Technical Note

Minced Meniscus: Biologic Augmented Meniscal Implant Treatment

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Abstract: Applications of meniscus scaffolds are crucial for preserving articular cartilage tissue, restoring normal joint mechanics, and stabilizing joints with partial meniscus deficits. Studies are still being conducted to determine how meniscus scaffold applications can create viable and durable tissue. The surgical procedure described in this study uses the meniscus scaffold and minced meniscus tissue.

The meniscus plays a key role in maintaining the homeostatic environment of the knee joint by facilitating force transmission, shock absorption, joint stability, and lubrication, as well as proprioception.[1-4] Because of a lack of blood supply, meniscal rips in avascular areas do not heal entirely. Consequently, partial meniscectomy is carried out to reduce symptoms. Big meniscus abnormalities frequently develop from partial or total meniscectomy for large radial, bucket-handle, or severe degenerative rips, which frequently cause osteoarthritis of the knee.[5] In these cases, the possibility of replacing the damaged meniscus should always be considered. Several options have been proposed to restore the meniscal structure.[2,3] Two procedures are now available in the clinical practice for meniscal substitution. These include meniscal allograft transplantation and meniscal scaffolds.[6-9] These procedures have different indications.[8,9] Meniscal allograft transplantation may be used after total or subtotal meniscectomy, whereas scaffolds are indicated only for partial defects, since they require an intact meniscal rim and the presence of both anterior and posterior horns.[9] The use of allografts raises concerns regarding immunogenicity and infection. Moreover, access to allografts is limited in several countries due to tissue banks, regulations, and social contexts, such as religion and beliefs around the use of human donors.[4] The limited success of 2 distinct meniscus scaffold applications that can be used in clinical practice has led to additional searches, nevertheless. A great effort has been made recently for the biological applications of meniscus implants in various laboratory and clinical research, in addition to the novel alterations in implant structures.[7,8]

With this surgical procedure, we hoped to improve the healing of the meniscal implant by implanting minced meniscal fragments. As a result, when the implant is resorbed, it aims to provide fresh, high-quality meniscus tissue in addition to using the patient's own meniscus tissue.

Indications

Indications for this technique are patients 18 to 55 years of age, stable knee joint, intact lateral meniscus, and partial absence of medial meniscus with intact posterior and anterior roots.

Surgical Technique (With Video Illustration)

The surgical technique is presented in Video 1. An arthroscopic view from the anterolateral portal is performed for diagnostic evaluation of the post-meniscectomy defect. The segmental defect of the medial meniscus is freshened with a shaver, up to the capsule (Fig 1). During the process, autologous meniscus fragments are harvested from the posterior and anterior meniscus as well as the meniscus tissue up to the capsule

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The author reports that he has no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received October 16, 2022; accepted January 19, 2023.

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2212-6287/221381

https://doi.org/10.1016/j.eats.2023.01.008

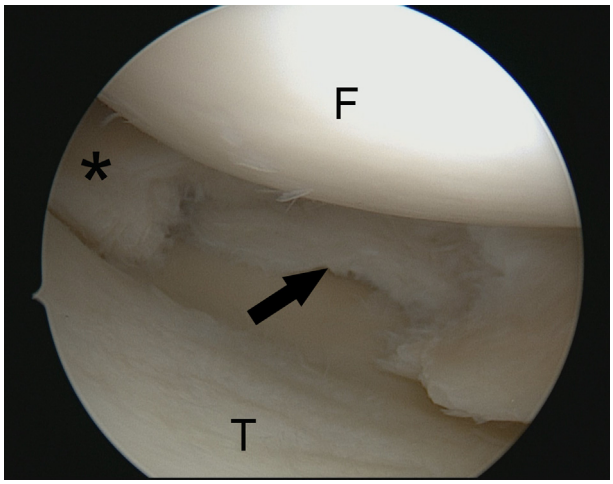

Fig 1. Black arrow shows the segmental defect of the medial meniscus up to the capsule (right knee, medial side, anterolateral portal view). Black asterisk indicates the posterior horn of the medial meniscus. (F, femur; T, tibia.)

