

The Lavender Fertilized Anterior Cruciate Ligament Reconstruction: A Quadriceps Tendon All-Inside Reconstruction Fertilized With Bone Marrow Concentrate, Demineralized Bone Matrix, and Autograft Bone



Chad Lavender, M.D., Brock Johnson, M.D., Vishavpreet Singh, M.D., Eric Dennis, M.D., and LeeAnne Torres, M.D.

Abstract: The use of biologics in sports medicine is increasing rapidly. Bone marrow concentrate has recently increased in popularity because it includes mesenchymal stem cells which, combined with AlloSync Pure, could lead to better incorporation and healing. The mixture of bone marrow concentrate and Allosync Pure can be used in anterior cruciate ligament reconstruction. We recently expanded on this approach with the addition of saving the host bone normally lost from tunnel reaming, using the GraftNet. After harvesting the autograft bone, we combine it with the AlloSync Pure and bone marrow concentrate. In this Technical Note, we show how this unique biologic composite is obtained and then added back into the tunnels on both the femur and tibia during a quadriceps tendon autograft all-inside anterior cruciate ligament reconstruction.

Recent literature suggests that graft rerupture rates after anterior cruciate ligament (ACL) reconstruction are as high as 6% to 11%.¹ Furthermore, athletes <25 years old have been found to have rates of secondary ACL injury of 23% when considering both the operative and contralateral sides.² Despite newer techniques and progress in graft choices, significant reductions in rerupture rates and return-to-play time have been elusive.

Bone marrow concentrate has shown promise in the treatment of many orthopaedic conditions, including osteochondral injuries, avascular necrosis, and tendon injuries.³ To encourage early biologic graft incorporation and prevent early graft rerupture, a technique was

recently created for augmentation of bone-patella tendon-bone ACL reconstruction with bone marrow concentrate and suture tape.⁴ This technique can also be used to enhance an all-inside ACL reconstruction that allows grafting of both the femoral and tibial tunnels with bone marrow concentrate and demineralized bone matrix. Furthermore, we have devised a way to



Fig 1. The right knee is flexed and the patient is supine. The shaver with the GraftNet (Arthrex) applied to the suction has been placed into the lateral portal, while the FlipCutter (Arthrex) can be seen creating the femoral tunnel. The 30° arthroscope has been placed into the medial portal.

From Marshall University, Charleston, WV, U.S.A.

The authors report the following potential conflicts of interest or sources of funding: C.L. reports personal fees and consultant for Arthrex. Full ICMJE author disclosure forms are available for this article online, as [supplementary material](#).

Received March 5, 2019; accepted May 11, 2019.

Address correspondence to Chad Lavender, M.D., 423 Woodbridge Drive, Charleston, WV 25311, U.S.A. E-mail: doclav@gmail.com

© 2019 by the Arthroscopy Association of North America. Published by Elsevier. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

2212-6287/19299

<https://doi.org/10.1016/j.eats.2019.05.013>

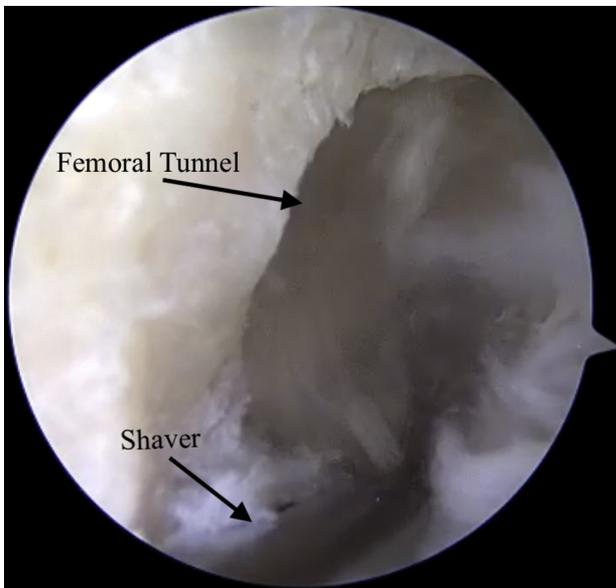


Fig 2. A view from the 30° arthroscope placed in the medial portal shows the femoral tunnel being reamed. The shaver with the GraftNet (Arthrex) applied has been placed inferior to the femoral tunnel and obtains autograft bone.

