Technical Note

# Meniscus Allograft Transplantation With Bone Plugs Using Knotless All-Suture Anchors and Cortical Button Suspensory Fixation

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**Abstract:** Meniscus allograft transplantation can be successful for treatment of meniscal deficiency using a number of transplant techniques. In this Technical Note, we describe a double bone plug medial meniscus allograft transplantation technique that uses knotless all-suture anchors with cortical-button suspensory fixation. This technique maintains the reported advantages for bone-plug fixation while mitigating the risk for meniscal root damage, facilitating easier bone plug insertion and seating, expanding tensioning capabilities, and preventing soft-tissue irritation from suture knot stacks.

Meniscus allograft transplantation (MAT) is an effective treatment option for patients with symptomatic meniscus deficiency who do not have degenerative joint disease or uncorrectable instability or malalignment.[1-10] Multiple techniques have been described for preparation and arthroscopic implantation—fixation of the meniscus allograft, which have been divided into 2 general categories: bony fixation (bridge-in-slot or bone plug techniques) and all soft-tissue (suture-only) fixation. Successful clinical outcomes have been reported using techniques in both categories, with consistent keys to success involving donor tissue processing and preservation methods; allograft sizing, tensioning, and root and peripheral fixation; treatment of relevant comorbidities; and patient adherence to post-MAT restriction and rehabilitation protocols.[2,10-13] Biomechanical studies have provided evidence for anatomic fixation with bone plugs in more effectively restoring normal articular contact mechanics to the knee.[4,14] As such, arthroscopic MAT using double bone plugs with suture-loop cortic al-button suspensory fixation in tibial sockets has become a popular transplantation technique.[11-13] Although clinical outcomes associated with

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this technique have been favorable, suboptimal features that have resulted in some intra- and postoperative complications, including bone plug socket-insertion difficulties, inability to fully tension the allograft, and meniscus root damage from encircling loop sutures. Therefore, the authors developed a method for lateral and medial MAT that addresses these concerns. This Technical Note describes a procedure for performing arthroscopic medial meniscus allograft transplantation using knotless all-suture anchors with cortical-button suspensory fixation of bone plugs in tibial sockets.

## Surgical Technique (With Video Illustration)

### Meniscus Allograft Preparation

This study was performed at the University of Missouri. A fresh size-matched meniscus-tibial hemi plateau allograft is obtained from a tissue bank and aseptically prepared in the operating room. A 2.4-mm guide pin is drilled through the center of the posterior root insertion ("footprint") of the meniscus. The guide pin is placed from the articular side of the graft and directed in an anterior position to match the angle of the tibial socket that will be created (Table 1). The pin is removed and the gap pusher for a cannulated coring reamer is then placed through the drilled hole in retrograde fashion. Depending on patient size, an 8- to 10-mm diameter cannulated coring reamer is then used to create a 7- to 9-mm diameter bone plug, respectively, in retrograde fashion to include the entire meniscus root footprint, taking care to not damage the root as the coring reamer reaches the articular surface (Fig 1). The process is then repeated to create the anterior bone plug with emphasis to match the angle that will be used for the anterior tibial socket. The posterior and anterior bone plugs are then cut to lengths of 6 mm and 8 mm, respectively. A shorter length is used posteriorly to facilitate passage of the bone plug through the intercondylar notch for insertion into the posterior tibial socket. A 2.6-mm knotless fibertak anchor (Arthrex, Naples, FL) is then passed through the pin hole in the posterior bone plug from its articular surface so that the knotless anchor is fully seated on the meniscal (superior) side of the bone plug (Fig 2). The repair stitch is then loaded through the pull suture and pulled through the anchor until it creates the closed loop construct and expands the all-suture anchor for secure engagement of the bone plug. The loop is initially left 4- to 6-cm long to facilitate passage through the tibia for subsequent cortical button placement, tensioning, and fixation. The pull suture is then placed through the loop and over the repair suture to avoid premature loop shortening during passage through the tibia. This anchor placement process is then repeated for the anterior bone plug (Fig 3). The anterior and posterior aspects of the meniscus are marked and a suture tape is passed through the

