

Arthroscopic Fixation of Knee Femoral Condyle Osteochondritis Dissecans Fragment With Bone Marrow Aspirate Concentrate



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Abstract: This article reviews a technique for arthroscopic fixation of an osteochondritis dissecans fragment with bone marrow aspirate concentrate augmentation. This technique involves safe harvest of bone marrow arthroscopically from the intercondylar notch, proper preparation and debridement of the parent bone, reduction of the progeny osteochondritis dissecans fragment, insertion of the bone marrow aspirate concentrate, and placement of multiple headless compression screws for fixation.

Osteochondritis dissecans (OCD) is an acquired condition of the joint that affects the articular cartilage and subchondral bone.^{1,2} The term “osteochondritis dissecans” was first characterized by König in 1888, and the condition was suggested as a delay or disorder of subchondral bone formation, with resultant damage of the overlying cartilage.^{1,3-5} The proposed causes of OCD are repetitive trauma, genetic factors, inflammation or ischemia, and accessory centers of ossification.^{1,2} Although stable juvenile OCD lesions have improved spontaneous healing rates compared with adult OCD lesions, refractory juvenile OCD cases and symptomatic adult OCD lesions may require surgical intervention.²

Reported surgical options include drilling, in situ fixation, open reduction—internal fixation, bone marrow stimulation, osteochondral allograft transfer, osteochondral autograft transplant surgery, and combined bone grafting and autologous chondrocyte implantation.² These procedures can be performed arthroscopically or in an open manner depending on the location, lesion size, patient demographic characteristics, and surgeon comfort with the techniques. In addition to the described autograft implantation techniques, mesenchymal cell augmentation techniques are being explored.^{2,6}

Bone marrow aspirate concentrate (BMAC) has been studied as a source of both mesenchymal stem cells and growth factors of cartilage generation.⁷ Studies have suggested that up to 0.01% of mononuclear cells in BMAC are mesenchymal stem cells.^{5,8-10} In addition, BMAC serves as a rich source of growth factors involved in inducing chondrogenesis, such as platelet-derived growth factor, vascular endothelial growth factor, insulin-like growth factor 1, and transforming growth factor β , suggesting an improved healing response at the site of injury.^{7,8,10,11}

We describe a technique for augmentation of OCD healing with BMAC. This article describes the methods for arthroscopic harvesting of bone marrow, reduction of the OCD fragment, and insertion of BMAC at the OCD healing site (Video 1).

Patient Evaluation

The classic patient vignette is an adolescent male patient (male 2 times higher than female) presenting with

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a variety of activity-related knee symptoms such as pain, clicking, popping, catching, and/or effusion.¹² The onset is often insidious instead of acute or injury related. The differential diagnosis can include meniscal injury, chondral lesions, and rheumatologic conditions, among other causes. Imaging can further help with diagnosis.

Imaging

The imaging evaluation typically starts with knee radiographs. In addition to a 3-view knee series including an anteroposterior view, lateral view, and sunrise view or other similar patellofemoral view, it is important to include a tunnel view for better characterization of the central portion of the more posterior aspect of the femoral condyles (Fig 1). Although radiographs have been reported in the literature as not particularly sensitive for atraumatic pediatric knee pain and swelling, they offer the additional benefit of ruling out concomitant pathology, loose bodies, or other bony pathology, in addition to the often-necessary process of obtaining insurance coverage for the more desired imaging study: magnetic resonance imaging (MRI).^{13,14}

MRI generally is the gold standard for evaluation, with the benefit of reliably showing the lesion size and “physeal patency.”¹⁵ The cartilage can be evaluated for surgical planning (Fig 2). The findings of MRI can include a high T2 signal rim, adjacent cyst, cartilage fracture, and fluid-filled lesion. Other imaging such as a computed tomography scan or bone scan may provide additional information about bone involvement and even stability but can result in additional radiation exposure to the patient.

