



The Fertilized Anterior Cruciate Ligament: An All-Inside Anterior Cruciate Ligament Reconstruction Augmented With Amnion, Bone Marrow Concentrate, and a Suture Tape

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Abstract: There is increasing research and interest surrounding biologics and sports medicine. Amnion has the potential to decrease adhesions and possibly protect anterior cruciate ligament (ACL) grafts along with increasing vascularization by acting as a scaffold. Bone marrow concentrate containing mesenchymal stem cells combined with Allosync Pure (Arthrex, Naples, FL) injected into ACL tunnels has the potential to increase the speed and quality of graft bone incorporation, especially when used in the setting of a soft-tissue allograft. Using suture tape augmentation (InternalBrace; Arthrex) with the reconstruction has been thought to increase the early strength of the reconstruction. In this article, we combine all 3 techniques into an all-inside ACL reconstruction that has great potential for an earlier return to play and advanced rehabilitation.

Among young athletes, anterior cruciate ligament (ACL) rupture is one of the most common ligamentous knee injuries, particularly in those sports requiring cutting and jumping movements.¹⁻⁵ It is estimated that over 100,000 athletes will require reconstructive surgery to avoid chronic instability and chondral injury.¹⁻⁵ Graft rerupture is a major complication affecting many of these athletes, with estimated rates of 6% to 11%.⁶ Despite changes in surgical technique and graft choice, these rates have not changed significantly over time.⁷ The current hope is that, by developing techniques that hasten biological incorporation, we can improve these rates and functional outcomes.

A recent study reported that when used with osteochondral allografts, bone marrow concentrate showed

superior radiographic outcomes in the knee.⁸ By combining this concentrate with Allosync Pure (Arthrex, Naples, FL) and grafting both the femoral and tibial tunnels, the goal is to improve graft incorporation. With advances in tissue engineering, biological augmentation of the graft itself may further improve graft incorporation.^{9,10} Although amniotic membrane-derived products have yet to be studied in ligament reconstruction of the knee, they have been shown to be effective in the realms of plastic surgery and ophthalmology, providing a theoretical basis for use.¹¹ By combining these 2 techniques with the use of a suture tape (Arthrex), the belief is that we can improve failure rates and functional outcomes of these patients.¹² There are early advantages to an all-inside ACL reconstruction such as decreased pain, and when this is combined with biologics, we may be able to accelerate rehabilitation and return to play more than previously anticipated. This article describes the fertilized ACL, a complete biological ACL reconstruction designed to enhance graft bone integration, in addition to faster and improved vascularization of the graft.

Technique

Figures 1-10 and Video 1 show the surgical technique.

Amnion and Graft Preparation

A standard graft-link allograft is prepared, and the femur-sided suspensory fixation loop is lengthened to

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Fig 1. Standard graft-link allograft while wrapping amnion circumferentially around graft.

allow space for injection of the composite graft into the femoral tunnel later in the case. With the epithelial side facing up, the 3×6 -mm amnion is wrapped around the central portion of the graft (Fig 1). By use of No. 4-0 Vicryl (Ethicon, Somerville, NJ), a standard loop stitch is placed 1 mm from each end of the amnion and tied. These stitches will help seal the amnion. With the use of the same No. 4-0 Vicryl suture, a baseball stitch is then placed in the seam created where the amnion edge is to complete the seal (Fig 2).

Patient Setup

The patient is placed supine in a standard knee arthroscopy position. The operative extremity is placed into a leg holder with a tourniquet applied to the thigh, and the nonoperative extremity is placed in a well-leg pillow.

Bone Marrow Aspiration

Before inflation of the tourniquet, a small stab incision is made just lateral to the tibial tubercle. The aspiration needle and central sharp trocar are inserted while angled proximally at 10° . A mark is made on the needle at 30 mm to avoid overinsertion. The central trocar is removed, and the first few milliliters of aspirate



Fig 2. Graft on preparation station. A No. 4-0 Vicryl suture is used to create a baseball stitch in a running fashion, which is then tied to compress the amnion.

