

Augmentation of Anterior Cruciate Ligament Reconstruction With Bone Marrow Concentrate and a Suture Tape



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Abstract: The use of biological agents in sports medicine is increasing rapidly. The use of bone marrow concentrate has recently increased in popularity owing to the presence of mesenchymal stem cells. These stem cells combined with Allosync Pure (Arthrex, Naples, FL) could lead to better incorporation and healing. The mixture of bone marrow concentrate and Allosync Pure can be used in anterior cruciate ligament reconstruction, and we have developed a technique to use it in the femoral tunnel and deliver the medium arthroscopically. In this article we present a technique for using suture tape augmentation (InternalBrace; Arthrex) through the interference screw during a bone–patellar tendon–bone anterior cruciate ligament reconstruction.

Graft rerupture is one of the major complications and causes of reoperation after anterior cruciate ligament (ACL) reconstruction. This is more common in younger athletes. On the basis of the recent literature, the rate of graft rerupture is about 6% to 11%.¹ Even with newer techniques and different types of grafts, the rerupture rates and return-to-play period have not been improved significantly. Athletes younger than 25 years have been found to have a 23% risk of secondary ACL injury on either the contralateral or ipsilateral side after an ACL reconstruction.² Therefore, there is a direct need to improve the outcomes of ACL reconstruction especially in younger athletes. This could be accomplished with earlier biological incorporation of the graft and further protection of the graft during the early postoperative period. Bone–patellar tendon–bone (BPTB) autograft reconstruction is widely considered the gold standard for younger athletes receiving surgery. Recently, autogenous bone

marrow aspirate was shown to have superior radiographic incorporation when used for osteochondral allograft transplantation in the knee.³ Bone marrow aspirate was also shown to have similar mesenchymal stem cell concentrations when harvested from the proximal tibia compared with when harvested from the iliac crest, providing a useful and safe alternative during knee surgery.⁴ This bone marrow concentrate can be combined with demineralized bone matrix as a medium for incorporation into a femoral tunnel during ACL reconstruction. In addition, suture tape augmentation (Arthrex, Naples, FL) was recently used for ACL allograft reconstruction and found to be safe and effective.⁵ This article describes our technique for augmentation of BPTB autograft ACL reconstruction with bone marrow concentrate mixed with Allosync Pure (Arthrex), as well as the addition of suture tape augmentation (Arthrex) for early strength.

Surgical Technique

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

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 on a well-leg pillow.

Bone Marrow Aspiration

Before inflation of the tourniquet, a small stab incision is made just lateral to the tibial tubercle. An

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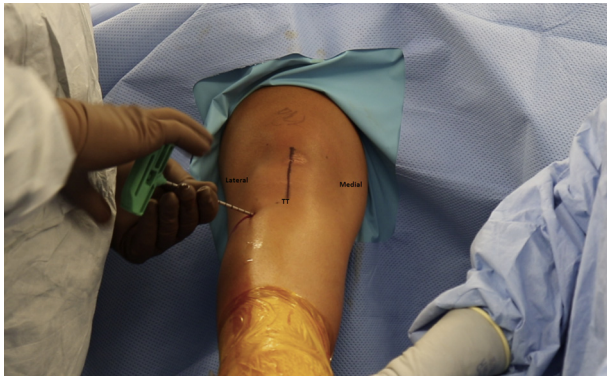


Fig 1. The patient's right knee is placed supine, and the aspiration needle with the trocar is inserted slightly lateral to the tibial tubercle angled 10° proximally. Insertion past a depth of 30 mm should not occur.

aspiration needle and central sharp trocar are inserted while angled 10° proximally (Fig 1). 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 is discarded because of the excess amount of bone. Then, 60 mL of bone marrow is aspirated into heparinized syringes (Fig 2).

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 bone marrow is mixed by hand with 5 mL of Allosync Pure. This mixture is then placed into an arthroscopic cannula delivery device.

ACL Technique

The tourniquet is inflated, and a standard diagnostic arthroscopy reveals the ACL rupture. A standard BPTB graft harvest is performed to achieve a graft length of 89 mm with 20-mm bone blocks. Two No. 2 FiberWire sutures (Arthrex) are placed tangentially to each other in the tibial bone block, while the BTB TightRope button system (Arthrex) is placed into the femoral-sided



Fig 2. While the patient is still supine, after insertion of the aspiration needle, the central trocar is removed. Then, 60 mL of bone marrow is aspirated into heparinized syringes.

