Lipoaspiration and Processing to Create Microfragmented Adipose Tissue

Cally McGee,* MD, Michael R. Baria,*† MD, MBA, Corey Gatewood,‡ BA, Maneesh Tiwari,* MD, W. Kelton Vasileff,§ MD, and Chad Lavender,‖ MD
Investigation performed at The Ohio State University Wexner Medical Center, Columbus, Ohio, USA

Background: Orthobiologics are increasingly used to treat musculoskeletal (MSK) conditions. Adipose may be a useful source of autologous cells for orthobiologic interventions. The lipoaspiration and processing techniques necessary to obtain these cells are not traditionally taught in most orthopedic training programs. Therefore, the goal of this video is to review the technique for adipose harvest and preparation to create microfragmented adipose tissue (MFAT).

Indications: Currently, all MFAT applications are off-label. In practice, this is most commonly used for osteoarthritis and tendon disease.

Technique Description: After local anesthesia is administered, a 17-gauge trochar is inserted into the subcutaneous adipose, and tumescent solution is injected. After a 5-minute waiting period, a separate 17-gauge harvest trochar is attached to the Autopose double-syringe (Arthrex; Naples, Florida) and is inserted into the subcutaneous adipose. Lipoaspiration is performed by moving the harvest device back and forth in a fan-like pattern. After 20 mL of lipoaspirate has been harvested from the first site, the lipoaspiration process is repeated on the contralateral side. After 40 mL of lipoaspirate has been harvested, the device is removed and decanted for 3 to 5 minutes. Then, 10 mL of sterile saline solution is injected into the device using the Luer lock attachment. This rinse process is repeated a second time. Once the excess fluid has been removed, the device is capped, and the outer syringe is slowly pushed down to move the tissue through the resizing filter. The inner syringe is removed and contains the final MFAT product.

Discussion/Conclusion: Lipoaspirate is a simple technique that can be performed in the clinic or operating room to create MFAT. This provides a unique population of autologous cells that may be beneficial for treating MSK pathology.

Keywords: lipoaspirate; microfragmented adipose tissue; osteoarthritis; tendinopathy; orthobiologics

VIDEO TRANSCRIPT

Orthobiologic interventions are used in sports medicine and orthopedic practices to treat musculoskeletal (MSK) conditions. Platelet-rich plasma (PRP) and bone marrow concentrate (BMC) are the most commonly used orthobiologics, but adipose is increasingly recognized as another reliable source of autologous cells, such as mesenchymal stem cells, fibroblasts, and macrophages.[1-3] One preparation of adipose for clinical use is referred to as microfragmented adipose tissue (MFAT). To create MFAT, adipose is harvested through lipoaspiration, then rinsed with saline solution, and resized through a filter, which yields the final product. Although PRP/BMC harvesting and processing are well understood in most orthopedic clinics, the technique for adipose is not routinely taught in orthopedic and sports training programs. Therefore, additional education is needed. The goal of this video is to review the technique for adipose harvest and preparation to create MFAT.

The supplies needed to perform the procedure are the following:

1. Two 10 mL syringes of 1% lidocaine with 25-gauge needles

†Address correspondence to Michael R. Baria, MD, MBA, Department of Physical Medicine and Rehabilitation, The Ohio State University, 2835 Fred Taylor Drive, Columbus, OH 43202, USA (email: michael.baria@osumc.edu).
*Department of Physical Medicine and Rehabilitation, The Ohio State University, Columbus, Ohio, USA.
‡College of Medicine, The Ohio State University, Columbus, Ohio, USA.
§Department of Orthopaedic Surgery, The Ohio State University, Columbus, Ohio, USA.
‖Department of Orthopaedic Surgery, Marshall University, Huntington, West Virginia, USA.

Submitted August 9, 2021; accepted December 16, 2021.

