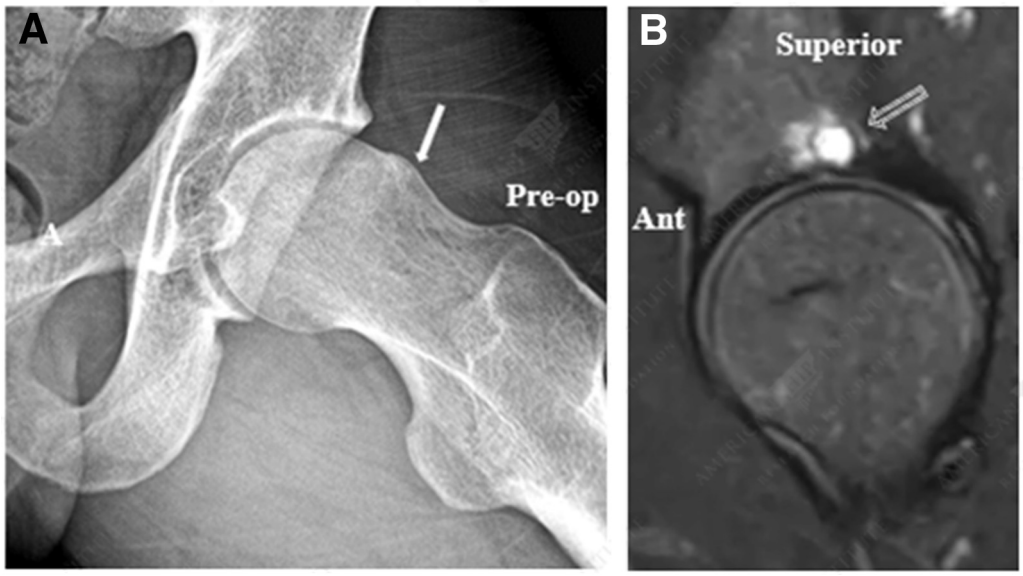

Fig 1. (A) Preoperative (Pre-op) plain radiograph of left hip, Dunn lateral view, showing large cam morphology (arrow) with acetabular cysts. (B) Magnetic resonance arthrogram (sagittal proton density plain radiograph) image depicting large subchondral acetabular cyst (arrow). A left hip is shown with the anterior (Ant) and superior aspects marked for orientation.

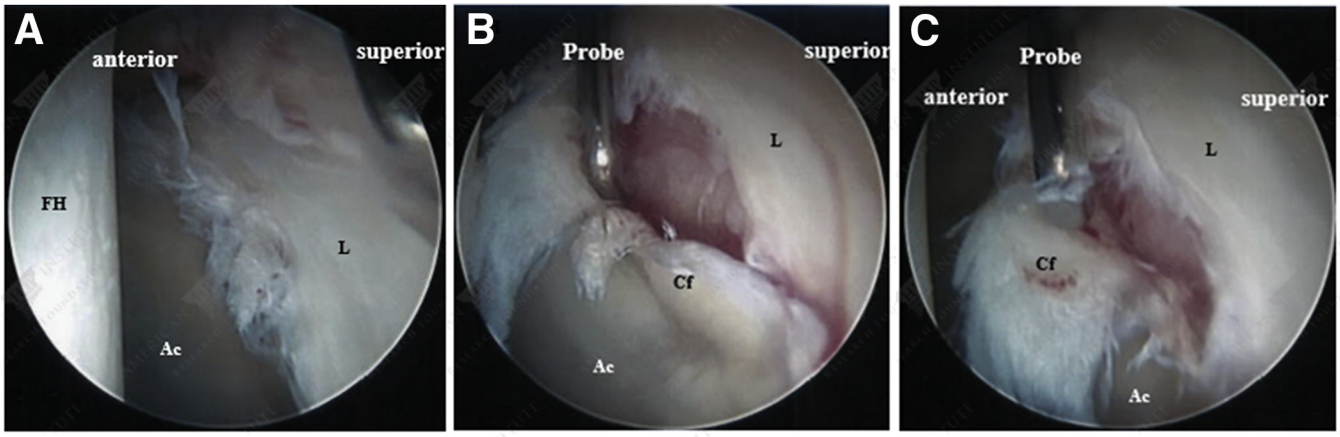

Fig 2. Arthroscopic images of left hip. (A) Chondrolabral separation with adjoining labral tear. (B-C) Grade 4 acetabular labrum articular disruption (ALAD) and (Outerbridge grade 4)—acetabular cartilage lesion measuring, for example, 3.0 cm^2 in 10- to 1-o'clock zone and an adjoining grade 3 acetabular labrum articular disruption (ALAD) and (Outerbridge grade 3)—acetabular cartilage lesion measuring 1.0 cm^2 in 1-o'clock to 2:30—clock face zone; can be found, adjacent to areas of known subchondral cystic regions noted on magnetic resonance images. A left hip is shown with the anterior and superior aspects marked for orientation. (Ac, acetabular cartilage; Cf, chondral flap; FH, femoral head; L, labrum.)