recover the reamings of the femoral and tibial tunnels for use as autograft using the GraftNet Autologous Tissue Collector (Arthrex, Naples, FL). The advantages of this are two-fold: first, autograft bone has been shown to be the gold standard for use in orthopaedic procedures owing to its osteogenic, osteoinductive, and osteoconductive properties; second, the addition of autograft allows for a smaller volume of demineralized bone matrix to be used, thus decreasing the overall cost of the procedure. This Technical Note presents our technique for all-inside quadriceps tendon autograft ACL reconstruction augmented with bone marrow concentrate, local autograft bone, and suture tape.

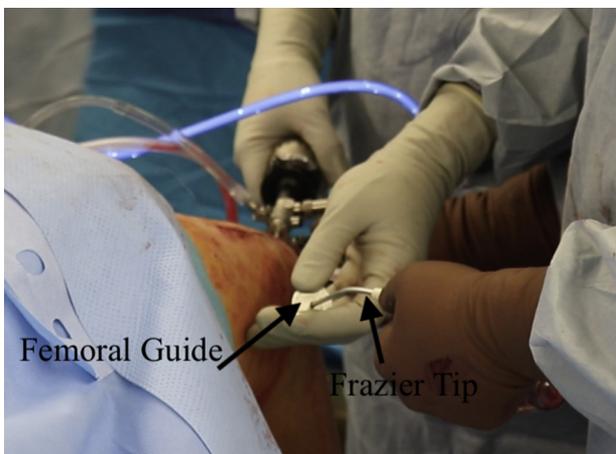


Fig 3. The right knee is flexed and the patient is supine. A view from outside the joint shows a Frazier suction tip placed through the femoral guide; the arthroscope is placed in the medial portal.

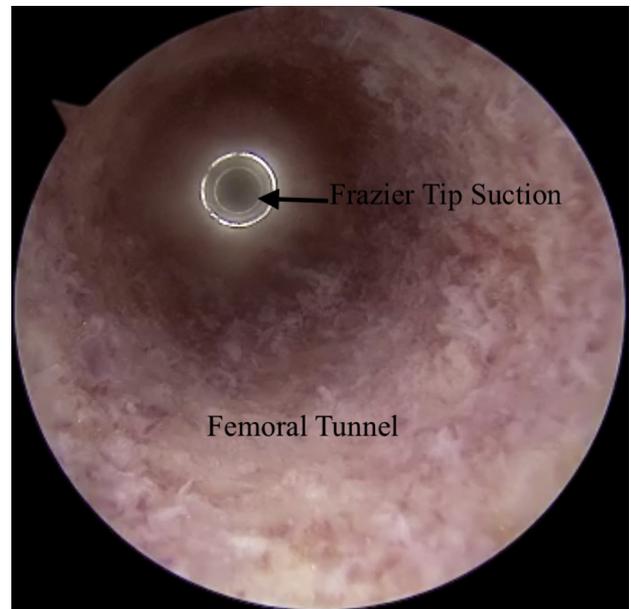


Fig 4. A view from the medial portal with the 30° arthroscope into the femoral tunnel shows the Frazier suction tip within the guide; all reamed bone has been removed from the tunnel.

Surgical Technique

Figures 1-13 and the Video show the surgical techniques.

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-padded leg pillow.

