Technical Note

Revision Meniscal Repair With Amniotic Membrane Augmentation

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Abstract: Meniscal injury is common, and despite modern techniques, the failure rate following repair remains high. While there are recent treatment advances in the form of biologics, there is limited evidence and agreement on these emerging therapies and their role in meniscal healing. Amniotic tissue (umbilical cord allograft) is a biologic augmentation therapy that has been utilized in other musculoskeletal applications but has not been reported for use in meniscal repair. We describe a technique to deliver an allograft amniotic membrane into a meniscus tear repair site, potentially optimizing healing.

Meniscus tears are one of the most common injuries treated by orthopaedic surgeons. Meniscectomy was historically utilized, but the importance of the meniscus in absorbing impact and distributing force throughout the knee has been demonstrated in biomechanical and comparative clinical studies. Meniscectomy is associated with progression of osteoarthritis and worse outcomes.[1] While meniscal repair decreases the long-term adverse effects of meniscectomy, long-term failure rates remain high. With a failure rate of 19.5% reported with modern techniques, there remains opportunity for optimization of meniscal repair.[1]

Biologic augmentation is one potential route to improve meniscal repair success rates. Amniotic membrane is an emerging therapeutic augment to promote orthopaedic soft tissue healing. It is a placental tissue that aids in fetal development during pregnancy and consists of collagen, growth factors, and collagen-rich extracellular matrix that are beneficial in tissue repair and regeneration.[2] It has been applied previously in dermatologic, hepatic, cardiac, neurologic, and more recently musculoskeletal approaches.[2] Amniotic membrane is commercially available and has shown promise in treating knee osteoarthritis and for spine and hand surgery but has not been reported for use in meniscal repair.[3-5] The purpose of this Technical Note is to describe a technique for implantation of amniotic membrane tissue to augment revision meniscal repair.

Surgical Technique

Preoperative Assessment

A meniscus tear is diagnosed through a combination of appropriate clinical history, supportive physical examination findings, and magnetic resonance imaging demonstrating a T2 hyperintensity that surfaces in the meniscus. Patients will commonly present after a noncontact twisting injury resulting in pain with twisting movements or deep knee flexion and they can often experience associated mechanical symptoms of locking and catching. On physical examination, the joint line should be evaluated for tenderness and provocative tests such as McMurray's and Thessaly are performed. Limb alignment is assessed with clinical examination and full-length hip to ankle radiographs. Additionally, ligamentous stability of the knee is evaluated.

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Diagnostic Arthroscopy/Meniscus Tear Site Preparation

The surgical procedure begins with an examination under anesthesia to assess for range of motion and concomitant ligamentous injury, as symptomatic knees can often preclude adequate examination in the clinic. A diagnostic arthroscopy is performed through a standard anterolateral viewing portal and anteromedial instrumentation portal. Ensure proper placement of the anteromedial portal to allow for the appropriate trajectory of instrumentation for meniscal repair while avoiding iatrogenic articular cartilage injury to the femoral condyles. The meniscal tear should be probed and assessed for pattern of tear, quality of tissue and repairability, and mobility and extrusion. If unable to safely perform repair of a partially visualized medial meniscal tear due to a tight medial compartment, we recommend percutaneous medial collateral ligament trephination to improve visualization and access to the tear. Trephinate with an 18-gauge spinal needle from posterior to anterior near the femoral origin just distal and posterior to the medial epicondyle while applying a valgus stress. During trephination, arthroscopically visualize the medial compartment for adequate opening.

Friable meniscal tissue should be removed with an arthroscopic shaver and any loose suture or anchors from a prior repair should also be removed with a combination of arthroscopic biters, graspers, and shaver. Utilize a probe to measure the length of the meniscal tear to allow for calibration of the size and location of the amniotic graft to be implanted. Mechanical abrasion should be performed within the tear with a rasp or shaver. The rasp is utilized for capsular and meniscal abrasion to promote healing.

