Technical Note

Arthroscopic Autologous Chondrocyte Bone Grafting of a Lateral Tibial Plateau Chondral Defect

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Abstract: Tibial plateau chondral defects can be difficult to diagnose and treat. Although grafting of femoral and patella chondral defects has become relatively commonplace, the tibial plateau offers unique challenges for some of the grafting techniques used in these locations, mostly because of limitations with exposure even in an open approach. Arthroscopic surgery makes treatment of these lesions more feasible, as it affords better access and visualization of tibial defects. The purpose of this article is to describe the arthroscopic management of a lateral tibial plateau chondral defect via autologous chondrocyte bone grafting. The technique consists of harvest of autologous cartilage from the intercondylar notch and repair of the tibial plateau defect with a slurry of autologous chondrocytes and bone marrow aspirate concentrate. In addition, CO_2 is used as a medium to distend the joint in a tight compartment to keep the chondral defect dry. This technique is technically simple and does not require an extensive open technique or an expensive osteochondral allograft. It also avoids the staged management required in other types of autologous chondrocyte implantation, which require cartilage biopsy to produce a final product for implantation.

Management of articular cartilage defects of the knee remains a challenging condition for treating orthopedic surgeons. Furthermore, surgical management of isolated tibial plateau chondral defects is less well studied than their counterparts involving the femoral condyles or patellofemoral surfaces.[1] Several challenges to surgical treatment exist, including both anatomic and technical considerations.[2] Several approaches and their outcomes have been previously described, each with different advantages and disadvantages.

Marrow simulation techniques, such as microfracture, have been described previously for tibial defects.[2] However, a major disadvantage of the microfracture technique includes reliance on a fibrocartilage fill rather than a hyaline-like cartilage. Retrograde osteochondral autograft transplantation has shown promising results in several small series, but this procedure can be technically challenging and limited by donor site morbidity.[3,4] Fresh osteochondral allograft transplantation has shown good long-term outcomes but is typically used for larger and more severe osteochondral defects.[5] Last, autologous chondrocyte implantation techniques have been reported for well-contained tibial lesions, without the risk of donor site morbidity. However, these techniques require a 2-stage procedure.[6] In addition, osteochondral allograft grafting can be difficult for tibial defects because of challenges with exposure of the articular surface in patients without concomitant ligamentous injury.

In this Technical Note, we describe a single-stage arthroscopic technique involving autologous chondrocyte bone grafting with adjunct bone marrow aspirate concentrate for focal chondral defects of the tibial plateau. A summary of the technique can be found in Video 1.

Surgical Technique

The patient is placed in a supine position with the leg in an arthroscopic leg holder and a tourniquet placed on the thigh. Before inflation of the tourniquet, the Arthrex Angel (Arthrex, Naples, FL, U.S.A.) bone marrow aspirate concentrate (BMAC) kit is used to harvest approximately 60 cc of bone marrow for later use at the repair site. A stab incision is made over the

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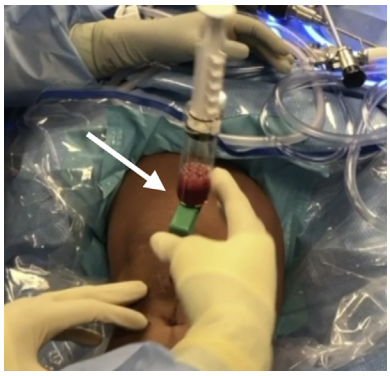

Fig 1. Approximately 60 cc of bone marrow is harvested from the right (ipsilateral) tibia using the Arthrex Angel (Arthrex, Naples, FL, U.S.A.) bone marrow aspirate concentrate (BMAC) kit (arrow) to be used later at the repair site.

medial tibial metaphysis, and the sharp trocar is malleted into the tibial bone at approximately 3 cm (Fig 1, Video 01:19). The collection syringe is preloaded with acid citrate dextrose to prevent clotting of the BMAC. Approximately 50 to 60 cc is harvested and passed off the surgical field to be spun down in the centrifuge at a concentration of 7%.[7]

