

Use of Bone Marrow Aspirate Concentrate with Acetabular Labral Repair for the Management of Chondrolabral Junction Breakdown



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Abstract: Despite advances in techniques for acetabular labral repair, strategies for mitigating or reversing damage to the chondrolabral junction do not yet exist. Cartilage repair techniques such as autologous chondrocyte implantation, matrix-induced autologous chondrocyte implantation, osteochondral autograft transfer, microfracture, and bone marrow aspirate concentrate (BMAC) have all been suggested to restore joint congruity and minimize further chondral deterioration. However, chondrocyte implantation techniques and osteochondral grafts are technically challenging in the hip because of its constrained nature, and many cell-based therapies have shown suboptimal results near the chondrolabral junction because of the increased shear forces at the peripheral acetabulum and increased stress at the weight-bearing region of the joint. By using BMAC to augment labral repairs and coat chondrolabral junction breakdown, we are able to introduce mesenchymal stem cells to peripheral acetabular tissue with little to no drawbacks, while avoiding donor-site morbidity, open procedures, and multiple surgeries. The purpose of this Technical Note is to describe a reproducible method for harvesting, processing, and applying BMAC to the chondrolabral surface of the hip during hip arthroscopy without the need for donor-site morbidity or increased labral repair time.

Femoroacetabular impingement is a well-known cause of damage to the acetabular labrum and chondrolabral junction.¹ Additionally, it has been proposed that disruption of hip biomechanics resulting from a labral tear causes a faster progression toward osteoarthritis.^{2,3} This progression has been observed to begin with breakdown of the chondrolabral junction, with later development of diffuse osteoarthritis. Use of hip arthroscopy has increased dramatically in recent years to treat symptomatic labral tears and potentially avoid the morbidity and cost associated with hip osteoarthritis.^{4,5} Despite the advances in techniques

for labral repair, strategies for mitigating or reversing damage to the chondrolabral junction do not yet exist.

Peripheral acetabular cartilage defects and chondrolabral junction breakdown present some of the most challenging clinical problems for orthopaedic surgeons because of the region's limited intrinsic healing capacity, increased shear forces, high load-bearing responsibilities,

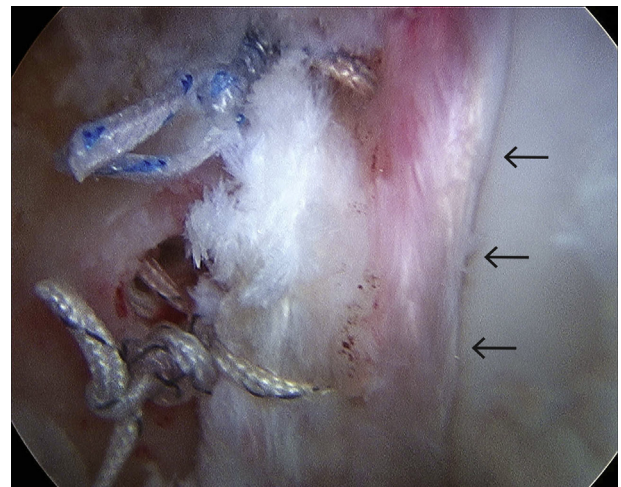


Fig 1. Right acetabular labral repair showing an “in-round” labral seal (arrows) with the femoral head reduced into the acetabulum, as viewed through the anterolateral portal.

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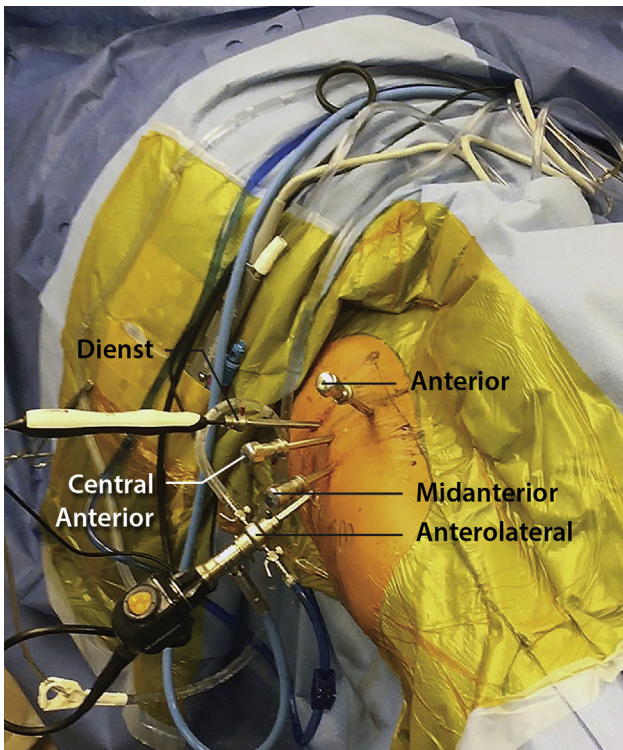


