



Synovialization and Revascularization Enhancement in Repaired and Reconstructed ACL: PCL Fat Pad Transfer Technique

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Abstract: The rapid development of anterior cruciate ligament (ACL) reconstruction and repair techniques has significantly improved the outcomes of these procedures. However, there is still some place for how to improve surgical techniques to limit the amount of revision surgeries. Over the past decade, biological solutions and methods of ligament remodeling enhancement have been proposed. The use of the native ACL remnants has been the most thoroughly analyzed technique. However, despite its benefits, this technique may not be sufficient to improve outcomes and may cause some technical difficulties. On the other hand, the posterior cruciate ligament (PCL) fat pad contains an abundant synovial vascular network and is located in close proximity to the ACL, which makes it a potential biological donor place of cells and tissue that could enhance the ligamentization of the repaired or reconstructed ACL. To optimize the use of this donor site, we propose the technique of ACL synovialization and revascularization enhancement with a PCL fat pad transfer.

Over the past few decades, a tremendous improvement in anterior cruciate ligament (ACL) tear management has occurred because of the initial advancements in anatomical and biomechanical research, followed by the development of reconstructive techniques that fulfilled those principles. Moreover, the development of efficient intraligamentous stabilization techniques has resulted in a renaissance of ACL repairs which had been forgotten for years. The final success of surgery depends, among others, on the healing and

remodeling of the repaired or reconstructed ACL. It was proven that for proper occurrence of this process, the revascularization of a ligament is necessary.¹ Vascular ingrowth in the ACL begins at the synovial membrane as it descends and ascends from the ligament stumps toward the mid-portion of the ligament.¹ Therefore, the enhancement of ligament synovialization may potentially be of great benefit. However, neither the preservation of ligament remnants nor the technique of enveloping the graft with periosteum seem to be sufficient and may be hampered by technical difficulties.^{2,3} Either way, there is a need to search for other biological options which may improve ACL synovialization. The answer may be the posterior cruciate ligament (PCL) fat pad, which appears to be well vascularized and rich in cell tissue to biologically enhance the healing and maturation of the repaired/reconstructed ACL.⁴ Our aim is to present an arthroscopic technique of PCL fat pad transfer for a reconstructed or repaired ACL, which is an easy and efficient procedure to potentially improve the ACL remodeling process.

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The authors report the following potential conflicts of interest or sources of funding: K.M. is a Zimmer Biomet consultant and serves on the PTArthro Board. R.F.L. is a consultant and receives royalties from Arthrex, Ossur, and Smith and Nephew and serves on the Editorial Boards of American Journal of Sports Medicine, Journal of Experimental Orthopaedics, and Knee Surgery, Sports Traumatology, Arthroscopy. Full ICMJE author disclosure forms are available for this article online, as [supplementary material](#).

Received April 17, 2020; accepted June 11, 2020.

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2212-6287/20712

<https://doi.org/10.1016/j.eats.2020.06.019>

Surgical Technique

Indications

The technique may be added to either an ACL repair or reconstruction. The technique may be especially of

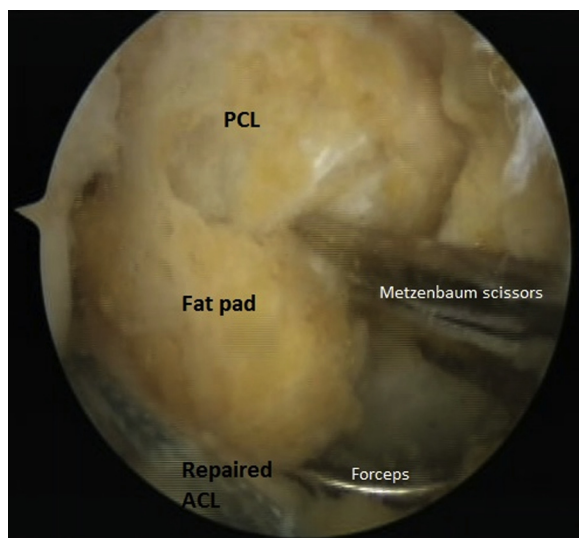


Fig 1. Arthroscopic view from the anterolateral viewing portal in a right knee joint. The fat pad transfer technique in the setting of the ACL repair. The fat pad, grasped with curved forceps, is being detached from the anterior surface of the PCL with Metzenbaum scissors. (ACL, anterior cruciate ligament; PCL, posterior cruciate ligament.)

benefit in patients with general comorbidities that could interfere with the native healing process.

