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Meniscus Allograft Transplantation

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The meniscus plays a vital role in chondroprotection, shock absorption, load distribution, proprioception, joint lubrication, and secondary stabilization. If a patient with meniscal deficiency becomes symptomatic, meniscal allograft transplantation (MAT) is one surgical option. Understanding the unique anatomic and biomechanical characteristics of the medial and lateral meniscus is essential when considering a meniscal transplantation. MAT is currently indicated for younger (up to age 50) symptomatic patients with meniscal deficiency following previous subtotal or functional meniscectomy. Surgeons must also correct any concomitant pathology, such as high-grade cartilage defects, ligament insufficiency, and limb malalignment, as failure to correct these comorbidities leads to less optimal outcomes and are often associated with early transplant failure. Each of the three standard MAT techniques will be discussed in detail: bone plug, bone bridge-in-channel (e.g., slot, trough, dovetail, keyhole, etc.), and soft tissue only fixation.

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Introduction

The meniscus plays a vital role in chondroprotection, shock absorption, load distribution, proprioception, joint lubrication, and secondary stabilization.^{1,2} Injury leads to altered mechanics and dysfunction that may impact daily life activities and lead to the development of osteoarthritis.³ Due to its significant role in a variety of functions, it is crucial that, whenever possible, the surgeon should attempt to preserve the meniscus.^{4,5} If a patient with meniscal deficiency becomes symptomatic, meniscal allograft transplantation (MAT) is a viable surgical option.

Meniscus allograft transplantation is used to restore the various biomechanical properties of the native meniscus.⁶⁻⁸ The overall goal is to reduce pain, improve quality of life,

increase patient activity level, and restore overall knee function. Proper patient selection, careful management of patient expectations (especially the “life expectancy” of the transplant: on the order of one decade), thorough presurgical planning, and meticulous surgical technique are critical for successful outcome.⁹ It is essential that the surgeon understands how and why to perform key surgical steps to provide the patient a reliable operation with reduced risk of complication. While general principles and guidelines for MAT exist, controversy still remains regarding indications, techniques, and overall outcomes of MAT.

Applied Surgical Anatomy

Understanding the unique anatomic and biomechanical characteristics of the medial and lateral meniscus is essential when considering the addition of MAT in the clinical practice. The differences between the two influence the timing and frequency of MAT, need for concomitant procedures, and the selection of the surgical technique.¹⁰

The medial compartment has a concave tibial articular surface with the meniscus covering an estimated 60%-65% of the plateau while, on average, bearing 50% of the medial compartment

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load.^{11,12} As a result, medial meniscectomy is often relatively well tolerated, as defined by the delay or absence of postmeniscectomy syndrome. Given the relative congruity of the medial compartment, chondral lesions may develop more slowly after functional meniscectomy than in the lateral compartment.¹³ It follows that concomitant medial MAT and cartilage restoration is also less common than on the lateral side.

The medial meniscus is inherently more stable than the lateral meniscus due to the attachments of the coronary (meniscotibial) ligaments to the deep MCL with excursions of 5-6 mm through range of motion medially and 10-12 mm laterally. These attachments should be restored during medial MAT. It is also well known that the posterior horn of the medial meniscus is an important secondary restraint to anterior tibial translation. Medial meniscus deficiency is one of the leading causes of primary anterior cruciate ligament (ACL) reconstruction failure.^{11,12,14,15} Medial MAT is, therefore, more commonly performed in association with ligamentous reconstruction than lateral MAT.

Several properties of the medial meniscus play a role in the choice of surgical MAT technique. In the sagittal plane, there is significant distance between the roots, and the anterior root inserts over the front of the tibia with multiple variations as classified by Fowler.¹⁶ Additionally, the anterior and posterior roots do not lie directly in line with each other in the axial plane (Fig. 1A). Many surgeons prefer bone plugs or