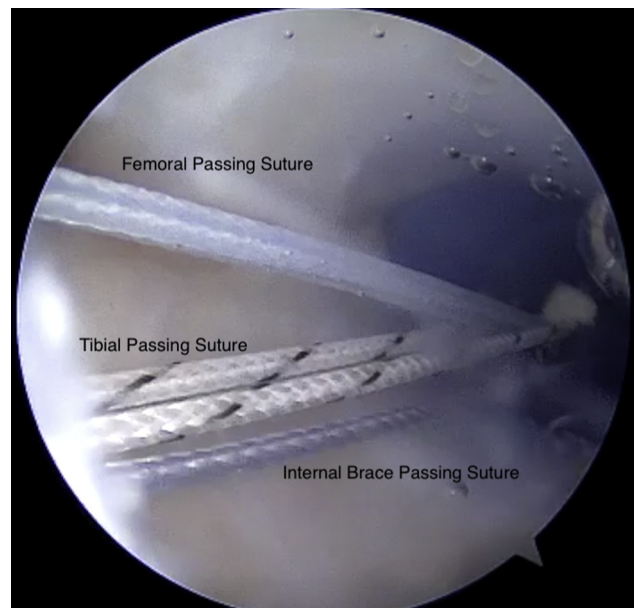


Fig 3. Viewing from the anterolateral portal with the 30° arthroscope, the medial portal is shown with a PassPort cannula inserted and all 3 passing sutures retrieved.

is discarded because of the excess amount of bone. Then, 60 mL of bone marrow is aspirated into heparinized syringes.

Mixing Bone Marrow Aspirate With Allosync Pure

After aspiration of the bone marrow, the aspirate is concentrated using the Arthrex Angel device and a total of 3 mL of the bone marrow is mixed by hand with 5 mL of the Allosync Pure. This mixture is then placed into an arthroscopic cannula delivery device. The remaining 3 mL of bone marrow concentrate is saved for later injection intra-articularly into the amnion after the graft is fixed.

ACL Technique

The tourniquet is inflated, and a standard diagnostic arthroscopy shows the ACL rupture. The allograft graft

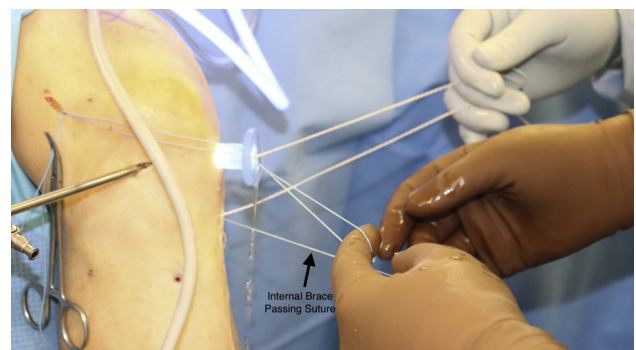


Fig 4. Viewing outside the knee, the tibial passing sutures, InternalBrace passing sutures, and femoral passing sutures can all be seen docked.



Fig 5. Viewing from the anterolateral portal with the 30° arthroscope, the InternalBrace is being passed from the medial portal and through the tibia.

link sized 74×9.5 mm has been prepared on the back table as mentioned earlier with an adjustable button system on the tibial side and suspensory fixation BTB TightRope (Arthrex) on the femoral side. The InternalBrace (Arthrex) is added to the TightRope button opposite the blue passing suture. The ACL remnants in the intercondylar notch are debrided, and a FlipCutter (Arthrex) is used to create a femoral socket through which a FiberStick (Arthrex) is placed and the suture is docked out of the lateral portal. A 12×4 mm PassPort

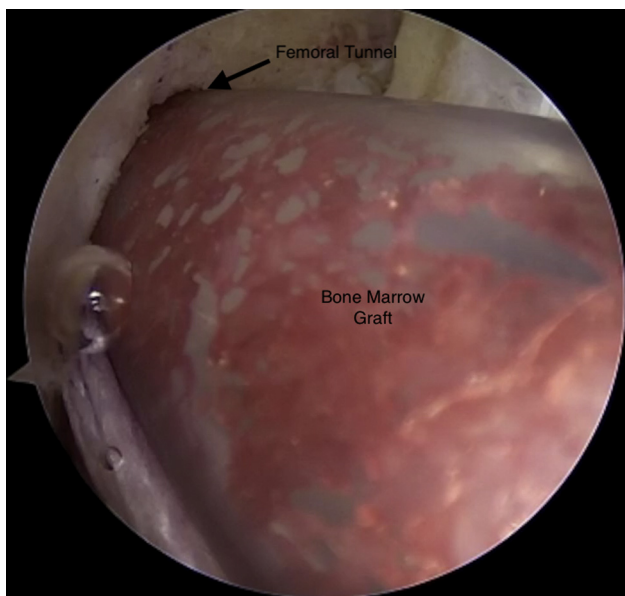


Fig 6. Viewing from the anterolateral portal with the 30° arthroscope, the composite graft is injected into the femoral tunnel using the arthroscopic delivery cannula.

