



# Segmental Medial Meniscus Transplantation in Combination With BMAC (Bone Marrow Aspirate Concentrate) Injection to Improve Healing and Prevent Extrusion

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**Abstract:** In recent years, the lack of permanent protection of meniscus scaffold applications in partial and segmental loss of meniscus tissue and the low rates of long-term survival of meniscus transplantation have brought partial meniscus transplantation applications into question. This technique aims to accelerate the capsular healing and prevent future extrusion of the segmental piece by performing biological augmentation with bone marrow aspirate concentrate together with a stable fixation of the partial meniscus allograft.

One of the most routine procedures in the world of orthopaedic surgery is meniscectomy, an operation capable of returning the knee to a state of satisfactory function after a meniscal tear. Nevertheless, there has been controversy regarding the stability of the joint in the months and years following the procedure. The fact that losing meniscal tissue permanently alters knee biomechanics and homeostasis is concerning, as are the secondary degenerative changes to the articular cartilage and the greater chance of developing symptomatic osteoarthritis.<sup>1,2</sup>

Knees affected by a meniscal allograft transplantation show observable similarities to those in their native condition. It is important to note that some patients are required to endure a significant excision of native meniscal tissue with proprioceptive capacity in order for the surgeon to perform a complete meniscal

transplantation. And unfortunately, the longevity of the allograft transplantation must be called into question, as only 52% survive past the first 10 years.<sup>3-5</sup>

In recent years, the lack of permanent protection of meniscus scaffold applications in partial and segmental loss of meniscus tissue and the low rates of long-term survival of meniscus transplantation have brought partial meniscus transplantation applications into question. To ensure these surgeries are both a routine and successful treatment method, studies are being conducted to increase both the stability of the allograft and the healing and integration into the tissue.<sup>1,5</sup> Unlike total meniscus transplantations, the absence of bone tissue increases the importance of capsular healing in partial meniscus transplantation. This technique aims to accelerate the capsular healing and prevent future extrusion of the segmental piece by performing biological augmentation with bone marrow aspirate concentrate (BMAC) together with a stable fixation of the partial meniscus allograft.

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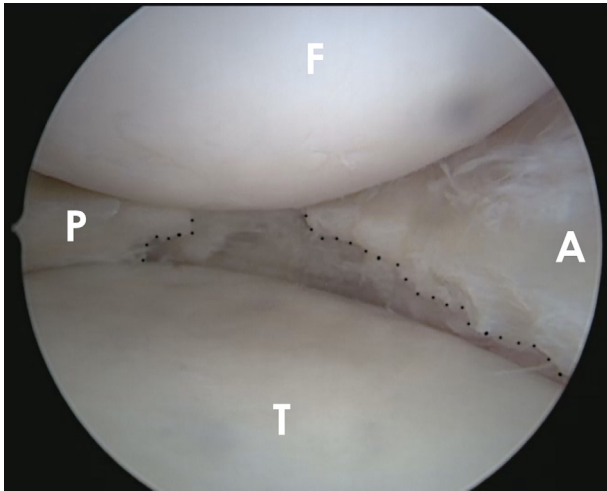
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## Surgical Technique (With Video Illustration)

The surgical technique is presented in [Video 1](#). Prior to this technique, a preoperative magnetic resonance imaging scan and long-leg weight-bearing radiograph should be taken. In this operation, diagnostic arthroscopy should be performed first. During this arthroscopy, the patellofemoral joint and the lateral and medial tibiofemoral cartilages are evaluated. In addition, the strength of the anterior cruciate ligament and posterior cruciate ligament is recorded by dynamic examination.

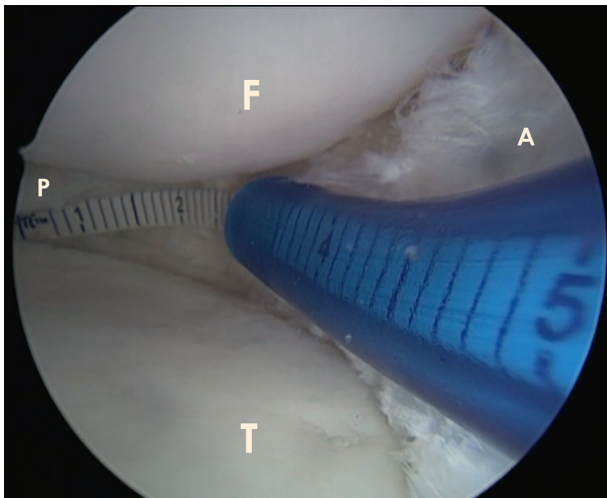


**Fig 1.** The regions of the posterior and anterior segments of the meniscus adjacent to the defected area are shaped. Dotted lines show the segmental defect of the meniscus.