Ultrasound evaluation is becoming more popular, especially as more providers become comfortable with

ultrasound joint evaluation. Jungesblut et al.¹⁶ found that using ultrasound correlated well with more advanced OCD lesions and offered the additional benefits of being able to monitor the lesion over time, as well as screen the contralateral limb. It was noted that the intercondylar notch and posterior aspects of the condyles were more difficult to assess.

Indications

The primary role of any of the imaging studies is to identify and characterize the lesion to help guide treatment decisions. Lesion stability is a key feature when deciding to proceed with surgical versus nonsurgical intervention. MRI suggestions of instability in a nondisplaced lesion include fluid behind the lesion, bone marrow edema adjacent to the lesion, and cartilage tears.¹⁷ For those patients starting on the nonsurgical path, continued symptoms after 3 to 6 months of nonoperative management are an indication for surgical intervention. Andriolo et al.¹⁸ evaluated patients who underwent nonsurgical measures and found several negative prognostic indicators, including a larger lesion, advanced lesion stage, patient maturity, location, time with continuing symptoms, swelling or locking on examination, and discoid meniscus. For those lesions deemed unstable or for which nonoperative measures have failed, a variety of surgical techniques have been described. This article describes a technique for arthroscopic fragment stabilization with BMAC augmentation.

Surgical Technique

The patient is prepared for a standard knee arthroscopy. The patient is placed supine on a standard table with a lateral post. Standard anterolateral and

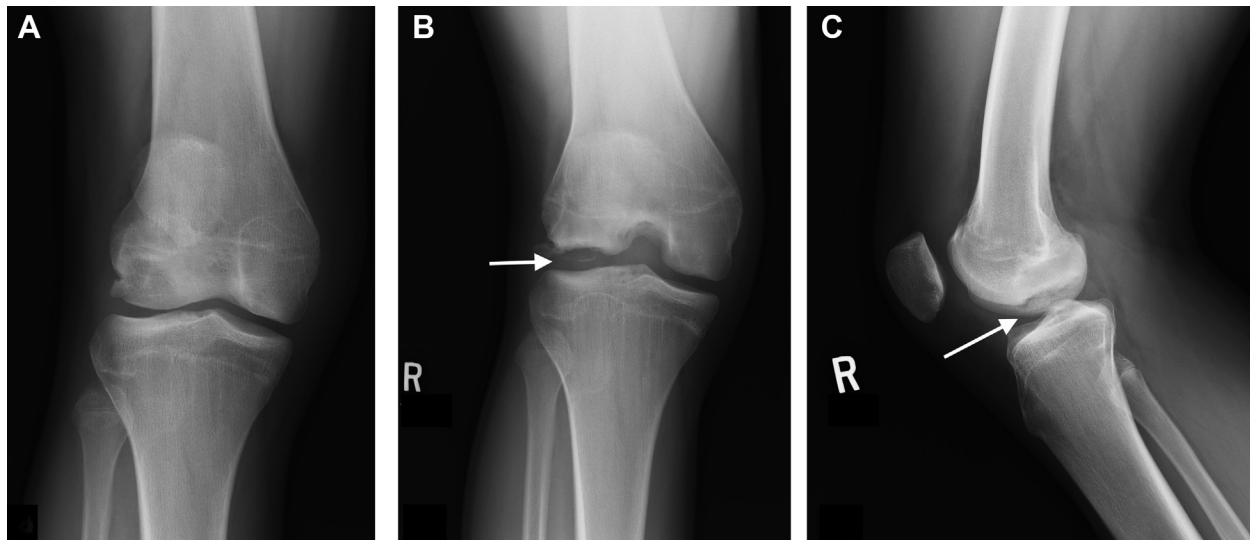


Fig 1. Anteroposterior (A), Rosenberg (B), and lateral (C) radiographs showing lateral osteochondritis dissecans fragment (arrows) of lateral femoral condyle in right (R) knee.