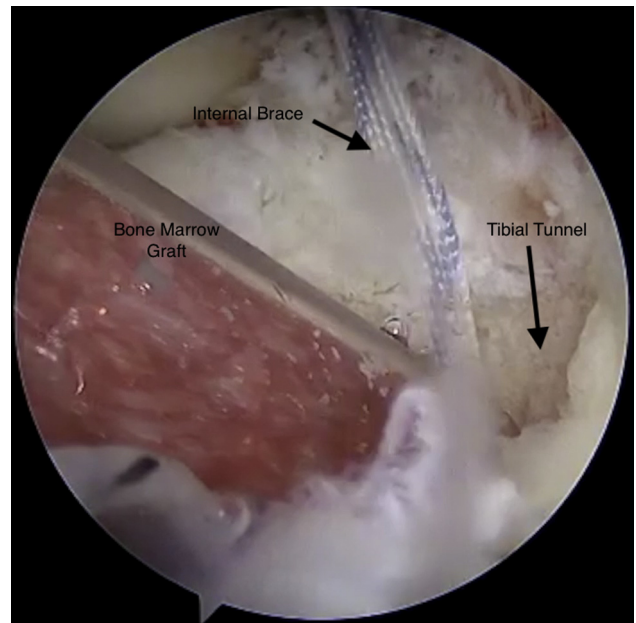


Fig 7. Viewing from the anteromedial portal with the 30° arthroscope, the composite graft is injected into the tibial tunnel using the arthroscopic delivery cannula.

cannula (Arthrex) is then placed in the medial portal. A FlipCutter is used to create the tibial socket. A Tiger-Stick (Arthrex) and passing suture for the InternalBrace are passed through the tibia.

Suture Management and Passage

All 3 passing sutures are brought through the PassPort cannula medially (Fig 3). These are docked and clamped to prevent suture bridges (Fig 4). First, the femoral sutures are loaded into the femoral FiberStick, and the TightRope button is deployed on the lateral cortex of

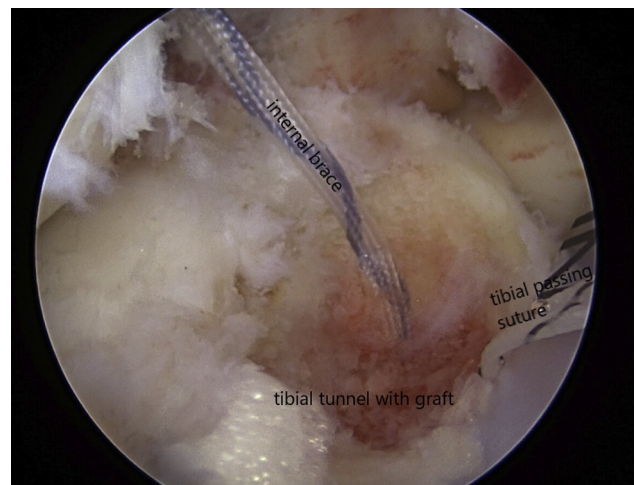


Fig 8. Viewing from the anterolateral portal with the 30° arthroscope, the composite graft can be seen filling the tibial tunnel.

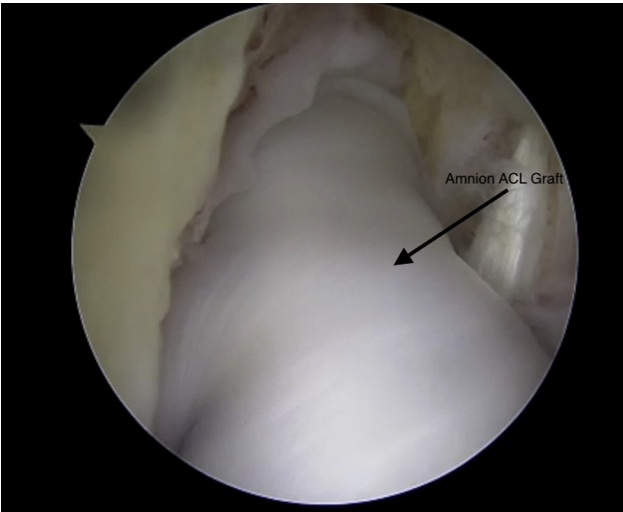


Fig 9. Viewing from the anterolateral portal with the 30° arthroscope, the amnion anterior cruciate ligament (ACL) can be seen within the joint.

the femur. Next, the InternalBrace suture is passed through the tibia using the InternalBrace passing suture (Fig 5).

Composite Graft Injection

By use of the arthroscopic cannula loaded with the bone marrow concentrate composite graft, we inject the graft into the femoral tunnel (Fig 6). This is performed through the medial PassPort cannula. The delivery device is then moved to the lateral portal, and the knee is hyperflexed to inject the composite graft into the tibial tunnel (Fig 7). The tibial graft is seen completely filling the tibial tunnel (Fig 8).

