Journal of Cartilage & Joint Preservation® xxx (xxxx) xxx

Contents lists available at ScienceDirect

Journal of Cartilage & Joint Preservation®

journal homepage: www.elsevier.com/locate/jcjp

Case Series

Medial femoral condyle cartilage restoration using a single-stage combined autologous-allogenic technique: a case report

Brendan Swift and Brian Chilelli*

Mercy Health-Cincinnati SportsMedicine and Orthopaedic Center, Cincinnati SportsMedicine Research and Education Foundation, Cincinnati, OH, USA

ARTICLE INFO

Keywords:
Autologous-allogenic
Cartilage restoration
Case report
Medial femoral condyle
Subchondral bone deficiency

ABSTRACT

Introduction: Cartilage injjuries in the knee pose a significant treatment dilemma. Multiple cartilage restoration procedures currently exist, but often come with significant cost and multistage procedures.

Case presentation: We report a case of a young, active female who, due to insurance limitations, was unable to undergo matrix-associated autologous chondrocyte implantation. The patient was instead treated with a single-stage combined autogenous-allogenic cartilage restoration. In the follow-up period, the patient endorsed marked improvements in Knee injury and Osteoarthritis Outcome Score, International Knee Documentation Committee Subjective Knee Form, and Western Ontario and McMaster Universities Osteoarthritis Index scores as compared to preoperative scores.

Conclusion: Single-stage cartilage restoration with a combined autogenous-allogenic graft technique offers an acceptable alternative to currently available cartilage techniques, with excellent short-term patient-reported outcomes.

Introduction

Untreated full-thickness cartilage injuries in young patients have the potential to adversely affect activity levels and may increase the risk of future progressive degeneration of the knee.[1,2] Advances in the treatment of these injuries have been the focus of much research in recent years. Common procedures currently in use include matrix-associated autologous chondrocyte implantation (MACI), osteochondral allograft transplantation (OCA), osteochondral autograft transplantation, marrow stimulation, as well as other allograft cell-based cartilage transplant procedures utilizing synthetic scaffolds and/or biologic augmentation.[3–7] Unfortunately, due to the costs associated with harvest and chondrocyte culture expansion in the case of MACI, and harvest and processing costs of cadaveric allograft tissue, these techniques are not equally accessible throughout the world. Stemming from these limitations, we describe a novel cartilage restoration technique that utilizes a single-stage harvest of autograft cartilage, with the addition of an allograft extracellular matrix scaffold, combined with bone marrow aspirate concentrate (BMAC) as a source of mesenchymal stem cells, and covered by a hyaluronic acid membrane to protect the construct from compressive and shear forces. The present case report aims to provide an example of the type of patient we feel will benefit from this technique, with a focus on patient-reported outcomes

* Brian Chilelli, Mercy Health-Cincinnati SportsMedicine and Orthopaedic Center, Cincinnati SportsMedicine Research and Education Foundation, 4700 E. Galbraith Road, 3rd Floor, Cincinnati, OH 45236.

Email address: brianchilelli@gmail.com (B. Chilelli).

https://doi.org/10.1016/j.jcjp.2024.100208
Received 9 November 2023; Revised 4 June 2024; Accepted 26 June 2024
Available online xxxx

at 1 year postoperatively. The patient discussed here provided informed consent for the publication of her case. Case report (CARE) guidelines were followed for this report.

Case report

A 22-year-old ex-collegiate softball player presented to the clinic with a 6-week history of left knee pain. She reported that there was no traumatic injury associated with the onset of her pain, however she states that she was kneeling, felt a pop and had immediate pain. She also endorsed catching in the knee. Physical exam demonstrated a trace effusion, full range of motion, and a stable ligamentous exam. Radiographs at her initial visit demonstrated subchondral irregularity of the medial femoral condyle and an associated loose body (Fig. 1), and magnetic resonance imaging (MRI) was ordered for further evaluation. The MRI confirmed intact cruciate and collateral ligaments with the absence of meniscal pathology. There was chondral irregularity over the medial femoral condyle concerning for articular cartilage defect (Fig. 2). This was assessed with computed tomography (CT) which demonstrated an irregularity of the subchondral bone in the area in question without evidence of significant subchondral bone deficiency (> 6 mm). The imaging appearance of the lesion combined with the lesion location and patient history was most consistent with the diagnosis of osteochondritis dissecans. Based on her ongoing mechanical symptoms, the decision was made to proceed with arthroscopic loose body removal and to further investigate the chondral surface.