Fig 2. Right hip arthroscopy portals are placed in a quadrilateral arrangement (black), as seen with the patient's head above the portal placement and the feet below. The central anterior portal (white) is placed cephalad to the midanterior portal, directly between the anterior and anterolateral portals. This portal allows the bone marrow aspiration needle insertion site to reach proximal to the sourcil and approximately 60° to the bone's surface.

and technical constraints. In recent years, bone marrow aspirate concentrate (BMAC) has shown promising results for the treatment of chondral insults,⁶⁻⁸ but reliable techniques and surgical outcomes have not yet been established for chondrolabral junction breakdown. The purpose of this Technical Note is to describe a reproducible method for harvesting, processing, and applying BMAC to the chondrolabral surface of the hip

during hip arthroscopy without the need for donor-site morbidity or increased labral repair time.

Surgical Technique

Surgical Approach

Once adequate intra-articular visualization of the lesion is achieved, acetabular labral repair is performed using a chondrolabral junction preservation technique (Fig 1, Video 1).⁹⁻¹¹ Following labral repair, a central anterior portal is established for the bone marrow aspiration needle. This portal is located superior to the midanterior portal, directly between the anterior and anterolateral portals (Fig 2). While working through the central anterior portal and viewing through the anterolateral portal, the bone marrow needle insertion site can be identified on the ilium, approximately 1 to 2 cm proximal to the superior suture anchors (Table 1).

This site is at the level of or proximal to the sourcil and laterally adjacent to the reflected head of the rectus femoris origin (Fig 3). The 15-gauge Jamshidi bone marrow biopsy aspiration needle (T-handle Jamshidi, Becton, Dickinson and Company, Franklin Lakes, NJ) is placed 60° to the bone's surface to avoid compromising the pelvic cavity upon insertion; location is further verified by direct visualization and fluoroscopy before insertion. Depending on the patient and subsequent angle of the aspiration needle against the bone, the Dienst portal may also be used a working portal for the aspiration needle to achieve the correct trajectory for bone marrow harvest. Next, the needle is driven through the bone's cortex by tapping the aspiration needle handle with a mallet; periodic trajectory confirmation with fluoroscopy is performed concurrently (Table 1). Once the cortex has been breached, the needle is guided approximately 0.5 to 1 cm further with constant pressure and a simultaneous back and forth rotation. The reduction of resistance will be noticed as the needle enters the cancellous bone marrow space; final confirmation of needle tip location is achieved with fluoroscopy (Fig 4). Next, the stylette is removed from the needle and a heparin-rinsed 60-mL

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
Centrifugation of venous whole blood is performed early in the case, simultaneously with the labral repair so additional time is not added to the procedure.	Bone marrow aspiration needle insertion site should be 1-2 cm proximal to the labral repair site to avoid compromising the suture anchors.
During bone marrow aspiration, pulling and holding the syringe plunger back to create a relative vacuum within the aspiration tube allows the aspiration to begin and continue at a steady rate.	Correct bone marrow aspiration needle trajectory is paramount to avoid compromising the abdominopelvic cavity or acetabulum.
Centrifugation of bone marrow aspirate is performed simultaneously with the final stages of surgery so surgical and traction times are not increased.	Vigilant, intermittent fluoroscopic imaging with an intraoperative C-arm is necessary to guide decision-making during bone marrow aspiration needle insertion and adjustment.
Approximately 3-5 minutes is sufficient for the thrombin to interact with the blood products, allowing for optimum megaclot viscosity.	Patience is key during bone marrow aspiration to achieve an adequate volume, especially in younger populations with dense cancellous bone.

