Arthroscopic Bone Marrow Aspirate Concentrate Harvesting From the Intercondylar Notch of the Knee

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Abstract: Bone marrow aspirate concentrate is commonly harvested to obtain mesenchymal stem cells, progenitor cells, and growth factors. The iliac crest is the most common donor site for bone marrow harvesting and is associated with donor site morbidity of an additional incision and pain from the harvest. Iliac crest harvesting can be cumbersome because it often requires different patient positioning from the surgical procedure and additional sedation or anesthesia for the harvest prior to repositioning. The purpose of this Technical Note and accompanying video is to describe a technique to arthroscopically aspirate bone marrow from the intercondylar femoral notch, reducing the need for iliac crest harvesting.

Bone marrow aspirate concentrate (BMAC) contains mesenchymal stem cells, progenitor cells, and cytokine/growth factors that are often used in orthopaedic applications to enhance and promote healing. In the setting of treating cartilage lesions, BMAC has been demonstrated to improve the symptoms of focal chondral lesions and promote hyaline-like cartilage growth, potentially curtailing the onset of mild to moderate osteoarthritis.[1-3] Additionally, when used in conjunction with core decompression, BMAC has been demonstrated to lead to a significant reduction in pain.[4] Most bone marrow is acquired from the iliac crest, concentrated, and injected into the site of interest.[1,4-6] The purpose of this Technical Note is to describe the harvest of bone marrow from the intercondylar femoral notch through an arthroscopic portal, allowing for an arthroscopic procedure of the knee that can precede the surgical intervention in the knee and eliminate the need for an iliac crest harvest.

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Technique

Patient Setup

The patient is placed supine on a standard operating table and anesthetized using general anesthesia. A tourniquet is placed around the proximal thigh, and the operative leg is placed in an arthroscopic leg holder (Mizuho OSI, Union City, CA). The operative leg is prepared with preoperative skin prep solution from the midthigh to the foot and is then draped in the usual sterile fashion.

Diagnostic Arthroscopy

The anterolateral portal is created using a No. 11 blade to make a vertical incision adjacent to the lateral border of the patellar tendon at the level of the joint line. The knee is then entered using a blunt trocar and scope sheath. The trocar is replaced with the 30° 4.0-mm arthroscope, and a complete diagnostic arthroscopy is performed, inspecting for associated chondral damage, loose bodies, ligament tears, or meniscus tears. A 22-gauge spinal needle is used to localize the anteromedial portal under arthroscopic visualization, and an incision is made in the same vertical fashion.

Bone Marrow Aspiration Harvest

While viewing from the anterolateral portal, a guide pin is drilled through the anteromedial portal into the intercondylar femoral notch in an inferior to superior

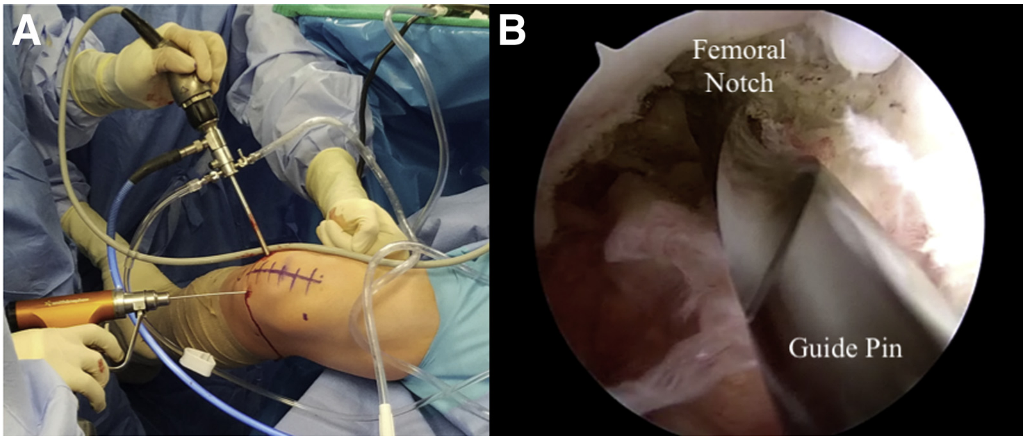

Fig 1. Insertion of the guide pin. (A) Intraoperative photo of arthroscopy-guided guide pin placement viewed from outside of the right knee. (B) Arthroscopic view of guide pin placement viewed from the lateral portal of the right knee.

