Technical Note

Lateral Meniscal Allograft Transplant: Dovetail Bone Bridge Preparation

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Abstract: Meniscal tears are among the most common knee injuries encountered by an orthopaedic surgeon. Once treated with total meniscectomy, meniscal preservation is now the standard of care. Not all meniscal tears are repairable, and meniscal allograft transplantation has become an integral part of the preservation algorithm. This procedure is often recommended in a young active patient with healthy articular cartilage who has undergone a previous subtotal or total meniscectomy. There are many surgical methods for meniscal allograft transplantation, and the bone bridge technique has shown good improvement in outcome scores and good long-term survival. We describe our preferred technique for preparation of the dovetail bone bridge meniscal allograft for lateral meniscal allograft transplantation.

The critical role of the meniscus in knee biomechanics has been well documented. It functions not only to dissipate forces to protect the articular cartilage but also provides proprioceptive feedback and is a secondary stabilizer.[1] Meniscal injuries were recognized as early as the 1930s, and standard treatment was an open total meniscectomy. Fortunately, Fairbank's landmark paper recognized the detrimental effects of total meniscectomy.[2] He documented the accelerated articular cartilage deterioration, which would be coined "Fairbank changes."[2,3] This breakthrough prompted the evolution of meniscal preservation and introduced the importance of the meniscus in knee homeostasis. Currently, total meniscectomy has been abandoned and supplanted with meniscal repair, partial meniscectomy, and meniscal allograft transplantation (MAT).

Milachowski et al.[4] first described MAT in 1989 as a treatment option when the native meniscus could not be salvaged. The indications and techniques for MAT have evolved over time with the development enhanced imaging and arthroscopic equipment. Presently, the typical candidate for MAT is younger than 50 years of age, with a stable, well-aligned knee with healthy articular cartilage and is symptomatic from a previous subtotal or total meniscectomy.[5] Common allograft preparation and fixation techniques include all-soft tissue fixation, bone plugs, or a bone bridge. Due to the anatomic difference between the medial and lateral menisci, surgical technique options often are dictated by the affected compartment and concomitant procedures. The distance between the native medial meniscal root attachments allows for bone plug and dual bone tunnel fixation. The close proximity of the lateral meniscal root attachments makes dual bone tunnel fixation more difficult and a bone bridge more favorable to preserve the anatomic relationship.[2,6] Multiple types of bone bridges have been described in the literature, including trough, keyhole, bridge-in-slot, and dovetail. Our surgical technique focuses on the dovetail bone bridge preparation for lateral MAT. Our technique is shown in Video 1.

Surgical Technique (With Video Illustration)

Preparation of a lateral meniscal allograft requires a separate sterile back table that is equipped with all the necessary instrumentation for the surgeon. Our

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Table 1. Key Steps of a Dovetail Lateral Meniscal Allograft Preparation

1. Identify and mark anterior and posterior horns of meniscus.
2. Remove excess bone from anterior and posterior aspects of bone block.
3. Outline trapezoidal dovetail guide on both ends of bone block.
3. Position allograft upside-down and secure within workstation posts.
4. Complete medial and inferior cuts with a saw.
5. Begin angled lateral cut with saw and finish with a knife.
7. Confirm the size and accuracy of cuts by placing the graft in sizer.

preference is to start the preparation of the meniscal allograft while the patient is being positioned, prepped, and draped to maximize operating room time. The meniscal allograft with bone block is initially placed in a basin of warm saline and allowed to thaw, and all extraneous soft tissue is removed from the meniscus. Although the meniscus may be prepared by a free-hand method, our preference is to use the Arthrex instrumentation (Arthrex, Naples, FL) to simplify the process through a series of bone cuts to form a dovetail-shaped bone block (Table 1).