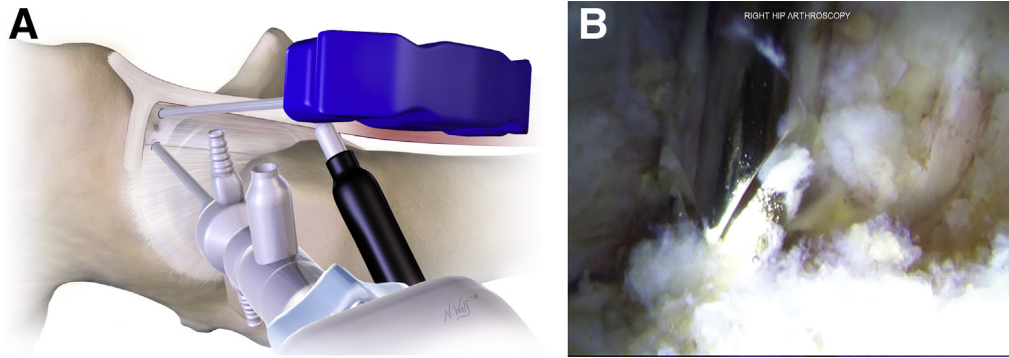


Fig 3. (A) The bone marrow needle insertion site can be identified on the ilium, approximately 1-2 cm proximal to the superior suture anchors. This site is at the level of or proximal to the sourcil and laterally adjacent to the reflected head of the rectus femoris origin. Illustration by Nicole Wolf, MS, ©2018. Printed with permission. (B) While working through the central anterior portal and viewing through the anterolateral portal, the site should be visualized intraoperatively before advancing the needle into the bone, as shown during right hip arthroscopy.

syringe is attached. Approximately 20 to 25 mL of bone marrow is aspirated into 3 separate 60-mL syringes, giving a total yield of 60 to 75 mL of bone marrow aspirate (Fig 5; Table 1).

BMAC Preparation and Usage

During the initial surgical portal placement, 51 mL of venous whole blood is drawn into a 60-mL syringe using aseptic technique from the patient's median cubital vein. A 9-mL solution containing 8 mL of normal 0.9% NaCl saline and 1 mL of heparin is

prepared in a 10-mL syringe and added to the whole blood, acting as an anticoagulant (Fig 6). The total 60 mL of anticoagulated whole blood is then injected into the processing centrifuge (Angel System, Arthrex, Naples, FL) for separation of the red blood cells, platelet-rich plasma (PRP), and platelet-poor plasma

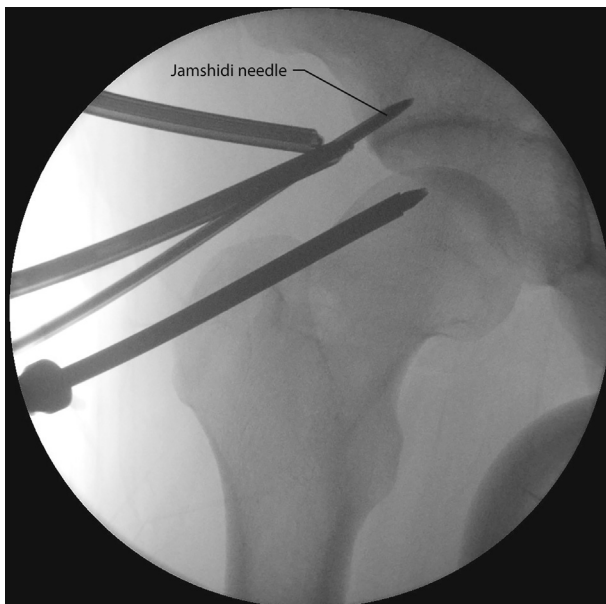


Fig 4. The Jamshidi bone marrow aspiration needle is driven through the bone's cortex by tapping the handle with a mallet while periodic trajectory confirmation is made with fluoroscopy, as seen during right hip arthroscopy. Final needle tip location can be confirmed with fluoroscopy because the Jamshidi needle is visualized in the right ilium.