One or more of the authors has declared the following potential conflict of interest or source of funding: M.R.B has received fees for services other than consulting from Terumo BCT, received educational consulting fees from Arthrex, and received course fees from SPR Therapeutics. W.K.V. has received consulting fees from Linvatec and is a paid educational consultant for ConMed and Zimmer Biomet. C.L. has received consulting and speaking fees from Arthrex. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

Video Journal of Sports Medicine (VJSM®), 2(3), 26350254221076855
DOI: 10.1177/26350254221076855

2. Eleven-blade scalpel
3. One 50 mL syringes of tumescent solution with a 17-gauge trochar
   - Tumescent solution is created by mixing 250 mL sterile saline, 1 ampule of epinephrine, and 50 mL 2% lidocaine
4. Autopose double-syringe (Arthrex; Naples, Florida)
5. Two 10 mL syringes of sterile saline solution
6. Decanting stand
7. One luer lock connector
8. Empty syringes for final product transfer

The patient is placed in the supine position with their hands folded across the chest or behind the head. The abdomen is examined to determine the optimal harvest site, which is generally half-way between the iliac crest and lower rib. Harvest sites are selected and marked bilaterally. A bilateral harvest minimizes the risk of a cosmetic asymmetry.

After a wide sterile field is prepared, the skin and subcutaneous tissue are anesthetized using 10 mL of 1% lidocaine without epinephrine. A minimally invasive incision is made using an 11-blade scalpel. The 17-gauge trochar is introduced through the incision and advanced in the horizontal plane. Passage through the fascia and entry into the subcutaneous adipose is felt as a single pop. Once the trochar is in the adipose layer, the device is moved back and forth in a 30° to 45° fan-like pattern while slowly infiltrating the tissue with the tumescent solution (injecting approximately 1-2 mL of solution per needle pass). Slow infiltration ensures that a wide area is covered with adequate anesthesia and vasoconstriction. During the infiltration process, the free hand is used to palpate and monitor trochar depth and acts as a barrier so as not to advance past the midline. The angle of the device is maintained in the horizontal plane to minimize the risk of contacting abdominal musculature. Once all tumescent solution is administered, it is allowed to sit for 5 minutes to achieve full anesthetic and vasoconstriction effects.

After the 5-minute waiting period and a second sterile scrub, a new 17-gauge harvest trochar is attached to the Autopose double-syringe and is inserted into the subcutaneous adipose. Once inserted approximately 50% of its length, the outer syringe is pulled back and locked, creating a vacuum. Lipoaspiration is performed by moving the device back and forth in the same pattern used above. If the trochar is retracted too far, the device will lose suction. In this event, remove the trochar, expel the excess air, reinsert, and re-create the vacuum. Loss of suction can be minimized by not withdrawing too far and keeping the initial incision as small as possible. After 20 mL of lipoaspirate has been harvested from the first site, the lipoaspiration process is repeated on the contralateral side. After 40 mL of lipoaspirate has been harvested, the device is removed, set aside on the sterile field, and the patient's incision sites are cleaned and bandaged.

The device is capped and placed in the decanting stand for 3 to 5 minutes. This allows the tumescent solution to settle and then can be discarded. Then, 10 mL of sterile saline solution is injected into the device using the luer lock attachment. This decants for 3 minutes, and the excess fluid is injected out. The saline solution rinse is repeated a second time. The purpose of these rinses is to remove cellular debris, blood, and reduce the amount of time the lidocaine contacts the cellular contents (given the known cytotoxicity of lidocaine). Clinically, removal of red blood cells is visually apparent. The number of rinsing cycles and time needed per cycle has not been studied.

Once the excess fluid has been removed, the device is capped, and the outer syringe is pushed down to move the tissue through the resizing filter. The inner syringe is removed and contains the final MFAT product, which can be transferred to a smaller sterile syringe, via the luer lock connector, for ease of application.

Clinical pearls for adipose harvest and processing:

1. If the patient has undergone abdominal surgeries, keep the harvest away from the region of scarring.
2. A small incision and short needle passes will minimize loss of suction.
3. Using 25 to 50 mL of tumescent solution per harvest site is adequate. Additional tumescence can complicate harvest processing, because the syringe will fill with tumescent fluid, rather than adipose, and require additional decanting. This interrupts the harvest and increases procedure time. The patient will also feel less abdominal bloating with a smaller volume.
4. Steady, gentle movements during infiltration and harvesting will improve patient comfort.
5. Keeping the trochar in the horizontal plane and using the free hand as a midline barrier minimize the risk of iatrogenic injury.