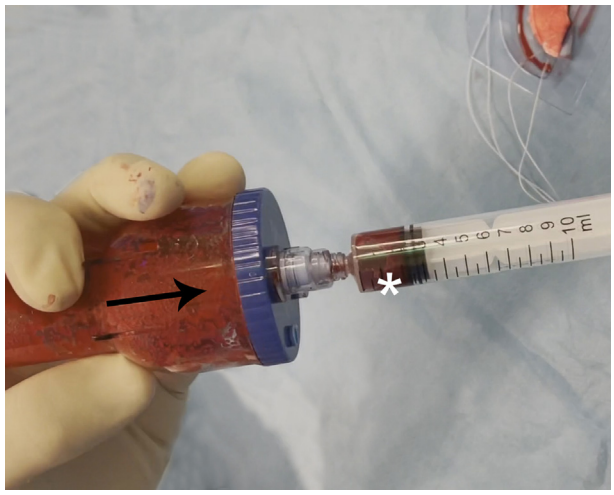

Fig 3. Black arrow shows autologous thrombin solution was removed through the port's filter, and thrombin solution (white asterisk) was made ready for use.

using a 4-mm bone cutter shaver blade. After that, the GraftNet (Arthrex, Naples, FL) system is used to store the collected meniscus fragments (Fig 2). The filter chamber and meniscal fragments are then removed after opening the tissue collector. With 1 mL of Autologous Conditioned Plasma (ACP; Arthrex), these fragments are created in specialized injectors.

Subsequently, the Arthrex ACP double syringe is used for the preparation of platelet-rich plasma and the associated concentrated growth factors. The Arthrex ACP double syringe and the Thrombinator system (Arthrex) are designed to obtain an autologous thrombin solution at the point of treatment for this surgery. Then, 3 mL of ACP (Arthrex) is injected into the Thrombinator (Arthrex) system before the autologous thrombin solution is made. The system is then agitated for 5 minutes, laid flat, and left for 10 to 15 minutes. Subsequently, the system is shaken to remove the clot. In addition, 5 seconds of shaking is followed by the reinjection of 6 cc of ACP. Once more, the system is set flat and shaken to dislodge the clot after waiting for 1 minute. The apparatus is then turned on its side, autologous thrombin solution is removed through the port's filter, and thrombin solution is made ready for usage (Fig 3).

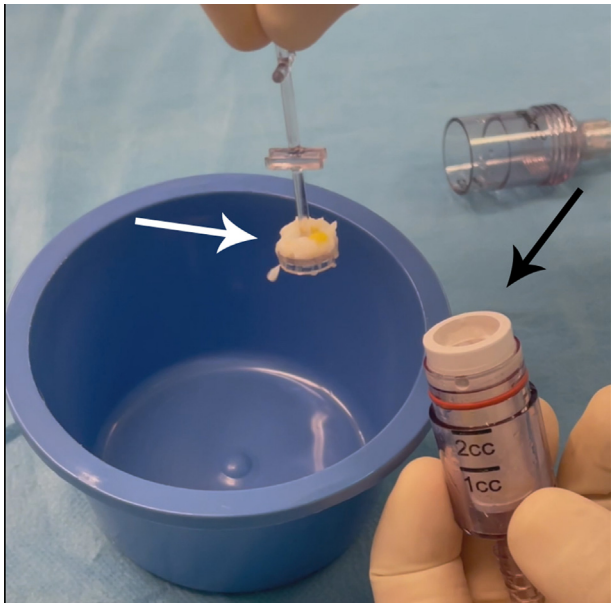

Fig 2. White arrow shows collected meniscus fragments harvested from the posterior and anterior meniscus as well as the meniscus tissue up to the capsule stored in the GraftNet system (black arrow).