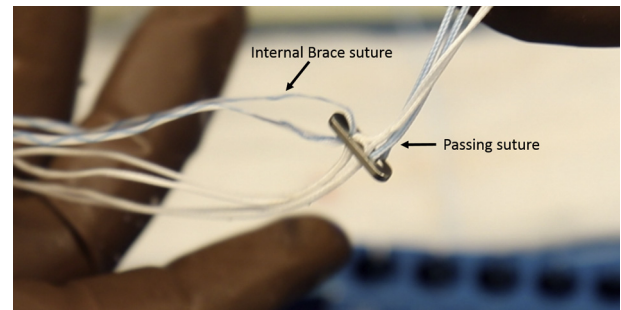


Fig 3. The TightRope system has been loosened to allow more length between the graft and button. The InternalBrace is threaded through the hole in the TightRope button opposite the blue passing sutures. It may be helpful to use a passing wire or needle.

bone block. The TightRope system should be loosened to add more length so that the surgeon can later flip the button on the femur and still have space available to inject the bone marrow graft into the femur before bringing the graft into the joint. At this point, after loosening the system, we place the suture tape augmentation (InternalBrace; Arthrex) through the button opposite the passing suture in the TightRope (Fig 3). The remnants of the ACL are debrided, and the FlipCutter (Arthrex) is used to make a femoral socket length of 30 mm in the standard location. After the femoral socket is made, a No. 2 FiberStick (Arthrex) is passed into the joint and docked outside the lateral portal until the tibial tunnel is completed. The tibial tunnel is also created with the FlipCutter, and it may be helpful to open the anterior surface of the tibia with an opening reamer. The passing suture is brought out of the tibial tunnel. By use of the passing suture, the

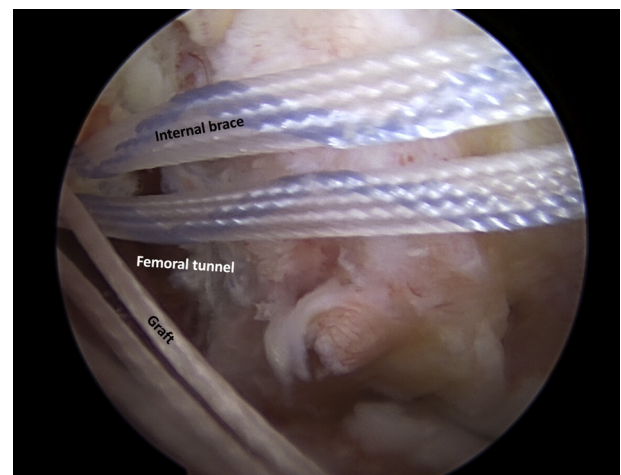


Fig 4. Viewing with the 30° arthroscope from the antero-lateral portal, the InternalBrace has been retrieved from the medial portal before the graft is passed into the joint and before the bone marrow graft is injected into the tunnel.

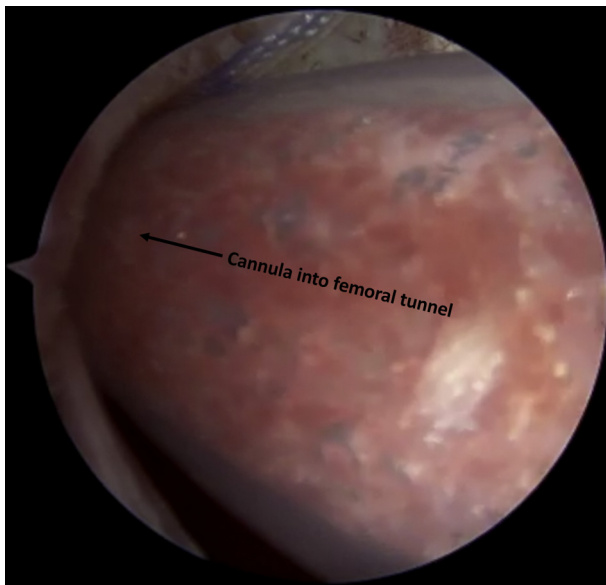


Fig 5. The patient's right knee is flexed to 90° and may need to be hyperflexed. Viewing from the anterolateral portal, the arthroscopic cannula is used to injection bone marrow graft into the femoral tunnel.

femoral TightRope portion is brought into the joint and then flipped on the lateral cortex of the femur.