Contraindications

There are no specific contraindications to this procedure.

Patient Positioning and Preparation

The patient is positioned supine with the operated leg placed in a leg holder. A nonsterile thigh tourniquet is used. After the induction of a regional or general anesthesia, the operated leg is prepared and draped in a sterile fashion. A diagnostic arthroscopy is performed through the standard anterolateral, anteromedial, and medial parapatellar arthroscopic portals to rule out concomitant intraarticular lesions and to establish the diagnosis of the ACL tear. Depending on the clinical setting, a repair or a reconstruction of the torn ACL is performed.

PCL Fat Pad Transfer Technique in the ACL Repair

The technique requires three arthroscopic portals: anterolateral, anteromedial, and medial parapatellar. With the knee in the 90° of flexion, a 30° arthroscope (Arthrex, Naples, FL) is positioned through the standard anterolateral portal. When a repair of the ACL is completed (Video shows the internal-bracing technique), a standard medial parapatellar portal is prepared. The fat pad covering the anterior part of the PCL is grasped with curved forceps (Praxisdienst Medical Supplies, Longuich, Germany), which was inserted through the anteromedial portal. Then, Metzenbaum

scissors (Praxisdienst Medical Supplies) are introduced through the medial parapatellar portal and the fat pad is sharply dissected at the medial and proximal portion and then bluntly detached from the ligament fibers (Fig 1). Special attention must be paid to maintain the distal and lateral pedicle of the fat pad (Video 1). A curved to the left 45° Spectrum Suture Passer (Conmed, Warsaw, Poland), loaded with a No. 1 PDS II suture (Ethicon), is inserted through medial parapatellar portal and subsequently pierced through the detached fat pad and the repaired ACL (Fig 2). The PDS suture is then identified in the joint and a Suture Retriever (Arthrex), inserted through medial parapatellar portal, is used to retrieve the suture outside the joint. The suture is tied with 5 to 7 half-stitches (Fig 3). The inflow is closed to visualize blood leakage and a blood clot forming on the transferred fat pad and the whole construct is inspected both from the anterolateral and anteromedial portals (Fig 4). It is important to validate that the lateral and distal fat pad pedicle that maintains the vascular supply to the construct is intact (Video 1).

PCL Fat Pad Transfer Technique in the ACL Reconstruction

When a reconstruction of the ACL was performed (Video presents the reconstruction with a quadriceps tendon-patellar bone autograft), the arthroscope is introduced through the anterolateral arthroscopic portal. Metzenbaum scissors, inserted through medial parapatellar portal, are used to separate the fat pad from the anterior surface of the PCL, preserving the lateral and distal pedicle of the fat pad. A Suture Retriever introduced through medial parapatellar portal is used to adjust the coverage of the graft with the fat pad (Video 1). Then,

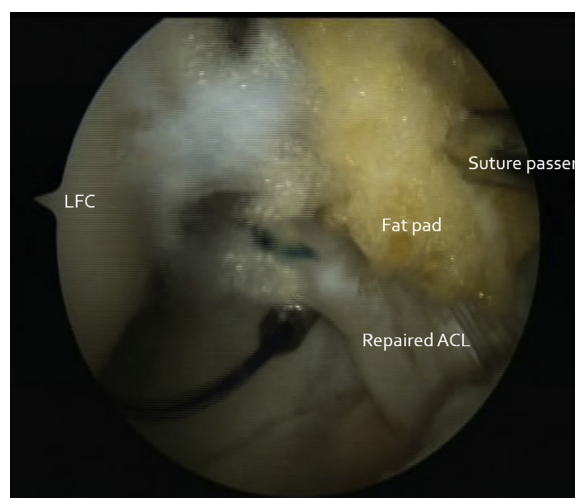


Fig 2. Arthroscopic view from the anterolateral viewing portal in a right knee joint. The fat pad transfer technique in the setting of the ACL repair. A left suture hook is pierced through the fat pad and repaired ACL. (ACL, anterior cruciate ligament; LFC, lateral femoral condyle.)