Fig 2. Proton density fat saturation magnetic resonance images of right knee. Coronal (A) and sagittal (B) images show a lateral femoral condyle osteochondritis dissecans fragment (arrows) with intact cartilage.



anteromedial portals are established, with the anterolateral portal used as the viewing portal for most of the procedure. A standard diagnostic evaluation is performed. The osteochondral lesion is visualized through the anterolateral portal with the knee flexed to 90° by use of a probe to assess the size of the parent region (Fig 3). The progeny OCD fragment is also probed and assessed for the viability of the overlying cartilage (Fig 4).

The bone marrow aspirate is obtained from the intercondylar femoral notch with the knee in 120° of flexion over the side of the table (Table 1). The BMAC system described includes a harvest trocar, anticoagulant citrate dextrose solution (ACD-A), and centrifuge tube (BioCUE System; Zimmer Biomet, Warsaw, IN). A bone marrow aspirate trocar is flushed with ACD-A and then inserted through the anteromedial portal into the anterior-superior intercondylar notch (Fig 5).

Under direct visualization with the arthroscope, the stylet and trocar are advanced into the bone to the bold

line using a mallet in a proximal trajectory, burying all holes at the distal tip. The inner trocar of the aspiration needle is removed, and a 30-mL syringe is attached. The syringe is preloaded with 5 mL of ACD-A to prevent coagulation of aspirate. The arthroscope water flow is then turned off, allowing for spontaneous outflow of bone marrow. The plunger of the syringe is pulled back, creating negative pressure within the syringe. Once bone marrow is visualized flowing into the syringe, the plunger is pulled back further and rotated to lock the plunger into place, allowing for continued flow of bone marrow into the syringe. If bone marrow return slows or stops, one can twist the stylet or remove the syringe from the needle to remove excess air, reattach it to the needle, and subsequently pull the plunger back. Once the syringe is full, the plunger is unlocked to stop the negative pressure, and the syringe is removed from the aspiration needle. The bone marrow aspirate trocar is then removed from the intercondylar notch with a careful twisting motion until

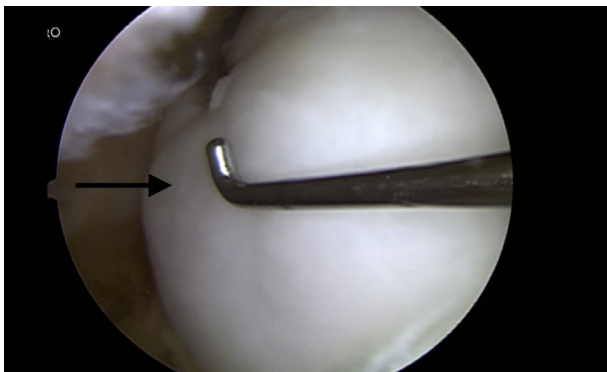


Fig 3. Lateral femoral condyle in right knee visualized through anterolateral portal with probe in anteromedial portal to measure size of osteochondritis dissecans parent region (arrow). The patient is positioned supine with the knee flexed to 90° over the side of the operating room table.

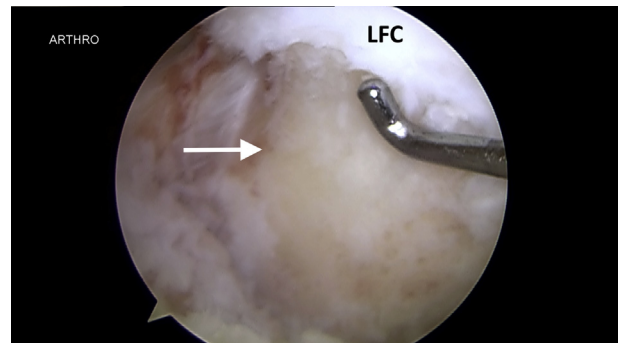


Fig 4. Lateral femoral condyle (LFC) in right knee visualized through anterolateral portal. A probe in the anteromedial portal is used to assess the quality of the progeny osteochondritis dissecans cartilage (arrow). The patient is positioned supine with the knee flexed to 90° over the side of the operating room table.