Diagnostic arthroscopy was carried out through standard portals, and a loose body measuring 2 × 2 cm was identified and removed. Similarly, a large osteochondral defect of the medial femoral condyle was identified and measured 2 × 2.5 cm, with partial coverage by overlying fibrocartilage. It was noted that there was no evidence of subchondral bone irregularity or deficiency > 6 mm. The loose cartilage flaps were debrided to stable margins with the use of an arthroscopic shaver, and the knee was subsequently evacuated. Following surgery, the patient described a resolution of her catching symptoms and reported some improvement in her pain for approximately 6 months. Unfortunately, as she increased her activity level and returned to running, she noted worsening pain and effusion related to activity. Due to the recurrence of her symptoms, further treatment was pursued in the form of osteochondral allograft. Ultimately due to hospital and insurance provider limitations, she was refused treatment with osteochondral allograft. As such, we were forced to pivot the surgical plan and instead prepared for a single-stage cartilage repair technique.

We utilized a technique that capitalizes on products already Food and Drug Administration (FDA)-cleared to incorporate local chondrocyte autograft in combination with an allogenic matrix, performed in a single stage with biologic augmentation. BMAC was collected at the start of the procedure, processed using the Arthrex Angel Bone Marrow Aspirate Processing System (Arthrex), and set aside for later incorporation into the graft. Through a standard medial parapatellar approach, a biopsy gouge was then used to harvest healthy cartilage from non-weightbearing portions of the joint adjacent to the trochlear notch. This cartilage graft was cut down into smaller fragments and minced using an arthroscopic shaver connected to a GraftNet tissue collector (Arthrex) (Fig. 3). The medial femoral condyle defect was noted to involve full-thickness cartilage without the involvement of a significant portion of the

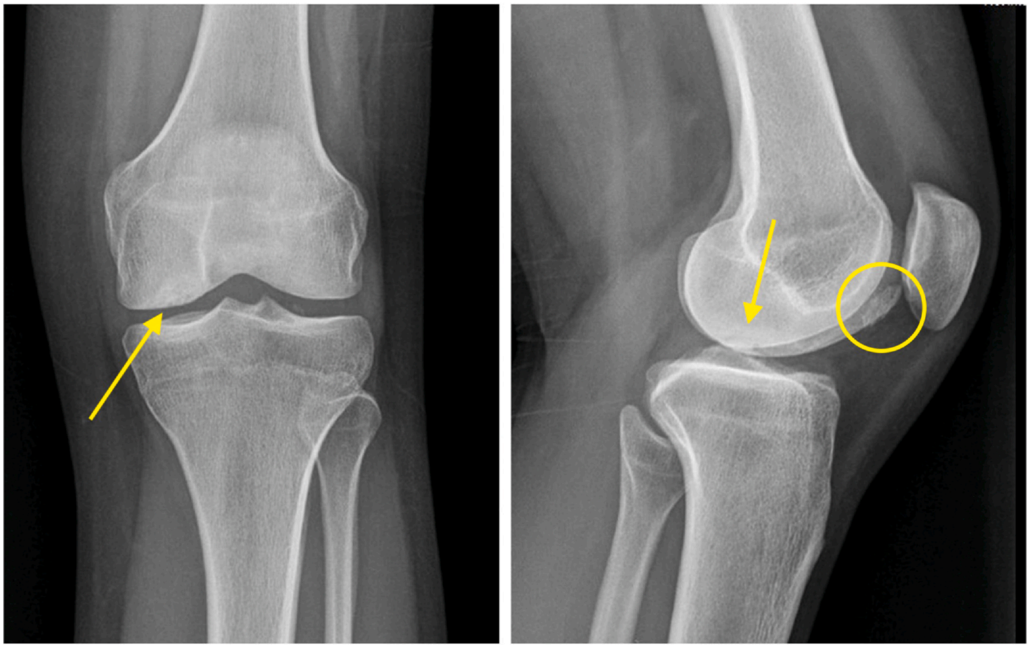

Fig. 1. Left knee radiographs demonstrating subtle subchondral irregularity of the medial femoral condyle (arrow) and associated loose body in the anterior knee (circled).