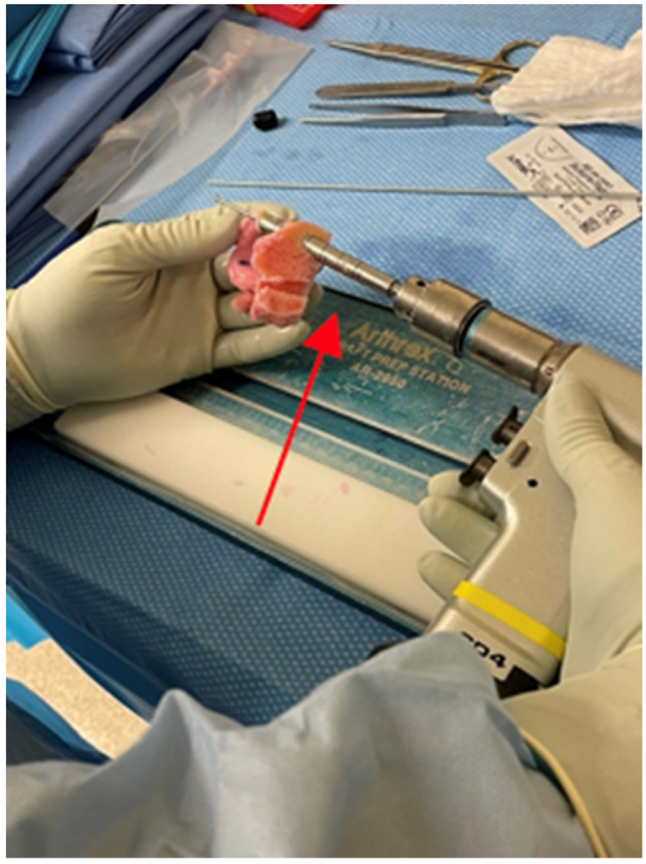

**Fig 1.** Meniscal allograft preparation. A core reamer (red arrow) is used to create the anterior bone plug from the allograft tissue.

**Table 1.** Pearls and Pitfalls

| Pearls | Pitfalls |
|---|---|
| • When creating bone plugs, drill the initial guidewire at same angle the tibial sockets will be drilled to ensure proper positioning of the bone block and meniscus<br>• Place the knotless portion of the suture anchor on top of the meniscal root and pass the repair suture within the device once the knotless suture anchor is well seated over the meniscus<br>• Pie-crusting the MCL may be necessary—proper preparation and access to the medial compartment will allow for adequate visualization and shuttling of bone plugs<br>• After placing each suture through the meniscus, re-evaluate the tension and position of the meniscus | • Bone plug and socket mismatch in angle and length/depth can lead to a proud bone plug within the joint<br>• Not maintaining enough length of the repair suture loop and free end to pass through the tibial tunnel |

MCL, medial collateral ligament.

