Technical Note

Arthroscopy with Lipoaspirate and Plasma Infiltration Using Adipose-Derived Stem Cells Plus Platelet-Rich Plasma: Harvesting and Injection for Arthroscopic Treatment of Cartilage Defects of the Knee

Patrick Weninger, M.D., Xaver Feichtinger, M.D., Caterina Steffel, B.Sc., Celina Kerschbaumer, B.A., B.Sc., and Dominik Duscher, M.D., Ph.D.

Abstract: Osteoarthritis, predominantly of the knee, is a highly prevalent disease leading to pain, reduced quality of life, and significantly reduced ability to work. With autologous orthobiologic options, new regenerative treatment methods have emerged, offering an alternative to early surgical intervention. Supercharged Liparthroplasty combines arthroscopy with lipoaspirate and plasma infiltration of the joint. Lipoaspirate contains high levels of adipose-derived stem cells, which show chondroprotective and anti-inflammatory qualities. Intra-articular injection, combined with platelet-rich plasma administration for accelerated cartilage metabolism, thus provides an optional approach in osteoarthritis treatment. This article aims to provide in detail our regimen for Supercharged Liparthroplasty, including tissue harvesting and preparation of the injectables, therefore enabling physicians to adopt this point-of-care technique.

Osteoarthritis (OA) of the knee joint is a commonly known and widespread disabling and painful disease.[1-3] Especially in developed countries, this entity causes millions of unproductive workdays annually and is therefore a huge socioeconomic problem.[4-6] It is commonly accepted that nonsurgical as well as surgical options are available when treating OA.[7,8]

Surgical options include cartilage transplantation, osteotomy around the knee, and partial or total knee arthroplasty.[8,9] As with every surgical procedure, perioperative and/or postsurgical complications and/or side effects are possible and, in some cases, inevitable.[10] Common adverse effects include swelling, loss of sensitivity, postoperative pain, limitation of range of motion, and anesthesia-related problems, as well as thromboembolic events.[11,12] Serious complications, although not frequent, include infection, blood loss, and irreversible nerve damage.[12-14]

Today, nonsurgical options include physiotherapy, extracorporeal shockwave therapy, magnetic field therapy, and orthobiologic options.[3,8,15,16] With autologous orthobiologic options such as platelet-rich plasma (PRP) or stromal vascular fraction, innovative treatment protocols for OA therapy have been described recently.[3,17,18] Whereas PRP is known to be a source of growth factors and cytokines, adipose-derived tissue has more recently attracted attention as a possible source of adipose-derived stem cells (ASCs) and progenitor cells to repair cartilage defects.[19-21] The definitive pathways of cartilage regeneration induced by orthobiologic therapies are still discussed controversially and are a matter of ongoing research.[3,22,23] Nevertheless, recent studies have pointed out promising and easy-to-handle techniques to harness the beneficial effects of regenerative orthobiologic

From Sports Medical Center, Vienna, Austria (P.W., X.F., C.S.); Academic Stem Cell Center Vienna, Vienna, Austria (P.W., C.S., C.K., D.D.); The Face and Longevity Center Munich, Munich, Germany (D.D.); and Department of Plastic, Reconstructive, Hand and Burn Surgery, BG-Trauma Center, Eberhard Karls University Tübingen, Tübingen, Germany (D.D.).

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Address correspondence to Patrick Weninger, M.D., Sports Medical Center, Am Hof 11/9, 1010 Vienna, Austria. E-mail: ordination@dr-weninger.at

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therapeutics.[9,23-25] In particular, abdominal adipose tissue has been recognized as a potential source of ASCs.[26]

Regenerative therapeutics from adipose tissue are easy to prepare from lipoaspirate at the point of care, and it has been shown that suction-assisted liposuction does not impair the regenerative potential of ASCs.[27,28] As a consequence, the focus on adipose-derived cell therapies led to the first clinical studies showing encouraging results in patients with OA.[25,29] Taking this approach 1 step further, in this article, we describe an easy, effective, and safe method to harvest ASC-rich fat for joint regeneration, called "Liparthroplasty,"[24] supercharged with simultaneous PRP administration, for the treatment of patients with knee OA.

