



Meniscal Allograft Transplantation Made Simple: Bridge and Slot Technique

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Abstract: Over recent years, appreciation for the critical role of the meniscus in joint biomechanics has led to an emphasis on meniscal preservation. Meniscal allograft transplant (MAT) is a promising biological solution for the symptomatic young patient with a meniscus-deficient knee that has not developed advanced osteoarthritis. As surgical techniques are refined and outcomes continue to improve, it is vital to consider the utility of such procedures and offer a straightforward approach to MAT. This article and accompanying video provide a step-by-step tutorial on how to perform a MAT using the bridge and slot technique, its key pearls and pitfalls as well as the relevant advantages and disadvantages of MAT.

Over the last few decades, the understanding of meniscal function and management of meniscal lesions has evolved greatly. One of its most important functions is to disperse our body weight. Baratz et al. showed that after partial meniscectomy, contact areas decreased approximately 10%, and peak local contact stresses increased approximately 65%. After total meniscectomy, contact areas decreased approximately 75%, and peak local contact stresses increased approximately 235%.¹ In a landmark 1948 study, Fairbank² described the characteristic degenerative radiographic changes that occur after meniscectomy caused by increased joint articulation forces and incongruent surfaces. This led the trend toward balancing the immediate gratification of relieving pain and mechanical symptoms with conserving as much native meniscal tissue as possible to prevent future joint degeneration.

The meniscus is relatively avascular, as only the most peripheral 20% to 30% of the medial and 10% to 25% of the lateral meniscus is vascularized.^{3,4} As a result, the

gold standard for small radial meniscal injuries is still a partial meniscectomy. This is not without consequence. Lee et al.⁵ showed that for a medial meniscus, progressive partial meniscectomy increased medial mean contact stress from 24% (50% meniscectomy) to 58% (75% meniscectomy) to 134% (total meniscectomy). Over recent years, appreciation for the critical role of the meniscus in joint biomechanics has led to an emphasis on meniscal preservation.

It has been nearly 30 years since the first meniscal allograft transplant (MAT) was performed. Today, it is a promising biological solution for the symptomatic young patient with a meniscus-deficient knee that has not developed advanced osteoarthritis. As surgical techniques are refined and outcomes continue to improve, it is vital to address these questions and offer a straightforward approach to MAT.

Methods

Two main methods for MATs have been developed: bone plugs and bone bridge. Using bone plugs avoids interference with a tibial tunnel for concomitant ACL reconstructions. Using a bone bridge technique maintains the anatomic relationship between the anterior and posterior meniscal horns. This technique guide centers on the bone bridge technique.

Patient Evaluation

Meniscal allografts are sized according to the Pollard technique. The anteroposterior width of the allograft is a 1:1 ratio relative to the distance from the peripheral aspect of the ipsilateral plateau to the tibial spine. The

From the NYU Hospital for Joint Diseases, New York, New York, U.S.A. The authors report that they have 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 March 31, 2017; accepted August 6, 2017.

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2212-6287/17482

<http://dx.doi.org/10.1016/j.eats.2017.08.023>

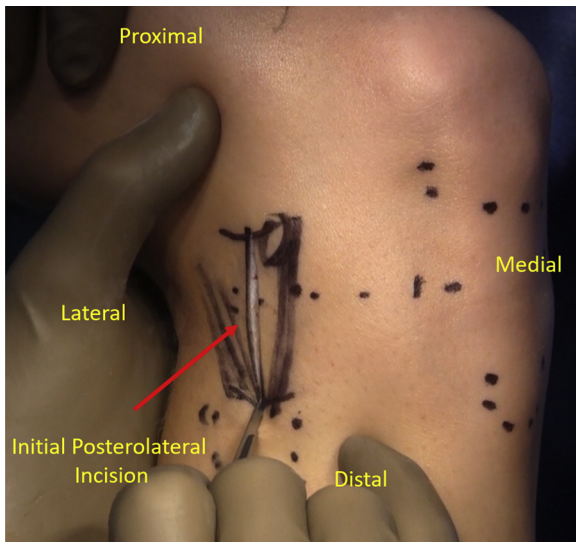


Fig 1. Viewing from the anterolateral position, the patient is positioned supine on the operative table with a leg holder to allow access to the posterolateral and posteromedial aspect of the operative knee. A 3-inch posterolateral incision is made anterior to the biceps femoris insertion to prevent injury to the common peroneal nerve. The incision is positioned one-third above and two-thirds below the level of the joint.