Common experiences include harvest site pain and ecchymosis. The treatment site is often painful for 24 to 72 hours, but this can be managed with rest, ice, and anti-inflammatory medications. We recommend the patient bring a driver, even for office-based procedures. Return to activity after joint injections can begin as tolerated, which generally occurs in the first 1 to 2 weeks. Return to activity after a tendon procedure has not been defined, and the patient should be supervised closely to minimize the risk of reinjury. Postprocedure pain and swelling should resolve prior to return to activity.

Potential harvest site complications include (1) hematoma (the risk is minimized with use of epinephrine and ensuring that the harvest is performed in a wedge pattern to prevent "tunneling") and (2) infection. At the application site, relevant potential complications include (1) joint effusion and (2) infection. In our practice, we have only encountered 2 postinjection joint effusions, which were aseptic and resolved completely with a joint aspiration.

A history of cancer has been a topic of concern when using fat grafts. Recent clinical studies have failed to demonstrate a recurrence of malignancy when using fat grafts in patients with cancer.[5,11] Although this is reassuring, it is still prudent for physicians to use their best clinical judgment, including consultation with their local oncology team to determine whether MFAT is suitable for their patients with a history of cancer.

The procedure should not be performed on patients currently taking anticoagulation, given the concern for hematoma development. The procedure could be performed if the patient is able to hold anticoagulation therapy for a brief period.

Adipose is a source of autologous cells that has several potential advantages as an orthobiologic treatment. The tissue is readily available in most patients. Harvesting is technically simple and well tolerated, even in clinic settings. After rinsing and resizing, the resultant MFAT is comprised of a heterogeneous cell population, including adipocytes, macrophages, fibroblasts, and mesenchymal stem cells.[7] The total nucleated cell count of MFAT ranges between 2700 and 370,000 per milliliter.[13,15] This composition is distinct from PRP and BMC, which means MFAT could serve as a therapeutic alternative for patients who failed to respond to blood-based orthobiologics.

All clinical uses of MFAT are currently off-label. That said, the primary off-label uses are osteoarthritis (OA) and tendon disease. Clinical data for MFAT are limited. For knee OA, Borić et al[4] treated 17 patients with MFAT and found improved cartilage quality on delayed gadolinium-enhanced magnetic resonance imaging of cartilage. Mautner et al[12] performed a retrospective comparison of MFAT versus BMC and found clinical improvement in both groups without a significant difference between groups at 1 year. In the only randomized study, Dallo et al[6] treated 25 patients with PRP and viscosupplement combination therapy versus 25 patients with MFAT. At 1 year, there was no difference in the Knee Injury and Osteoarthritis Outcome Score or the Visual Analog Scale for pain. The MFAT group had a slightly higher Tegner activity level, but this was of uncertain clinical significance.

Data for MFAT in tendon disease are also limited. Hogaboom et al[10] performed a pilot study on MFAT injections for rotator cuff tendinopathy in 10 spinal cord injured wheelchair users. They reported improvement in patient-reported outcomes, but follow-up was limited and there was no control group.[10] Ferracini et al[8] performed a small case-control study on Achilles tendon repair augmented with MFAT. Eight patients had their Achilles repair augmented with MFAT and were compared with nonaugmented repair. Ultrasound examination 3 months after repair demonstrated improved tendon remodeling in the MFAT group. There was no difference in patient-reported outcomes at 3 months. Larger studies are needed to further define the clinical utility of MFAT for joint and tendon pathology.

The technique presented in this video has several advantages. The setup is simple and requires minimal workspace. In addition, it is a closed system, which improves efficiency and reduces the risk for contamination. In our experience, the final injectate volume is predictable. After the 40 mL harvest and processing, the final volume of MFAT available for use is 15 to 20 mL. Although optimal dosing has not been established, volumes ranging between 5 and 9 mL per injection are the most commonly reported.[9] Therefore, the technique described here would provide volume sufficient for 2 injections. If only a single site is being treated, the harvest volume could be reduced to a 10 mL harvest per side.