Our first step is to mark the anterior horn with an "A" and the posterior horn with a "P" to maintain the orientation during the preparation (Fig 1). We also use a suture looped around the meniscus during cutting to allow gentle traction of the meniscus away from the saw to avoid inadvertent injury. The posterior bone block is cut flush with the posterior horn of the meniscus to ensure that the posterior horn is positioned posterior in the tibia trough during implantation. The anterior bone block is cut initially to create a flush surface to permit fitting into the cutting workstation. We prefer to leave the anterior aspect of the bone block long and remove excess length after measurement of the tibia bone trough.

The ends of the bone block are marked with a surgical marking pen by tracing around the end of the trapezoidal rasp that will be used in tibial trough preparation (Fig 2). We emphasize that the trapezoidal rasp is placed proximal on the bone block and in line with the meniscal roots to ensure adequate preparation. Special attention to ensure that the angled cut is toward the meniscus (lateral) and the vertical cut is away from the meniscus (medial) is imperative to match the tibial trough. The meniscus is placed into the cutting workstation with attention placed on matching the outline of the trapezoidal shape on the bone block with the holding posts (Fig 3). We advocate that the surgeon holds the meniscal bone block in place and the assistant tightens the workstation to ensure proper positioning and accuracy of the subsequent cuts.

Cutting guide 1 is secured onto the workstation to complete the vertical or medial side cut on the bone block. This cut should be directly adjacent to the medial aspect of the meniscal roots to ensure that the entire root is preserved. We advocate placing a saw blade against the cutting guide to evaluate the potential cut during all steps before cutting the bone block. A sagittal saw is used to complete the vertical cut. Cold saline irrigation is applied to the bone and saw during cutting to minimize the potential for heat osteonecrosis. Scissors may be used to remove remnants from the cut. Cutting guide 2 is secured onto the workstation to complete an additional vertical cut to the inferior aspect of the bone block. Cutting guide 3 is secured onto workstation to complete the angled cut to the lateral aspect of the bone block. This cut has the potential to amputate the meniscus from the bone block, and we advocate starting the cut using the guide but completing the cut by hand under direct visualization to avoid this concern (Fig 4).

The meniscus is removed from the workstation and placed into graft sizing block to ensure an adequate fit (Fig 5). Slight modifications to the bone block are often necessary to ensure an easy sliding of the bone block in the sizing block and insertion in the tibia.

Discussion

Meniscal preservation has been one of the greatest evolutions in knee surgery in the last century. Expansion of meniscal repair indications and techniques have mirrored the advancements in arthroscopy and arthroscopic equipment. Trends in meniscal repair have demonstrated a consistent escalation, which has been reflected most significantly in younger surgeons.[7,8] Although incidence of meniscal repair is on the rise, MAT is still regarded as a salvage procedure, and the necessity has remained constant.[9] MAT is considered a joint-preservation surgical procedure and is often encountered along with limb malalignment, chondral injury, and knee instability. Identification and concomitant management of these associated conditions has been shown to be paramount for success of a MAT. Failure to treat these conditions in combination may lead to lower success rates and eventual failure of the allograft.[10,11]

Success rates of MAT vary widely throughout the literature. Early studies demonstrated lower success rates and outcome scores.[12,13] However, as advances in instrumentation and techniques evolved, more recent studies have shown good mid- to long-term results. In 2014, McCormick et al.[14] reported a 95% allograft survival rate at a mean of 5 years when looking at 172 consecutive meniscal transplants. Novaretti et al.[15] found that 73.5% and 60.3% of menisci remained functional at 10 and 15 years' post-transplantation, respectively. They also found that outcome scores improved at 10 years compared with preoperative baselines.[15] Most recently, Kim et al.[16] evaluated long-term survival of 49 meniscal allograft transplants. They