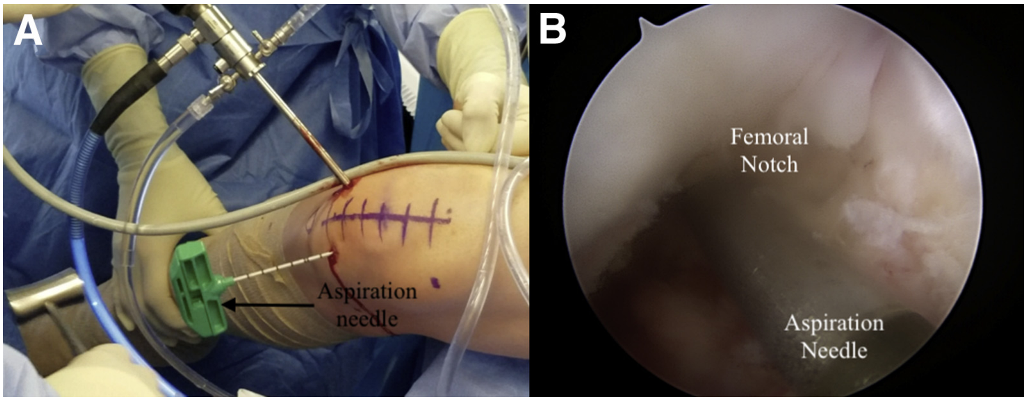

Fig 2. Advancement of the aspiration needle. (A) Intraoperative photo of arthroscopy-guided aspiration needle advancement, viewed from outside of the right knee. (B) Arthroscopic view of aspiration needle advancement viewed from the lateral portal of the right knee.

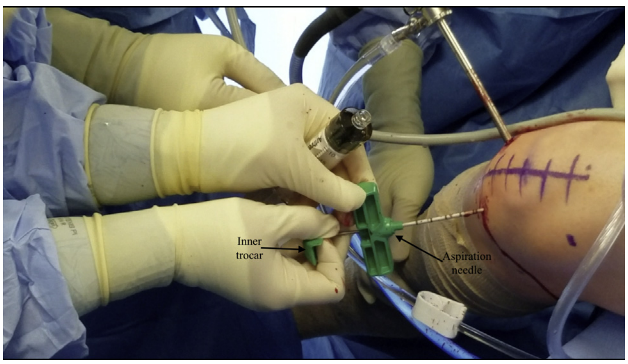

Fig 3. Removal of the inner trocar of the aspiration needle during femoral notch bone marrow harvest of the right knee.

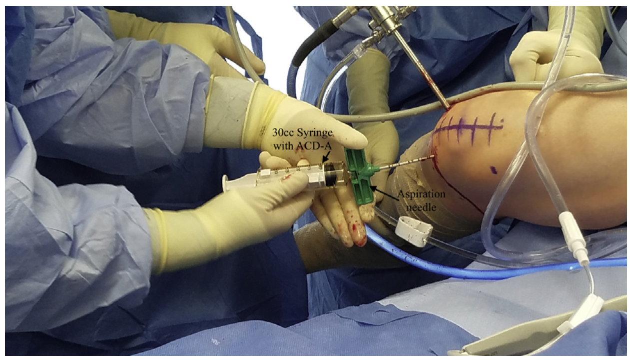

Fig 4. The 30-mL syringe, preloaded with 5 mL of acid-citrate-dextrose formula A, is connected to the adaptor of the aspiration needle, which has been placed through the medial portal and into the femoral notch during the bone marrow harvest of the right knee.

orientation (Fig 1), taking care to drill in line with the femoral shaft to avoid breaching the posterior femoral cortex. The guide pin is removed, and the 11-gauge aspiration needle is inserted into the guide hole with the same inferior to superior orientation. The aspiration needle is advanced to the bold line using a mallet (Fig 2). The inner trocar of the aspiration needle is then removed (Fig 3), and a 30-mL syringe, preloaded with 5 mL of acid-citrate-dextrose formula A, is connected to the adaptor of the aspiration needle (Fig 4). The plunger of the syringe is pulled back to approximately

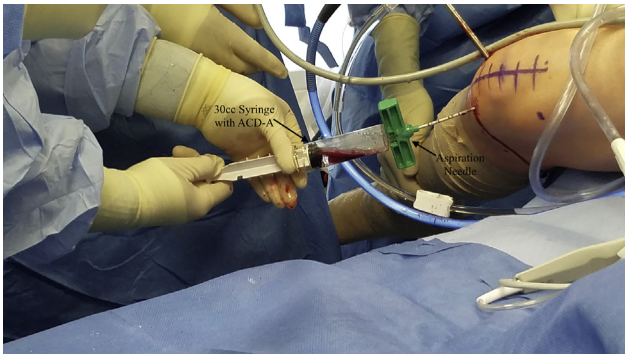

Fig 5. The 30 mL syringe with acid-citrate-dextrose formula A (ACD-A), connected to the aspiration needle and locked at 30 mL of negative pressure to aspirate bone marrow from the femoral notch of the right knee.

10 mL to create a negative pressure within the syringe. Once there is a flash of blood within the syringe, the negative pressure released. The plunger is drawn back once more and locked into place at 30 mL (Fig 5). Once this syringe is full, the plunger is unlocked and the second syringe is filled in the same fashion.