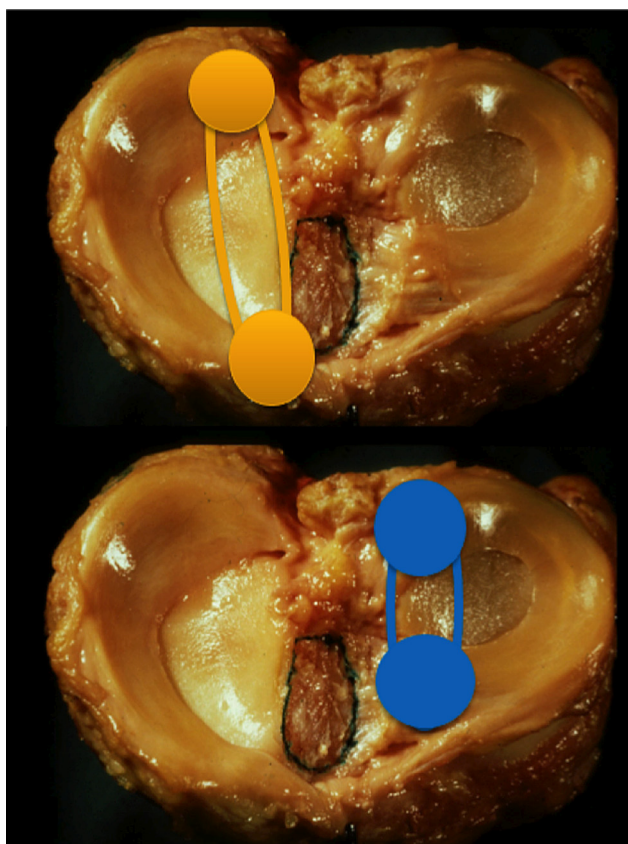


Figure 1 Left knee showing (A) the wide spread and oblique root insertions of the medial meniscus (orange) and (B) the narrow, linear root insertions of the lateral meniscus (blue). ACL footprint is outlined in black. (Color version of figure is available online.)

soft tissue only (i.e., Europe) grafts for medial MAT; advantages conferred include preservation of bone stock, relative ease of concomitant ACL reconstruction, and/or avoidance of the native ACL insertion.^{15,17,18}

Conversely, the tibial plateau of the lateral compartment is convex, which conveys some inherent instability to the bony and/or chondral articulation. As a result, the lateral meniscus covers 80%-85% of the plateau to help alleviate some of this geometric instability. It bears up to 70% of the lateral compartment load due to its high relative surface area.¹⁴ Due to its essential role in compartment congruity, lateral meniscectomy is poorly tolerated with a much higher incidence of postmeniscectomy symptoms. Additionally, the risk of chondral degeneration is higher in the lateral compartment with earlier clinical symptoms than the medial compartment.^{19,20} Therefore, concomitant cartilage restoration is often required in the setting of lateral meniscus deficiency.¹⁵

The lateral meniscus is nearly a circular C-shape (anteroposterior, AP, and mediolateral, ML, dimensions are similar as opposed to the greater AP than ML dimensions of a medial meniscus); the meniscal roots are relatively close together and lie in line with each other in the axial plane (Fig. 1B). As a result, many surgeons prefer a bone block technique for lateral MAT; this allows for maintenance of the relationship of the meniscal roots with strong time-zero fixation.^{15,17,18} The lateral meniscus is also more mobile than the medial meniscus, with no additional attachments to the lateral collateral ligament (LCL) or the popliteal hiatus. Surgeons should avoid over constraining the lateral MAT during fixation to avoid nonphysiologic tension and early graft extrusion.

Indications

Despite increased desire to preserve the meniscus, meniscal deficiency is still commonly encountered in clinical practice. This is often due to irreparable tear patterns, failed prior attempts at repair, or aggressive subtotal or functional meniscectomy. Meniscal allograft transplant is currently indicated for younger (up to age 50) symptomatic patients with meniscal deficiency following previous subtotal or functional meniscectomy. The symptoms usually consist of painful effusions and unicompartmental pain following previous injury or surgery. When these symptoms persist despite appropriate conservative management (i.e., nonsteroidal anti-inflammatory drugs, unloader bracing, biologic injections, and rehabilitation programs), MAT may be a consideration.^{6,17,21,22}

Meniscus deficiency in the setting of failed primary ACL reconstruction or chronic ACL instability is a relative indication for MAT.²³ As above, it is well known that the medial meniscus plays a role as a secondary stabilizer to anterior tibial translation (i.e., brakestop mechanism) and the lateral meniscus likely has stabilizing properties during the pivot shift.^{2,23} Therefore, MAT should be considered as an adjunct to ACL reconstruction for patients with functional instability and meniscal deficiency, particularly for those with high-grade sagittal instability (Lachman grade IIIB) and grade III pivot shift. The majority of these cases will present

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