disposable cannulas are placed in the MA and DALA portals. The bite size and number of sutures are tailored to produce appropriate anatomic tension on the capsule. The sutures exiting the proximal limb of the capsulotomy (adjacent to the acetabular margin) are kept short to be used as posts, and the opposite ends of the sutures exiting the distal limb of the capsulotomy are left long (throwing strands) for knot tying (Fig 9B). The 2 sets of sutures fixing the anteromedial half of the capsulotomy are drawn through the MA portal, and the other 2 suture sets fixing the posterosuperior half of the capsulotomy are drawn through the DALA portal (Fig 10B). To distinguish the sutures between the 2 sets in each cannula, 1 pair (post and corresponding throwing strand) is colored dark with a marking pen to facilitate appropriate anatomic closure of the joint capsule in a blind manner toward the end of the procedure (Fig 9).

Filling of Acetabular Chondral Defect With BioCartilage and Fixation With Thrombin

The joint is sucked dry, and the graft delivery cannula is inserted along the acetabular face. The cartilage defect bed that is prepared by microfracture drilling and chondroplasty is kept dry and receptive (Fig 8B). The cartilage substitute paste (BioCartilage) is then injected into the cartilage defect and microfracture areas using the curved delivery cannula under direct arthroscopic

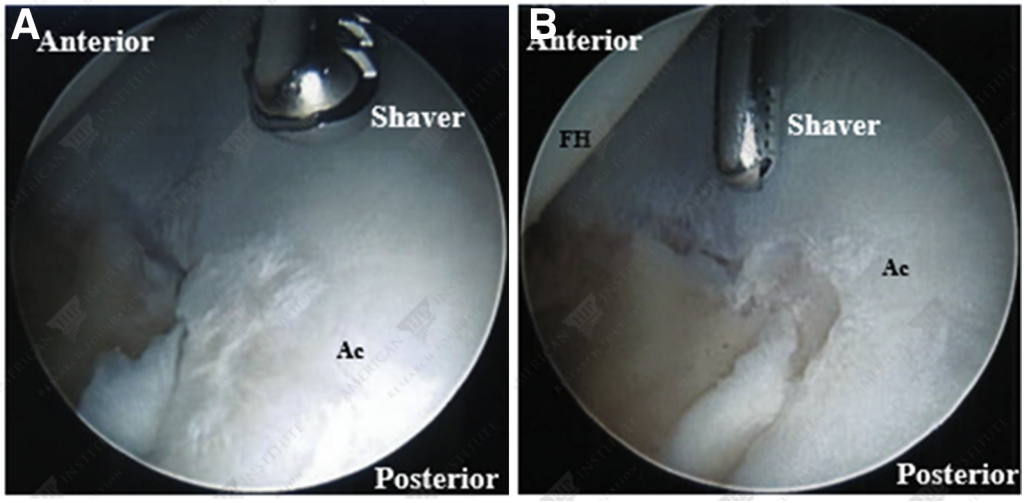

Fig 3. Arthroscopic images of left hip. (A) Acetabular notch osteophytes before being debrided with arthroscopic shaver. (B) Notchplasty. (Ac, acetabular cartilage; FH, femoral head.)