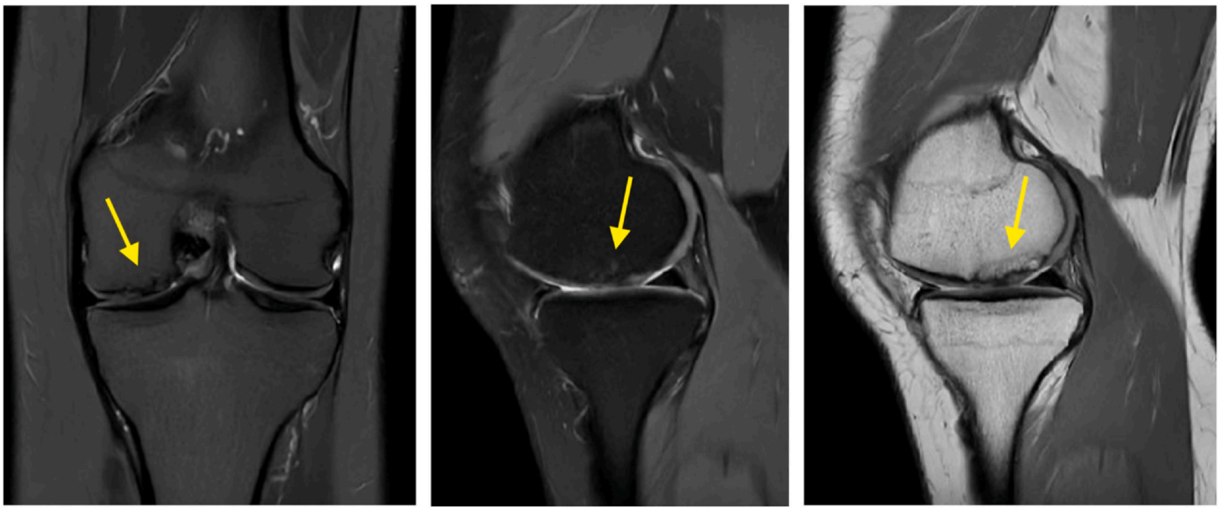

Fig. 2. Left knee MRI demonstrating chondral deficiency, with limited involvement of subchondral bone identified with arrow. MRI, magnetic resonance imaging.

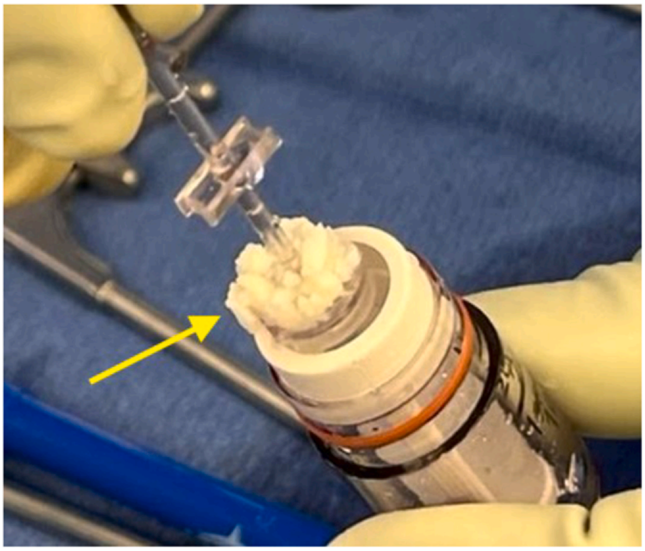

Fig. 3. A biopsy gouge can be used to collect autograft cartilage from non-weightbearing regions on the periphery of the intercondylar notch. This autograft is then fragmented with a scalpel and minced using an arthroscopic shaver. A GraftNet tissue collector is pictured here with collected, minced autograft cartilage (arrow).

underlying bone. The defect was then prepared using ring curettes cutting back to stable cartilage margins. Care was taken not to violate the subchondral bone.

The bed of the defect was then sized using a foil sizing sheet, and a size-matched section was cut out of a hyaluronic acid membrane (Hyalofast; Anika Therapeutics) (Fig. 4). This membrane was seeded with the previously collected BMAC and set aside.

An autologous-allogenic admixture was then created using the collected minced cartilage combined with BioCartilage allograft extracellular matrix (Arthrex). This mixture was packed into the base of the cartilage defect and covered with a light layer of Tisseal fibrin glue (Baxter) (Fig. 5A). The BMAC-soaked hyaluronic acid membrane was then placed over the defect and secured to peripheral cartilage using 6-0 vicryl suture (Fig. 5B).