Table 1. Surgical Pearls of Knee OCD Fixation With BMAC

Steps	Pearls
BMAC procurement	<p>Insert the BMAC harvest trocar with the tip aiming upward and the knee in 120° of flexion to safely enter the intramedullary canal.</p> <p>If there is poor bone marrow aspirate flow, twist the cannula.</p> <p>If the flow is dilute, turn off the water prior to aspiration.</p> <p>To avoid intra-articular bleeding, direct arthroscopy flow to the insertion site on trocar removal.</p> <p>If considering cartilage biopsy as a subsequent salvage procedure in the future, harvest a cartilage biopsy specimen from the intercondylar notch prior to inserting the trocar to avoid damaging the specimen.</p>
Preparation of recipient site and parent bone	<p>Thoroughly debride all fibrous tissue.</p> <p>Bear in mind that adequate debridement is demonstrated when the bony bed has punctate bleeding after turning off the water inflow.</p>
Fragment manipulation	<p>If the lesion is peripheral, pin the fragment with the percutaneous wire first; then, spin the fragment into proper alignment.</p> <p>Use a probe to assist in rotation and placement of the fragment.</p> <p>For larger OCD fragments, place a second pin prior to placement of the first screw to prevent rotation.</p> <p>If proper reduction is not achieved, trim the cartilage flaps on the fragment with a No. 15 blade to allow the fragment to reduce.</p>
Injection of BMAC	<p>Ensure that the BMAC injection needle is between the OCD progeny fragment and parent bone.</p> <p>Save a portion for use just before final tightening.</p>
Screw insertion	<p>Use a tissue protector to mitigate local soft-tissue injury.</p> <p>Bear in mind that arthroscopic confirmation of reduction is essential to prevent hardware prominence.</p>

BMAC, bone marrow aspirate concentrate; OCD, osteochondritis dissecans.

the first hole is visible out of the bone. The arthroscopy flow from the camera is turned back on and directed toward the exposed holes of the trocar. This is held for 10 seconds; then, the trocar is twisted and completely removed from the knee. This step helps to decrease intra-articular bleeding from the harvest site after trocar removal. The full syringe is sterilely transferred to a trained individual and is then placed in a centrifuge chamber and spun for approximately 15 minutes. After

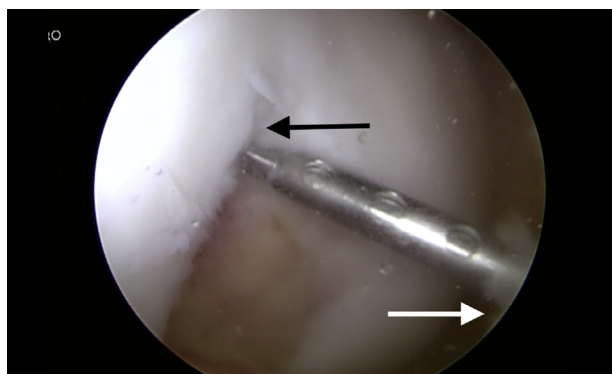


Fig 5. Femoral intercondylar notch in right knee visualized through anterolateral portal. A bone marrow aspirate trocar (white arrow) through the anteromedial portal is inserted into the anterior-superior notch (black arrow). The patient is positioned supine with the knee flexed to 120° over the side of the operating room table.

the bone marrow aspirate has completed centrifugation, the BMAC is removed with a 5-mL syringe and 3 to 4 mL of BMAC is carefully injected into a sterile bowl on the sterile field. The scrub technician then fills a sterile 5-mL syringe with the BMAC on the sterile field for later injection.

After completion of the BMAC harvest, attention is returned to the osteochondral lesion. To prepare the bony bed for fragment fixation, a ring curette is used to clean any irregular borders and fibrous tissue down to subchondral bone (Fig 6). The osteochondral fragment is localized and skewered percutaneously with a headless compression screw guidewire (Fig 7).