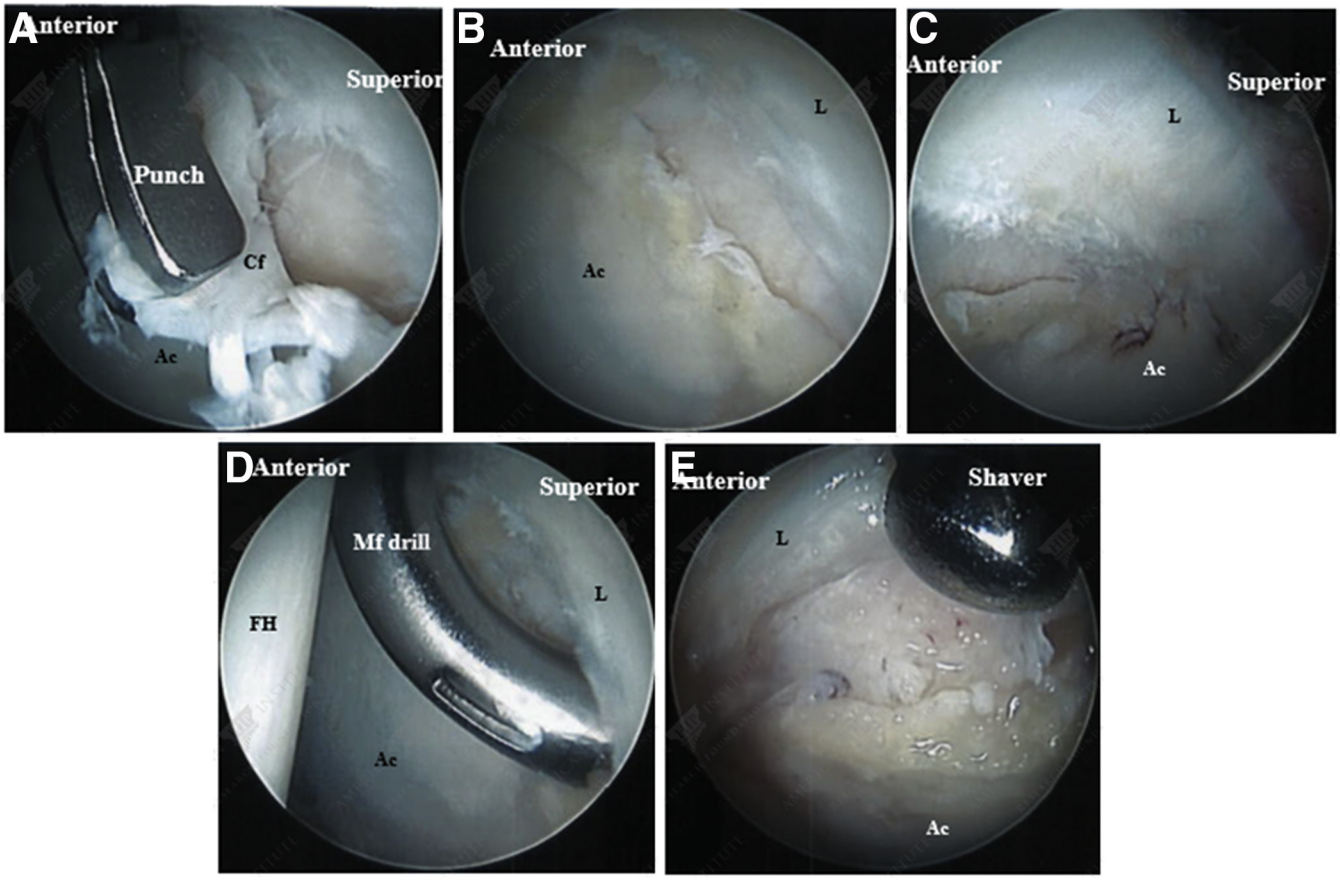

Fig 4. Arthroscopic images of left hip. (A) Loose and unhealthy chondral flap being trimmed with arthroscopic biter (punch). (B, C) The chondral defect and adjoining chondrolabral junction are prepared with debridement and abrasion chondroplasty. (D) Microfracture of the acetabular cartilage defect is performed using the MicroFX drill. (E) Microfracture drill holes are created 4 mm apart in the cartilage defect bed and then dried with arthroscopic shaver suction in the superior aspect of the joint, removing debris and decompressed cystic fluid, in preparation for receiving BioCartilage graft. A left hip is shown with the anterior and superior aspects marked for orientation. (Ac, acetabular cartilage; Cf, chondral flap; FH, femoral head; L, labrum; Mf, microfracture.)

view in a dry, intra-articular environment (Fig 10 A-C). The BioCartilage graft is spread evenly across the defect using a spatula and is made flush or slightly recessed and less proud than the native surrounding cartilage.[32] The BioCartilage graft is then stabilized and fixated with thrombin (Fig 10D) using an autologous thrombin