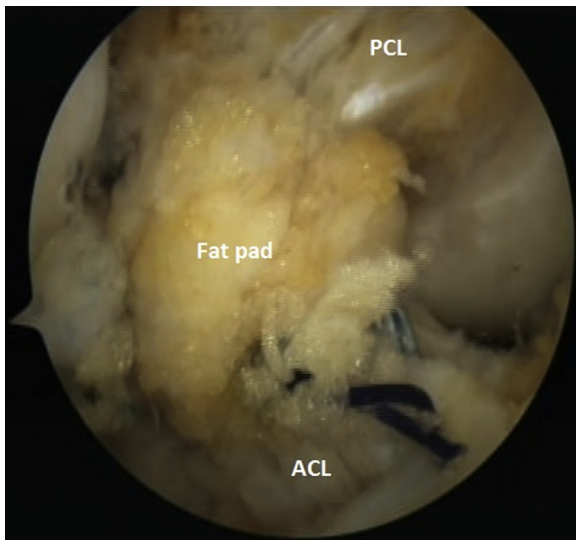


Fig 3. Arthroscopic view from the anterolateral viewing portal in a right knee joint. The fat pad transfer technique in the setting of an ACL repair. The fat pad is sutured with the repaired ACL. (ACL, anterior cruciate ligament; PCL, posterior cruciate ligament.)

a curved to the left 45° Spectrum Suture Passer, loaded with a No. 1 PDS II suture, is introduced through the medial parapatellar portal and is pierced through the fat pad, the graft, and along with any distal remnants of the native ACL, to align them together (Fig 5). The PDS suture is passed into the joint, retrieved through the medial parapatellar portal with a suture retriever, and tied using

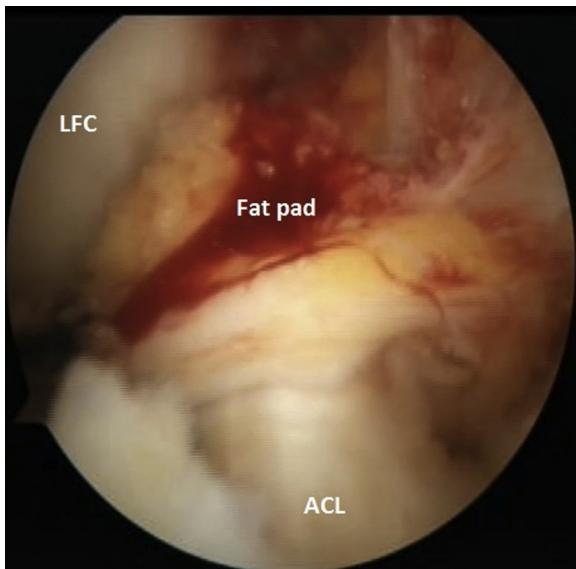


Fig 4. Arthroscopic view from the anterolateral viewing portal in a right knee joint. The fat pad transfer technique in the setting of an ACL repair. The final construct consisting of the fat pad covering the surface of the ACL. Note the blood inflow to the synovial vessels of the fat pad and the hematoma forming on its surface. (ACL, anterior cruciate ligament; LFC, lateral femoral condyle.)

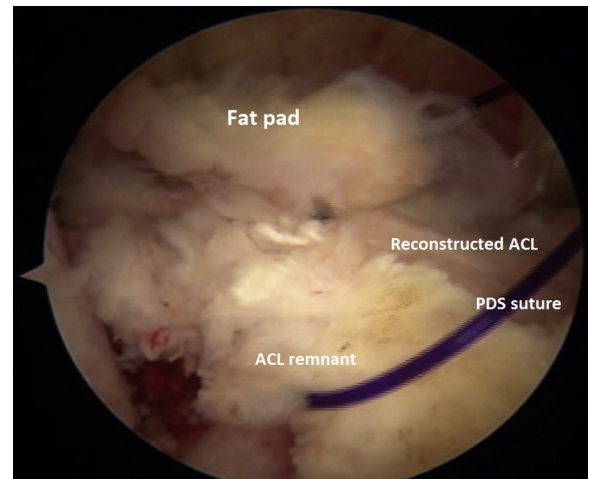


Fig 5. Arthroscopic view from the anterolateral viewing portal in a right knee joint. The fat pad transfer technique in the setting of the ACL reconstruction. The PDS suture has been passed through the PCL fat pad, the reconstructed ACL, and the ACL distal remnant. (ACL, anterior cruciate ligament.)