Bone Marrow Graft Passage

Before the ACL graft is brought into the joint, the InternalBrace is retrieved and docked outside the medial portal (Fig 4). The arthroscopic cannula is placed through the medial portal, and the knee is hyperflexed. The graft is injected into the femoral tunnel to fill

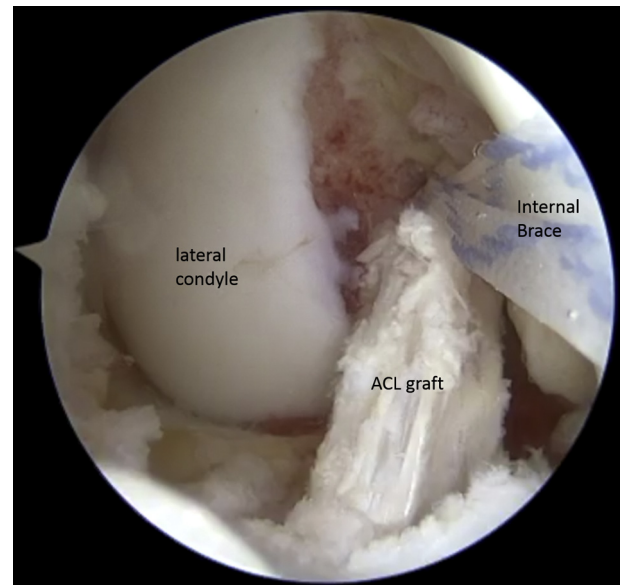


Fig 7. Viewing the right knee in 90° of flexion with the 30° arthroscope from the anteromedial portal, the anterior cruciate ligament (ACL) graft has been pulled from the tibial tunnel and tensioned into the femoral tunnel in standard fashion. It should be noted that no bone marrow graft was displaced into the knee joint.

approximately half of the tunnel (Video 1, Figs 5 and 6). The ACL graft is pulled into the femoral tunnel using alternating pulls on the white sutures coming out of the TightRope device (Fig 7). The ACL graft is then fixed at 30° of extension in standard fashion on the tibia with a 9 × 23-mm BioComposite interference screw (Arthrex). The screw should be as anterior as possible to help locate the wire within the joint.

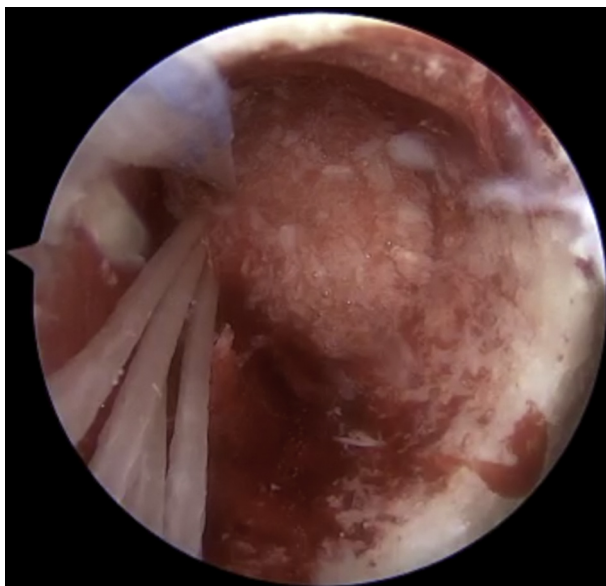


Fig 6. Viewing the right knee with the 30° arthroscope from the anteromedial portal, looking into the femoral tunnel, half of the tunnel has been filled with the bone marrow graft.



Fig 8. Viewing the right knee with the 30° arthroscope from the anteromedial portal, the passing wire is located within the joint and retrieved through the medial portal with the InternalBrace, which had been docked in that portal.

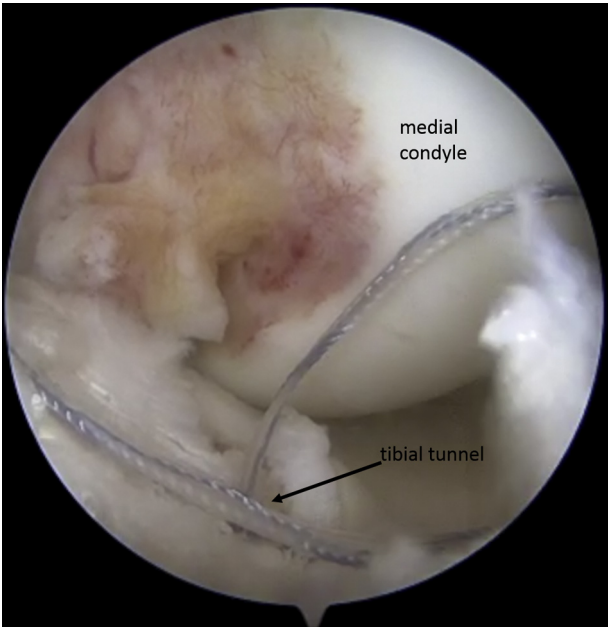


Fig 9. Viewing the right knee in 90° of flexion with the 30° arthroscope from the anterolateral portal, the InternalBrace is passed using the passing wire through the tibial interference screw.