Operative Technique

The procedural steps are summarized in a flowchart (Fig 1) and Video 1. First, the patient is placed in the supine position for harvesting of autologous abdominal fat. A perioperative intravenous single-shot antibiotic (cefazolin) is administered 15 minutes preoperatively. The harvesting site is draped with 4 square drapes, and sterile washing is performed. Lipoaspirate is harvested with the patient under regional anesthesia by use of 1% lidocaine and epinephrine, 1:1,000, from the abdominal region via a single umbilical stab incision made by a No. 11 blade (Fig 2). After infiltration of 100 mL of tumescent solution (1,000 mL of saline solution, 1 mL of 1:200,000 epinephrine, and 600 mg of lidocaine), fat is obtained from the lower abdomen (Fig 3A). For harvesting, a 20-mL syringe is connected to a steel blunt liposuction cannula of 3 mm in diameter (Tulip Medical, San Diego, CA). The cannula is inserted into the subcutaneous fat, and by aspiration of the syringe, a vacuum is obtained. Liposuction is then performed by back-and-forth motions of the cannula, oriented parallel to the underlying fascia. Meanwhile, the nondominant hand applies pressure to the abdominal wall to ensure the depth and direction of the cannula (Fig 3B).

After harvesting of the abdominal fat graft, the patient is prepared and draped in the supine position for knee arthroscopy in a leg holder without a tourniquet. An anterolateral incision is made, and the knee is inflated with saline solution with 70 mm Hg of pressure. Possible meniscal tears are repaired and cartilage fragments removed. The cartilage defect will then be prepared: (1) In patients with focal and deep defects, a shaver (Arthrex, Naples, FL) and a curette are used to debride the defect and to expose the subchondral layer of bone. In such defects, a power pick (Arthrex) drill is used to create micro-holes within the defect to allow bone marrow tissue to migrate into the defect. (2) In patients with degenerative OA, an arthroscopy is performed to remove cartilage fragments and to remove osteophytes if they lead to reduced range of motion.

During arthroscopy, the autologous fat graft is prepared. The fat tissue is separated from fluids and oils by