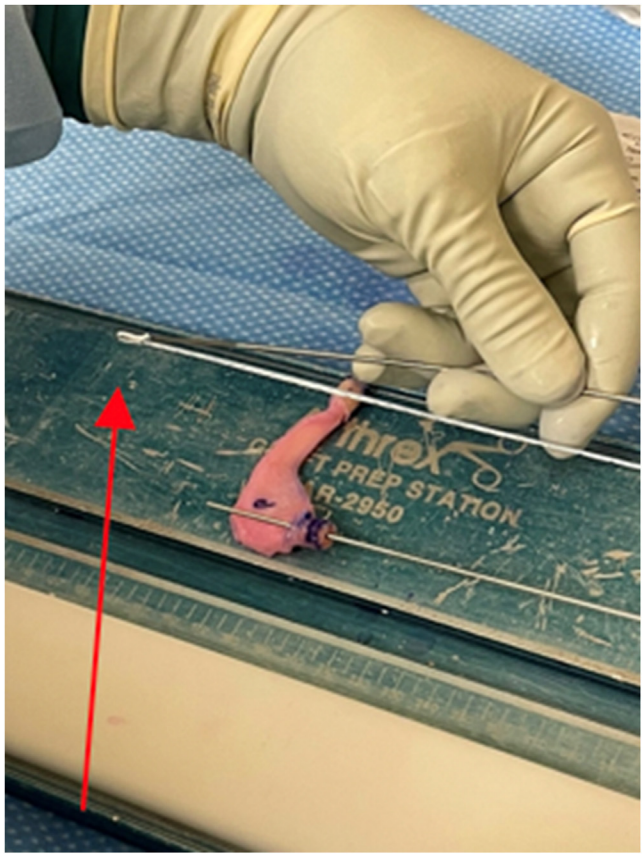


**Fig 2.** Meniscal allograft preparation: Knotless all-suture anchor (red arrow) shown adjacent to the meniscus, which will be placed retrograde through the previously created guide pin hole in the meniscal bone plug.

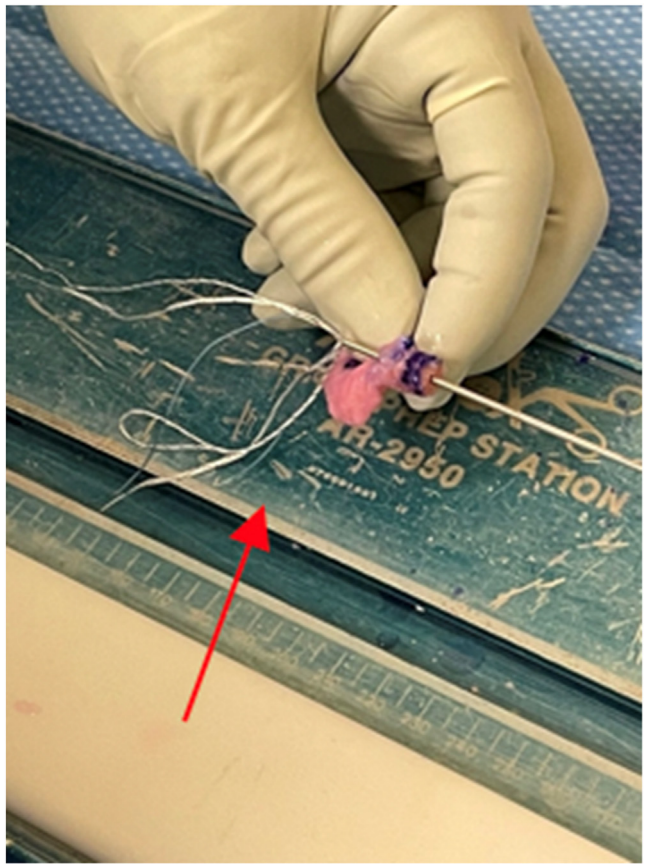


**Fig 3.** Meniscal allograft preparation: knotless all-suture anchor (red arrow) is placed in retrograde fashion with the suture anchor seated on top (superior) of the meniscus.

peripheral rim of the meniscus at the junction of body and posterior horn to facilitate allograft passage, positioning, and fixation. This completes the allograft preparation (Fig 4).

## Patient Setup and Diagnostic Arthroscopy

The patient is positioned supine on the operative table with a standard knee arthroscopy setup using a lateral post per preference of the surgeon. A standard anterolateral portal is created followed by an anteromedial portal through needle localization. A diagnostic knee arthroscopy is then performed to evaluate for associated injuries.

## Medial Meniscus Transplantation

Following a diagnostic arthroscopy, the medial compartment is prepared. If needed, a percutaneous release of the medial collateral ligament is recommended to provide adequate visualization and access to the medial compartment (Table 1). The remaining portion of the deficient medial meniscus is debrided to smooth, bleeding capsule as an optimal healing surface. An anterior cruciate ligament (ACL) guide is then placed into the appropriate position at the posterior root of the medial meniscus and a small stab incision is made over the anteromedial tibia to allow for the guide sleeve to be advanced down to bone. A retrograde cutting device (Arthrex) is then used to drill into the tibia and once the proper position is confirmed within the joint, a socket is retro-drilled to a diameter that is 0.5 mm larger than the corresponding bone plug and 10 to 12 mm in length to facilitate passage and seating of the plug into the socket and optimal tensioning of the meniscus allograft. A looped FiberStick passing suture is then placed through the tibia into the joint and pulled out the anteromedial portal.