sagittal length is 80% of the sagittal diameter for the medial meniscus and 70% of the sagittal diameter for the lateral meniscus.⁶ Magnetic resonance imaging has also been used to size allografts, but recent studies have shown the Pollard technique to be just as reliable.⁷

Positioning and Approach

A step-by-step video can be seen in [Video 1](#). The patient is positioned supine on the operative table with a leg holder to allow access to the posterolateral and posteromedial aspect of the operative knee. The contralateral

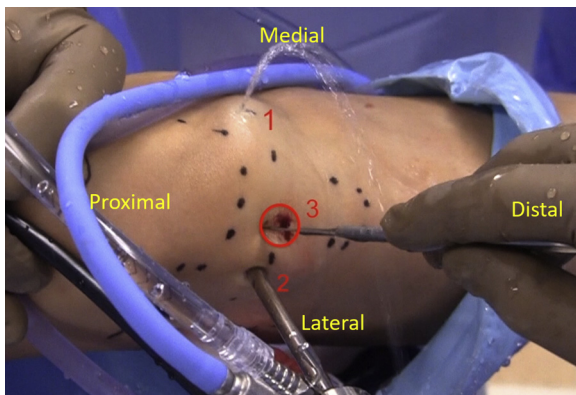


Fig 2. Viewing from superior to the right operative knee with the patient supine, a third central accessory portal is made oriented in line with the anterior and posterior root attachments of the lateral meniscus in addition to the standard anterolateral and anteromedial portals. This facilitates instrumentation placement.

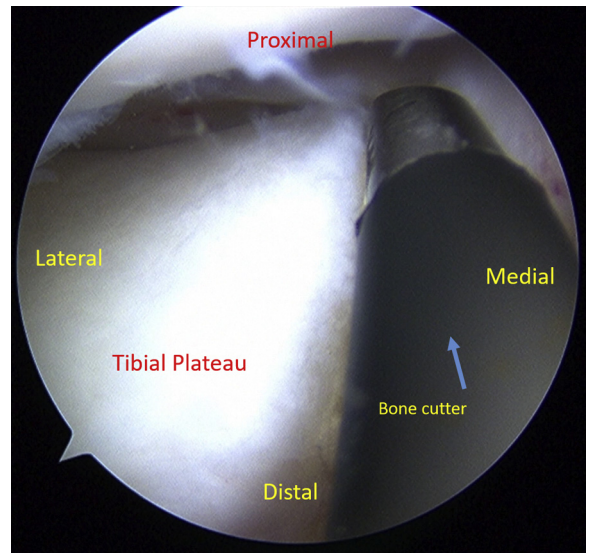


Fig 3. The patient is positioned supine on the operative table with a leg holder (arthroscopic view of right operative knee viewing from the anterolateral portal). Through the accessory anteromedial portal, a 4-mm bone cutter is introduced and a preliminary superficial reference slot is created connecting the anterior and posterior horns. This is where the graft will be placed.

leg is positioned in a well-leg holder. A 3-inch posterolateral incision is made anterior to the biceps femoris insertion to prevent injury to the common peroneal nerve ([Fig 1](#)). The incision is positioned one-third above and two-thirds below the level of the joint. This approach will later be used for the inside-out meniscus fixation. Deep dissection is carried out to identify the lateral head