Bone Marrow Aspiration

Before inflating the tourniquet, a small stab incision is made just lateral to the tibial tubercle. A Jamshidi

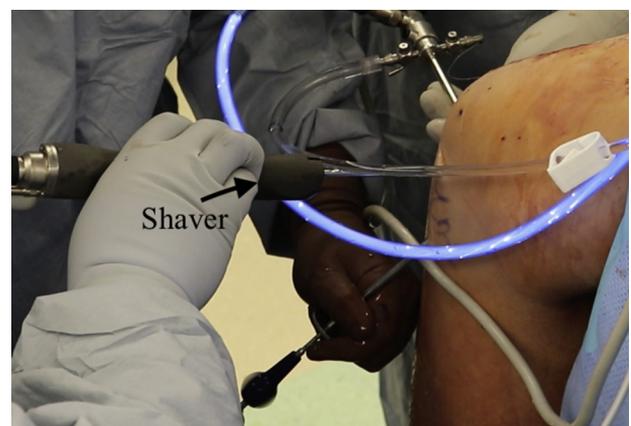


Fig 5. The right knee is flexed and the patient is supine. A view from outside of the joint shows the tibia reamed with the FlipCutter; the shaver with GraftNet (Arthrex) has been placed through the medial portal while viewing from the lateral portal with the 30° arthroscope.



Fig 6. The GraftNet (Arthrex) can be seen with bone graft within the cartridge.

needle (Arthrex) and central sharp trocar are inserted proximally at an $\sim 10^\circ$ angle. A mark is made on the needle at 30 mm to avoid overinsertion. Then 60 cc of bone marrow are aspirated into heparinized syringes. This aspiration is then concentrated using the Arthrex Angel System to 5 cc of bone marrow concentrate.

ACL Technique

The tourniquet is inflated, and a standard diagnostic arthroscopy reveals the ACL rupture. A standard quadriceps tendon graft harvest is performed to achieve a graft length of 66 mm, all soft tissue. FiberTag (Arthrex) is then used to prepare the quadriceps into an all-inside construct. The femoral side has a TightRope RT (Arthrex), while the tibial side has an attachable button system (Arthrex) added. The TightRope system should be loosened to add more length so that the button on the femur can later be flipped and still leave space to inject the bone marrow graft into the femur before bringing the graft into the joint. At this point, after loosening the system, the suture tape (Internal-Brace; Arthrex) is placed through the button in a reinforcement fashion. The remnants of the ACL are debrided, and the FlipCutter (Arthrex) is used to make a 30-mm femoral socket in the standard location.

Femoral Socket Preparation and Autograft Collection

An aggressive shaver with the GraftNet applied is placed through the lateral portal just under the FlipCutter (Fig 1). The shaver is turned on, and the



Fig 7. The inner sleeve can be seen after being removed from the GraftNet (Arthrex); it contains the collected autograft bone.

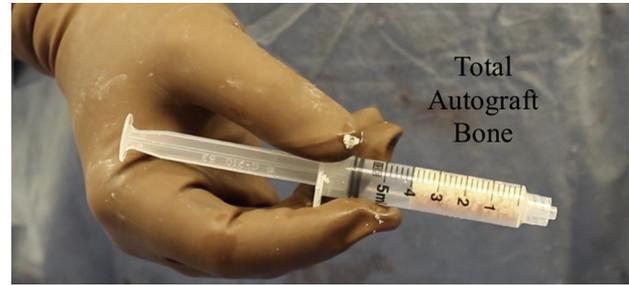


Fig 8. Autograft bone is transferred to a small syringe to give an accurate calculation of the amount, which in this case was 4 cc.

FlipCutter retrograde drills the socket (Fig 2). After the socket is created, the water is turned off and the GraftNet is hooked into a Frazier suction tip (Conmed, Utica, NY) and replaces the FlipCutter (Arthrex) in the guide (Figs 3 and 4). Flow is turned back on. After making the femoral socket, a no. 2 FiberStick (Arthrex) is introduced into the joint and docked outside the lateral portal until the tibial tunnel is completed.

Tibial Tunnel Socket Preparation and Autograft Bone Collection

The tibial tunnel is also created with the FlipCutter, and the shaver with GraftNet applied is placed through the medial portal while drilling (Fig 5). Again, the Frazier suction tip can be used with the GraftNet up through the guide. A second passing FiberStick is passed through the tibia, and both sutures are brought out medially. The TightRope is then passed into the joint in standard fashion and brought out of the femur and flipped on the lateral cortex (Table 1).