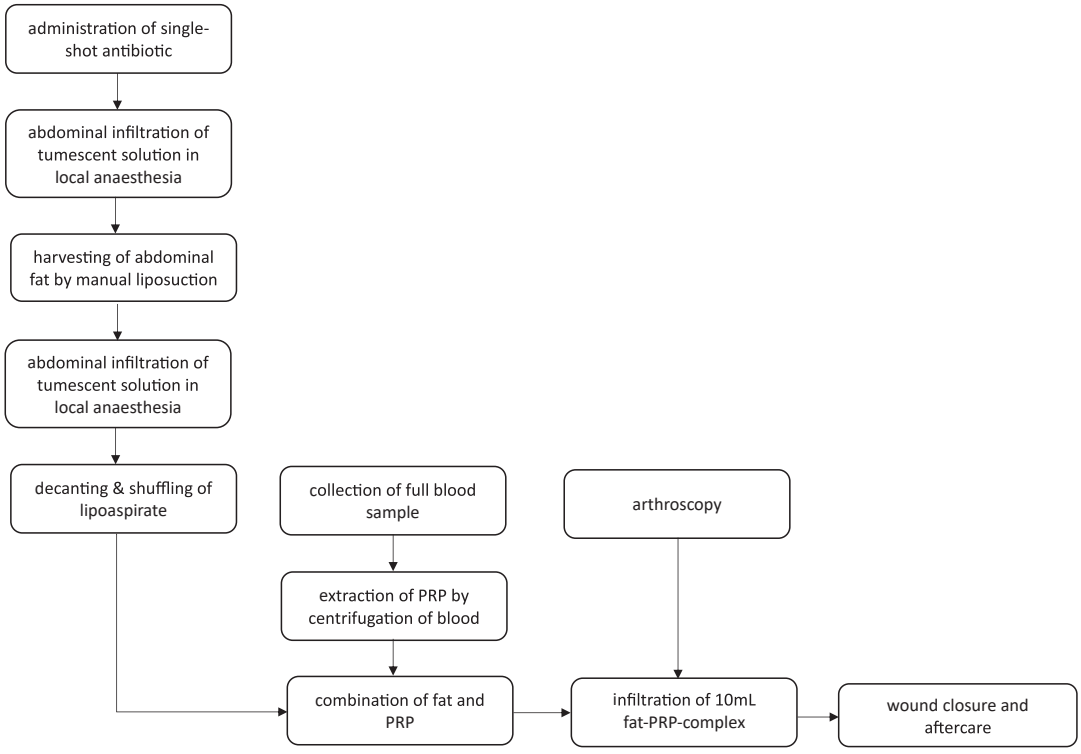

Fig 1. Step-by-step guide for Supercharged Liparthroplasty technique. (PRP, platelet-rich plasma.)

Fig 2. Material necessary for fat harvesting. (A) Components of tumescent solution. (B) Instruments for fat infiltration and harvesting.

the decanting method without the need for centrifugation (Fig 4A). Therefore, the syringes are placed upright, and after a few minutes, the lipoaspirate separates. The fluid layer is then decanted by disposing it out of the syringe (Fig 4B). Next, the fat is mechanically homogenized with 2 syringes (shuffling method): One fat-containing syringe is connected to a second, empty syringe by a 3-way valve. The fat is shuffled by transferring the content of 1 syringe to the other syringe 10 times, thus creating a refined fat graft (Fig 4C). Meanwhile, 15 mL of peripheral venous blood is drawn from the patient's cubital vein with a double-chamber syringe (Arthrex) by the anesthetist. This sample of venous full blood is then centrifuged in a standard centrifuge (Rotofix 32 A; Hettich, Tuttlingen, Germany) with 1,500 rounds for 5 minutes. The PRP fraction will be inserted into the smaller of the 2 syringe chambers (Fig 5A). The cellular whole blood fraction