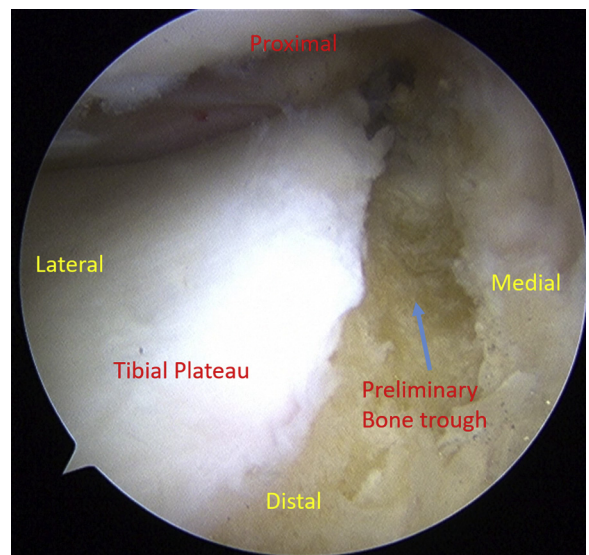


Fig 4. The patient is positioned supine on the operative table with a leg holder (arthroscopic view of right operative knee viewing from the anterolateral portal). The completed preliminary bone tunnel can be appreciated.

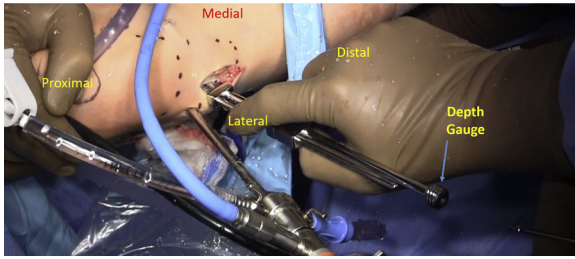


Fig 5. Viewing from superior to the right operative knee with the patient supine, the portal is expanded into an arthrotomy to allow the introduction of a hook depth gauge tip. The depth gauge tip is held parallel to the slope of the tibial plateau against the posterior tibial cortex. The drill guide is then advanced over the depth gauge tip and secured against the anterior tibial cortex. A guide pin is inserted through the drill guide referenced off the depth gauge and secured at a depth to prevent overpenetration of the pin and neurovascular injury.

of the gastrocnemius, which is confirmed by palpation while plantar and dorsiflexing the foot.

Diagnostic Arthroscopy and Debridement

A diagnostic arthroscopy is performed with standard anterolateral and anteromedial portals to confirm meniscal deficiency and assess the integrity of articular surfaces. The remnant meniscus is debrided, leaving a small, 1 to 2 mm peripheral rim.

Slot Preparation

We prefer a bone bridge slot technique for lateral or isolated medial MAT to maintain the anatomic relationship between the anterior and posterior horns. A

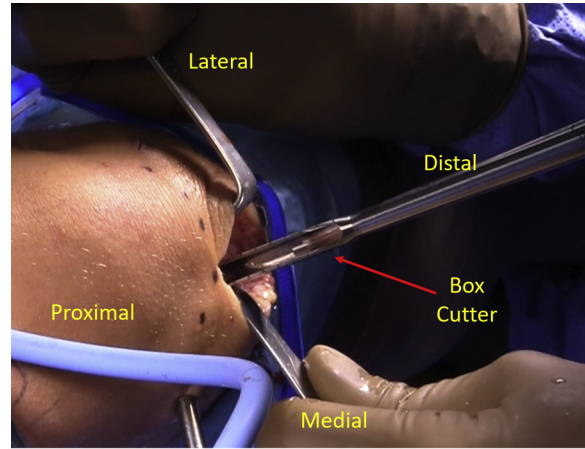


Fig 7. Viewing from superior to the right operative knee with the patient supine, the drill bit and guide pin are removed and an 8-mm box chisel is inserted by placing the bullet nose of the cutter into the drill hole. The box cutter is then gently impacted with a mallet to advance it into the tunnel and remove any residual bone around the tunnel and between the tunnel and the reference slot. The box chisel creates a slot 8 mm in width by 10 mm in depth. The tines of the box cutter should be visualized arthroscopically as it is advanced through the articular surface, with special care not to injure the articular surface of the femoral condyle. Finally the 7-mm followed by 8-mm rasps are used to ensure the tunnel accommodates a 7-mm bone bridge. Once the 8-mm rasp sits flush with the tibial plateau, the slot is complete.