Following the BMAC harvest, the arthroscopic procedure is begun. The tourniquet is inflated to 250 mm Hg for optimal visualization. A standard anterolateral viewing portal is created and a diagnostic arthroscopy is performed and any associated pathology treated. An anteromedial portal is created under direct visualization using an outside-in technique. When creating the medial portal, it is crucial to ensure that your instrumentation will be able to access the desired area of interest. Instruments are introduced via the anteromedial portal while viewing from the lateral portal. In

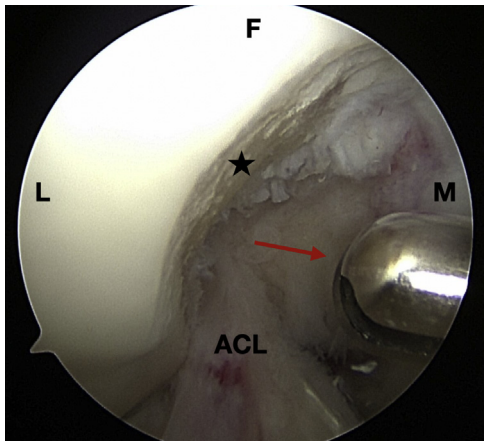

Fig 3. Viewing the right knee from the standard lateral portal. Autologous cartilage is collected from the lateral intercondylar notch (star), a nonweightbearing portion of the right knee, while visualizing from the anteromedial portal. The autologous tissue collector (Arthrex, Naples, FL, U.S.A.) is attached to the bone-cutting shaver (arrow). Standard patient orientation: top of image is toward the femur (F), left side of image is lateral (L), right is medial (M), and anterior cruciate ligament is identified.

cases such as this, particularly more chronic ones, it is not unusual to have a large degree of synovitis or a hypertrophic fat pad. This is debrided with an oscillating shaver until adequate visualization is achieved. The lateral tibial plateau chondral defect is identified (Fig 2, Video 01:29). A combination of ringed curette and full-radius shaver is used to prepare the chondral defect by removing any loose or unstable cartilage. The lesion should be debrided until the calcified cartilage zone is removed. Once the lesion has been debrided to a stable base, the Arthrex GraftNet autologous tissue collector

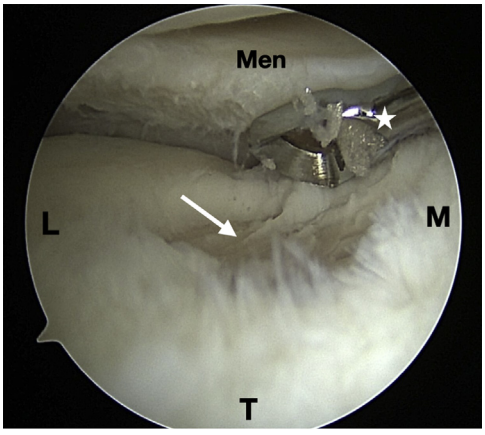

Fig 2. Viewing the right knee from the anteromedial portal, the lateral tibial plateau chondral defect is identified (arrow). A ringed curette (star) is introduced via the medial portal and used to remove any loose or unstable cartilage. Standard patient orientation: bottom of the image is toward the tibia (T), left side of image is lateral (L), right is medial (M), and the meniscus is marked (Men).

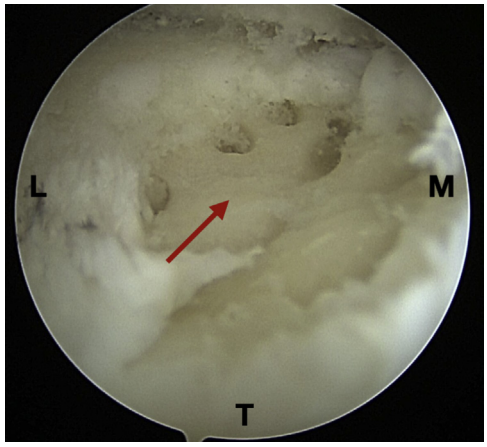

Fig 4. Viewing the right knee from the lateral portal and working via the anteromedial portal, the subchondral bone of the defect (arrow) on the right knee is microfractured using the Arthrex PowerPick microfracture instrument (Arthrex, Naples, FL, U.S.A.). Standard patient orientation: bottom of the image is toward the tibia (T), left side of image is lateral (L), and right is medial (M).