This technique should only be performed under sterile conditions for the creation of minimally manipulated autologous cells that are removed, rinsed, resized, and reimplanted in the same patient during the same procedure.[14]

Lipoaspirate is a simple technique that can be performed in the clinic or operating room to create MFAT, which provides a unique population of autologous cells that may be beneficial for treating MSK pathology.

REFERENCES

1. Acosta JR, Douagi I, Andersson DP, et al. Human adipose tissue macrophages: which types are we talking about? *Obesity Facts*. 2016;9:189.
2. Alemany M, Fernández-López JA. Adipose tissue: something more than just adipocytes. *Curr Nutr Food Sci*. 2006;2(2):141-150.
3. Algire C, Medrikova D, Herzig S. White and brown adipose stem cells: from signaling to clinical implications. *Biochim Biophys Acta Mol Cell Biol Lipids*. 2013;1831(5):896-904.
4. Borić I, Hudetz D, Rod E, et al. A 24-month follow-up study of the effect of intra-articular injection of autologous microfragmented fat tissue on proteoglycan synthesis in patients with knee osteoarthritis. *Genes*. 2019;10(12):1051.
5. Calabrese C, Kothari A, Badylak S, et al. Oncological safety of stromal vascular fraction enriched fat grafting in two-stage breast reconstruction after nipple sparing mastectomy: long-term results of a prospective study. *Eur Rev Med Pharmacol Sci*. 2018;22(15): 4768-4777.
6. Dallo I, Szwedowski D, Mobasheri A, Irlandini E, Gobbi A. A prospective study comparing leukocyte-poor platelet-rich plasma combined with hyaluronic acid and autologous microfragmented adipose tissue in patients with early knee osteoarthritis. *Stem Cells Dev*. 2021; 30(13):651-659.
7. Eto H, Suga H, Matsumoto D, et al. Characterization of structure and cellular components of aspirated and excised adipose tissue. *Plast Reconstr Surg*. 2009;124(4):1087-1097.
8. Ferracini R, Artiaco S, Daghino W, et al. Microfragmented adipose tissue (M-FATS) for improved healing of surgically repaired Achilles tendon tears: a preliminary study [published online ahead of print November 26, 2020]. *Foot Ankle Spec*. doi:10.1177/19386400 20974557.
9. Gobbi A, Dallo I, Rogers C, et al. Two-year clinical outcomes of autologous microfragmented adipose tissue in elderly patients with knee osteoarthritis: a multi-centric, international study. *Int Orthop*. 2021; 45(5):1179-1188.
10. Hogaboom N, Malanga G, Cherian C, Dyson-Hudson T. A pilot study to evaluate micro-fragmented adipose tissue injection under ultrasound guidance for the treatment of refractory rotator cuff disease in wheelchair users with spinal cord injury. *J Spinal Cord Med.* 2021:44(6):886-895. doi: 10.1080/10790268.2021.1903140. Epub 2021 Apr 8. PMID: 33830898; PMCID: PMC8725703.
11. Krastev T, van Turnhout A, Vriens E, Smits L, van der Hulst R. Long-term follow-up of autologous fat transfer vs conventional breast reconstruction and association with cancer relapse in patients with breast cancer. *JAMA Surg*. 2019;154(1):56-63.
12. Mautner K, Bowers R, Easley K, Fausel Z, Robinson R. Functional outcomes following microfragmented adipose tissue versus bone marrow aspirate concentrate injections for symptomatic knee osteoarthritis. *Stem Cells Transl Med*. 2019;8(11):1149-1156.
13. Nava S, Sordi V, Pascucci L, et al. Long-lasting anti-inflammatory activity of human microfragmented adipose tissue. *Stem Cells Int*. 2019;2019:5901479.
14. Rodeo SA. Moving toward responsible use of biologics in sports medicine. *Am J Sports Med*. 2018;46(8):1797-1799.
15. Vezzani B, Shaw I, Lesme H, et al. Higher pericyte content and secretory activity of microfragmented human adipose tissue compared to enzymatically derived stromal vascular fraction. *Stem Cells Transl Med*. 2018;7(12):876-886.