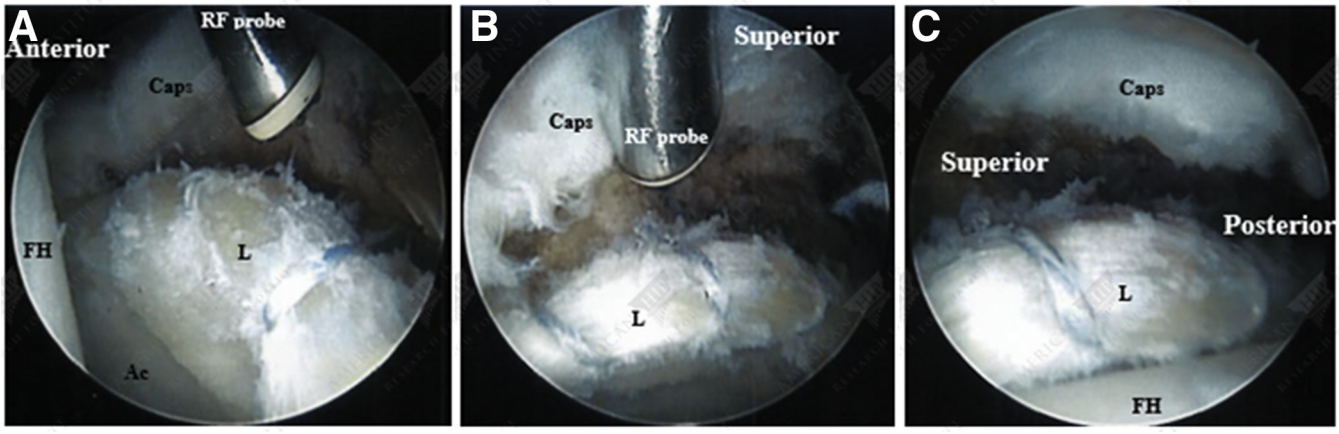

Fig 5. Arthroscopic images of left hip. (A, B) Completed labral repair. (C) Release of hip traction verifying labral suction seal. A left hip is shown with the anterior, posterior, and superior aspects marked for orientation. (Ac, acetabular cartilage; Caps, capsule; FH, femoral head; L, labrum; RF, radiofrequency ablation.)

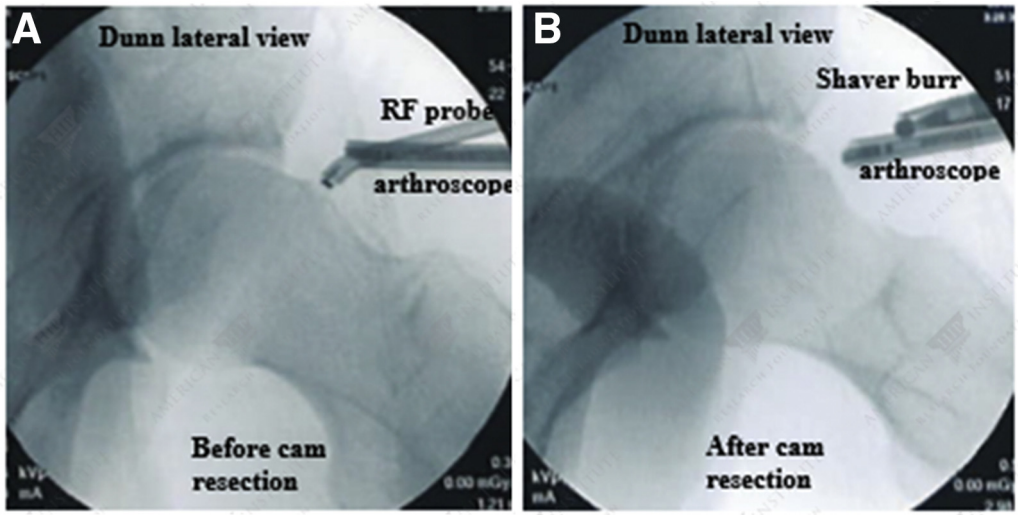

Fig 6. Fluoroscopy images of left hip. (A, B) Arthroscopic femoroplasty is performed using a 5.5-mm burr to remove cam impingement under direct fluoroscopic visualization. Adequate resection is verified via use of the Stryker HipMap and HipCheck system before proceeding with BioCartilage grafting. (RF, radiofrequency ablation.)

system (Thrombinator; Arthrex) (Fig 7 B-D, Video 1). To allow adequate graft stabilization, the joint environment is left undisturbed for a few minutes before releasing traction from the joint, restoring the labral seal, and compressing the graft.