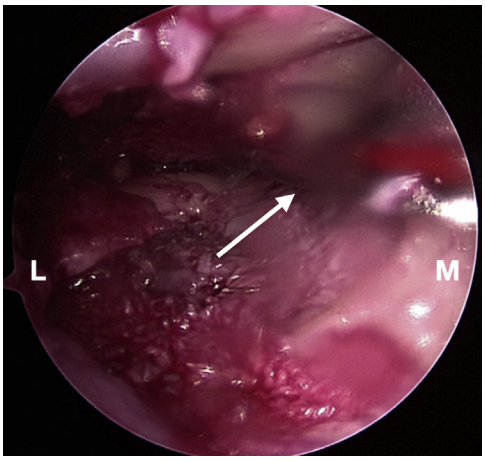

Fig 5. From the anteromedial portal, the graft material is spread evenly into the defect using a fryer (arrow) located on the right knee, and final inspection is performed. Standard patient orientation: left side of the image is lateral (L), and right is medial (M).

(Arthrex) is attached to the 5.0-mm bone-cutting shaver and used to harvest autologous cartilage from a nonweightbearing portion of the knee. In this case, the lateral intercondylar notch was used (Fig 3, Video 01:43). If additional cartilage is required, it can be taken from the superior trochlea. The collected chondrocyte graft material is then taken to the back table and combined with the previously collected BMAC.

The Arthrex PowerPick microfracture instrument (Arthrex) is then used to perform microfracture of the subchondral bone of the defect (Fig 4, Video 02:45). The joint is then evacuated of fluid and distended using CO_2. The CO_2 helps distend the joint for ease of visualization and graft placement, and it also provides a drying effect to the joint. The graft material is then evenly spread into the defect, and a fryer can be used to distribute the graft (Fig 5, Video 03:31). Final inspection is performed, and the portals are closed in the standard fashion. Pears and pitfalls of this surgical technique are listed in Table 1. Advantages and disadvantages are outlined in Table 2.

Following the procedure, the patient is kept nonweightbearing for a total of 6 weeks. Range of motion is initiated on postoperative day 1 from 0 to 90 degrees. Typically, full return to activity is allowed around the 6-month postoperative mark.

Discussion

Chondral defects involving the tibial plateau present challenges to the orthopedic surgeon given anatomic and technical considerations as well as the limited existing literature to guide surgical decision making. Several techniques have been previously described for proximal tibial chondral defects ranging from simple microfracture to more complex osteochondral transplantation.[1,3-5] Marrow-stimulating techniques, such as microfracture, remain a mainstay single-stage treatment option for small articular cartilage defects, with good short-term to midterm outcomes reported.[8,9] Despite this, some evidence suggests deterioration of these effects over time, likely related to formation of a fibrocartilage layer with little hyaline-like repair tissue, inadequate volume of repair tissue, and degeneration of repair tissue over time.[8,10-13] Given this, there has been a growing interest into augmenting microfracture techniques with various growth factors and cell-based scaffolds with the goal of improving outcomes and stimulating normal cartilage healing.[14]

More recently, biologic adjuncts to microfracture procedures, such as particulated cartilage allograft, BMAC, and platelet-rich plasma (PRP), have become popularized with the purpose of increasing chondrogenesis and enhancing cartilage repair over microfracture alone.[2,15,16] There has been growing interest into the regenerative properties of BMAC as both a standalone therapeutic as well as an augmentation to other cartilage procedures.[17] BMAC used in conjunction with microfracture is thought to improve cartilage repair through enhanced recruitment of chondroprogenitor cells and