third central accessory portal is made oriented in line with the anterior and posterior root attachments of the lateral meniscus (Fig 2). Through this portal, a 4-mm bone cutter (Stryker, Kalamazoo, MI) (Figs 3 and 4) is

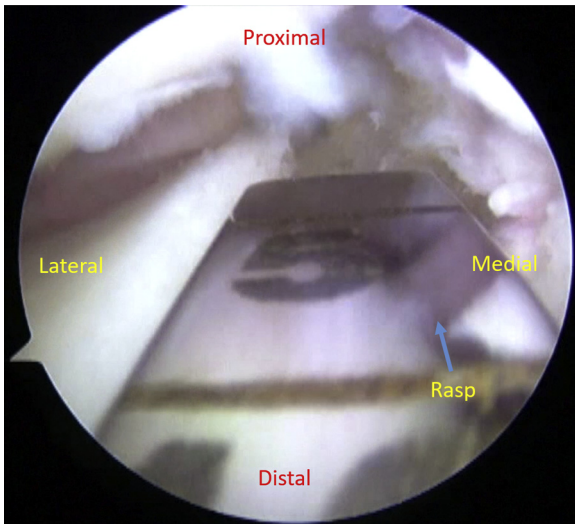


Fig 6. The patient is positioned supine on the operative table with a leg holder (arthroscopic view of right operative knee viewing from anterolateral portal). The 7-mm followed by 8-mm rasps are used to ensure the tunnel accommodates a 7-mm bone bridge. Once the 8-mm rasp sits flush with the tibial plateau, the slot is complete.

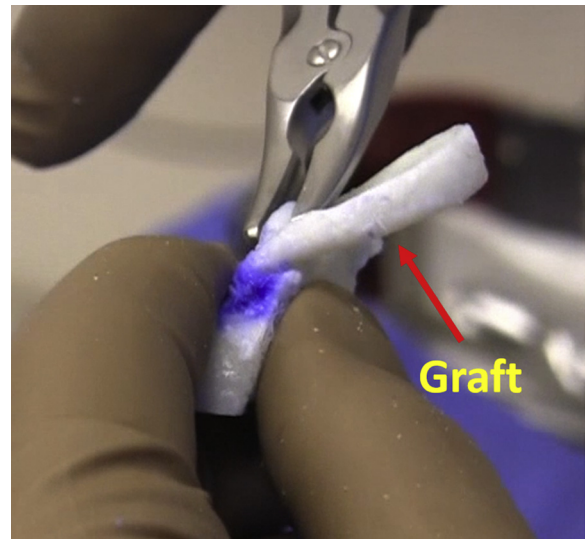


Fig 8. This is an image of the completed sized allograft. The allograft is prepared on the back table at the same time that the arthroscopy is performed. A cutting block is used to create a bone bridge 7 mm in width by 10 mm in depth. The bone bridge is trimmed to incorporate the anterior and posterior horns, and the lateral tibial spine is removed.

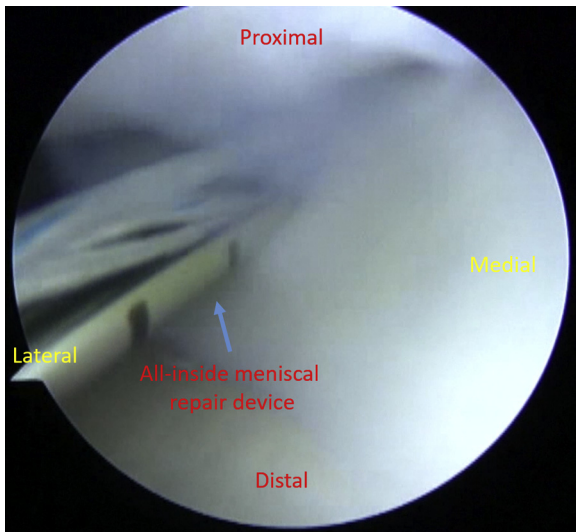


Fig 9. The patient is positioned supine on the operative table with a leg holder (arthroscopic view of right operative knee viewing from anterolateral portal). Directly posterior to the popliteus tendon, an all-inside (Arthrex) technique of suture passage is used. This is also used to fix the posterior horn of the allograft.