A posteromedial incision is then made and dissection is taken down to the posteromedial capsule. Care is taken to avoid the saphenous nerve near the medial joint line. A retractor is placed posteriorly to protect the posterior soft tissue and neurovascular structures. A curved suture lasso or 18-g spinal needle is then placed through this incision and through the capsule into the posteromedial aspect of the medial compartment. A nitinol wire is passed through the lasso/needle (Fig 5) and pulled through the anteromedial portal and a looped passing suture is shuttled via the nitinol wire. This step can be repeated so that there are superior and

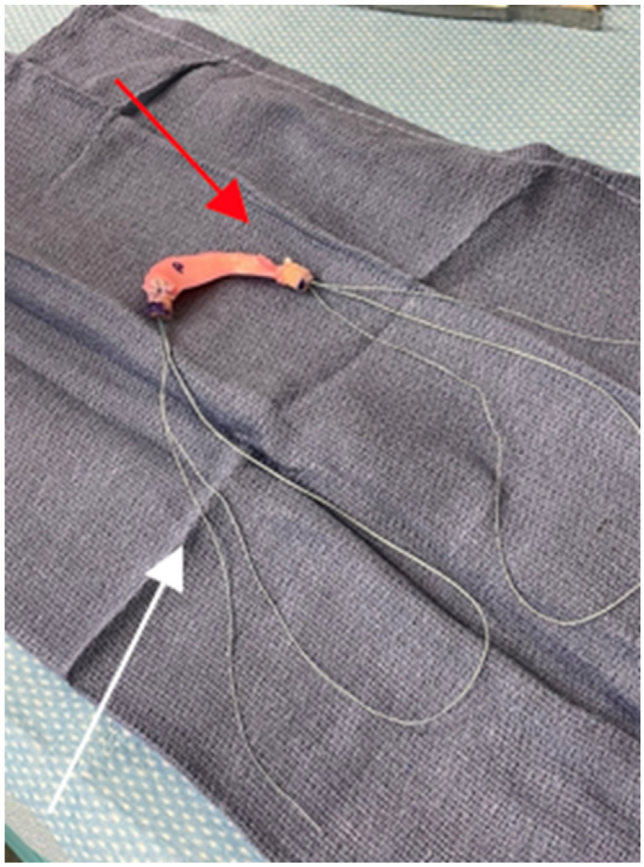

**Fig 4.** Meniscal allograft preparation: final meniscal allograft with bone plugs, knotless all-suture anchors (red arrow) seated on top the of bone plugs and the closed loop sutures and pull sutures (white arrow) through the bone plugs.

inferior passing sutures out the posteromedial knee in preparation for passing the suture tape that was previously placed in the posterior aspect of the meniscal allograft for capsular and tibial fixation, as desired.

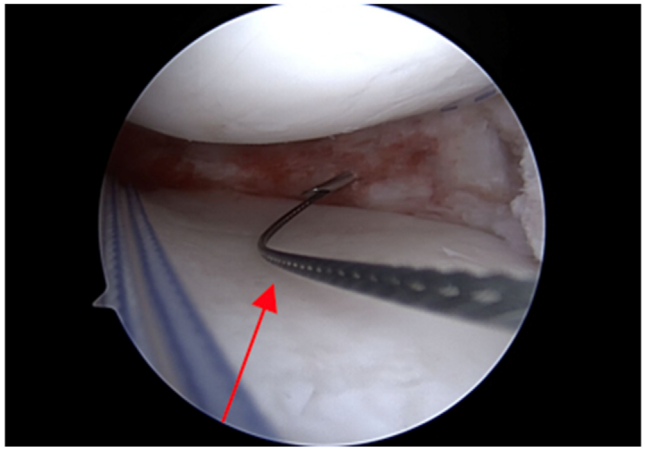

**Fig 5.** Arthroscopic image of a right knee viewing from the anteromedial portal with a 30° arthroscope: placement of a posterior medial suture lasso and nitinol wire (red arrow) passage through the medial compartment of the knee for shuttling posterior horn suture tapes.