Amniotic Membrane Graft Preparation/Implantation

Video 1 demonstrates a revision meniscal repair with umbilical cord allograft augmentation utilizing the AmnionXpress Delivery Device (Arthrex) and Amnion 5-mm × 40-mm streamer (Arthrex) shown in Figure 1. The umbilical cord allograft is a cell-free structural allograft with a growth factor profile that is anti-inflammatory and supportive of angiogenesis. Table 1 outlines the steps for implant preparation and loading into the delivery device while in the operating room. Table 2 outlines the steps for implant delivery into the meniscal tear site and is represented in Figure 2. Table 3 outlines pearls and pitfalls for this technique.

Meniscal Repair

The senior author's (C.J.T.) preferred technique is to utilize an all-inside suture repair with a combination of both meniscal-based and capsular-based implants, as demonstrated in Figure 3. Following completion of the repair, the meniscus is assessed with a probe for adequate tension across the repair site and for lack of meniscal extrusion. Additional biologic augmentation of the meniscal repair to promote healing is completed by performing marrow venting in the intercondylar notch with a microfracture awl, ensuring bone marrow elements are visualized entering the knee joint with the arthroscopy fluid inflow turned off.

Postoperative Rehabilitation

Amniotic membrane augmentation does not alter the standard postoperative rehabilitation protocol for

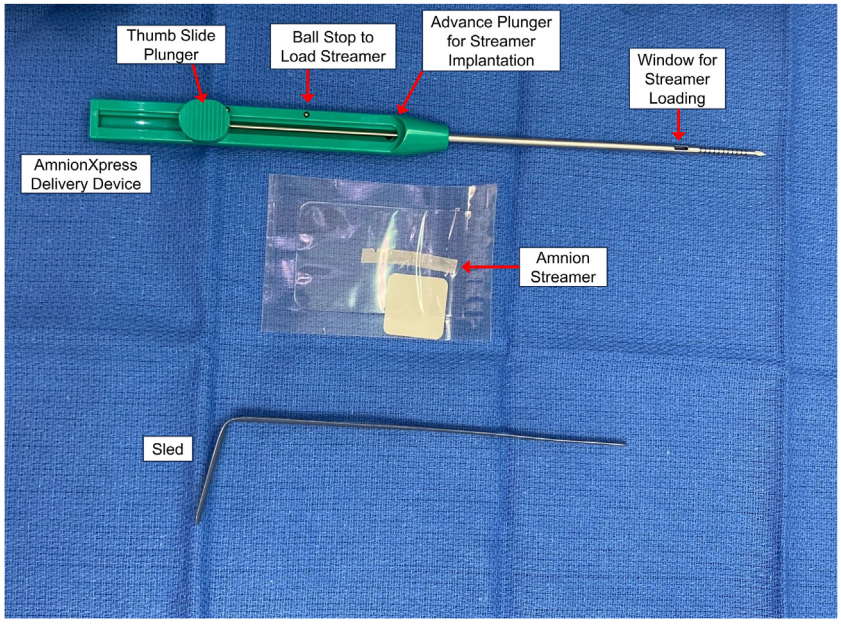

Fig 1. Amnion 5-mm × 40-mm streamer (Arthrex) is loaded into the AmnionXpress Delivery Device (Arthrex) on the back table in the operating room for arthroscopic implantation into the meniscal repair site. The sled is used through the anteromedial portal to guide the delivery device through the soft tissues into the knee joint.

Table 1. Steps for Implant Preparation and Loading Into the Delivery Device

- Put on a new pair of dry sterile gloves for initial handling of the Amnion streamer (Arthrex) since the tissue becomes tacky once moist, making it difficult to handle and insert through the slot of the delivery device.
- If the tear measurements require shortening of the graft, cut half of the excess length from the 40-mm streamer prior to loading the streamer into the delivery device.
- Mark the streamer at its midpoint to easily identify when it is loaded to that point in the delivery device.
- Once the membrane is gently pulled halfway through the slot, it is moistened by hand and folded in half, in line with the delivery device. Alternatively, a saline-filled syringe can be used to hydrate the graft after it is loaded.
- Advance the thumb slide plunger to the second ball stop on the delivery device. Advance slowly to avoid cutting the membrane.
- The graft is ready for insertion into the meniscal tear.