Mixing Bone Marrow Aspiration with AlloSync Pure

The aspirated bone marrow is concentrated using the Arthrex Angel device. We collected 4 cc of autograft



Fig 9. The mixture of bone marrow concentrate and AlloSync Pure (Arthrex) with autograft bone being mixed by hand.

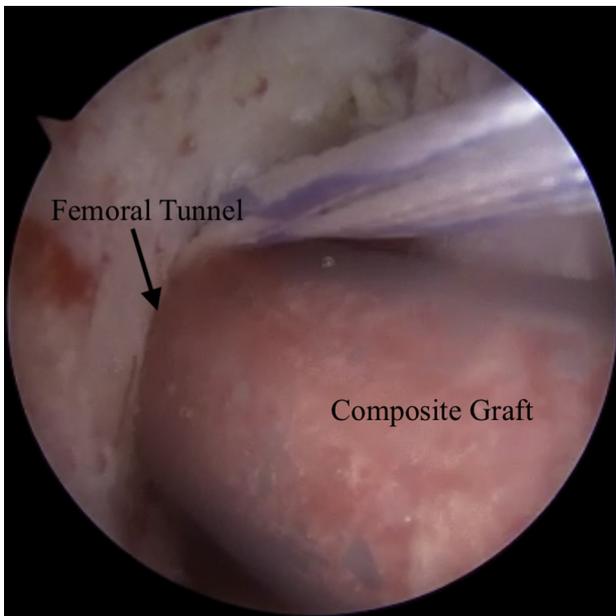


Fig 10. Viewing from the lateral portal with a 30° arthroscope, the delivery cannula is placed through the medial portal and can be seen while the composite graft is injected into the femoral tunnel.

bone, which is mixed with 5 cc of AlloSync Pure (Arthrex) (Figs 6, 7, and 8). This mixture is added to 5 cc of bone marrow concentrate (Fig 9), and the resulting mixture is then placed into an arthroscopic cannula delivery device.

Bone Marrow Graft Passage

The arthroscopic cannula is placed through the medial portal, and the knee is hyperflexed. The graft is injected into the femoral tunnel to fill the entire tunnel



Fig 11. The right knee is flexed and the patient is supine. A view from outside the joint shows the composite graft being injected into the femoral tunnel from the medial portal.

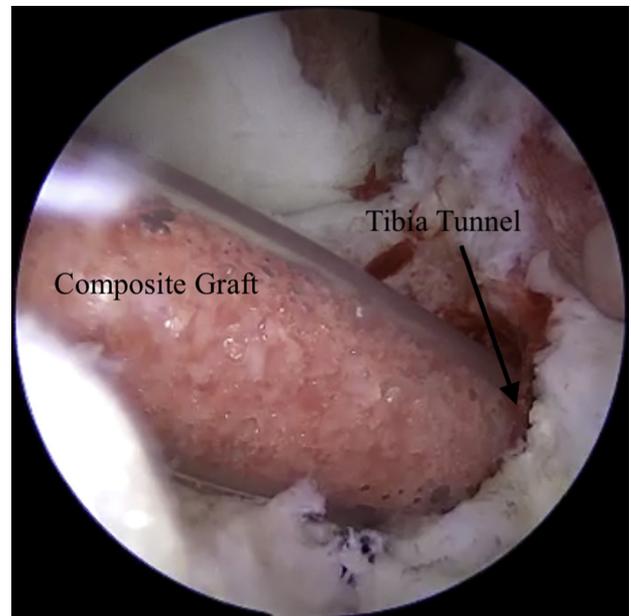


Fig 12. A view from the medial portal with a 30° arthroscope shows the delivery device placed through the lateral portal and the composite graft being injected into the tibial tunnel.