introduced and a preliminary superficial reference slot is created connecting the anterior and posterior horns. The portal is expanded into an arthrotomy to allow the introduction of a hook depth gauge tip. The depth

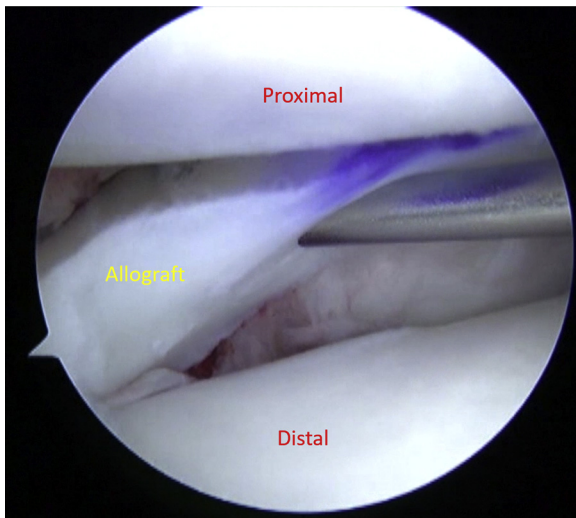


Fig 10. The patient is positioned supine on the operative table with a leg holder (arthroscopic view of right operative knee viewing from posterolateral portal). Once in position, the meniscus is stabilized using multiple inside-out vertical mattress sutures around the periphery. Directly posterior to the popliteus tendon, we prefer to use an all-inside technique of suture passage. This is also used to fix the posterior horn of the allograft. If the meniscus is sitting superiorly, we will place the odd inside-out vertical mattress suture on the undersurface of the allograft to bring it back into anatomic position.

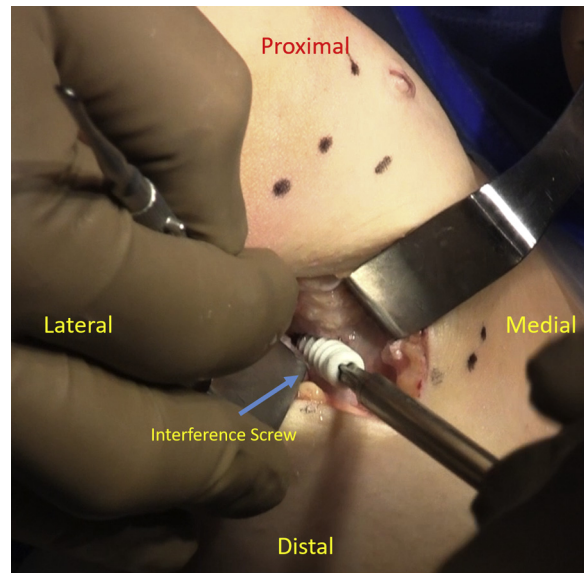


Fig 11. Viewing from the anterolateral position, the patient is positioned supine on the operative table with a leg. After inspection and confirmation that the graft has a stable periphery, the bone bridge is stabilized with a single 7 × 23-mm bioabsorbable interference screw placed medially. The anterior meniscus can then be stabilized with a direct repair through the arthrotomy.

gauge tip is held parallel to the slope of the tibial plateau against the posterior tibial cortex. The drill guide is then advanced over the depth gauge tip and secured against the anterior tibial cortex. A guide pin is inserted through the drill guide referenced off the depth gauge, and secured at a depth to prevent overpenetration of the pin and neurovascular injury (Fig 5). Special care is