Table 2. Steps for Implant Delivery Into the Meniscal Tear Site

- Insert the delivery device tip through the standard anteromedial portal over a sled and into the repair site.
- Carefully advance the thumb slide plunger on the delivery device to deploy the implant. Use the measured markings on the delivery device with the previously measured tear size to ensure precise implantation along the full length of the tear. Folded in half, the full streamer will be 2 cm in length, and the nitinol forked tip will advance 25 mm from the end of the delivery device when the thumb slide plunger is advanced fully.
- Maintain pressure on the thumb slide plunger while retracting the delivery device, leaving behind the amniotic membrane inside the repair site.
- Probe any extruded implant into the repair site.

meniscal repair. The senior author's rehabilitation protocol typically involves toe-touch weight bearing for the first 2 weeks postoperatively with crutch support, followed by progression to weight bearing as tolerated with the knee locked in extension for ambulation for weeks 2 to 6 postoperatively. Range of motion is limited to 0° to 90° of flexion for the first 6 weeks post-operatively. Past 6 weeks, the brace is weaned as the patient regains full range of motion and limb control with improved strengthening. Blood flow restriction therapy is initiated at 2 weeks postoperatively when indicated. Return to impact activities to include jogging is typically allowed at 12 weeks postoperatively, with return to sports at 4 to 6 months.

Discussion

Amniotic membrane augmentation is an emerging biologic therapy for operative orthopaedic applications.