The probe may be used to rotate the fragment so that it is correctly aligned and reduced over the prepared bony bed. Once the fragment is in the desired position, the fragment is pinned in place with the cannulated screw guidewire through the fragment and into the bony bed. With the fragment pinned in place, the spinal needle is inserted through the fracture line to the bone-fragment interface through the anteromedial portal. The BMAC syringe is attached to the spinal needle, the flow from the arthroscope is stopped, and the BMAC is slowly injected behind the osteochondral fragment (Fig 8).

After the fragment is positioned and BMAC is injected, the fragment is fixated to the bony bed. For larger OCD lesions requiring multiple screws, it is helpful to add an additional guidewire percutaneously into the

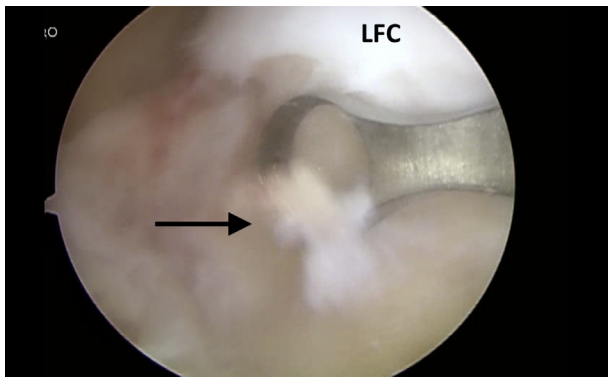


Fig 6. Lateral femoral condyle (LFC) in right knee visualized through anterolateral portal. A ring curette through the anteromedial portal is used to remove fibrous tissue and expose the subchondral bone on the LFC parent region (arrow). The patient is positioned supine with the knee flexed to 90° over the side of the operating room table.

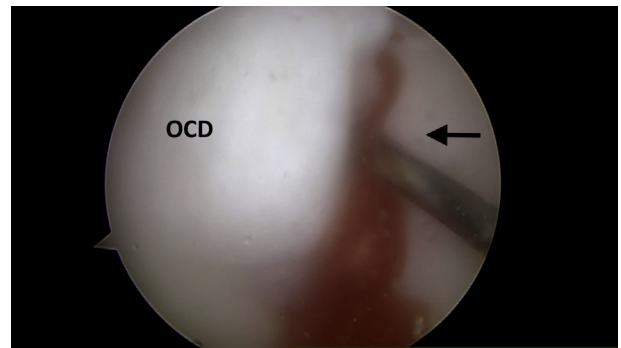


Fig 8. Lateral femoral condyle in right knee visualized through anterolateral portal. Through the anteromedial portal, the bone marrow aspirate concentrate needle is inserted between the osteochondritis dissecans (OCD) progeny and parent bone (arrow). The bone marrow aspirate concentrate is injected behind the OCD lesion. The patient is positioned supine with the knee flexed to 90° over the side of the operating room table.

fragment. This acts as an anti-rotation pin when inserting the first screw. A headless compression screw system (2.5-mm headless titanium Compression FT; Arthrex, Naples, FL) is used for fragment fixation. A small incision is made at the skin where the first percutaneous wire was placed. A depth gauge is placed over the wire to determine how long the drill depth and screw length will be. A tissue protector with an inner dilator is placed over the guidewire. The dilator is removed, and a cannulated drill is then inserted over the guidewire and drilled through the fragment and into the bony bed. The depth of the drill hole is measured using the marks on the side of the drill bit. The appropriate conical, headless compression cannulated screw is inserted over the guidewire and countersunk just below the cartilage surface (Fig 9).

The position is confirmed arthroscopically to ensure there is no hardware prominence and fluoroscopically

regarding the trajectory and reduction. Depending on the size of the fragment, additional screws can be placed in a similar fashion over a guidewire. We attempt at least 2 screw fixations to assist with rotational stability (Fig 10).