The anteromedial portal is enlarged in preparation for shuttling in the meniscal allograft. The fibertak pull sutures and the suture tape suture(s) within the posterior meniscus allograft are loaded into their corresponding passing sutures and shuttled into the joint taking care to maintain allograft orientation during passage. The allograft is gently guided into the joint using a grasping instrument to push the posterior bone plug through the anteromedial portal and by alternating pulling of the posterior passing sutures through the tibial tunnel and the posteromedial incision. The posterior bone plug is seated into its tibial socket, the passing and pull sutures are removed, and a cortical button is placed in the fibertak loop for initial fixation on the anterior tibial cortex (Figs 6-8). The posterior horn suture tape(s) are tensioned through the medial incision and an initial all-inside suture(s) may be used to fix the posterior horn of the meniscus to the capsule, as desired, to prevent displacement and/or eversion of the allograft.

Medial tension on the anterior bone plug pull suture is maintained at the portal while the anterior tibial socket is created. A 2.4-mm guide pin is placed at the anatomic insertion site of the native anterior root of the medial meniscus in a vertical orientation. Using a low-profile cannulated reamer, the anterior tibial socket is reamed over the pin to a diameter that is 0.5 mm larger than the corresponding bone plug and 12 to 15 mm in length to facilitate passage and seating of the plug into the socket and optimal tensioning of the meniscus allograft. An ACL point-to-point guide is then placed into the socket and its angle is adjusted to be able to connect a drill hole from the anterior tibia to the distal part of the socket (Fig 9). The guide sleeve is advanced down to tibial bone posterior to the posterior tibial tunnel exit site using the same or a separate skin incision. A retro cutting device (FlipCutter) is drilled through the point-to-point guide to create a tunnel to the anterior tibial socket. The retro cutter is removed and a fiberstick passing suture is passed into the socket and shuttled out the anteromedial portal (Fig 10).

The anterior bone plug's pull suture is loaded into the passing suture and pulled through the tibial tunnel to seat the anterior bone plug into its tibial socket. The passing and pull sutures are removed and a cortical button is placed in the fibertak loop for initial fixation on the tibial cortex (Fig 11). The fibertak repair sutures are used to further seat the anterior and posterior bone plugs to create the desired positioning and tensioned of the allograft and firm seating of the cortical buttons on tibial bone. Multiple inside-out and/or all-inside meniscus allograft-capsular fixation sutures are placed to obtain the desired tensioning and positioning of the allograft based on arthroscope visualization and probing (Fig 12). In addition, pre-placed suture tape(s) can be

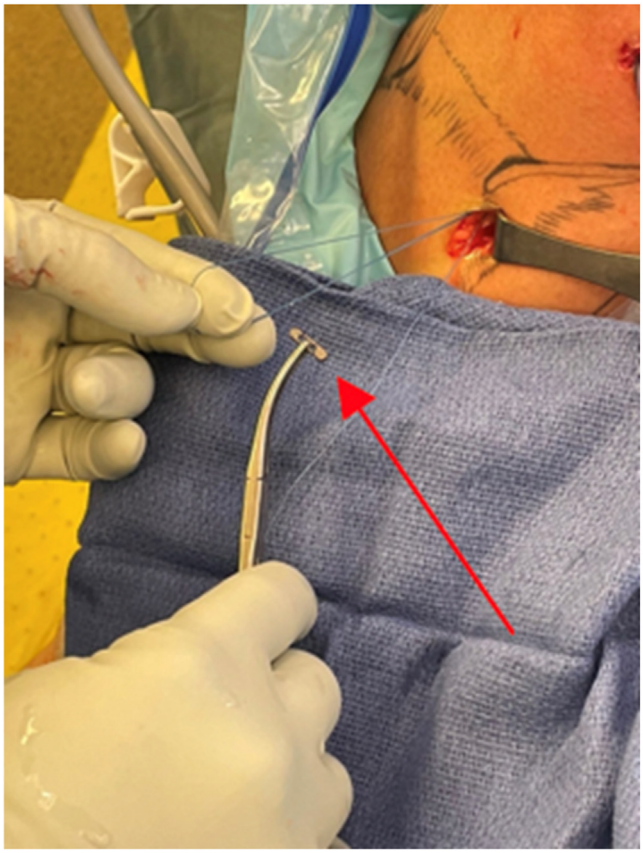

**Fig 6.** Anteromedial view of a right knee for meniscal allograft transplantation: repair suture loop, repair free end pull suture, and suture button (red arrow) outside the knee before placement of the suture loop over the cortical button.

