Preparation of Bone Patellar Tendon Bone Allograft With Biocomposite Scaffold Augmentation

Peter Serour, B.S., Lasun O. Oladeji, M.D., Ph.D., Clayton W. Nuelle, M.D., and Steven F. DeFroda, M.D., M.Eng.

Abstract: Anterior cruciate ligament (ACL) injuries and subsequent surgical reconstruction are exceedingly common orthopaedic procedures. Surgical technique and graft preparation techniques continue to evolve as surgeons seek to increase surgical outcomes and decrease recovery time. As such, there is significant interest in identifying tools and techniques that may enhance the surgical process for patients undergoing an ACL reconstruction. Recently, there has been significant interest in evaluating biologic scaffolds that may augment graft healing. This Technical Note describes our technique for the preparation of a bone—patellar tendon—bone ACL graft with a BioBrace biocomposite scaffold augmentation.

Anterior cruciate ligament (ACL) injuries are commonly seen in the young, active patient population. Recent estimates suggest that the incidence of isolated ACL tears in the United States is 68.6 per 100,000.[1] Nearly 90% of patients with ACL injuries opt for surgical treatment.[2] As a result, more than 350,000 ACL reconstructions (ACLRs) are performed every year in the United States at an annual financial cost of nearly 1 billion dollars.[3] Despite the scientific inquiry and significant financial investment in this procedure, results are less than ideal. Between 3% and 14% of patients experience failure after ACLR,[4] and up to 35% of athletes fail to return to their previous level of play within 2 years of their injury.[2,5] As a result, there remains significant interest in identifying surgical advancements and augments that can enhance biologic healing and support improved patient outcomes.

The BioBrace (ConMed) is a reinforced, bioinductive collagen scaffold designed to support soft tissue healing by facilitating tissue ingrowth and remodeling. This implant is composed of a highly porous type I collagen matrix (20 μm average pore size) and bioresorbable poly(L-lactide) (PLLA) microfilaments (15 μm in diameter) that offer a time zero load-sharing strength of 141 N.[6,7] The BioBrace is produced as an off-the-shelf implant available in either ligamentous (5 × 250 mm) or patch form (23 × 30 mm). This product contributes both biologic and mechanical support that may ultimately lead to improved outcomes in the appropriately selected patient cohort. As a result, there has been significant interest in evaluating this scaffold in patients undergoing allograft ligament reconstruction; patients with diminutive, harvested autografts; and those with impaired tissue quality.[8-10]

This article aims to describe a reproducible surgical technique for bone—patella tendon—bone (BTB) ACLR allograft preparation with a reinforced, bioinductive collagen scaffold.

Surgical Technique

Graft Selection

A variety of factors must be considered before selecting an ACLR graft. The first decision point is whether to proceed with an autograft or allograft. Autografts are frequently selected in the young, active patient population because they are associated with lower rates of failure in this cohort.[11,12] The most popular autografts include BTB, quadriceps tendon (with or without a bone block), and hamstrings.[13] There are a variety of benefits unique to each graft, so

From the Department of Orthopaedic Surgery, University of Missouri Columbia, Columbia, Missouri, U.S.A.

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Address correspondence to Steven F. DeFroda, M.D., M.Eng., Missouri Orthopaedic Institute, University of Missouri Columbia, 1100 Virginia Avenue, Columbia, MO 65212, U.S.A. E-mail: DeFrodaS@health.missouri.edu

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the final decision is dependent on patient-specific factors as well as surgeon preference.

Fresh-frozen allografts are another option for a select group of patients proceeding with ACLR. Frequently used allografts include BTB, tibialis anterior, Achilles tendon, quadriceps tendon, and hamstrings.[13] A unique set of characteristics must be considered when using allografts. Allografts are associated with decreased surgical time, no harvest site morbidity, and a consistent graft size.[14] Previous studies demonstrate that allografts have comparable strength and stiffness to autografts at time zero, but there is some individual variability because the tensile strength and elasticity of allografts are inversely related to the donor's age.[13,15] Ultimately, studies demonstrate similar outcomes compared with autograft ACLR in patients older than 40 years.[16,17]

There remains significant interest in identifying modalities that can support the ACLR graft healing.[18,19] Recent work suggests that more than 20% of high-volume ACLR surgeons use biologic augmentation in primary ACLR.[20] The BioBrace is one such augment that has been used in ACLR surgery to support soft tissue healing by facilitating tissue ingrowth and remodeling. This product offers biologic and mechanical support that may ultimately lead to improved patient outcomes. The senior author (S.F.D.) prefers to use this product in patients undergoing allograft ACLR when there is some uncertainty relating to allograft size, tissue quality, or healing potential.