Capsular Closure

The capsular repair is then completed with the sutures that are already passed and kept ready for knot tying to produce appropriate anatomic tension on the capsule. To recap, during the preparation for capsular closure, alternate Vicryl suture strands (size No. 1) are colored dark (2 of 4 sets) for easy identification (Fig 9). By separating the 4 set of sutures into 2 sets each, brought out through the MA portal (anteromedial set of 2 capsular sutures) and the DALA portal (posterolateral set of 2 capsular sutures), easy suture management is facilitated without entanglement (Fig 9B). Knot tying is performed sequentially with a sliding-locking type of knot, with the short strand exiting the proximal limb of the capsulotomy treated as post in each suture set (Fig 9B). The distal limb of the capsulotomy is approximated onto the proximal limb, and knots are laid close to the acetabular margin, maintaining tension during capsular repair (Fig 9C). The capsular preparation and suture management are performed beforehand in anticipation of completing capsular closure successfully after BioCartilage grafting without irrigation to avoid disturbing the graft bed.

All instruments are withdrawn from the joint. The portals are closed using No. 3-0 nylon sutures. Steri-Strips (3M, St Paul, MN) and sterile dressings are

Fig 7. Angel system. (A) Front and side view. The bone marrow aspirate is injected into the rightmost bag (whole blood in), and the automated process starts dividing the different blood components. First, the platelet-poor plasma is discarded in the leftmost bag (platelet-poor plasma out). Then, the bone marrow aspirate concentrate (BMAC) rich in platelet-rich plasma is collected in the syringe on top of the system, and finally, the red blood cells are collected in the middle bag. The length of this process depends on the quantity of bone marrow aspirate used. In this case, it was approximately 17 minutes for 60 mL of aspirate. The BMAC obtained from the Angel system is mixed with BioCartilage graft until the result is a thick paste inserted in a syringe. (B, C) The Thrombinator device is used with the Angel BMAC system for the preparation of autologous serum from anticoagulated peripheral blood. (D) The resultant thrombin serum is mixed with the platelet-rich plasma and BioCartilage graft prior to application to the cartilage defect for improved handling characteristics.

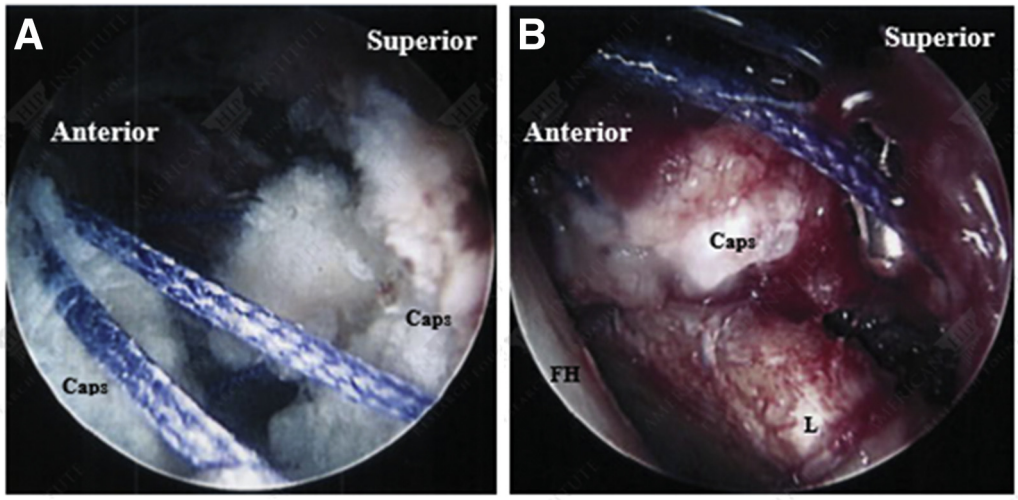

Fig 8. Arthroscopic images of left hip. (A) Capsular sutures placed prior to BioCartilage, under normal arthroscopic conditions with irrigation to avoid graft bed disruption. (B) Dry view without irrigation showing capsular sutures, after BioCartilage placement, prior to capsular closure. A left hip is shown with the anterior and superior aspects marked for orientation. (Caps, capsule; FH, femoral head; L, labrum.)