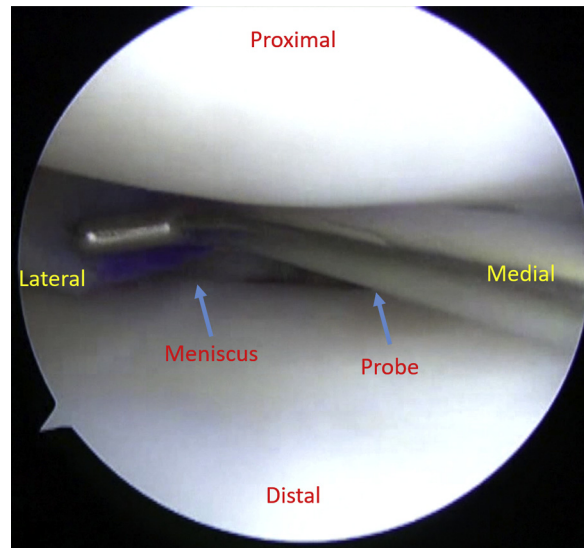


Fig 12. The patient is positioned supine on the operative table with a leg holder (arthroscopic view of right operative knee viewing from anterolateral portal). A probe is used for final inspection and confirmation of stable graft periphery.

Table 1. Pearls, Pitfalls, and Complications

Pearls	Technical Considerations	
	Pitfalls	Complications
Allograft is sized with Pollard technique	Leave 1-2 mm peripheral meniscus rim during initial debridement	Insert guide pin through drill guide referenced off the depth gauge to prevent overpenetration of the pin and neurovascular injury
A 3-inch posterolateral incision is made anterior to the biceps femoris insertion to prevent injury to the common peroneal nerve	For accurate measurement, hold depth gauge tip parallel to slope of tibial plateau against the posterior tibial cortex	A spoon retractor can be placed in this portal for additional protection
When creating the bone tunnel, once the 8-mm rasp sits flush with the tibial plateau, the slot is complete	If the meniscus is sitting superiorly, place the odd inside-out vertical mattress suture on the undersurface of the allograft to bring it back into anatomic position	
Place nonabsorbable suture just medial to the popliteus tendon in the lateral compartment to aid in graft introduction		

taken to drill just up to, but not through, the posterior cortex. In addition, if there is concern that the posterior cortex was violated, direct palpation can be performed through the posterolateral portal. A spoon retractor can be placed in this portal for additional protection. Additionally, fluoroscopy can be used to ensure proper drill depth. Once positioned, the guide pin is then overreamed using an 8-mm cannulated reamer through the accessory incision. The drill bit and guide pin are removed and an 8-mm box chisel (Synthes, West Chester, PA) is inserted by placing the bullet nose of the cutter into the drill hole. The box cutter is then gently impacted with a mallet to advance it into the tunnel and remove any residual bone around the tunnel and between the tunnel and the reference slot. The box chisel creates a slot 8 mm in width by 10 mm in depth. The tines of the box cutter should be visualized arthroscopically as it is advanced through the articular surface, with special care not to injure the articular surface of the femoral condyle. Finally, the 7-mm followed by 8-mm rasps (Fig 6) are used to ensure the tunnel accommodates a 7-mm bone bridge. Once the 8-mm rasp sits flush with the tibial plateau, the slot is complete (Fig 7).

Bone Bridge Preparation

The allograft is prepared on the back table at the same time that the arthroscopy is performed. A cutting block is used to create a bone bridge 7 mm in width by 10 mm in depth. The bone bridge is trimmed to incorporate the anterior and posterior horns, and the lateral tibial spine is removed (Fig 8).

Allograft Meniscus Fixation

A No. 2 nonabsorbable suture is passed at the 10:30 position for a right lateral meniscal allograft to aid in graft introduction into the knee. This is calculated to be

just medial to the popliteus tendon in the lateral compartment. A zone-specific cannula is placed into the medial portal and the suture is passed medial to the popliteus tendon. This will aid in manually introducing the meniscus once the allograft is placed in the prepared trough. Once in position, the meniscus is stabilized using multiple inside-out vertical mattress sutures around the periphery. Directly posterior to the popliteus tendon, we prefer to use an all-inside (Arthrex, Naples, FL) technique of suture passage (Fig 9). This is also used to fix the posterior horn of the allograft. If the meniscus is sitting superiorly, we will place the odd inside-out vertical mattress suture on the undersurface of the allograft to bring it back into anatomic position (Fig 10). After inspection and confirmation that the graft has a stable periphery, the bone bridge is stabilized with a single 7 × 23-mm bioabsorbable interference screw (Arthrex) placed medially (Fig 11). The anterior meniscus can then be stabilized with a direct repair through the arthrotomy. Confirmation of stability can