5 to 7 half-stitches. The final construct consists of the ACL graft, the transferred fat pad, and the distal ACL remnant sutured together (Fig 6).

A second-look arthroscopy performed after 9 months for unrelated indications reveals completed synovial coverage of a repaired ACL, which synovialization was enhanced with PCL fat pad transfer technique (Video 1).

Rehabilitation

Fat pad transfer does not change the physiotherapy protocol but is adapted to the basic procedure. It does not influence on postoperative range of motion and weightbearing possibilities. Walking on crutches is recommended for 2 to 4 postoperative weeks, depending

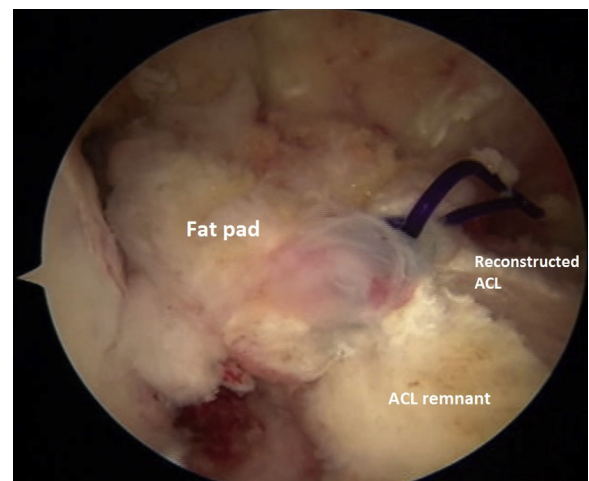


Figure 6. Arthroscopic view from the anterolateral viewing portal in a right knee joint. The fat pad transfer technique in the setting of the ACL reconstruction. The final construct is viewed consisting of the fat pad, the reconstructed ACL, and the ACL distal remnant. (ACL, anterior cruciate ligament.)

Table 1. Summary of the PCL Fat Pad Transfer Technique

The PCL fat pad transfer technique- basic steps

1. Create an additional medial parapatellar portal.
2. Grasp a fat pad with curved forceps.
3. Separate the fat pad from the anterior aspect of the posterior cruciate ligament with a Metzenbaum scissors.
4. Check the coverage of an ACL with the fat pad.
5. Pierce the fat pad and the ACL with a Suture Passer.
6. Tie the knot with 5 to 7 half-stitches to repair the fat pad to the ACL.

ACL, anterior cruciate ligament; PCL, posterior cruciate ligament.

on muscle control and patient's individual tolerance. Full weightbearing is allowed as tolerated. Axiom-D Elite (BREG, Inc. Carlsbad, CA) knee brace is recommended between 2 and 8 postoperative weeks for repaired ACL and between 4 and 12 postoperative weeks after ACL reconstruction.

Discussion

The presented PCL fat pad transfer technique is a simple, quick, and effective tool to attempt to enhance the process of ACL synovialization. The main aim of this technique is to provide the so-called "synovial graft" that augments the ACL with its vascular and synovial supply at the time of surgery, which may lead to an improvement in the healing and remodelling process during recovery. The basic steps of this technique are summarized in the [Table 1](#).