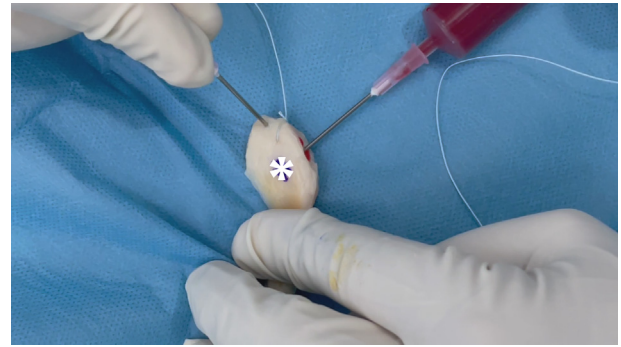
The area with the loss of the medial meniscus is evaluated more clearly after the release of the medial collateral ligament with the pie-crust technique. The segmental defect of the medial meniscus is freshened with a shaver up to the capsule (Fig 1). The regions of the posterior and anterior segments of the meniscus adjacent to the defected area are shaped with a meniscal rasp and shaver. Afterwards, the shape of the defect is determined and measured with an intra-articular flexible ruler (Fig 2). At this stage, preparations are made for the insertion of the meniscus allograft into the joint from the capsular region of the posterior and anterior segments with 2 transport sutures.

#### Graft Preparation and Preparation of the BMAC

The allograft, which was purchased from the Musculoskeletal Transplant Foundation (MTF Biologics,



**Fig 2.** The shape of the defect is determined and measured with an intra-articular flexible ruler. (A, anterior; F, femur; P, posterior; T, tibia.)

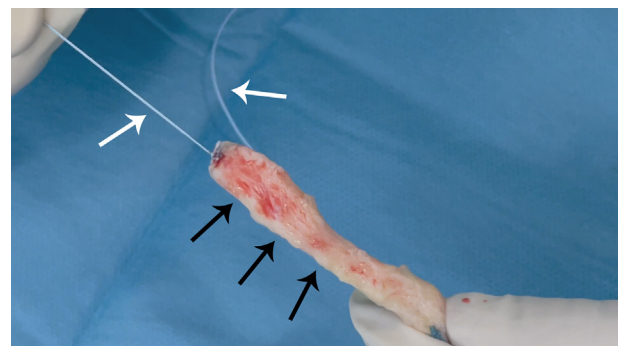


**Fig 3.** Bone marrow aspirate concentrate is injected into the meniscus graft tissue. White asterisk shows superior surface of the meniscus. (A, anterior; F, femur; P, posterior; T, tibia.)

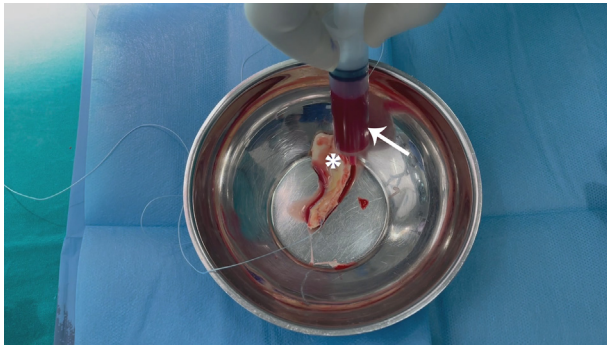
Edison, NJ), is first thawed at room temperature in a normal saline solution.

On the surgical side, the anterior iliac crest is selected to be the donor site for harvesting of the BMAC. Following surgical cleaning of the selected surgical area in addition to sterile draping, the aspiration of 60 mL of bone marrow is performed, using a bone marrow aspiration needle, from the position of the anterior iliac bone. Next, it is concentrated using the BMAC procedure pack (Angel System, Bone Marrow Concentrate; Arthrex, Naples, FL) of the Arthrex Angel BMAC Cellular Therapy System.