Postoperatively, the patient was placed in a hinged knee brace locked in extension while being encouraged to unlock the brace and flex to 90° when not ambulating. Continuous passive motion was initiated at 72 hours following surgery from 0 to 30° with the goal of increasing gradually toward 90° until 6 weeks post-op. She remained touchdown weightbearing for 4 weeks before transitioning to partial weightbearing, and subsequently weightbearing as tolerated at 6 weeks postoperatively. At her 6-week post-operative visit, her pain was well controlled, and her range of motion was 0 to 120 with a stable ligamentous exam. By 3 months post-

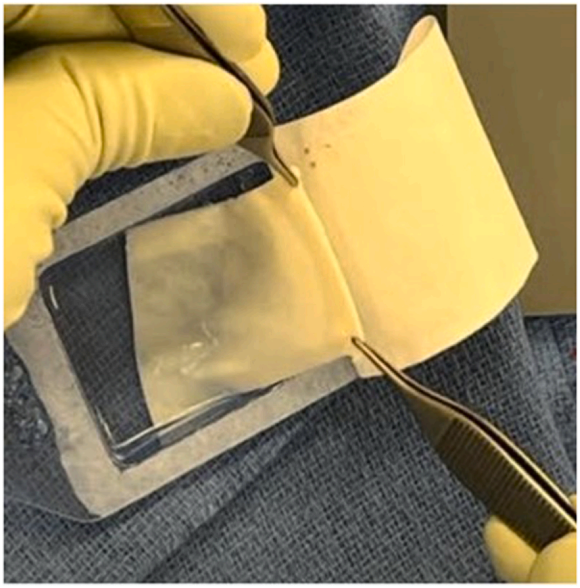

Fig. 4. A hyaluronic acid membrane (Hyalofast) was used in the restoration of the cartilage defect. The membrane is viewed here prior to sizing to the area of defect and prior to saturation with bone marrow aspirate concentrate (BMAC).

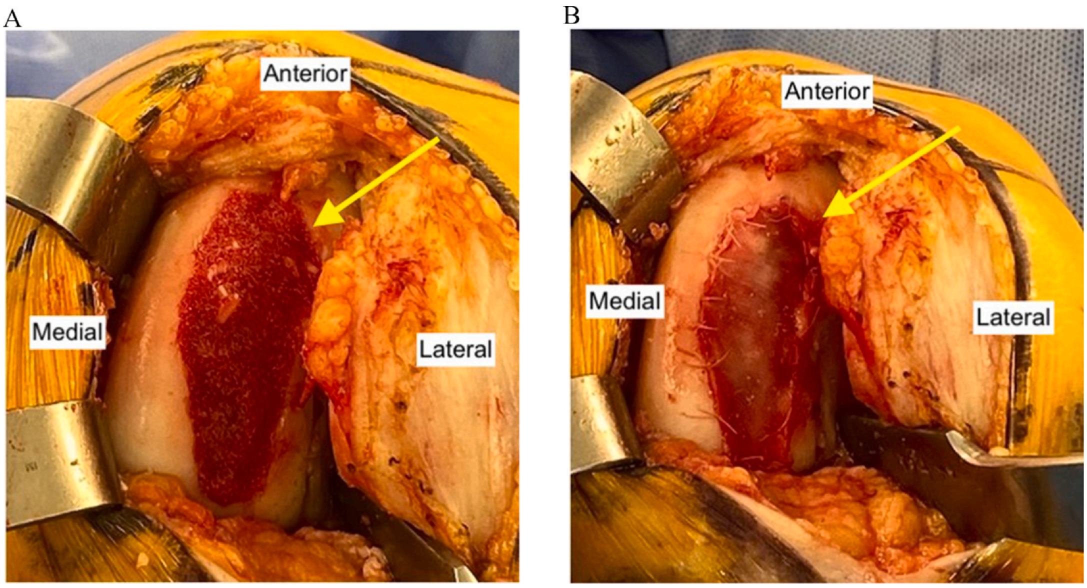

Fig. 5. **A**, Medial femoral condyle defect filled with an admixture of minced autograft cartilage, allogenic micronized cartilage scaffold, and bone marrow aspirate concentrate (BMAC) (arrow). **B**, Filled cartilage defect after suturing hyaluronic acid membrane (arrow) in place.

op, she reported that her preoperative pain completely resolved. She was allowed to progress to running at the 6-month mark. She was seen in the clinic at the 1-year post-op mark and consented to proceed with an in-office needle arthroscopy for assessment of cartilage healing. Under local anesthetic, the needle arthroscopy demonstrated macroscopic healing of her previous defect site with overall good fill. At 2 years postoperatively, an MRI was obtained to evaluate the healing and fill of the medial femoral condyle lesion. Figure 6 demonstrates excellent fill of the defect area without any graft hypertrophy. Cartilage signal is similar to surrounding native cartilage, without evidence of subchondral edema.