Occasionally, a No. 15 blade may be used to carefully slice excess cartilage flaps around the fragment to be fully reducible. After final screw placement, stable reduction is confirmed using probe evaluation (Fig 11). The BMAC concentrate can be visualized at the edge of the lesion. The screws may be removed in 6 to 12 months, once radiographic healing has been confirmed.

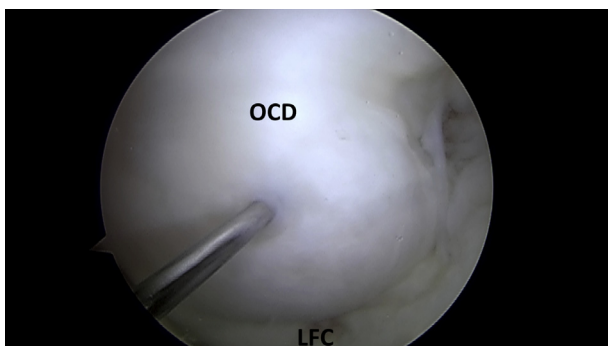


Fig 7. Lateral femoral condyle (LFC) in right knee visualized through anterolateral portal. An anterolateral percutaneous headless compression screw guidewire pins the osteochondritis dissecans fragment (OCD). The patient is positioned supine with the knee flexed to 90° over the side of the operating room table.

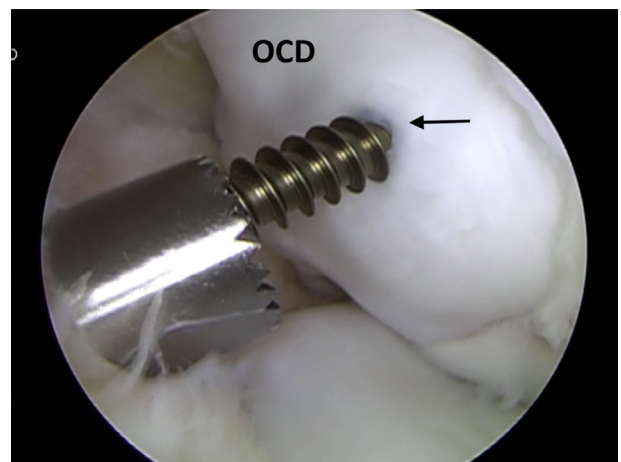


Fig 9. Lateral femoral condyle in right knee visualized through anterolateral portal. Osteochondritis dissecans (OCD) fragment fixation is performed with a headless compression screw (arrow) inserted over the guidewire through the tissue protector. The patient is positioned supine with the knee flexed to 90° over the side of the operating room table.

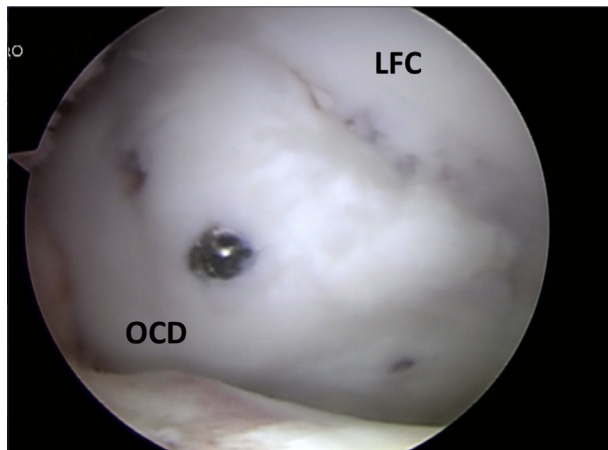


Fig 10. Lateral femoral condyle (LFC) in right knee visualized through anterolateral portal. Osteochondritis dissecans (OCD) fragment fixation is performed with 3 countersunk headless compression screws. The patient is positioned supine with the knee flexed to 90° over the side of the operating room table.