The meniscus allograft is cut to the measured size, prepared in accordance with the size of the segmental defect, and transport sutures are placed on the graft in accordance with the intra-articular transport sutures. Afterwards, BMAC is injected into the meniscus graft tissue (Fig 3). Infiltration of BMAC into meniscal tissue is observed from the periphery (Fig 4). Following that, the meniscus allograft is kept in a container in BMAC (Fig 5). Then, the anteromedial portal incision is increased and the joint is exposed. Intra-articular transport sutures and meniscus allograft transport suture connections are made, and the meniscus allograft



**Fig 4.** Infiltration of bone marrow aspirate concentrate into meniscal tissue is observed from the periphery. Black arrows show the periphery of the meniscus and white arrows show transport sutures.



**Fig 5.** the meniscus allograft was kept in a container in BMAC. White asterisk shows superior surface of the meniscus and white arrow shows BMAC. (BMAC, bone marrow aspirate concentrate.)

is placed into the joint. Intra-articular reduction of the graft, which is observed with a scope from the anterolateral side, is then performed. The graft periphery prepared according to the defect with the arthroscopic probe is placed in full contact with the capsule. The transport sutures are withdrawn from the capsule and the graft is kept in a reduced state. At this stage, the graft is sutured side to side with a suture to pass through the meniscus posterior horn. Then, the same procedure is repeated in the anterior. Afterward, vertical and horizontal sutures are fixed with inside-out and all-inside sutures. A soft anchor is used to fix the anterior tibial plateau with a suture passing through the anterior of the meniscus tissue. Inside-out sutures are stitched over the capsule with a medial incision. BMAC is injected into the periphery of the capsule and allograft through this incision. Finally, the stability of the graft and the presence of impingement are checked with joint movements through observation with arthroscopy (Fig 6).

### Step-by-Step Technique Summary

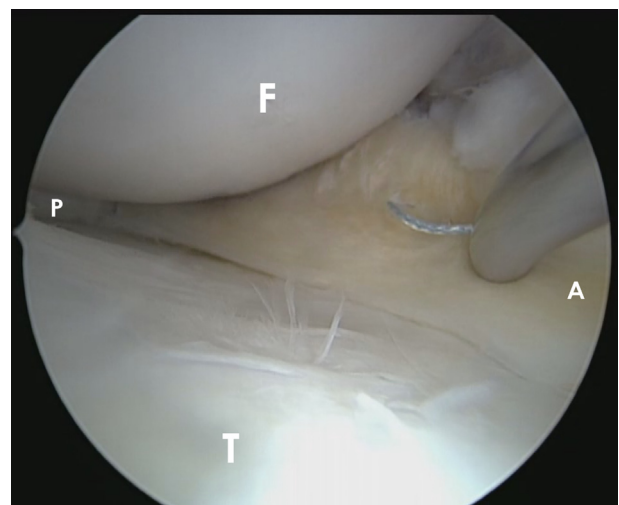
1. Arthroscopic examination of the patient is performed.
2. The segmental defect of the medial meniscus is freshened with a shaver up to the capsule (Fig 1).
3. The shape of the defect is determined and measured with an intra-articular flexible ruler (Fig 2).
4. Preparations are made for the insertion of the meniscus allograft into the joint from the capsular region of the posterior and anterior segments with 2 transport sutures.
5. The aspiration of 60 mL of bone marrow is performed, using a bone marrow aspiration needle, from the position of the anterior iliac bone.
6. The meniscus allograft is cut to the measured size, prepared in accordance with the size of the segmental defect.
7. BMAC is injected into the meniscus graft tissue (Fig 3).

8. Infiltration of BMAC into meniscal tissue is observed from the periphery (Fig 4).
9. The meniscus allograft is kept in a container in BMAC (Fig 5).
10. The graft periphery prepared according to the defect with the arthroscopic probe is placed in full contact with the capsule.
11. The transport sutures are withdrawn from the capsule and the graft is kept in a reduced state.
12. Vertical and horizontal sutures are fixed with inside-out and all-inside sutures. A soft anchor is used to fix the anterior tibial plateau with a suture passing through the anterior of the meniscus tissue. Inside-out sutures are stitched over the capsule with a medial incision.
13. BMAC is injected into the periphery of the capsule and allograft through this incision.
14. Finally, the stability of the graft and the presence of impingement are checked with joint movements through observation with arthroscopy (Fig 6).