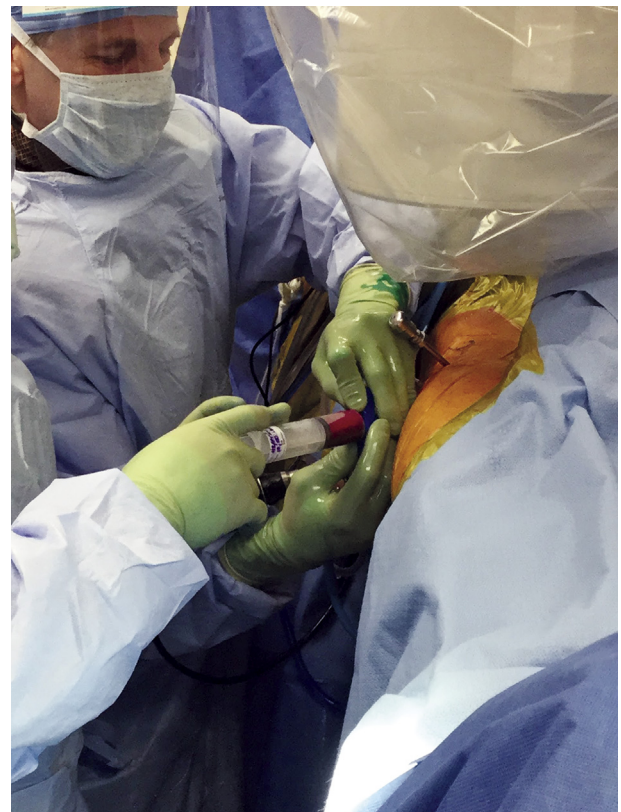


Fig 5. The bone marrow is aspirated from the right hip through the central anterior portal, as seen with the patient's head above the portal placement and the feet below. The needle is held securely while 3 heparin-rinsed 60-mL syringes are each used to obtain a minimum of 20-25 mL of bone marrow.



Fig 6. Using aseptic technique, approximately 51 mL of whole blood (bottom) is combined with a 9-mL diluted-heparin solution comprising 8 mL of normal 0.9% NaCl saline and 1 cc of heparin (top). This 60 mL of anticoagulated whole blood is used to obtain the platelet-rich and platelet-poor plasma.

(PPP). The spin time for the whole venous blood centrifugation is approximately 15 minutes. When the centrifugation is complete, approximately 4 mL of PRP is aseptically drawn into a 20-mL syringe. An additional 16 mL of PPP is aseptically drawn into the same syringe to yield a total of 20 mL of PRP/PPP solution. The 20 mL PRP/PPP mixture is put into a sterile cup for the future addition of mesenchymal stem cells (Fig 7). This process takes place early in the operation, simultaneously with the labral repair so that no additional time is added to the procedure (Table 1).

The 60 to 75 mL of bone marrow aspirate obtained from the ilium is then injected into the processing centrifuge (Arthrex) for separation of the concentrated stem cells. The spin time for the bone marrow aspirate

centrifugation is approximately 15 minutes. This process is concurrent with the final stages of surgery so that surgical and traction times are not increased during BMAC preparation (Table 1). When the bone marrow centrifugation is complete, approximately 3 mL of BMAC is aseptically drawn into a syringe and injected into the sterile cup that contains the 20 mL of PRP/PPP mixture (Fig 8). This 23-mL stem cell mixture comprised 3 mL of BMAC and 20 mL of PRP/PPP is then aseptically drawn into a 30-mL syringe. Approximately 3 to 5 minutes before the final stem cell application, approximately 7 mL of thrombin is added to the 23 mL of stem cell mixture (Table 1). With the addition of the clotting factor, the clotting cascade begins to form a sticky megaclot in the 30-mL syringe. It is imperative to gently rock the syringe from the time of thrombin introduction to the time of megaclot application to mix the agents appropriately and prevent stasis of the solution during the clotting process.