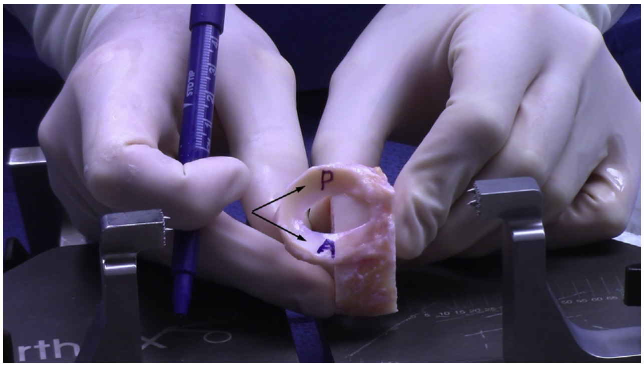

Fig 1. Tthe marking of the anterior horn of the lateral meniscal allograft with an "A" for anterior and the posterior horn with a "P" for posterior (arrows) to ensure proper orientation during preparation of the dovetail bone bridge technique.

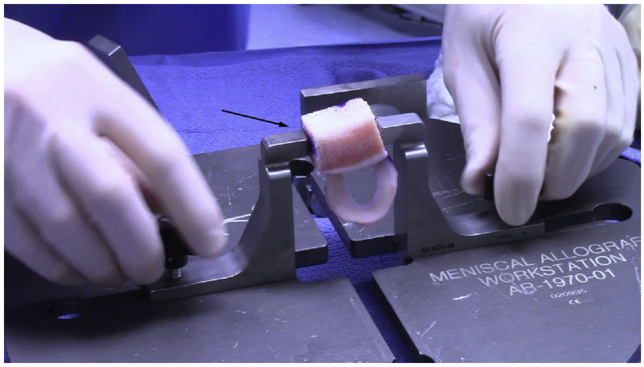

Fig 3. The lateral meniscal allograft positioned within the holding posts of the meniscal workstation (arrow) during preparation of the dovetail bone bridge technique.

used the bone bridge technique on 34 lateral transplants and the bone plug technique on 15 medial transplants. The mean follow-up was 11 years, and the authors showed 98% and 93% survival at 10 and 15 years, respectively.[16]

Comparisons between the different preparation and fixation techniques have been well-studied. Soft-tissue fixation, bone plug fixation, and bone bridge fixation have been the primary focus of the laboratory literature. Multiple cadaveric studies have shown that bone fixation techniques yield results closer to the native meniscus when compared to soft tissue fixation alone. Alhalki et al.[17] compared fixation methods using bone plugs versus soft tissue and evaluated contact pressure and contact area. The authors concluded that the use of bone plugs restores contact pressures and contact area close to a native meniscus.[17] McDermott et al.[18] also studied tibial contact pressures after MAT and concluded that bone plug fixation showed a lower contact pressure when compared with soft-tissue fixation. Finally, Wang et al.[19] evaluated tibial contact pressure as well as contact area during simulated gait after MAT and compared bone plug fixation versus soft-tissue fixation. Bone plug fixation proved to produce more evenly distributed contact pressures after MAT.[19]

While some studies have shown similar outcomes between bone fixation and soft-tissue fixation, others have highlighted the advantages of the bone bridge fixation on the lateral side.[20] Brial et al.[21] performed a study evaluating tibial contact forces of a native lateral meniscus and compared those results with forces measured after a lateral keyhole MAT, bone plug MAT, and all-soft tissue MAT. The authors found that while both bone fixation techniques outperformed the all-soft tissue fixation, the keyhole bone bridge most closely reproduced the tibial contact forces of an intact native lateral meniscus.[21] The close proximity of the lateral meniscal roots makes the bone bridge technique very attractive to avoid convergent tunnel complications and replicate the normal anatomy with strong initial fixation. Kim et al.[22] showed restoration of anatomic horn

Fig 2. The marking of the lateral meniscal allograft with the trapezoidal guide (arrow) to ensure proper orientation of the graft during preparation of the dovetail bone bridge technique.