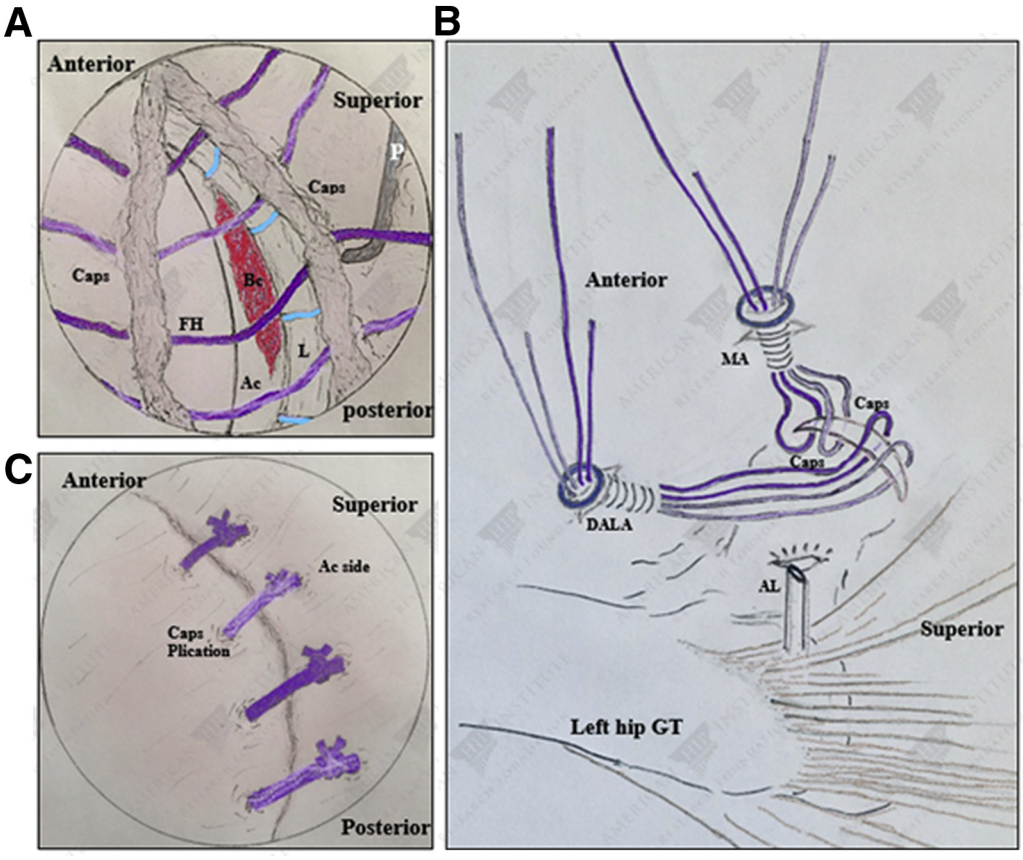

Fig 9. Artistic rendering of arthroscopic and surgical images of left hip. (A, B) Arthroscopic and surgical views of left hip capsular suture management. The alternate suture strands for capsular repair are colored dark (2 of 4 sets) for easy identification. The anteromedial set of capsular sutures (×2) is brought out through the cannula in the midanterior (MA) portal. The posterolateral set of capsular sutures (×2) is brought out through the cannula in the distal anterolateral accessory (DALA) portal. In each suture set, the short strand exits the proximal limb of the capsulotomy and is treated as post, in preparation for knot tying. (C) Completed interportal capsulotomy closure after arthroscopic knot tying performed with hip off traction, with dry hip joint without irrigation and arthroscopic camera removed. A left hip is shown with the anterior, posterior, and superior aspects marked for orientation. (Ac, acetabular cartilage; AL, anterolateral; Bc, BioCartilage; Caps, capsule; FH, femoral head; GT, greater trochanter; L, labrum; P, probe.)