Outcomes

Patient-reported outcome measures are presented in Table. The patient endorsed notable limitations preoperatively, with marked improvements by the 1-year postoperative mark. International Knee Documentation Committee Subjective Knee Form scores

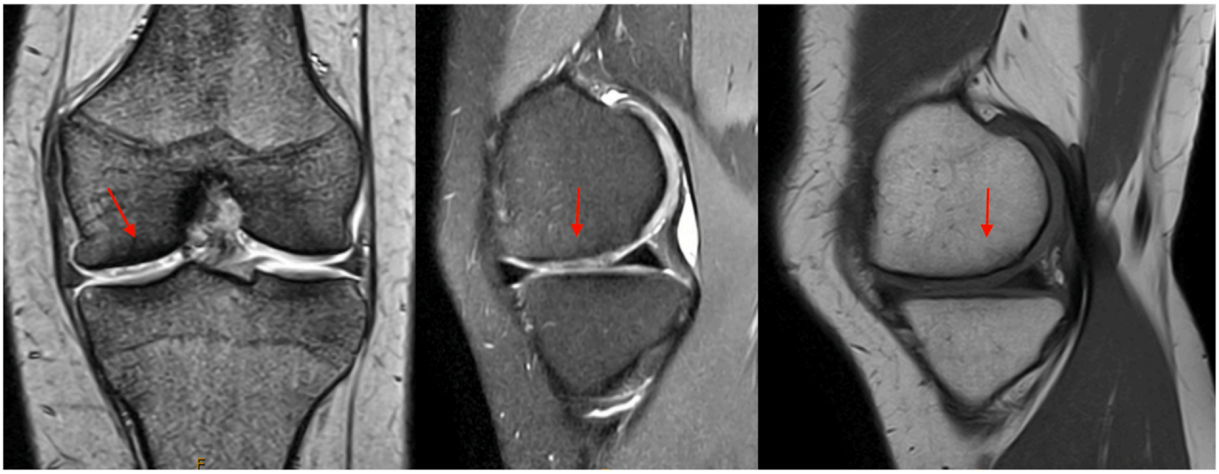

Fig. 6. Left knee MRI at 2 years postoperatively assessing cartilage infill following single-stage autologous-allogenic cartilage restoration. Stable filling of the previous medial femoral condyle lesion with a signal similar to surrounding healthy cartilage is identified (arrow). MRI, magnetic resonance imaging.

Table

Patient-reported outcome measures at baseline, 6 months, 1, and 2 years postoperatively.

	IKDC	KOOS pain	KOOS symptoms	KOOS ADL	KOOS sport & recreation	KOOS QOL	WOMAC function
Baseline	34	47	61	50	30	44	50
6 Months post-op	67	94	100	100	30	81	100
1 Year post-op	93	100	100	100	75	100	100
2 Year post-op	100	100	100	100	100	100	100

Abbreviations: IKDC, International Knee Documentation Committee Subjective Knee Form; KOOS, Knee injury and Osteoarthritis Outcome Score; ADL, Activities of daily living; QOL, Quality of Life; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index.

improved from 34 pre-op to 93 post-op. Similarly large improvements were noted in the sport and recreation subscale from 30 pre-op to 75 at 1 year. At 2 years postoperatively, International Knee Documentation Committee Subjective Knee Form, Knee injury and Osteoarthritis Outcome Score, and Western Ontario and McMaster Universities Osteoarthritis Index scores reached a ceiling effect, at the maximum possible scores of 100.

Discussion

The present case report reviews a clinical indication, and short-term outcomes for a single stage, combined autologous-allogenic cartilage restoration technique. Owing to insurance funding limitations, the above patient was restricted from receiving the well-proven treatments of MACI or OCA. This inspired the development of an alternative technique, which evolved from other cartilage restoration techniques with their own growing bodies of support while trying to avoid marrow stimulation due to its potential alteration of the subchondral bone.[5,8–11] Although a formal cost analysis was beyond the scope of this report, by foregoing the need for multistage procedure and chondrocyte culture expansion, the present technique is markedly less costly than current generation MACI products which run well over $65,000 USD.[12] In the present case, the implant-related costs for the hyaluronic acid membrane ($1500), GraftNet ($500), Biocartilage ($1400), and BMAC kit ($1400) total roughly $4800, markedly less than the product costs associated with MACI. It is important to note that the authors prefer to treat osteochondritis dissecans lesions of the knee that have a subchondral deficiency or irregularity > 6 mm with either OCA or the MACI sandwich technique. However, due to the lack of significant structural subchondral abnormality, it was decided to proceed with a purely surface-based cartilage procedure in this particular case.