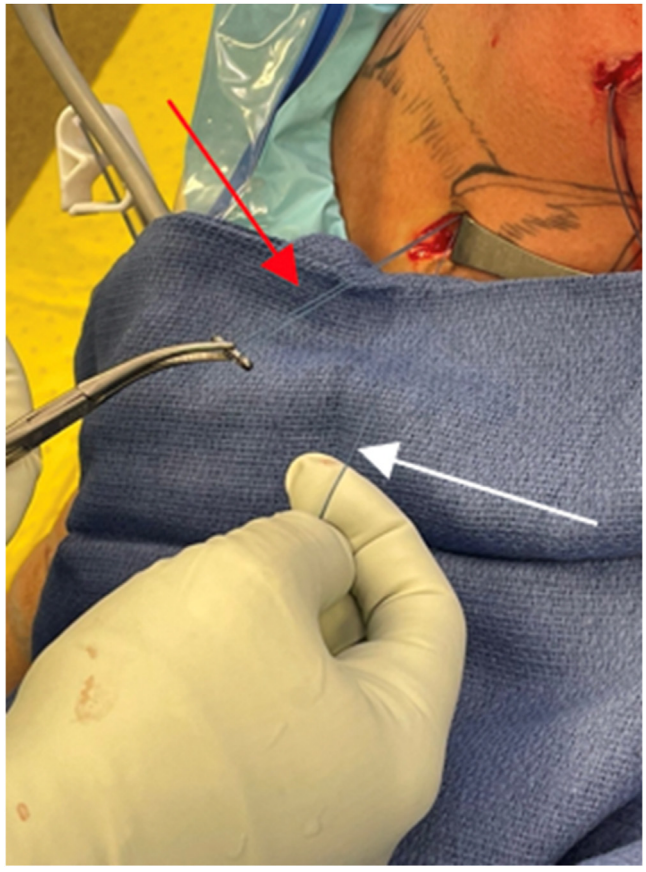

**Fig 7.** Anteromedial view of a right knee for meniscal allograft transplantation: repair suture loop (red arrow) placed within suture button and repair free end pull suture (white arrow) used to tension down the suture button and reduce it down to the anteromedial tibial cortex.

used for meniscotibial fixation[13] or tied extra-articularly for additional meniscocapsular fixation. The incisions are then closed in a layered fashion and sterile dressings are placed on the wounds, followed by a hinge knee brace locked in extension. The medial MAT technique is demonstrated in Video 1.

A similar technique is used for lateral MAT, with the key differences being that the anterior tibial socket can be effectively created using the ACL guide and retro cutter and care must be taken to protect the popliteal tendon in addition to the lateral neurovascular structures.

### Postoperative Course

Postoperatively, the patient is made toe-touch weight-bearing for 6 weeks with the brace locked in extension during transfers. The knee range of motion is limited from 0 to 60° for the first 2 weeks and then 0 to 90° for a total of 6 weeks to protect the meniscus.

## Discussion

MAT is a safe and effective treatment for symptomatic meniscus deficiency in the appropriate patient population.[15-17] Although transplantation of meniscus allografts can be accomplished in a variety of ways,[17-22] studies have demonstrated the biomechanical superiority of bone plug versus soft-tissue fixation of the meniscal

**Fig 8.** Arthroscopic image of a right knee viewing from the anterolateral portal with a 30° arthroscope: tensioned posterior root bone block of the medial meniscus transplant.