Rehabilitation

Our rehabilitation protocol starts by limiting weight bearing and working on range of motion. For the first 2 weeks, the patient is non-weight bearing, followed by toe-touch weight bearing up to week 6 and progression to full weight bearing thereafter. The main concern that we have found is regaining extension. The brace is used in full extension for the first 2 weeks, except during therapy, and then opened to motion up to week 6 as the quadriceps function improves. Range of motion is supported with the use of a continuous passive motion machine in the early postoperative

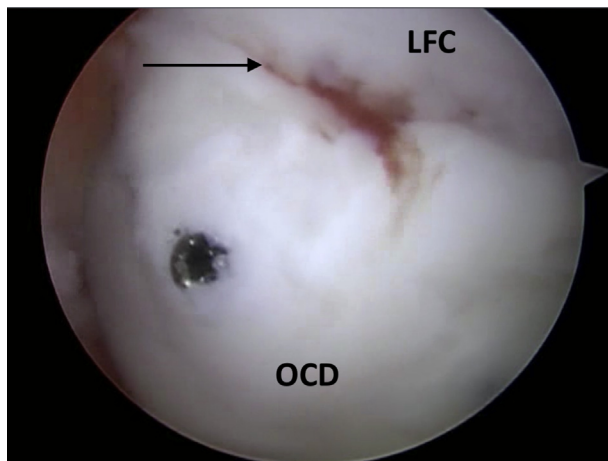


Fig 11. Lateral femoral condyle (LFC) in right knee visualized through anterolateral portal. The osteochondritis dissecans (OCD) fragment is fixated with headless compression screws. The bone marrow aspirate concentrate is visualized leaking through the edge of the fragment (arrow). The patient is positioned supine with the knee flexed to 90° over the side of the operating room table.

Table 2. Advantages and Limitations of Arthroscopic Fixation of Knee Femoral Condyle OCD Fragment With BMAC

Advantages

- All-arthroscopic technique that is minimally invasive for harvest of BMAC
- No additional incisions required for BMAC
- No change in draping or positioning of patient such as changes that may be required for harvesting from separate sites
- Not associated with donor-site pain compared with bone graft harvest
- Ability to directly inject bone marrow aspirate around OCD fragment and pathology, as well as ability to place concentrate in small spaces

Limitations

- Bone graft, if needed, not provided
- Technically difficult in patients with very large, displaced OCD fragments

BMAC, bone marrow aspirate concentrate; OCD, osteochondritis dissecans.

period. Early exercises include isometric and closed-chain exercises, with open-chain activities restricted until 3 months postoperatively. A full return to activity is estimated to occur at between 4 and 6 months.

Discussion

It is well established that BMAC augmentation is a valuable tool for the treatment of fracture nonunion.^{19,20} It is also suggested that BMAC augmentation can lead to improved healing of focal chondral lesions and promote hyaline-like cartilage growth owing to the high concentration of growth factors present, including vascular endothelial growth factor, platelet-derived growth factor, insulin-like growth factor 1, transforming growth factor β , and bone morphogenetic protein 2.^{7,8,10,11,21} There have been several clinical studies supporting the use of BMAC for the treatment of cartilage lesions.^{9,10,22-25}

As the use of BMAC for osteochondral lesions continues to be evaluated, we offer a technique for use in treating OCD lesions, with tips from our experience in implementing this technique. Another technique has described in which the parent bone of an OCD undergoes microfracture to release mesenchymal cells on the parent bone.² This technique is able to be performed in an all-arthroscopic manner and offers bone marrow augmentation (Table 2). Our technique differs in that the BMAC is concentrated with potentially higher amounts of mesenchymal progenitor cells, and our technique does not require violation of the parent bone with microfracture holes. It has been shown that BMAC yields improved cartilage healing compared with microfracture in an animal model.²⁶ Human clinical studies have also shown improved clinical outcomes and decreased revision rates with BMAC compared with microfracture for cartilage lesions.^{27,28}

As the use of BMAC for osteochondral lesions continues to be evaluated, we describe a technique for

arthroscopic fixation of an OCD and augmentation with BMAC. This technique offers several advantages, including being able to be performed in an all-arthroscopic manner and not requiring violation of the parent bone with microfracture holes.

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