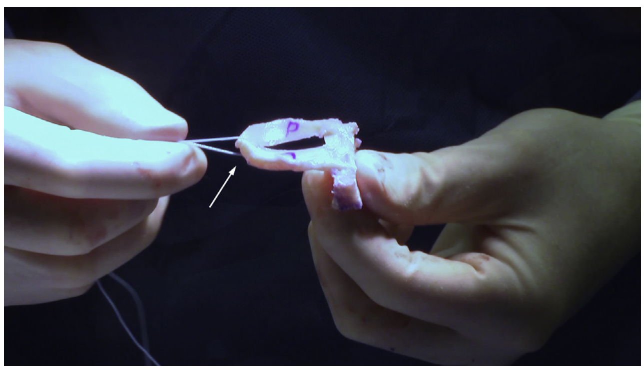

Fig 4. The lateral meniscal allograft after the bone cuts with a suture (arrow) holding meniscus during preparation of the dovetail bone bridge technique.

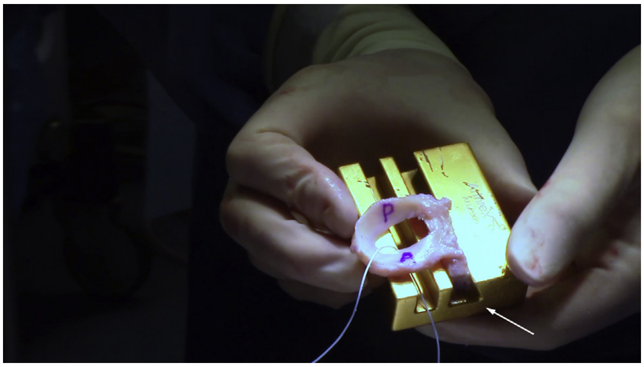

Fig 5. The lateral meniscal allograft within the meniscal graft sizing block (arrow) with a suture holding meniscus during preparation of the dovetail bone bridge technique.

placement within 5 mm of the native sites, both anteriorly and posteriorly, with the use of a bone bridge.

MAT is an important part of the joint-preservation algorithm in a young patient with meniscal deficiency. Recent literature has shown good survivorship and patient outcome scores following MAT. The use of a bone bridge technique in a lateral meniscal allograft transplant reliably restores anatomy and can prevent potentially devastating intraoperative complications (Tables 2 and 3). Although there are several ways to prepare the bone bridge, we have found the dovetail bone bridge to be reproducible and straightforward while using the instrumentation to produce a robust graft.

Table 2. Pearls and Pitfalls of Dovetail Lateral Meniscal Allograft Preparation

Pearls
1. Mark the anterior and posterior horns of the graft to ensure proper orientation.
2. Cut excess bone from the posterior graft to ensure posterior positioning during implantation.
3. Ensure superior aspect of trapezoidal dovetail guide is in line with superior aspect of graft while the guide is outlined with a marking pen. This will avoid superior prominence of the graft within the trough.
3. Use a free saw blade to confirm cutting guide surfaces are aligned before the actual cut.
4. Complete the angled lateral cut with a knife to avoid amputation of the meniscus from the bone block.
5. Use a free suture to control the meniscus during preparation.
Pitfalls
1. Leaving excess bone posterior places the meniscus too anterior in the trough.
2. Placing the trapezoidal guide too low on the bone block leads to the graft being prominent in the trough.
3. The cutting block posts do not match up with the bone block markings from the trapezoidal guide.
4. Amputation of the meniscus from the bone block during the lateral cut.
5. Fracture of the bone block while inserting into the sizing guide.

Table 3. Advantages of Dovetail Lateral MAT

Advantages
1. Reproducible preparation steps and straightforward instrumentation.
2. Meniscus is well-protected during preparation.
3. Dovetail allows a robust bone block with little chance of fracture and excellent stability within the trough.
4. Anatomic anterior and posterior horn positions.
5. Avoids potential converging tunnels associated with the bone plug technique for lateral MAT.

MAT, meniscal allograft preparation.

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