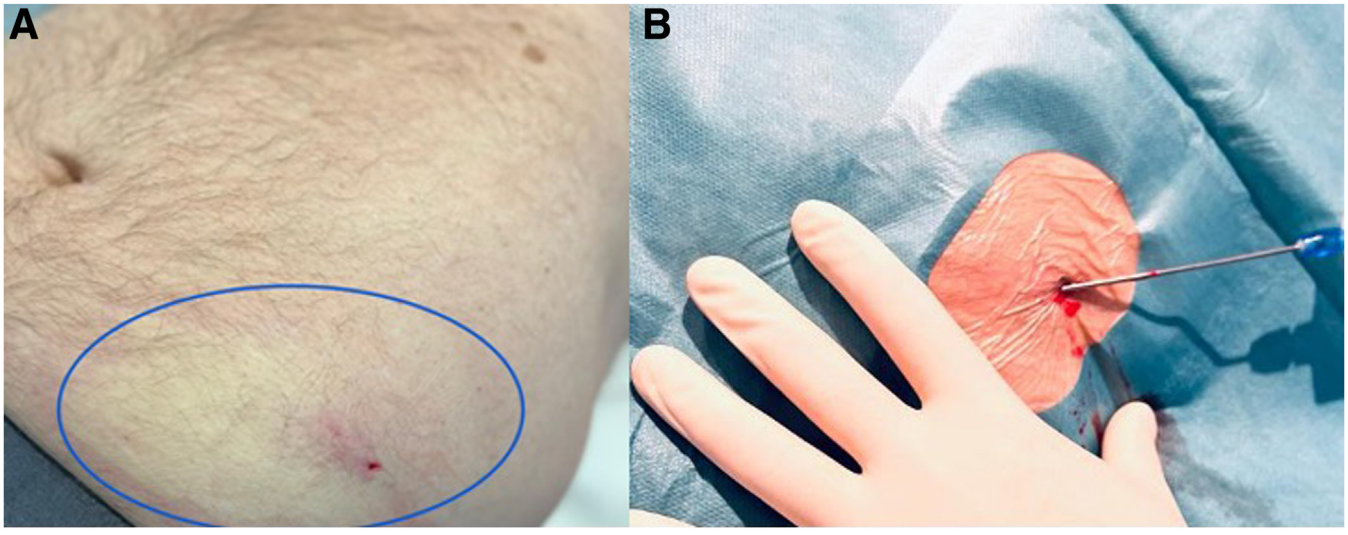

Fig 3. Liposuction technique. (A) Typical clinical aspect of abdominal infiltration site. One should note the white color of the skin (oval) induced by the local anesthesia component of the tumescent solution. (B) Manual liposuction is performed using a cannula. The cannula is inserted into the subcutaneous fat, and by aspiration of the syringe, a vacuum is obtained. Liposuction is then performed by back-and-forth motions of the cannula, oriented parallel to the underlying fascia. Meanwhile, the nondominant hand applies pressure to the abdominal wall to ensure the depth and direction of the cannula.

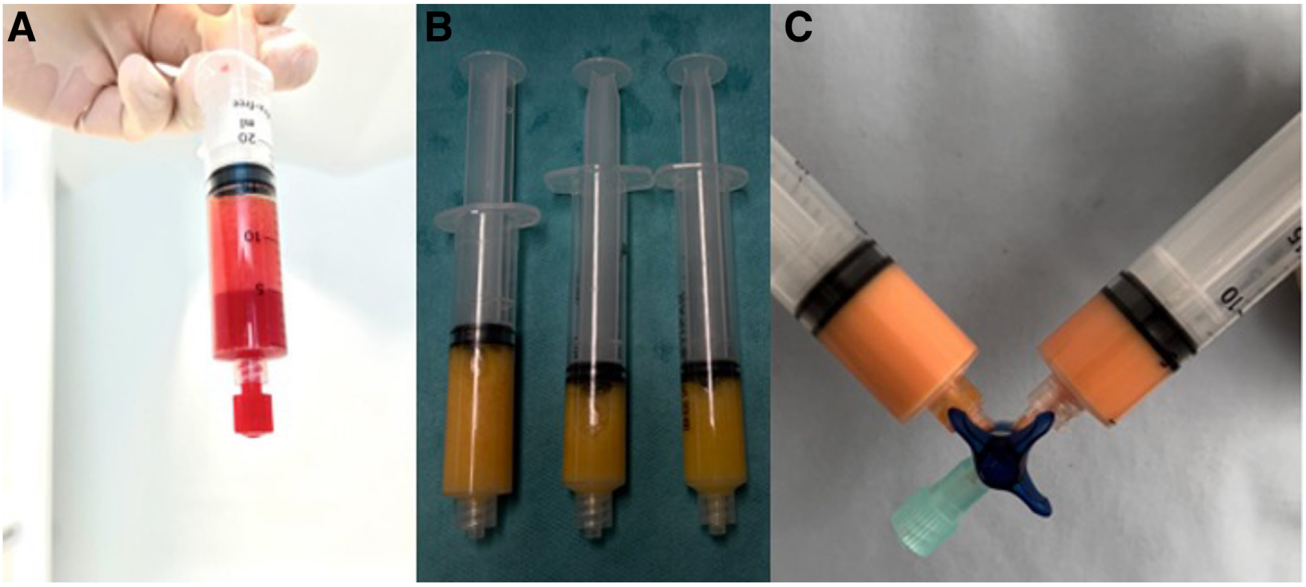

Fig 4. Cell therapeutic preparation. (A) Fat after decanting with fluid separated. (B) Pure fat grafts after extraction of tumescent fluid. (C) Refinement via shuffling technique, making graft smooth and ready for combination with platelet-rich plasma and intra-articular injection.

will then be dismissed. The PRP fraction is added to the fat graft. If 2 knees are treated, 2 double syringes are used to create PRP. A single-use 20-gauge needle is used to inject 10 mL of the combined PRP—fat graft into the knee joint (Fig 5B). The knee joint is cycled afterward.