(Video, Figs 10 and 11). The delivery cannula is then placed from the lateral portal and down into the tibia, and the tibia is completely filled with the composite graft (Figs 12 and 13).

Graft Passage

Ten millimeters of the femoral side of the graft is then delivered into the femur, and the tibial tails are dunked along with the internal brace sutures. The graft is tensioned on each side. The attachable button system is then secured on the tibia with a 12-mm button. Once



Fig 13. A view from the lateral portal with a 30° arthroscope shows the tibial tunnel completely filled with the composite graft mixture.

Table 1. Pearls and Pitfalls of Using Tunnel Reamings as Autograft

Pearls
A Frazier suction tip is needed to maximize volume of autograft collected
Detach and reattach GraftNet after femoral reamings
Pitfalls
A low-caliber Frazier tip will lead to clogging
High pressure for suction is unadvised

the graft is fixed, the internal brace is placed into a 4.75-mm SwivelLock (Arthrex), which is placed in standard fashion on the anterior medial tibia at 0° extension.

Discussion

All-inside ACL reconstruction has been shown to be equivalent to the full tibial tunnel technique in functional outcome measures, with the possible advantage of decreased pain based on visual analog scale.⁵ When used with our technique, the all-inside approach allows for bone marrow concentrate grafting of both the femoral and tibial tunnels, which we hypothesize will aid in early biologic graft incorporation, less tunnel widening, and more substantial graft incorporation on both the femoral and tibial sides. The use of local autograft recovered from tunnel reamings provides a convenient and reliable source of bone that bolsters our previously used mixture of bone marrow aspirate and demineralized bone matrix, with virtually no increase in surgical time or added morbidity. The local autograft that we recovered allowed us to use a smaller volume of demineralized bone matrix, helping to mitigate costs while theoretically improving the biologic properties of the graft mixture (Table 2).

We do recognize that there are limitations to our technique. There is a theoretical risk of donor site morbidity at the bone marrow harvest site, but given the small size of the Jamshidi needle and the close proximity to our existing operative field, we believe that this risk is small. There is also added difficulty in this technique compared with standard ACL reconstruction.

Table 2. Advantages and Disadvantages of Using Tunnel Reamings as Autograft

Advantages
Improved biologic properties of graft mixture
Eliminates any risk of disease transmission compared with allograft
Decreased cost because of less demineralized bone matrix required in graft mixture
Disadvantages
Added equipment cost of GraftNet (however, offset by reduced demineralized bone matrix cost)
Added time associated with the learning curve of the procedure

Conclusions

Although bone-patella tendon-bone graft is the current gold standard in ACL reconstruction for the young athlete, we believe that the biologic advantages of bone marrow concentrate combined with local autograft, in addition to the added strength of suture tape, make this technique ideal in this patient population. We are optimistic that our new technique will lead to fewer early complications and earlier return to play in high-risk athletes.

References

1. Crawford SN, Waterman BR, Lubowitz JH. Long-term failure of anterior cruciate ligament reconstruction. *Arthroscopy* 2013;39:1566-1571.
2. Wiggins AJ, Grandhi RK, Schneider DK, Stanfield D, Webster KE, Myer GD. Risk of secondary injury in younger athletes after anterior cruciate ligament reconstruction: A systematic review and meta-analysis. *Am J Sports Med* 2016;44:1861-1876.
3. Imam MA, Mahmoud SSS, Holton J, Abouelmaati D, Elsherbini Y, Snow M. A systematic review of the concept and clinical applications of bone marrow aspirate concentrate in orthopaedics. *SICOT J* 2017;3:17.
4. Lavender C, Johnson B, Kopiec A. Augmentation of anterior cruciate ligament reconstruction with bone marrow concentrate and a suture tape. *Arthroscopy Tech* 2018;7:e1289-e1293.
5. Lubowitz JH, Schwartzberg R, Smith P. Randomized controlled trial comparing all-inside anterior cruciate ligament reconstruction technique with anterior cruciate ligament reconstruction with a full tibial tunnel. *Arthroscopy* 2013;29:1195-1200.