A presence of the synovial coverage is the mainstay of a vascular supply of the native ACL. Because the ACL does not receive any vascular branches from its tendon–bone interface, its bone attachments do not contribute significantly to the blood supply of the ligament.^{5,6} Therefore, its vasculature is derived mostly from the superficial branches of the middle genicular artery and small infrapatellar ramifications of the interior genicular arteries, lying beneath the synovial membrane.^{6,7} For this reason, the progress of synovialization ensures remodeling and maturation of the reconstructed

ACL because the ingrowth of vessels proceeds from the peripheral synovial coverage toward the central zone.¹

These principles are reflected in the results of clinical trials, proving that the amount of a synovial coverage influences outcomes in ACL tear management. It has been reported that an intact synovial coverage results in a greater survival rate of the ACL repair.⁸ For an ACL reconstruction, it has been reported that a greater extent of synovium was positively correlated with decreased anterior laxity and translation of the pivot-shift test as well as improved International Knee Documentation Committee and Lysholm scores.⁹⁻¹¹ These foregoing considerations lead to the conclusion that optimal restoration of the synovial coverage is of the utmost importance during the management of an ACL tear along with its reconstruction or repair.

The middle zone of an ACL is especially prone to necrosis after the injury because the scarce synovial vascularity in this region is unable to maintain the vitality of the torn ligament.⁶ Similarly, ingrowth of vessels into a repaired ACL or the ACL graft appears to be most difficult in this zone. A pedunculated PCL fat pad graft fulfills this critical region with synovial coverage and abundant vascular network; thus, it may improve healing and remodelling potential. Moreover, we believe that our "synovial graft" preparation technique preserves most of the middle genicular artery vessels descending in connective tissue septa between the cruciate ligaments^{4,6} and potentially provides an immediate blood supply over the treated ACL.

Preservation of the ACL remnants, which is recommended as another option to enhance graft remodeling, may cause difficulties during graft passage, especially while using grafts with bone blocks. In contrast, the PCL fat pad transfer is performed after the final repair or reconstruction; as a consequence, it does not interfere with the main procedure. Moreover, it does not use any scaffolds nor grafts; accordingly, it reduces the risk of donor site morbidity or adverse reaction to foreign materials. Last, these technique does not exhaust other methods of augmentation and may be combined for

Table 2. Advantages and Disadvantages of the PCL Fat Pad Transfer Technique

Advantages	Disadvantages
<ul style="list-style-type: none"> • Greater capability of blood clot formation. • Application of a vascularized graft, rich in synoviocytes and dense vascular network. • The graft is easily accessible and invariably localized. • Ease of graft harvesting with basic surgical instruments. • Lack of donor site morbidity. • The ability to combine this technique with other synovialization-enhancing procedures. • The strengthening of the central, most vulnerable part of a repaired ACL. • Performed at the end of the surgery; it does not impair the ACL repair/reconstruction procedure. 	<ul style="list-style-type: none"> • The necessity of an additional medial parapatellar portal creation. • Increased time of the operative procedure. • Theoretical impairment of the PCL vascular supply. • Theoretical increased risk of the arthrofibrosis.

ACL, anterior cruciate ligament; PCL, posterior cruciate ligament.

example with a preservation of the native ACL remnants, as presented previously.

The main disadvantage of the presented technique is that this procedure increases the length of an ACL repair/reconstruction leading to an increased time of ischemia, if a tourniquet is used. Next, there is the necessity of an additional medial parapatellar portal creation. Moreover, one may claim that harvesting the fat pad may weaken the blood supply to the PCL. However, the posterior capsule has been reported to provide a dense vascular supply to the PCL, what makes necrosis after fat pad harvesting a theoretical issue.⁶ Although the stimulation of the healing is the primary goal of this technique, it may also increase the risk of arthrofibrosis. The advantages and disadvantages of this technique are summarized in [Table 2](#).

The majority of augmentation techniques focus on strengthening an ACL graft and its attachments. These included, among others, enveloping the graft with a periosteum as well as an application of variety of cellular and acellular scaffolds.^{3,12} One method that potentially facilitates healing of the repaired ACL is the use of collagen platelet composites.¹³ However, none of these methods provides direct vascularized synovial tissue to the place of healing/ remodelling.

Given these points, the PCL fat pad transfer technique appears to be a reliable method of the enhancement of graft maturation during reconstruction and healing of repaired ACL tears. The technique is easy to apply, does not impede the main procedure, augments the most vulnerable part of repaired/reconstructed ACL, and can be easily combined with other ligamentization-enhancing procedures.

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