Table 1. Pears and Pitfalls of Surgical Technique

Pearls	Pitfalls
Ensure defect is well contained and debrided to a stable vertical border of surrounding cartilage.	Avoid using this technique when the subchondral bone is affected or damaged.
Ensure adequate debridement of the calcified cartilage layer without injuring the underlying subchondral bone.	Avoid using this technique for large, uncontained tibial defects or significant bipolar lesions.
Use of a motorized microfracture device allows for more consistent and precise penetration into subchondral bone as well as removal of debris from holes as opposed to traditional picks that compact bone into holes.	This technique fails to address concomitant pathology such as instability, meniscal pathology, or significant coronal malalignment.
Use of the "oscillate" setting on the Arthrex GraftNet tissue collector provides the optimal harvest collection and particle size.	Avoid overfill of tibial defect with bone graft and BMAC mixture.
Use of CO_2 can help obtain a drier chondral defect bed prior to application of bone graft and BMAC mixture as well as adding distention in a tight joint space.	

BMAC, bone marrow aspirate concentrate.

Table 2. Advantages and Disadvantages of Surgical Technique

Advantages	Disadvantages
Arthroscopic, minimally invasive procedure	Potential fibrocartilage fill
No arthrotomy or osteotomy needed	Added time and expense with BMAC harvest
Single-stage procedure	Clinical outcomes and potential benefit over traditional microfracture unknown
Use of autologous cartilage	Potential donor site morbidity

BMAC, bone marrow aspirate concentrate.

growth factors to produce a structurally superior repair tissue with improved integration.[18] Animal models evaluating microfracture augmentation with BMAC for cartilage defects have shown improved integration of repair tissue into surrounding normal cartilage, better defect filling, and a higher percentage of type II collagen with increased proteoglycan content and more normal histologic grading of repair tissue compared with microfracture alone.[19,20] de Girolamo et al.[16] reported on a small cohort of patients who underwent microfracture with adjunct porcine collagen matrix and BMAC application for articular cartilage defects of the knee. In this study, the authors compared cellular characteristics from the microfractured defect site, noting a significantly higher concentration of mesenchymal stem cells from bone marrow aspirate than from subchondral bone underneath the defect site. Studies have shown a direct correlation between higher concentrations of proteoglycans and production of type II collagen with increasing concentrations of mesenchymal stem cells from bone marrow aspirate, highlighting the potential benefits of BMAC augmentation in cartilage repair.[21,22] Use of BMAC in conjunction with autologous chondrocyte grafting as described in our technique theoretically can act synergistically to further increase the hyaline-like component of cartilage repair.

Similar to our technique, Wang et al.[2] described an all-arthroscopic single-stage enhanced microfracture technique using micronized allogeneic cartilage and PRP augmentation for the treatment of tibial chondral defects. Although there are limited clinical outcomes regarding this technique, equine studies have demonstrated a more robust repair with better integration and higher percentage of type II collagen using augmentation with micronized allogeneic cartilage and PRP compared with just microfracture alone.[15] Despite evidence of only a few adverse events associated with allogeneic cartilage, the use of autologous cartilage as graft matrix negates the theoretical risk of a host immune response. In addition, autologous grafts lower added costs associated with an allograft source. Last, the use of BMAC directly increases the concentration of mesenchymal stem cells at the defect site with the goal of increasing the proportion of type II collagen repair tissue produced.

The primary limitation of using BMAC with autologous chondrocyte grafting to augment microfracture for well-contained tibial articular cartilage defects relates to its limited clinical outcome data available. Despite this, BMAC-augmented microfracture has demonstrated efficacy in improving cartilage repair and integration with a safe profile. Overall, the presented technique provides a single-stage all-arthroscopic procedure that is minimally invasive, technically feasible, and cost-efficient that can potentially enhance cartilage repair following microfracture for articular cartilage defects involving the tibial plateau.

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