A slotted guide is used to direct the bone marrow biopsy aspiration needle to the chondrolabral junction and labral repair site while viewing through the

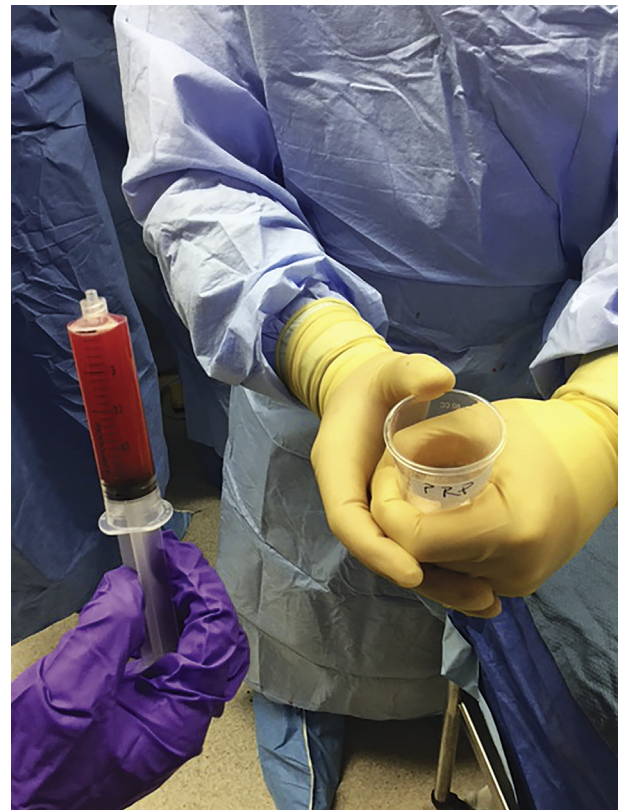


Fig 7. When the centrifugation of the anticoagulated whole blood is complete, approximately 4 mL of platelet-rich plasma (PRP) and 16 mL of platelet-poor plasma is aseptically drawn into a 20-mL syringe (left) and added into a sterile cup (right). This 20 mL of PRP/platelet-poor plasma solution is the medium to which the bone marrow aspirate concentrate and thrombin will later be added.

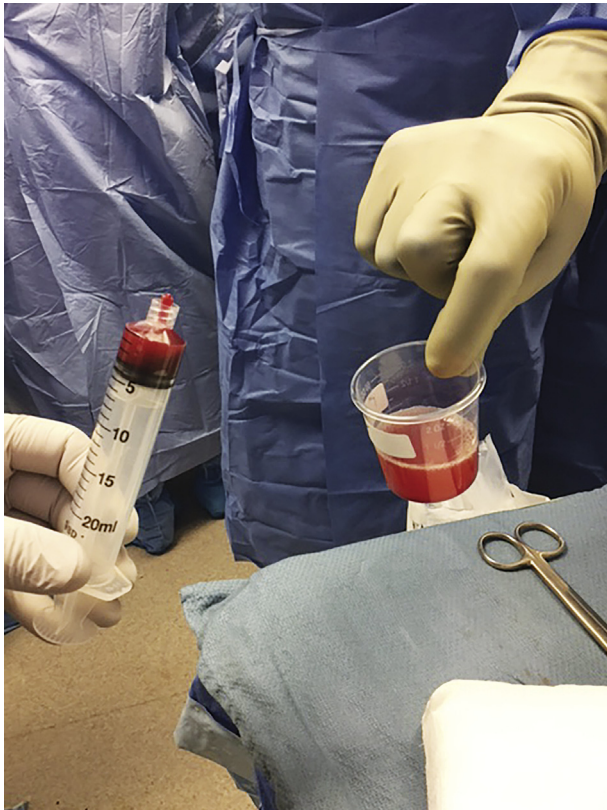


Fig 8. Approximately 3 mL of bone marrow aspirate concentrate (left, syringe) is aseptically drawn into a syringe and injected into the sterile cup which contains the 20 mL of platelet-rich plasma/platelet-poor plasma mixture (right, cup). Thrombin will later be added to this solution and subsequently begin the clotting cascade to form the megaclot.

anterolateral portal. Next, the 30-mL syringe containing the megaclot is attached to the correctly positioned needle, and saline irrigation is turned off within the joint capsule. The megaclot is then applied to the chondrolabral junction and labral repair site while slight traction is maintained to visualize and adequately coat the chondrolabral junction (Fig 9). After traction is released, the megaclot and repair site are visualized while the patient's hip is flexed from 0 to 45° (Fig 10). Following surgery, the patient is discharged on an outpatient basis and managed postoperatively with previously established protocols.^{9,11}