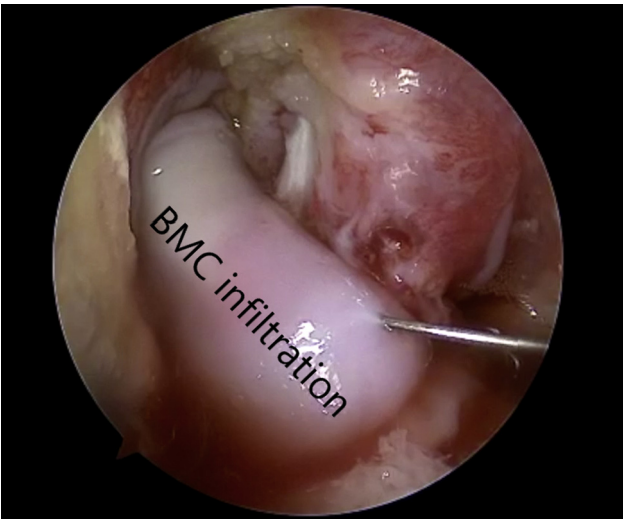


Fig 10. Viewing from the anterolateral portal with the 30° arthroscope, the bone marrow concentrate (BMC) is seen being injected into the amnion anterior cruciate ligament.

ACL Graft Passage

With the white suture out of the femoral tunnel, 10 mm of femoral graft is pulled into the femur. The TigerStick sutures are then used to pass the tibia-sided sutures through the tibia. After the tibia side of the graft is docked into the tunnel, the remaining femur-sided graft is pulled into the femur until the amnion is centered in the joint. Standard button fixation on the tibia is used at 30° of flexion of the knee (Fig 9). The InternalBrace is then placed into a 4.75 mm SwiveLock (Arthrex) and fixed into the anterior medial tibia at full extension of the knee.

Bone Marrow Concentrate Injection

After fixation of the ACL graft, a 25-gauge needle is used to inject the remaining bone marrow concentrate into the amnion. The amnion should swell and become pink. Some small amounts of leakage from the amnion will occur (Fig 10).

Discussion

Incorporation of the graft at the tendon-to-bone interface is paramount to the success of ACL reconstructive surgery. Tunnel osteolysis has been a consistent problem regardless of graft type and remains a problem despite changing surgical techniques.^{13,14} We recently published the Lavender technique of tunnel grafting with bone marrow concentrate and Allosync Pure,¹⁵ and the current technique combines that technique with the use of amnion. With this multifactorial approach, we are optimistic that we can improve not only tunnel widening but also overall graft incorporation as well as vascularization and, by extension, clinical outcomes. To our knowledge, no clinical studies exist evaluating tunnel grafting in primary ACL reconstruction; however, using biologics as described here, we hope to show revolutionary clinical and radiographic outcomes.⁸ Likewise, amniotic membrane-derived grafts have not been previously used for this

Table 1. Advantages and Disadvantages of Amnion Graft Augmentation, Bone Marrow Concentrate Injection, and Suture Tape Augmentation in ACL Reconstruction

Advantages	
Amnion may lead to faster synovialization and vascularization of the graft.	
Bone marrow harvesting can be performed in the same surgical field.	
Stem cells and bone grafting may lead to faster and more robust incorporation in both tunnels.	
Suture tape augmentation may lead to improved early outcomes and an earlier return to play.	
Disadvantages	
Increased cost	
Increased graft preparation time and operating time	
Added incision for bone marrow harvest	
Theoretically increased risk of fracture at aspiration site of tibia	

ACL, anterior cruciate ligament.

application. The use as a biological scaffold, however, has been occurring for quite some time in the field of wound care and plastic surgery, in which it was applied for complex soft-tissue regeneration.¹¹ We recognize that the cost of the biologics may inhibit widespread use, but for patients at risk of rerupture and for higher-level athletes, this may become a great option to improve outcomes. There are several disadvantages and limitations to the procedure, which include extra time spent in the operating room and increased technical aspects of the procedure (Table 1). The risks of this procedure include those associated with allograft use, including infection, disease transmission, and host rejection. The possibility of host rejection or reaction against the amnion is a concern. We believe this needs to be prospectively studied further to examine these complications. Despite those disadvantages when combined with an allograft reconstruction and using the all-inside technique, the fertilized ACL may be the correct balance to advance rehabilitation and return to play. Together, these modalities provide an approach to improve graft incorporation in ACL reconstruction with the goal of improving clinical outcomes and decreasing graft rerupture rates.

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