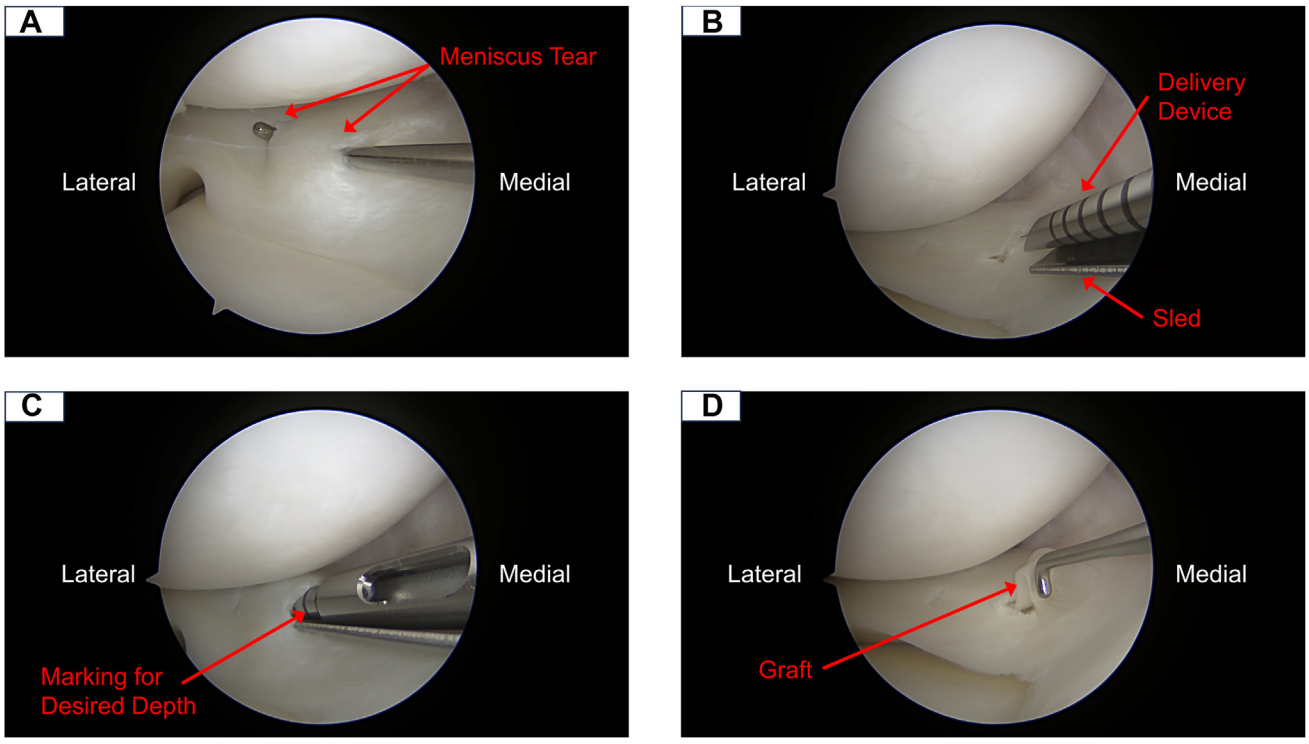

Fig 2. Viewing the medial compartment of a right knee from the anterolateral portal. (A) An arthroscopic probe is utilized to assess the tear site and measure the length of the tear for graft implantation. (B) The delivery device is inserted through the anteromedial portal on top of the sled to avoid getting caught in the soft tissues or causing iatrogenic chondral or meniscal injury. (C) Once the delivery device has been inserted into the tear site using the measured markings for reference, the thumb slide plunger is advanced to the measured depth for the meniscal tear length to implant the amniotic membrane allograft. (D) Following retraction of the delivery device, a probe can position any remaining graft into the tear site prior to meniscal repair.

Table 3. Pearls and Pitfalls for Revision Meniscal Repair With Amniotic Membrane Augmentation

Pearls	Pitfalls
• Assess risk factors for repair failure to include limb alignment and ligament stability preoperatively. • Obtain patient consent for off-label use of amniotic membrane augmentation. • If repairing a medial meniscus tear, consider MCL trephination to improve visualization and room for instrumentation. • Prepare the tear site for healing through abrasion with a rasp and shaver. • Mark the Amnion streamer (Arthrex) at the midpoint for visual confirmation that it has been loaded halfway through the delivery device. • Use dry gloves when handling the Amnion streamer until loaded into the delivery device to its midpoint. • Keep pressure on the thumb slide plunger when retracting the delivery device from the recipient site. • Perform marrow venting of the intercondylar notch to further augment biological healing with native bone marrow elements.	• Inadequate medial compartment visualization may lead to iatrogenic cartilage damage with instrumentation. • Failure to load the Amnion streamer halfway through the delivery device can cause it to be captured in the cylinder when retracting the delivery device from the knee. • Once the Amnion streamer is wet, it becomes pliable and tacky and can be difficult to load or handle. • Without applying pressure to the thumb slide plunger, the graft can get caught in the delivery device when retracting from the knee.

MCL, medial collateral ligament.

Inherent to any new therapy is the need for further study and standardization of its application to better appreciate its effects on outcomes and associated complications.

Dehydrated human amnion/chorion membrane allografts, as used in this technique, are composed of cytokines and growth factors with regenerative properties. This is thought to be beneficial in orthopaedic soft tissue procedures by decreasing pain and promoting healing without fibrous tissue formation.[6] Several studies have demonstrated a favorable safety profile, which is attributed to their lack of tumorigenicity and lack of immunologic response stimulation.[7] Recent orthopaedic applications have demonstrated promising results. In a randomized controlled trial of 80 patients undergoing lumbar microdiscectomy, the administration of cryopreserved amniotic membrane resulted in greater functional outcomes and no recurrent herniations at 2-year follow-up.[4] For plantar fasciitis, micronized dehydrated amniotic/chorionic membrane allograft also reduced symptoms compared with controls after 8 weeks of follow-up in a prospective randomized control study with no reported adverse events related to the treatment.[8] For nerve-related surgery, amniotic membrane implantation with carpal tunnel release significantly improved outcomes compared with carpal tunnel release alone in a small, level I randomized controlled trial.[3]