Discussion

In this Technical Note, we present a unique BMAC harvest site during hip arthroscopy to efficiently obtain mesenchymal stem cells without multiple procedures or second-site morbidity. Cartilage repair techniques such as autologous chondrocyte implantation (ACI), matrix-induced ACI (MACI), osteochondral autograft transfer, microfracture, and BMAC have all been suggested to restore joint congruity and minimize further chondral deterioration.¹²⁻¹⁷ These cell-based therapies work by

introducing mature cartilage or mesenchymal stem cells to bridge articular cartilage defects.

Although results have shown success in the knee, cartilage implantation techniques such as ACI, MACI, and osteochondral autograft transfer have limited application in the hip because of the technical difficulties of the joint and increased morbidity of open procedures.¹⁸ Also, these techniques use harvested hyaline cartilage only, whereas the hip's chondrolabral

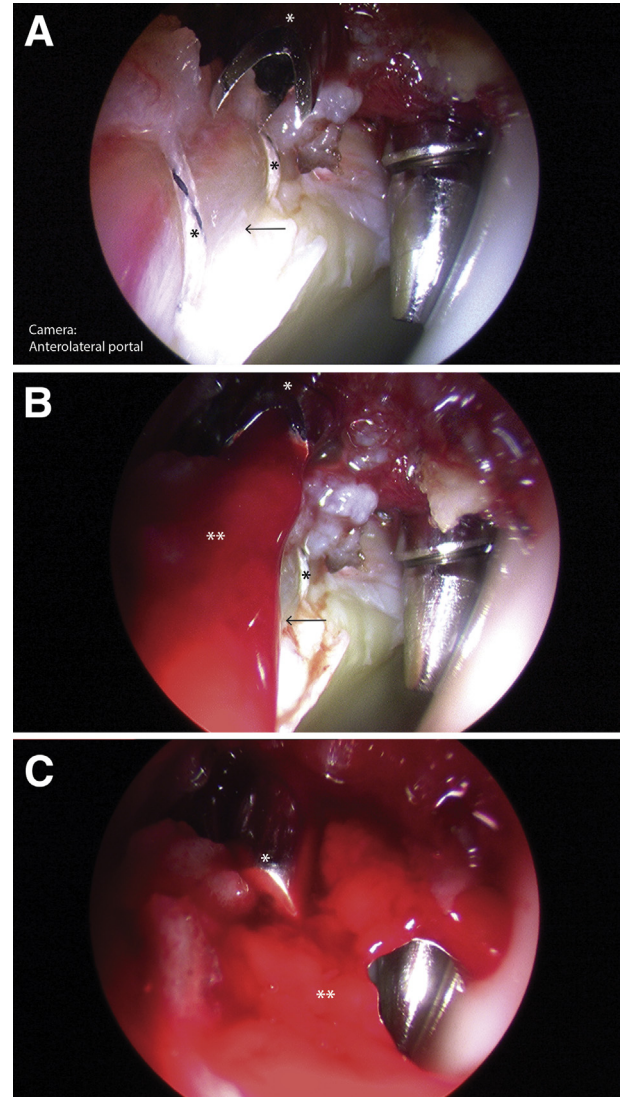


Fig 9. (A) While working through the central anterior portal with saline irrigation turned off, a slotted guide is used to direct the bone marrow biopsy aspiration needle (white asterisk) to the chondrolabral junction (arrow) and labral repair site (labral repair sutures visualized with black asterisk), while viewing through the anterolateral portal. (B) After the syringe containing the megaclot (double asterisk) is attached to the bone marrow aspiration needle (white asterisk), the megaclot is applied to the chondrolabral junction (arrow) and labral repair site (black asterisk) while slight traction is maintained to visualize and (C) adequately coat the chondrolabral junction.