InternalBrace Passage and Fixation

After placing the interference screw, the surgeon leaves the driver in the screw and passes a wire with a loop through the cannulation. This wire is then located within the joint (Fig 8). The wire is retrieved through the medial portal along with the InternalBrace, and the InternalBrace is threaded through the loop in the wire. The wire is then pulled through the tibial screw, and the InternalBrace follows the wire (Fig 9). The InternalBrace and tibial bone block sutures are threaded through a 4.75-mm SwiveLock anchor (Arthrex), and



Fig 10. With the right knee supine and the knee in 30° of flexion, the InternalBrace is placed through a SwiveLock anchor and the anchor is fixed in standard fashion on the anteromedial surface of the tibia.

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

Advantages
Bone marrow harvesting can be performed at a site that has already been prepared and draped.
Stem cells and bone grafting may lead to stronger and more substantial graft incorporation in the femoral tunnel.
Remaining bone graft can be used to fill the defects in the patella and tibia from graft harvest, which may decrease anterior knee pain.
Suture tape augmentation could lead to improved early outcomes and possibly an earlier return to play for athletes.
Disadvantages
Increased cost
Increased operating room time
Added incision from bone marrow harvest site
Increased risk of fracture due to addition of aspiration site to tibia

ACL, anterior cruciate ligament.

the SwiveLock is fixed on the anterior surface of the tibia in standard fashion at 0° of extension (Fig 10). Table 1 lists advantages and disadvantages of our technique, and Table 2 presents technical pearls.

Indications

The indications for biological and suture tape augmentation of an ACL reconstruction include patients at increased risk of rerupture. This patient population comprises young active athletes playing competitive sports, as well as patients undergoing revision ACL reconstruction. We also think this technique is indicated in patients attempting to return to play more quickly than 7 to 9 months after surgery.

Contraindications

Our technique is contraindicated in patients with open physes, as well as patients with severe tunnel enlargement from previous surgery in need of bone grafting.

Rehabilitation

We use our standard ACL rehabilitation protocol. The patient is placed in a hinged knee brace locked in full extension until full quadriceps control is achieved. The patient is allowed full weight bearing in the brace immediately after surgery. In our protocol, early passive

Table 2. Technical Pearls of Bone Marrow Concentrate and Suture Tape Augmentation in ACL Reconstruction

Aspirate the bone marrow before the tourniquet is inflated.
If the syringe stops filling during bone marrow aspiration, rotate the aspiration needle.
Place the interference screw anterior to help with locating the passing wire.
Use a cannula to prevent a suture bridge when passing the InternalBrace.
Use suture tape (InternalBrace) rather than FiberTape (Arthrex).

ACL, anterior cruciate ligament.

range of motion with formal physical therapy is started within the first week. The patient is then progressed through strengthening with standard ACL rehabilitation techniques.

Discussion

BPTB autograft ACL reconstruction is widely accepted as the gold standard in treating young athletes with ACL ruptures. Reruptures and return to play are still concerning issues facing younger high-risk patients. Currently, there are very few techniques involving biological augmentation of the ACL reconstruction. The advantages of the described technique include the location of harvesting through a site that has already been prepared and draped. This adds very little surgical time to the operation, and the graft can be injected arthroscopically. The stem cells and bone grafting should lead to stronger and more substantial graft incorporation in the femoral tunnel. The remaining graft can also be used to fill the defects in the patella and tibia from graft harvest and may lead to less pain. If we consider a socket to be a pot and the ACL graft to be a plant, then the addition of mesenchymal stem cells as we have described should be termed a “fertilized” ACL. There are some added risks with this procedure primarily from the addition of the bone marrow aspiration site. This additional harvest site could be a source of postoperative pain. Theoretically, there is an added risk of fracture because of the addition of the aspiration site to the tibia, although we believe this is a limited risk. One limitation of this technique is the cost it adds to the operation; however, we believe the benefits are worth

the cost in young patients at high risk of rerupture and in revision cases. Another limitation is the increased difficulty the technique adds to the standard ACL reconstruction. Although our technique has risks and limitations, we believe this will improve patient outcomes especially in those at risk of complications. When the biological advantages of the bone marrow graft are combined with the strength of the suture tape augmentation, we believe this could lead to improved early outcomes and possibly an earlier return to play for these athletes. In these high-risk populations, this is now our procedure of choice for ACL reconstruction.

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