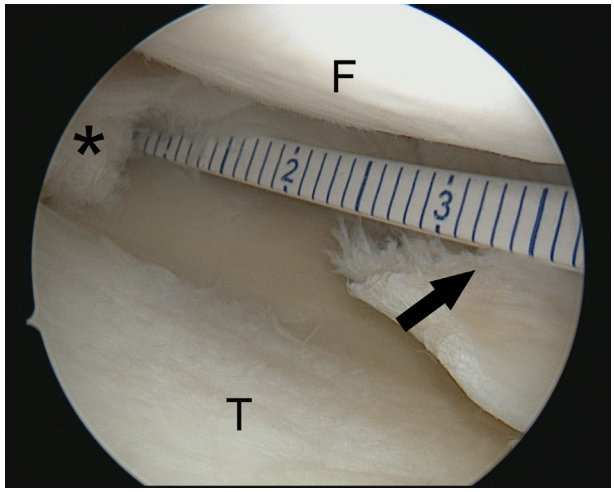

Fig 4. The meniscal defects are measured using an arthroscopic ruler to determine the size of the implant (right knee, medial side, anterolateral portal view). Black arrow shows final length of meniscal implant. Black asterisk indicates the posterior horn of the medial meniscus. (F, femur; T, tibia.)

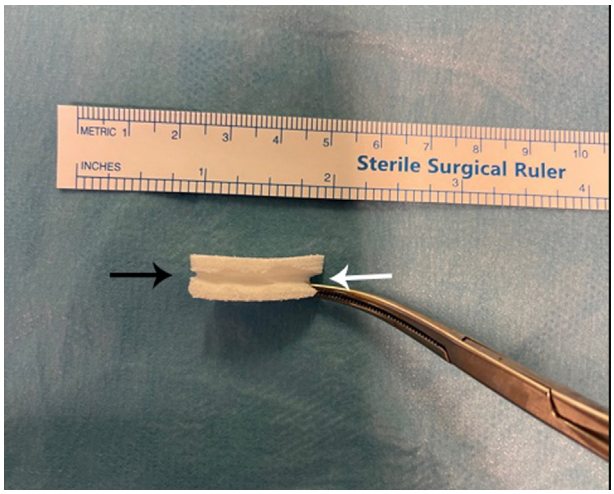

Fig 5. White and black arrows show a groove was formed in the meniscus implant at both sides, and the implant body was separated apart in the shape of a slit.

In addition, the meniscal defects are measured using an arthroscopic ruler to determine the size of the implant (Fig 4). A polyurethane-based medial meniscus implant (Actifit, Orteq Bioengineering, London, United Kingdom) oversized by 10% is prepared for optimal fitting. Both tips of the implant are marked to determine its surface and direction within the joint. To prevent the prepared meniscus implant from disintegrating, a groove is formed in the meniscus perimeter, and the implant body is separated apart in the shape of a slit (Fig 5). This slit is filled with minced meniscus pieces that are repaired with thrombin (Fig 6 A and B). Later, 2 pieces of 2/0 sutures are used to close the fissure (Fig 7). Using carrier sutures, the meniscus implant is inserted into the joint and set at the location of the deficiency. The implant is fixed using all-inside and inside-out techniques (Fig 8). After fixing the implant, stability is checked carefully using an arthroscopic probe while moving the knee by 0 to 90°. The advantages and disadvantages of the technique are presented in Table 1.

Step-by-Step Surgical Technique

Step 1: Arthroscopy is performed for diagnostic evaluation of the postmeniscectomy defect. Step 2: The segmental defect of the medial meniscus is freshened with a shaver, up to the capsule. Step 3: Autologous meniscus fragments are harvested from the posterior and anterior meniscus as well as the meniscus tissue up to the capsule using a 4-mm bone cutter shaver blade. After that, the GraftNet system is used to store the collected meniscus fragments. Step 4: Then, 3 mL of ACP is injected into the Thrombinator system before the Autologous thrombin solution is made. The system is then agitated for 5 minutes, laid flat, and left for 10 to 15 minutes. Subsequently, the system is shaken to remove the clot. Additionally, 5 seconds of shaking is followed by the reinjection of 6 cc of ACP. Once more, the system is set flat and shaken to dislodge the clot after waiting for 1 minute. Step 5: The apparatus is then turned on its side, autologous thrombin solution is removed through the port's filter, and thrombin solution is made ready for usage. Step 6: The meniscal defects are measured using an arthroscopic ruler to determine the size of the implant. Step 7: A polyurethane-based medial meniscus implant oversized by 10% is prepared for optimal fitting. Both tips of the implant are marked to determine its surface and direction within the joint. To prevent the prepared meniscus implant from disintegrating, a groove is formed in the meniscus perimeter, and the implant body is separated apart in the shape of a slit. Step 8: The slit is filled with minced meniscus fragments that are repaired with thrombin. Step 9: Sutures are used to close the slit. Step 10: The implant is fixed using all-inside and inside-out techniques. After fixing the implant, stability is checked arthroscopically. Pearls and pitfalls of this technique are presented in Table 2.