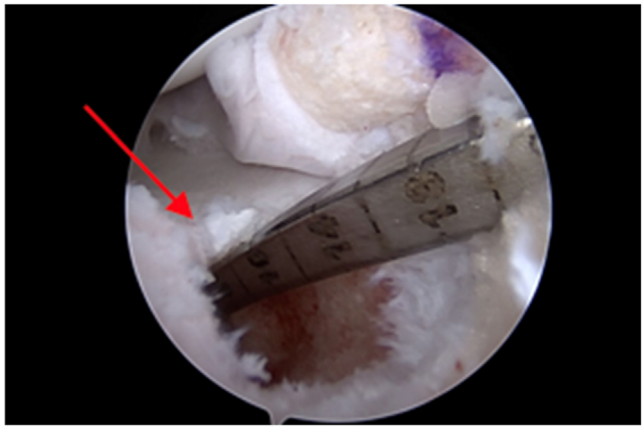

**Fig 9.** Arthroscopic image of a right knee viewing from the anterolateral portal with a 30° arthroscope: anterior meniscal root socket has been reamed to size and a point-to-point guide (red arrow) is brought in through the anteromedial portal and used to create tibial tunnel for suture passage prior to seating the anterior medial meniscus bone plug.

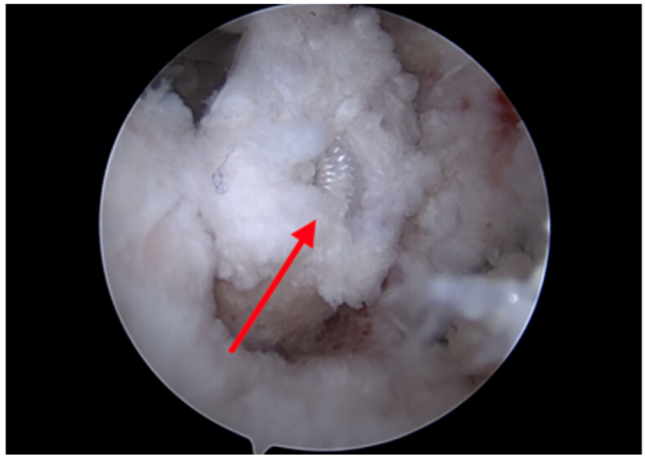

**Fig 11.** Arthroscopic image of a right knee viewing from the anterolateral portal with a 30° arthroscope: anterior medial meniscal transplant bone block tensioning into the anterior socket with the all-suture anchor (red arrow) visible over the top of the bone block

roots with respect to restoration of tibiofemoral contact mechanics and prevention of extrusion.[23-28] In regard to extrusion, a recent systematic review demonstrated that medial meniscus extrusion following MAT ranged from 24.8% to 53.7%, with nonanatomical placement of anterior and posterior roots appearing to increase extrusion.[29] As such, multiple techniques for MAT bone plug fixation have been described.[18,19] However, these techniques have been associated with intra- and postoperative complications, including bone plug socket-insertion difficulties, inability to fully tension the allograft, and meniscus root damage from encircling loop sutures, as well as the potential for soft-tissue irritation from suture knots. A recent study demonstrated that 23% of patients who underwent MAT required a minimum of 1 subsequent surgery for various concerns.[30] This article describes a reproducible technique for meniscus allograft transplant using knotless all-suture anchors with cortical-button suspensory fixation designed to mitigate these complications.

This technique provides a number of advantages as compared with knotted suture-loop cortical-button suspensory, solid anchor, or other bone plug fixation techniques (Table 2). The primary advantage involves the mechanism of anchor fixation on the bone plug that avoids encircling of the meniscus root with loop sutures that apply a horizontally directed load at the soft-tissue—bone plug junction, which can result in strangulation and subsequent tearing of the meniscus root. Instead, the all-suture anchors apply an axially directed