There are inherent limitations in the present case report which must be considered, notably this report outlines the experience of one young, healthy patient with relatively short-term follow-up and as such may not be generalized across all populations. Furthermore, without a histologic assessment the cellular composition of the infill cannot be accurately determined, leaving question as to whether the lesion infill experiences a fibrocartilage or more hyaline-like response. Future studies will explore the present technique over a larger patient sample size.

The present case report demonstrates a positive patient-reported outcome in a single patient after undergoing a recently developed single-stage cartilage restoration technique. This outcome lends support to the described technique and provides another treatment option, particularly in situations in which resources may be relatively limited. Future studies will continue to assess outcomes in a larger patient cohort over a longer duration follow-up and will be compared to current cartilage restoration procedures.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Ethics approval

The patient highlighted in our case report gave permission for her information to be used. The patient was made aware of what information would be used and understood that all submitted information and documentation would be deidentified.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Brian Chilelli reports a relationship with Vericel Corporation that includes: speaking and lecture fees. Brian Chilelli reports a relationship with DePuy Synthes Mitek Sports Medicine that includes: consulting or advisory. Brendan Swift reports a relationship with Enovis Corporation that includes: speaking and lecture fees. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

1. Lefkoe TP, Trafton PG, Ehrlich MG, et al. An experimental model of femoral condylar defect leading to osteoarthrosis. *J Orthop Trauma.* 1993;7(5):458–467.
2. Messner K, Maletius W. The long-term prognosis for severe damage to weight-bearing cartilage in the knee: a 14-year clinical and radiographic follow-up in 28 young athletes. *Acta Orthop Scand.* 1996;67(2):165–168.
3. Riboh JC, Cvetanovich GL, Cole BJ, Yanke AB. Comparative efficacy of cartilage repair procedures in the knee: a network meta-analysis. *Knee Surg Sport Traumatol Arthrosc.* 2017;25(12):3786–3799.
4. Lu Y, Dhanaraj S, Wang Z, et al. Minced cartilage without cell culture serves as an effective intraoperative cell source for cartilage repair. *J Orthop Res.* 2006;24(6):1261–1270.
5. Salzmann GM, Ossendorff R, Gilat R, Cole BJ. Autologous minced cartilage implantation for treatment of chondral and osteochondral lesions in the knee joint: an overview. *Cartilage.* 2021;13(1_suppl):1124S–1136S.
6. Solheim E, Hegna J, Øyen J, et al. Results at 10 to 14years after osteochondral autografting (mosaicplasty) in articular cartilage defects in the knee. *Knee.* 2013;20(4):287–290.
7. Dhillon J, Decilveo AP, Kraeutler MJ, et al. Third-generation autologous chondrocyte implantation (cells cultured within collagen membrane) is superior to microfracture for focal chondral defects of the knee joint: systematic review and meta-analysis. *Arthrosc - J Arthrosc Relat Surg.* 2022;38(8):2579–2586.
8. Cole BJ, Haunschild ED, Carter T, et al. Clinically significant outcomes following the treatment of focal cartilage defects of the knee with microfracture augmentation using cartilage allograft extracellular matrix: a multicenter prospective study. *Arthrosc - J Arthrosc Relat Surg.* 2021;37(5):1512–1521.
9. Gobbi A, Whyte GP. Long-term Clinical outcomes of one-stage cartilage repair in the knee with hyaluronic acid–based scaffold embedded with mesenchymal stem cells sourced from bone marrow aspirate concentrate. *Am J Sports Med.* 2019;47(7):1621–1628.
10. Gobbi A, Whyte GP. One-stage cartilage repair using a hyaluronic acid-based scaffold with activated bone marrow-derived mesenchymal stem cells compared with microfracture. *Am J Sports Med.* 2016;44(11):2846–2854.
11. Gobbi A, Karnatzikos G, Scotti C, et al. One-step cartilage repair with bone marrow aspirate concentrated cells and collagen matrix in full-thickness knee cartilage lesions: results at 2-year follow-up. *Cartilage.* 2011;2(3):286–299.
12. Everhart JS, Campbell AB, Abouljoud MM, et al. Cost-efficacy of knee cartilage defect treatments in the United States. *Am J Sports Med.* 2020;48(1):242–251.