Wound closure is performed using interrupted sutures and a sterile, self-adhesive dressing. Postoperatively, no crouches are used and patients are allowed to bear full weight as tolerated according to pain threshold. A daily dose of 5,000 IU of low-molecular-weight heparin is recommended. We also recommend the administration of a nonsteroidal anti-inflammatory drug (e.g., diclofenac, 75 mg) 2 times daily combined with pantoprazole, 40 mg, for 3 days. In all patients, we routinely recommend local cryotherapy 3 times postoperatively. Ergometer and/or indoor bicycle riding is recommended after 3 days; gentle running is allowed after 3 weeks at the earliest. Stop-and-go sports should be avoided for 6 weeks.

Discussion

Orthobiologic treatment options in patients with cartilage damage and arthritis are emerging techniques. Recently, promising results have been described by different authors on this topic. In 2022, Mayoly et al.[30] published data on patients with wrist OA. They found significantly decreased pain and improved function after injecting autologous microfat and PRP. Dallo et al.[19] recently reported on the combination of PRP and adipose stroma to treat knee OA. They pointed out that the optimal use of stromal vascular fraction plus PRP has not yet been identified.

To date, we know that the density of ASCs is highest when harvested from abdominal fat compared with other harvest regions.[31,32] Furthermore, it has been repeatedly stated that even ultrasound-assisted aspiration liposuction does not compromise the regenerative potential of ASCs.[26,27,33,34] Therefore, it can be assumed that the preparation of a cell therapeutic based on lipoaspirate samples can be effectively performed as a point-of-care procedure.

Liparthroplasty was described by Duscher et al.[34] in 2017 for the first time. In their article, they reported a technique to treat metacarpo-carpal arthritis of the thumb as an alternative to surgical arthroplasty. In 2022, the same group published the 5-year results of thumb Liparthroplasty and showed a significant reduction in all post-intervention Disabilities of the Arm, Shoulder and Hand (DASH) scores and pain levels compared with those prior to Liparthroplasty.[35] These data confirm Liparthroplasty as a reliable bridging therapy for preserving joint integrity as long as possible.

Although basic research has provided proof of the anti-inflammatory and chondroprotective effects of ASCs,[36,37] the exact mode of action of Liparthroplasty is still unclear. Intra-articular fat tissue may also involve beneficial mechanical properties in terms of a buffer effect cushioning force transduction, as well as favorable lubricant effects. Recently, PRP was described as promising method to treat OA. Principally, its effects of reducing the inflammatory process and altering cartilage metabolism seem to logically add to Liparthroplasty. Additionally, PRP has the benefit of being able to be harvested by drawing blood from a peripheral vein without the requirement for an operating room.