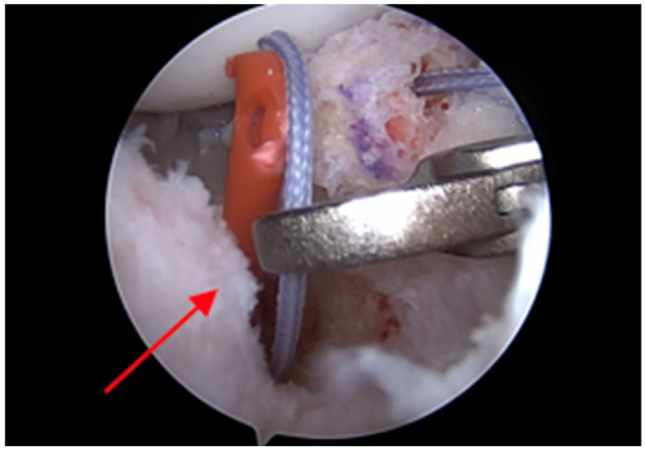

**Fig 10.** Arthroscopic image of a right knee viewing from the anterolateral portal with a 30° arthroscope: FiberStick looped passing suture shuttled into anterior socket (red arrow) for suture passage prior to seating the anterior medial meniscus bone plug.

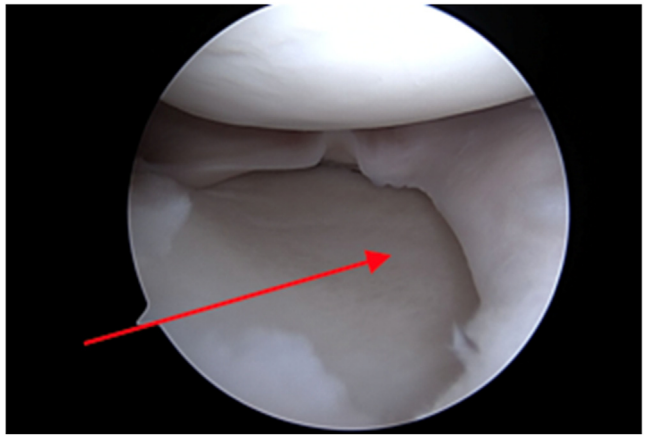

**Fig 12.** Arthroscopic image of a right knee viewing from the anterolateral portal with a 30° arthroscope: final medial meniscus allograft transplant (red arrow).

**Table 2.** Advantages and Disadvantages of the Technique

| Advantages | Disadvantages |
|---|---|
| • Arthroscopy allows complete visualization of any associated intra-articular injuries<br>• Assortment of knotless devices can be used<br>• All-suture anchor applies an axial load directly on the bone plug facilitating passage and seating within the socket<br>• Avoids encircling the meniscus root with loop sutures at the soft-tissue–bone plug junction, which can result in strangulation and tearing of the meniscus root<br>• Ability to tension and retension the bone plug fixation while visualizing through the arthroscope to achieve appropriate graft tension<br>• Cortical buttons are small, resulting in minimal risk of soft tissue or skin irritation over the anteromedial tibia | • Access to knotless suture anchors is required<br>• Cost of suture anchors<br>• Careful placement, deployment, and tensioning of the suture anchors is necessary to ensure adequate graft fixation and prevent prominence or fixation failure<br>• A potentially bulky suture anchor present within the joint space overlying the meniscal roots if not seated appropriately |

load directly on the bone plugs, which facilitates their passage and seating in sockets while negating the possibility for meniscus root damage. In addition, the all-suture anchor mechanism allows for a fully closed loop using knotless fixation over a cortical button that does not require a minimum bone tunnel length extending beyond the sockets or potentially irritating knots while providing biomechanically equivalent fixation stiffness and ultimate load to failure.[31,32]

This technique is also associated with some potential disadvantages (Table 2). One disadvantage is the requirement of a knotless suture anchor device that may not be readily available to all surgeons. In addition, the knotless suture anchor must be carefully placed, deployed, and tensioned in order to prevent prominence or fixation failure.

In this Technical Note, we describe a double bone plug meniscus allograft transplantation technique that uses knotless all-suture anchors with cortical-button suspensory fixation. This technique uses an anterior and posterior bone plugs placed into sockets for anatomic meniscal root fixation in conjunction with meniscocapsular and meniscotibial suture fixation to achieve optimal meniscus allograft positioning, tensioning, and contact mechanics. This reproducible and reliable technique maintains the reported advantages for bone-plug fixation while mitigating the risk for meniscal root damage, facilitating easier bone plug insertion and seating, expanding tensioning capabilities, and preventing soft-tissue irritation from suture knot stacks.

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