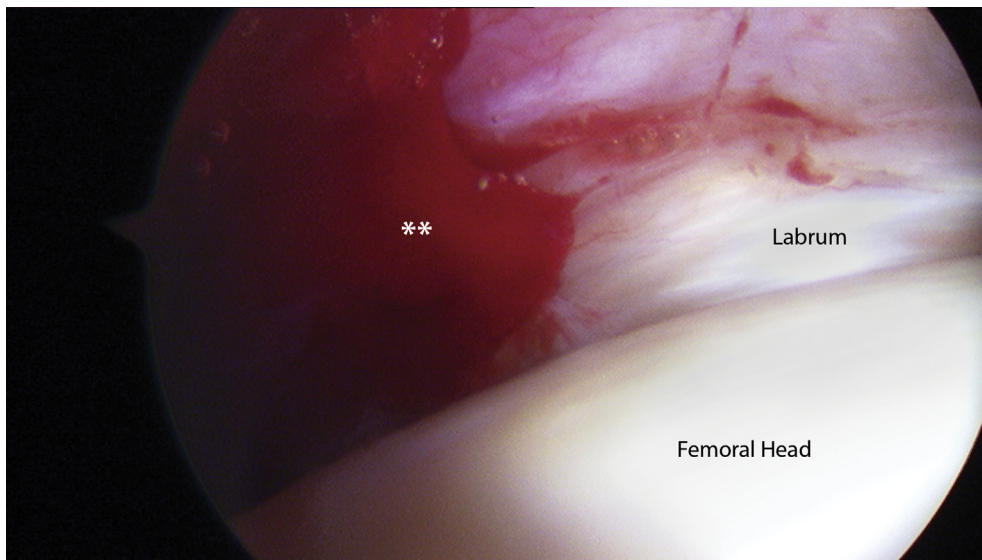


Fig 10. With the right femoral head reduced into the acetabulum and the hip flexed to 45°, the megaclot (double asterisk), which was applied to the labral repair site and chondrolabral junction, can be visualized in the peripheral compartment while using the anterolateral skin incision.

junction is a transition zone consisting of both hyaline and fibrocartilage.¹⁹ The mesenchymal stem cells in BMAC are ideal for the chondrolabral junction, because they have the ability to differentiate into both fibrocartilage and hyaline-like tissue products.^{20,21} Additionally, ACI and MACI require multiple procedures that significantly lengthen cartilage repair time.

Techniques that introduce mesenchymal stem cells to chondral defects include microfracture and BMAC. Microfracture disrupts subcortical bone, allowing mesenchymal stem cells within the blood to clot along cartilage defects. Microfracture has been effective in small, specific patient populations,^{22,23} but because of subchondral bone disruption at the weight-bearing portion of the joint, acceleration of cartilage degeneration may be seen, unfortunately leading to faster progression to hip arthroplasty.¹⁶

Recent clinical studies have shown BMAC to be safe and effective in treating arthritic cartilage symptoms and focal chondral lesions.^{7,8,24,25} When used in conjunction with other treatment modalities, such as microfracture and biologic scaffolds, BMAC has shown significant cartilage growth.^{26,27} Although the exact mechanism is debated, BMAC has ability to exhibit anti-inflammatory properties, mesenchymal stem cell differentiation, and paracrine growth factor modulation.²⁸⁻³⁰ These factors are further activated by inflammatory stimuli, making the surgical trauma produced during acetabular labral repair a potential benefit in priming mesenchymal stem cells.^{31,32}

Within the technical constraints of the hip joint, BMAC is a safe, feasible, and potentially efficacious option for the augmentation of labral healing and treatment of chondrolabral defects. This technique

further affords patients little to no drawbacks by avoiding donor-site morbidity, open procedures, and multiple surgeries. Risks of the procedure include bleeding, neurovascular injury, infection, or pelvic cavity compromise from inadvertent needle placement. For this reason, positioning and trajectory of the bone marrow aspiration needle is paramount for reducing procedural risk and optimizing bone marrow aspiration (Table 1). Insufficient bone marrow aspiration volume or a “dry tap” may be an indication of inadvertent needle placement. Finally, when adjusting needle trajectory, caution should be taken to not break the aspiration needle, which is a risk specific to the bone marrow harvest procedure. Long-term outcome measures and repeat advanced imaging will be necessary to confirm this single-site BMAC application as a viable treatment option for chondrolabral degeneration.

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