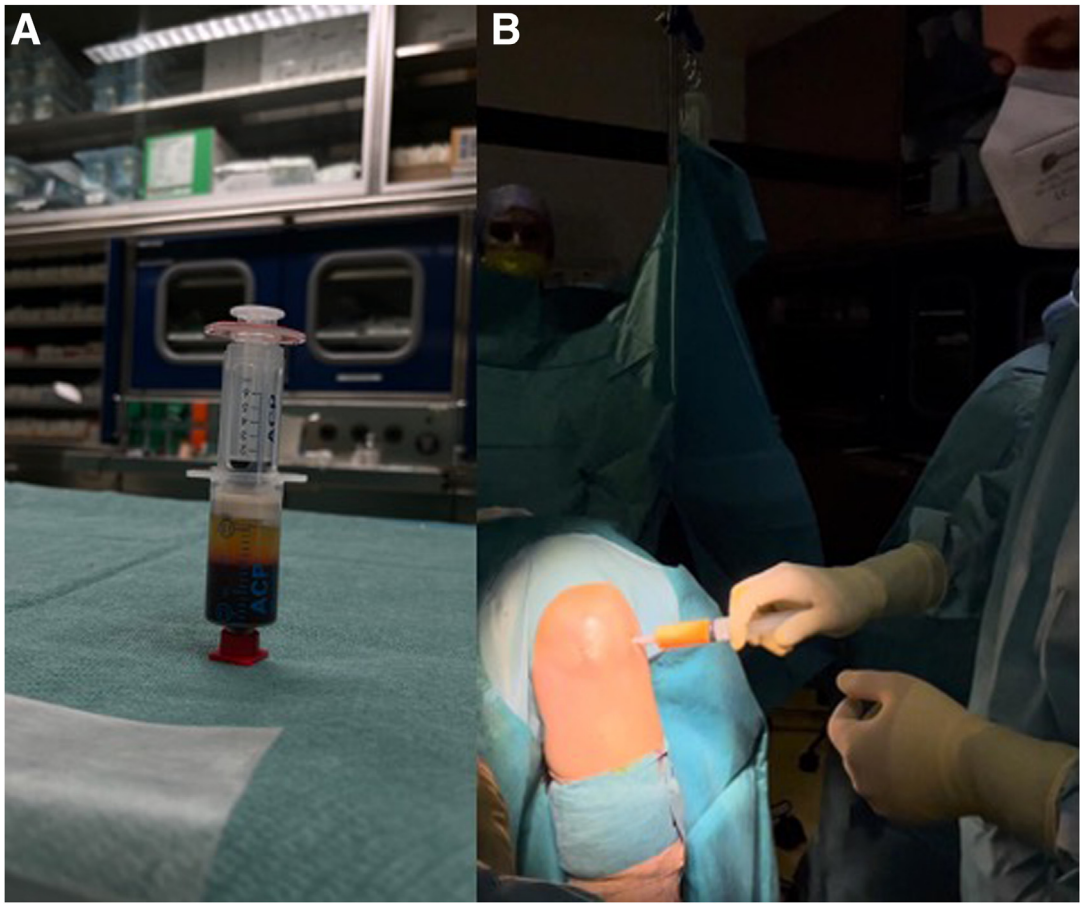

Fig 5. Supercharged Liparthroplasty procedure. (A) Double-chamber syringe (Arthrex) after centrifugation of patient's venous full blood, containing separated platelet-rich plasma and cellular blood components. (B) Intra-articular injection of cell therapeutic.

However, previous studies have reported the need for a sequential injection consisting of 2 sessions.[38] Ultimately, this technique must prove its sustainability in improving pain levels and functional parameters when used as a stand-alone approach.

Table 1. Advantages, Pearls, Disadvantages, and Pitfalls of Supercharged Liparthroplasty

Advantages and pearls
Minimally invasive procedure
Possible with patient under local anesthesia
Low complication risk
Secondary TKA as salvage procedure possible at any time
Day-clinic procedure
High patient satisfaction
Disadvantages and pitfalls
Long-term results pending
No standardized operating protocol regarding cell quality and/or quantity
No data regarding clinical effect and no comparison between different types of ASC preparation (fat graft, SVF, and bone marrow stem cells)

ASC, adipose-derived stem cell; SVF, stromal vascular fraction; TKA, total knee arthroplasty.

Table 1 shows the advantages and limitations of the described technique. In our opinion, there are 2 major drawbacks as with every technique focusing on OA and cell- or tissue-based therapy: the lack of long-term results and the lack of standardization of orthobiologic treatment preparations. This means that, so far, it is still unclear how the therapeutic needs to be composed and whether multiple sessions are required to successfully treat OA. Therefore, further randomized controlled clinical studies, ideally combined with magnetic resonance imaging, are necessary to clearly delineate the regenerative effect of Supercharged Liparthroplasty in patients with knee OA and to assess possible side effects of its use.

In conclusion, Supercharged Liparthroplasty, comprising harvesting of lipoaspirate and PRP, as well as intra-articular injection, is an easy-to-handle point-of-care procedure, offering an alternative to early extensive surgical intervention in patients with knee OA. The minimally invasive procedure exhibits a low risk of complications; we report no adverse events during surgery or postoperatively in patients treated thus far.

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