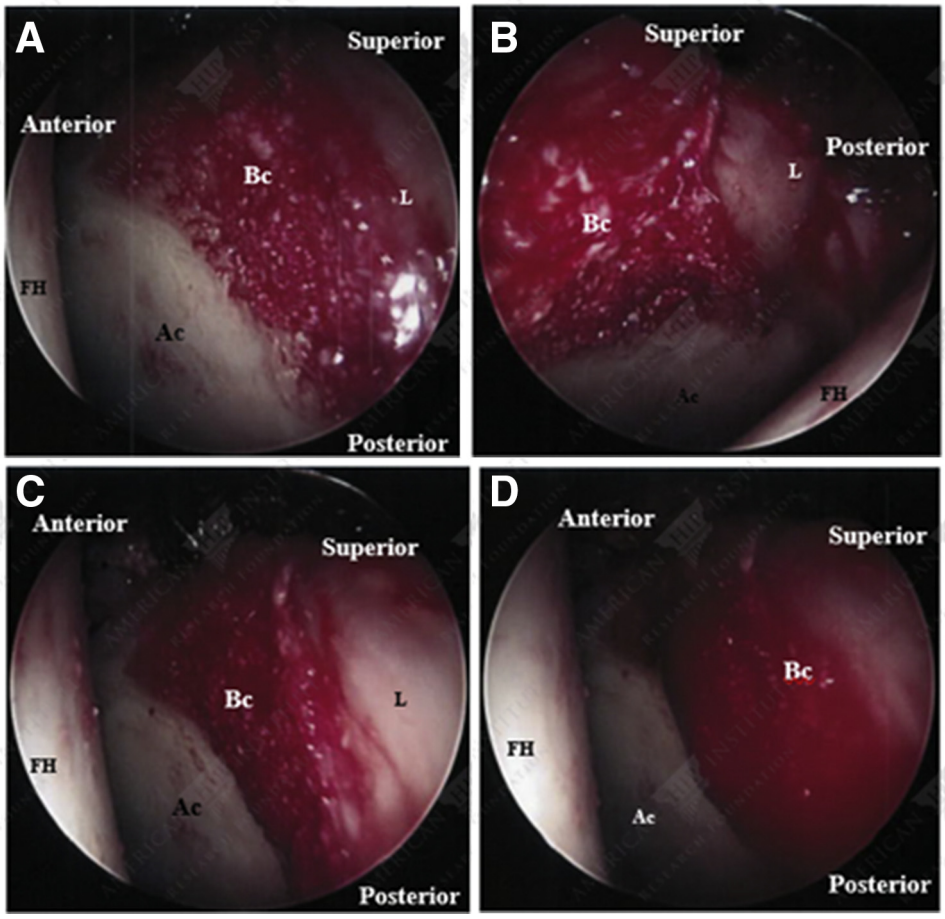

Fig 10. Dry arthroscopic images of left hip. (A-C) Multiple bird's-eye views of well-placed BioCartilage graft combined with autologous bone marrow aspirate concentrate mixture filling defect bed. (D) Final dry arthroscopic image depicting BioCartilage graft stabilized with Thrombin prior to release of hip traction. A left hip is shown with the anterior, posterior, and superior aspects marked for orientation. (Ac, acetabular cartilage; Bc, BioCartilage; FH, femoral head; L, labrum.)

applied, and the hip is placed in a hip brace, locked in 0° to 90° of flexion. The patient is safely awakened, extubated, and taken to the recovery room in stable condition. The patient is advised to remain partially weight bearing (20 lb) on the operative extremity with crutches for 8 weeks while continuing to use the hip brace for postoperative stability for the initial 2-week period. Physical therapy is started the day after surgery.

Discussion

This Technical Note describes our preferred method for capsular management after hip arthroscopic chondral resurfacing with microfracture drilling and BioCartilage augmentation as part of FAIS treatment.[22] Arthroscopic management of hip joint chondral damage has evolved from microfracture to cartilage grafting, with all methods showing variable long-term outcomes.[9,13] The recent literature on hip joint arthroscopic chondral resurfacing has focused on techniques using different cartilage products that are available for clinicians to choose from. Several reports on chondral resurfacing have focused on different sources of cartilage graft in the knee, shoulder, and hip. Furthermore, multiple publications in the hip literature have mentioned autologous cartilage grafts[8-13] harvested from either the acetabular fossa (pulvinar area) or femoral head-neck junction, close to the cam morphology. In addition, a reasonable number of studies have reported using synthetic matrix substances[14,15] inducing chondrogenesis as a single-stage procedure or as a staged procedure using the harvested autologous chondrocytes as described earlier.

Recently, multiple short-term outcome studies have been published quoting superior results when microfracture is augmented with synthetic matrix substances (BioCartilage in particular) resulting in hyaline-like cartilage repair in the knee, ankle (talus), and

Table 1. Indications and Contraindications for Capsular Closure After Hip Arthroscopic BioCartilage Grafting

Indications
Interportal capsulotomy or T-capsulotomy
Known microinstability or macroinstability of hip
Cartilage graft protection
Contraindications
Severe adhesions
Stiff hip with severely limited range of motion
Revision scenario with capsular defect in which capsular reconstruction is indicated

Table 2. Advantages and Disadvantages of Capsular Closure After Hip Arthroscopic BioCartilage Grafting

Advantages
Avoids iatrogenic instability
Restores normal joint anatomy
Protects graft integrity from extracapsular environment
Addresses cases of coexisting microinstability
Disadvantages
Has increased operative time
Is technically demanding procedure with steep learning curve
Has potential for complications inherent to hip arthroscopy