Several studies of amniotic tissue use in various musculoskeletal applications have demonstrated favorable results warranting further investigation. A small case series of patients undergoing a second revision ulnar neurolysis with amniotic nerve wrapping experienced significant improvements in patient-reported outcomes.[3] In a study of 42 patients with moderate to severe knee osteoarthritis, the injection of amniotic membrane/umbilical cord particulate resulted in 74% of patients noting significant clinical improvement for an average of 12 months, with only 1 patient experiencing an adverse event of knee swelling.[9] A systematic review for placenta-derived products further demonstrated efficacy for safely treating knee osteoarthritis across a variety of administration methods.[5] Injection of amniotic membrane and umbilical cord into 10 cases of partial rotator cuff tears refractory to conservative treatment resulted in improvements in pain, satisfaction, and function with no adverse events.[10] Of note, each of these studies used a different cell type and/or route of administration of the amniotic-derived biologic tissue. Ultimately, while the use of amniotic membrane in orthopaedics is growing with some promising early results, we are currently unable to draw definitive conclusions on its efficacy given the heterogeneity of the supporting evidence.

While amniotic membrane is commercially available, it may not qualify for coverage of payment by insurance and is currently off-label for use in meniscal repair augmentation by the US Food and Drug Administration. While prior orthopaedic use demonstrates safety, further clinical trials are needed to demonstrate the efficacy and complication profile and affirm the proposed theoretical benefits. Our described technique with amniotic tissue implantation may not be comparable to placental or amniotic injections, and these various administration techniques should also be delineated in future studies given the potential for heterogeneity of results with variability of tissue administration.

This Technical Note presents a technique for implantation of amniotic membrane tissue to augment revision meniscal repair. This technique can be performed in conjunction with standard arthroscopic meniscal repair methods and delivers the graft directly to the repair site, where its proposed impact is desired. Further studies are needed to determine the efficacy of this biologic therapy for meniscal repair, determine its

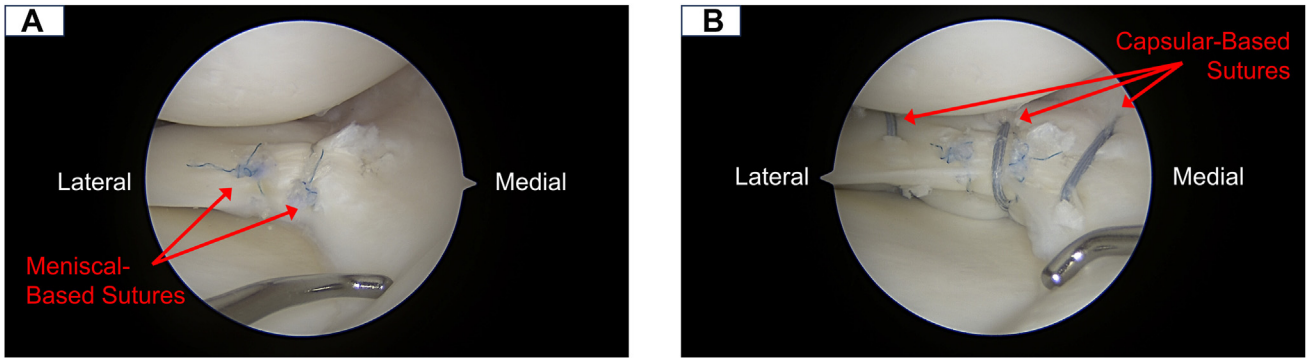

Fig 3. A posterior horn/body medial meniscal repair is viewed with a 30° arthroscope from the anterolateral portal in a right knee. (A) Meniscal-based suturing with a Novostitch all-inside meniscal repair system (Smith & Nephew) achieves vertical compressive forces across the tear site while capturing the implanted graft. (B) Capsular-based suturing with a FiberStitch knotless all-inside implant system (Arthrex) achieves horizontal compressive forces.

complication profile, and more clearly define appropriate indications.

Disclosures

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: J.M.T. is a board member of the Arthroscopy Association of North America, Orthopedics Today, and *Journal of Shoulder and Elbow Surgery*; is a consultant or advisor for Johnson & Johnson and Arthrex; receives speaking and lecture fees from Arthrex; and receives funding grants and nonfinancial support from the *Journal of Shoulder and Elbow Surgery*. C.J.T. is a board member of the Society of Military Orthopaedic Surgeons and is Podcast Editor for *Arthroscopy Journal.* All other authors (S.M.F., M.W.F., C.F.M., D.F.C.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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