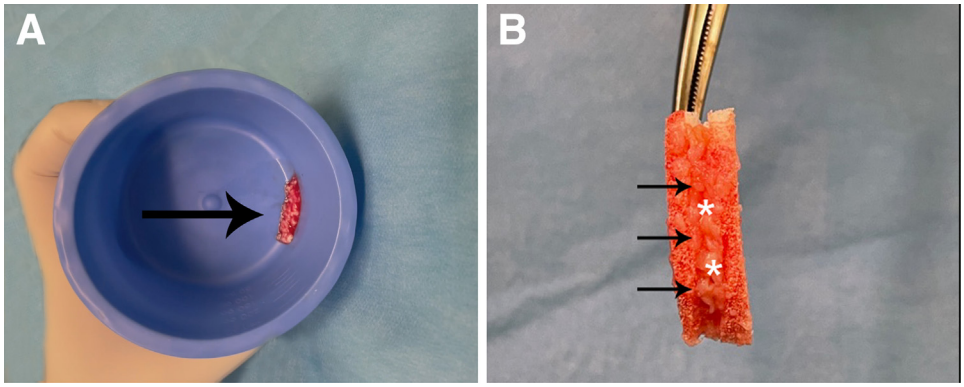

Fig 6. (A) Black arrow shows final preparation of meniscus pieces that were repaired with thrombin. (B) Black arrows show a groove was formed in the meniscus implant to prevent the prepared meniscus pieces (white asterisks).

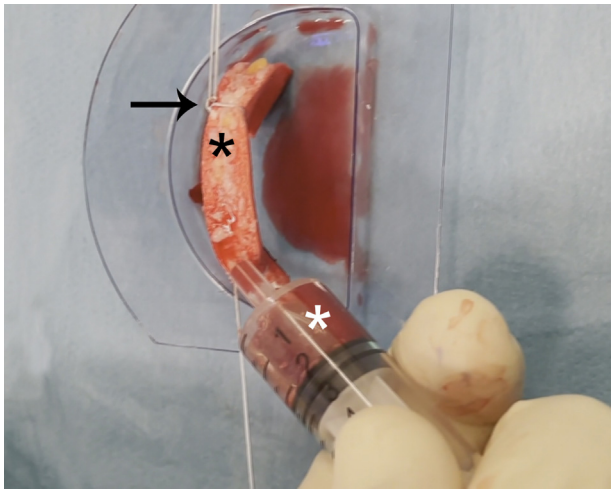

Fig 7. Black arrow shows suture were used to close the fissure and final thrombin (white asterisk) added to prevent minced meniscus fragments (black arrow).

Discussion

Long-term results of meniscal scaffolds are less predictable. As a result of fragmentation, shrinkage, and extrusion, the meniscal scaffold has been shown to lose its function, failing to minimize peak pressure across the knee joint, enhance articular cartilage coverage, and maintain an even load distribution across the knee.[4,10] Existing literature has established some biological augmentation methods to improve long-term meniscus scaffold survival and lower the risk of problems. Akkaya et al.[6] reported that in some situations bone marrow aspirate concentrate injection, in combination with medial meniscus scaffold implantation, provided statistically clinical improvement in all functions and pain scores as well as improvement in Tegner, International Knee Documentation Committee, and Knee injury and Osteoarthritis Outcome Score values during short-term follow-up. Clinical and laboratory investigations on the use of mesenchymal stem cells in meniscal injuries have grown recently in the literature. For instance, there are several publications on this by Dai et al.[11] and Rinonapoli et al.[12] New research on the implant's structure also seems to open new possibilities for treating meniscus shortage. Otsuki et al.[4] reported that the bioabsorbable polyglycolic acid (PGA) scaffold coated with P(LA/CL) they developed improves the initial biomechanical strength of the meniscus. They stated that the preservation of the meniscus perimeter is a crucial indication for this surgery and that the technique of implanting the PGA scaffold coated with P(LA/CL) is used. If not, the hoop tension is insufficient to support the implantation of the scaffold. Cojocaru et al.[13] hold that using meniscus-shaped PGA—hyaluronan implants might be a suitable therapeutic approach to support repair tissue formation in partial meniscectomy.