Table 4. Risks and Limitations of Capsular Closure After Hip Arthroscopic BioCartilage Grafting

Risks
Risk of suture strand entanglement, air knot, and/or breakage
Inadequate capsular tension
Failure to complete closure
Limitations
Lack of visibility
Blind knot-tying technique
Potential for incomplete closure and plication

shoulder.[19-21,23-25] Recently, arthroscopic chondral resurfacing with microfracture and BioCartilage augmentation has been described for the treatment of focal chondral defects of the acetabulum.[22,26] This is usually performed in combination with FAIS treatment as an adjunct to arthroscopic hip preservation.[22] BioCartilage contains dehydrated, micronized allogeneic cartilage extracellular matrix rich in type II collagen, proteoglycans, and additional growth factors. BioCartilage serves as a scaffold over the microfracture defect, providing a tissue network that can potentially signal autologous cellular interactions between clot marrow elements in the defect bed, promoting growth and chondrogenic differentiation.[33] Previous reports have described the use of fibrin sealant to protect the graft while avoiding a proud state of the graft filling the defect with a "recessed" technique.[28,32] Instead, we prefer to stabilize the graft (BioCartilage) with an autologous activation serum produced by the autologous thrombin system (Thrombinator) to improve the handling of the cartilage graft. However, the optimal technique and protocol for construct adherence and clot stability are yet to be established[28] and beyond the scope of this study.

Table 3. Pearls and Pitfalls During Capsular Closure After Hip Arthroscopic BioCartilage Grafting

Pearls
Capsular suture placement is performed under direct visualization with irrigation, prior to grafting.
Sutures exiting the proximal limb of the capsulotomy are kept short and treated as post, whereas sutures exiting the distal limb of the capsulotomy are kept long as throwing strands.
Alternate suture strands are colored dark with a marking pen for easy identification within the same portal.
Appropriate suture management must be maintained, with anteromedial sets of capsular sutures brought out from the MA portal and posterolateral sets of sutures brought out from the DALA portal to avoid entanglement.
After grafting with traction released, capsular closure commences sequentially without disturbing the intra-articular environment.
Sutures must be tied blindly, with only the feel of the knot pusher against the capsular tissue.
Pitfalls
Improper suture color coding for medial to lateral set identification
Failure to pre-identify post and non-post suture ends
Entanglement of adjacent sutures during blind knot tying with joint dry
Suture breakage during knot tying
Air knots placed mistakenly during knot-tying procedure, leading to poorly approximated capsular closure
Attempting to re-engage arthroscopic visualization with irrigation, leading to disruption of chondral grafting

DALA, distal anterolateral accessory; MA, midanterior.

None of the published reports on arthroscopic hip chondral resurfacing have commented on hip joint capsular closure at the end of the procedure. This is likely because of the increased difficulty of capsular closure in the dry arthroscopic environment required for graft stabilization. With the existing methods, this step has precluded proper visualization and handling of the hip joint capsulotomy. Most of the chondral grafting methodology has come from the knee, ankle (talus), and shoulder literature.[19-21,23,24,34,35] However, the potential instability induced by interportal capsulotomy without closure[36,37] can be detrimental to the existing joint architecture and possibly to the cartilage graft construct adherence and clot stability. Capsular plication in the hip joint is of paramount importance to minimize microinstability[38,39] and can potentially enhance the chance of a successful outcome after chondral resurfacing with autograft or allograft cartilage.

Capsular closure is a vital step in arthroscopic acetabular chondral resurfacing with BioCartilage with potential advantages that can positively influence patient outcomes. We believe this is a safe and easily reproducible method when performed using the proper technique, described in this article with a step-by-step approach, including tips and pearls for capsular management. Additionally, arthroscopic labral repair, acetabuloplasty, femoroplasty, and capsulorrhaphy were performed, addressing the coexisting pathologies in our patient's hip. There are some contraindications for this technique, as well as a few disadvantages, pitfalls, risks, and limitations, that have been addressed in Tables 1 through 4. Capsular management during arthroscopic acetabular chondral resurfacing with BioCartilage is an important step during hip preservation surgery. The described technique addresses the potential instability from an unrepaired capsulotomy that would mechanically compromise an already injured hip joint. This procedure has the potential to be used as an

adjunct during arthroscopic hip preservation surgery with chondral resurfacing to enhance the chances of a successful outcome.

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