Table 2. Advantages and Disadvantages of Meniscal Allograft Procedures

MAT Considerations	
Advantages	Disadvantages
Potentially chondroprotective based on biomechanical evidence	Chondroprotective evidence not yet conclusive
Can regain lost function	High reoperation rate
Symptomatic pain relief	High failure rate
May delay arthroplasty	Potential rejection
Option for young patients with irreparable tears	Possible pathogen transmission
	Not indicated for patients above roughly 50 years

be performed with a probe (Fig 12). Useful pearls, pitfalls, and complications can be found in Table 1.

Postoperative Care

There is no consensus in the literature on the appropriate postoperative rehabilitation protocol. At our institution the patient is kept toe-touch weight bearing for the first 2 weeks followed by weight bearing as tolerated from weeks 2 to 6. Crutches are discontinued at 4 weeks postoperatively if their gait has normalized. Weight bearing at greater than 90° is avoided for the first 8 weeks. By weeks 8 to 12, range of motion should be full. At 2 months postoperatively, the patient begins rehabilitation exercises on a stationary bike, followed by jogging at 3 months and return to sports at 6 to 9 months.

Discussion

MAT remains a controversial topic, though with increasing evidence, practitioners are gaining a better understanding of its uses and limitations. Perhaps paramount to successful outcomes is appropriate patient selection, as the procedure is certainly not right for everyone with deficient menisci.

Indications and Patient Selection

The ideal candidate for a meniscal allograft is a young, active patient who has pain secondary to a total meniscectomy.⁸ After a complete meniscectomy, that joint compartment experiences excess weight-bearing forces leading to early-onset arthritis. Given the limited survivorship of total and unicompartmental knee arthroplasty, they are not recommended procedures for the young, active patient. Axial malalignment correction, knee stabilization procedures, and treatment of focal cartilage defects should be performed concomitantly at the time of procedure.⁹ Axial malalignment of greater than 2° of deviation to the involved compartment should be corrected lest they lead to increased pressure to the graft causing loosening, degeneration, and failure.¹⁰ ACL reconstruction in conjunction with a MAT produces a synergistic-protective effect in which each structure aids in the survivorship of the other. Currently, indications are limited to symptomatic patients as prophylactic MATs in the asymptomatic meniscectomized knee have not yet been proven to be successful.¹¹

Contraindications to transplant include advanced chondral degeneration, usually greater than grade 3.¹² Also, osteophyte formation and chondral flattening that alter the structure of the condyles leads to inadequate seating of the graft. Usually, patients older than age 50 years are considered suboptimal candidates because of the likelihood of multiple cartilage lesions.¹³ Other contraindications include obesity, skeletal immaturity, synovial disease, inflammatory arthritis, and previous joint infection.

Other Considerations

Beyond the patient's native anatomy, surgeons must consider the advantages and disadvantages inherent to the procedure (Table 2). In the short to intermediate term, MAT has been shown to improve pain according to Lysholm and IKDC subjective scales^{12,14,15} and regain lost function.⁸ Long-term, it may be chondroprotective based on biomechanical evidence,¹⁵ which ultimately may delay arthroplasty.

Conversely, there has been a reported failure rate from 4.7% to 12% when defined as revision MAT or arthroplasty within 5 years of index procedure, and a reoperation rate (any subsequent return to the operating room) as high as 32%, with 69% of these being debridements or hardware removals.⁸ There also exists the risk for graft rejection or pathogen transmission from graft to host, though chances for these are small.¹² Additionally, the clinical evidence for the chondroprotective effects are not yet conclusive,¹⁵ so we cannot definitely say MAT delays arthroplasty in patients. Finally, although it makes for a nice option for young patients with irreparable meniscal tears, it is of little to no use for patients above roughly 50 to 55 years of age.¹¹

MATs have greatly increased our options for young patients who sustain meniscal injury necessitating a total meniscectomy. When properly indicated, MATs have had medium to long-term success rates ranging from 76% to 90%.¹¹

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