An important issue to be discussed in the use of this technique in clinical practice is the donor-site morbidity of harvest meniscus fragments. Because the meniscus

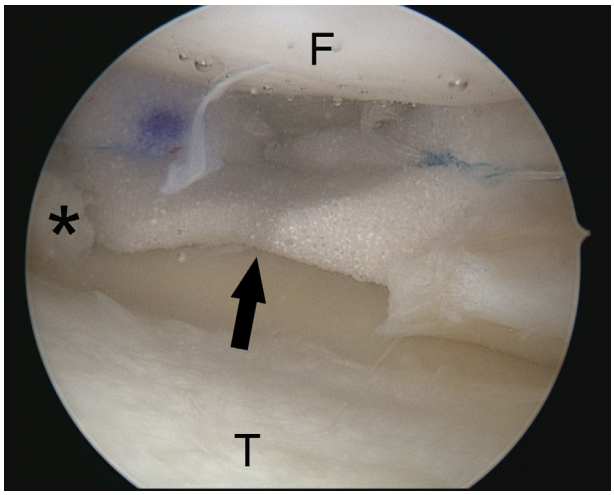

Fig 8. Black arrow shows final construct of the meniscal implant after suturing. Black asterisk indicates the posterior horn of the medial meniscus. (F, femur; T, tibia.)

Table 1. Advantages and Disadvantages of Minced Meniscal Scaffold Implantation

Advantages
In the long term, the meniscus scaffold will produce better tissue that resembles native tissue.
It enables the use of biological and individual tissue for meniscus implants.
It allows access to the scaffold without raising immune system issues or moral dilemmas.
The distribution of peripheral loads follows the laws of ordinary mechanics.
Disadvantages
Meniscus peripheral tissue preservation is essential.
The difficulty of implanting chopped meniscus tissue in a steady manner.
There is no specified quantity to harvest for the meniscus.
The long-term result is yet unclear.

Table 2. Pearls and Pitfalls

Pearls
Meniscus tissue should be harvested both from the healthy meniscus tissue as well as from the deteriorated area.
The peripheral meniscus tissue needs to be safeguarded and contact between the minced meniscus tissue and the peripheral meniscus tissue needs to be guaranteed.
For both biological enhancement and the stability of the minced meniscus fragments, thrombin tissue preparation is crucial. During the procedure, this needs to be verified.
Pitfalls
Excessive strain during the inside-out suture administration could result in the scaffold extruding.
When inserting minced meniscus fragments into the scaffold, the scaffold runs the danger of disintegrating.
Controlled preparation of meniscal fragments embedded in the meniscal implant is important for donor-site morbidity.

fragments used in this technique are harvested from the debrided area, both the recipient site is prepared for the implant and the fragments obtained in this way are used in the bioaugmented implant.

The treatment of cartilage tissue with minced cartilage served as a guidance in the method we outlined. This treatment has been used in various forms for a very long time, and numerous laboratory and clinical investigations on the subject have documented it in the literature.[5,11,14] Similar autologous meniscus pieces have been used in in vitro and animal trials to treat meniscus deficit. Matsubara et al.[5] reported that cells in minced meniscus can proliferate, and that implantation of the minced meniscus within atelocollagen induces meniscus regeneration, thus suggesting a novel therapeutic alternative for meniscus tears. Juvenile meniscus allograft pieces were used in a study by Dai et al.[11] on in vitro organ culture, and they highlighted the findings that this treatment may be successful in treating avascular meniscus injuries.

The polyurethane meniscus scaffold, which has so far had good medium- and long-term results, was given a special shape, and biological application of the minced meniscus parts embedded in the scaffold was conducted using the surgical application sets for minced cartilage that are readily available on the market. The goal of applying it to the meniscus periphery is to ensure that the tissue that remains is compatible with the meniscus tissue and that the meniscus operates mechanically even after the scaffold has resorbed.

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