Once the harvest is complete, both syringes are connected to the Angel System (Arthrex), a bone marrow processing system that prepares customized bone marrow concentrate (Fig 6). The processing time to obtain the concentrate from 60 mL of aspirate is approximately 17 minutes. These key steps are demonstrated in Video 1.

Discussion

Regenerating lost hyaline cartilage remains an unsolved challenge. BMAC, which possesses various growth factors including mesenchymal stem cells and platelet-derived growth factors, has been shown to generate hyaline-like cartilage.[1,5] Current clinical applications of BMAC focus on harvesting the bone marrow from the iliac crest. This technique involves percutaneously inserting a bone marrow aspiration trochar and needle into the crest under monitored anesthesia, local anesthesia, or general anesthesia.[1,4-6] Donor site morbidity is not insignificant with iliac crest harvesting and also involves additional operating room time and attention to position and draping of the patient for the harvesting procedure prior to draping and sterile preparation for the main operative procedure.

The proposed technique maintains the advantages provided by the traditional iliac crest bone marrow harvest technique but allows harvesting in an arthroscopic manner concomitant with an operative knee procedure. Both forms of aspiration do not require culture expansion, unlike autologous chondrocyte implantation, which requires additional cultivation of chondrocytes, increasing the total cost of treatment.[5] Additionally, both techniques to collect bone marrow can be performed as a single-step procedure, which decreases surgical risk.[5]

This technique, when used for procedures that require either an incision or arthroscopic portals in the knee, eliminates the need for an additional surgical site as well as additional anesthesia (Table 1). This is ideal for procedures that treat focal chondral lesions, which are often treated arthroscopically. Harvesting bone marrow from the intercondylar femoral notch can also be used for osteochondral allograft transplantation surgery, because the marrow can be harvested from the initial arthroscopic portals created during the diagnostic phase of the procedure. Thus, by reducing surgical sites, this procedure may potentially reduce postoperative rehabilitation time and lead to a swifter recovery.

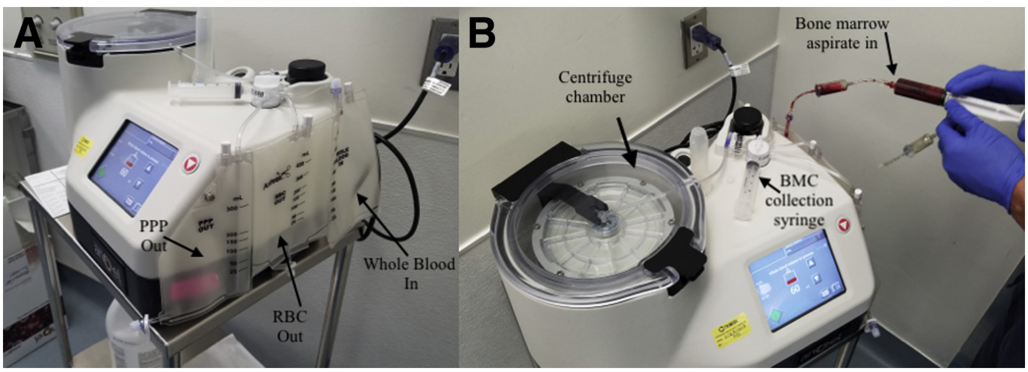

Fig 6. The Angel System. (A) The bone marrow aspirate will be injected in the rightmost bag (whole blood in), and the automated process will start dividing the different blood components. First the platelet-poor plasma (PPP) will be discarded in the leftmost bag (PPP out). Then the bone marrow concentrate (BMC) will be collected in the syringe on top of the system, and finally the red blood cells (RBCs) will be collected in the bag in the middle. 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. (B) The syringe with the harvested bone marrow is screwed in, and the bone aspirate is injected in the rightmost bag; the centrifugation process is about to start.

Table 1. Advantages and Risks of Bone Marrow Harvest Through the Femoral Notch

Advantages	Disadvantages
Reduces the number of surgical sites compared with harvest from the iliac crest.	Donor site morbidity.
No additional anesthesia is necessary.	Blood marrow from the femoral notch may have reduced concentration of mesenchymal stem cells.
Uses the patient's own bone marrow, eliminating the potential of allogenic disease transfer.	Mesenchymal stem cell quantity is contingent on patient age and sex.

A potential disadvantage of this procedure includes the risk of donor site morbidity; in addition, some studies indicate that BMAC from the femoral head contains decreased amounts of mesenchymal stem cells compared with BMAC derived from the iliac crest.[5,7] However, it is important to note that mesenchymal stem cell concentrations differ based on the age and sex of the patient.[8] Further studies are necessary to conclude whether BMAC derived from the intercondylar femoral notch has a clinical difference with regard to outcome.

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