### Discussion

The majority of treatment algorithms support meniscal repair when the necessary tissue is amenable. Despite this, focal meniscal loss can become a concerning side effect of failed meniscal repair, as well as in tear patterns where the surgery is impossible to perform. In such cases, meniscal allograft transplantation can be a worthwhile option, although current techniques are likely to include a complete excision of the native meniscus, which may include healthy native meniscal tissue flanking the focal meniscal deficiency. This will almost certainly lead to additional consequences.<sup>4,6-8</sup>

Moreover, for situations when a repair is impossible or the surgery has been unsuccessful, various innovative



**Fig 6.** Suture of the meniscus allograft to the capsule. (A, anterior; F, femur; P, posterior; T, tibia.)

**Table 1.** Pearls and Pitfalls

Pearls
The meniscus allograft must be in direct contact with the capsule.
Excessive stretching should be avoided while suturing.
Through pie crusting, the image is provided in the most ideal fashion, and the circulation of BMAC between the capsule and the allograft is ensured.
The anterior horn is fixed in a supporting manner with a soft anchor on the anteromedial of the tibia to increase stability.
BMACs should be injected into the meniscus tissue, and allograft soaking should be performed.
BMAC injection into the capsular region where the inside-out sutures are attached is important for the healing of the tissue.
BMAC capsule injection should be done under arthroscopic monitoring in the last stage when the joint is dry.
Pitfalls
In case of stability problems, a lengthy period of controlled rehabilitation can be applied to increase range of motion in the joints.
Considering the 3-dimensional anatomy of the meniscus tissue, impingement can be seen in the joint.
Neurinoma problems may occur due to medial incisions.
BMAC, bone marrow aspirate concentrate.

options implementing biological or synthetic scaffolds are currently available to regenerate meniscus-like tissue. The hope for this alternative methodology is that it would bring about significant clinical improvement to the patients' knee health. However, the role of chondroprotection continues to be questionable, and there is also controversy regarding the long-term outcomes after application of such technology.<sup>1,2,4,6-9</sup>

Nyland et al.<sup>10</sup> demonstrated in a study on porcine biomechanics that segmental meniscus transplantation restores focal contact forces to values similar to those of the native meniscus state. Strauss et al.<sup>6</sup> examined collagen healing in sheep at the 39th and 90th days following segmental meniscus transplantation. In their observations, they discovered that although there was still room for improvement after 90 days, progressive collagen healing was evident at the 90-day time frame at the peripheral, posterior, and anterior interfaces.

Although case reports, different surgical techniques, and biomechanical studies have been made recently regarding the use of this technique in segmental meniscal deficiencies, the lack of large series with long follow-up and still the absence of clear clinical indications are a limitation. The primary concern for partial meniscus transplantation is the patient having difficulties in recovery.<sup>3,4,7</sup> It is clear that for bone bridge or bone plug meniscal allograft transplantations, good results are obtained in both stability and healing of the allograft.<sup>11</sup> However, when we evaluate this in partial meniscus transplantation, it is clear that there are risks in terms of stability and recovery. The aforementioned studies with animals have revealed problems in this regard. Therefore, efforts to solve the problems will also improve this procedure, as we have recently begun to see clinical applications of partial

meniscal allograft transplantation, which has advantages over both scaffold application and meniscus allograft transplantation. This is why it is important to accelerate healing along with stability. It is thought that biological augmentation, with which we have previous experience in meniscus surgery, would also be useful in partial meniscal allograft transplantation. Combining a BMAC injection with lateral meniscal allograft transplantation in patients who had undergone a meniscectomy ensured noteworthy improvement in the early period in regard to both clinical scores and pain levels of the patients. These findings support what is found in the literature, which also has revealed that the histologic improvement on the allograft will be accelerated by a BMAC injection.<sup>12,13</sup> The simultaneous application of partial meniscus transplantation and BMAC is, therefore, highly recommended for clinical practice. In this context, it is clear that partial meniscal allograft transplantation will be preferred more frequently in the future and it will be performed safely by accelerating the recovery. Pearls and pitfalls of this technique are shown in Table 1.

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