Graft Preparation

A fresh-frozen BTB allograft is trimmed to create a 10-mm × 20-mm bone plug for the femoral side and a 10-mm × 30-mm bone plug for the tibial side, with an 11-mm-wide soft tissue graft (Table 1, Video 1). The graft is marked with sutures placed according to the senior author's preferences. A 5-mm × 250-mm BioBrace is used. The BioBrace is then trimmed to correspond with the length of the tendinous portion of the BTB allograft (Fig 1). A free Vicryl (Ethicon) suture, folded in half, is loaded into a free needle and passed through both the BioBrace and ACL in order to attach the BioBrace to the graft. The loop portion of the suture is looped through, then looped over the graft, and finally tied. This will link the graft to the BioBrace implant. By doing this, we increase surface area for fixation by the suture. The graft is pulled down flush with the ligamentous tissue, and the sutures are tied. This suture passage is then repeated at the other end of the BTB allograft to ensure that the BioBrace is secured to the allograft on both ends. Additional locking loop sutures are subsequently applied to the tendinous portion of the graft to further secure the BioBrace to the BTB allograft. This process can be repeat 2 to 3 times depending on the length of the tendinous portion of the graft. In total, the final construct will have 4 to 5 sutures securing it (Fig 2). After securing the BioBrace to the BTB allograft, the construct can be soaked in a biologic (whole blood, platelet-rich plasma, bone marrow aspirate concentrate) of the surgeons choosing to hydrate the graft (Fig 3). In this case, the senior author decided to use whole blood, to increase growth factor production in the graft during healing. The graft can then be brought to the surgical field allowing for graft passage and fixation according to surgeon preference (Fig 4).

Table 1. BTB ACLR BioBrace Graft Preparation Technique Tips/Pearls

1. Trim ACLR allograft according to the surgeon's standard preferences.
2. Trim the BioBrace graft to align with the length of the tendinous portion of the BTB allograft.
3. A locking loop stitch is performed at the proximal end of the graft:
   a. A free Vicryl (Ethicon) suture, folded in half, is loaded into a needle and passed through both the BioBrace and ACL, in order to attach the BioBrace to the BTB allograft.
   b. The loop portion of the suture is looped through and then looped over the graft.
   c. The graft is pulled down flush with the ligamentous tissue, and the sutures are tied.
4. A second locking loop stitch is performed as described in step 3 to secure the distal end of the BTB allograft to the BioBrace.
5. Two to 3 more locking loop stitches can be performed to secure the BioBrace to the BTB allograft depending on the length of the allograft.
6. Finally, the BioBrace BTB construct is soaked in a biologic of the surgeon's preference (e.g., whole blood and bone marrow aspirate concentrate).

ACLR, anterior cruciate ligament reconstruction; BTB, bone−patella tendon−bone.

Discussion

This Technical Note outlines a reproducible ACLR graft preparation process for a BTB allograft with a biocomposite scaffold composed of a highly porous type I collagen matrix and bioresorbable PLLA microfilaments. This technique also reviews potential considerations regarding graft selection and graft augmentation. To date, BioBrace has been used to supplement surgical management of the ACL, medial collateral ligament, rotator cuff, meniscus, and distal biceps, which highlights the interest in this technology.[8,9,21-23] It is important to note that this implant is load sharing at time 0 but fully resorbable over 2 years as the graft undergoes ligamentization and ingrowth.

There are multiple modalities of ACLR augmentation, including soft tissue procedures (anterolateral ligament reconstruction or lateral extraarticular tenodesis), mechanical implants (i.e., suture tape or scaffolds), and biologics (i.e., platelet-rich plasma or fibrin clots).[19,24-27] Each of these adjuvants offers a unique set of benefits, but they are all used with the goal of improving patient outcomes. The BioBrace is unique in that it is an off-the-shelf implant that theoretically offers both biologic and mechanical benefits in the acute period

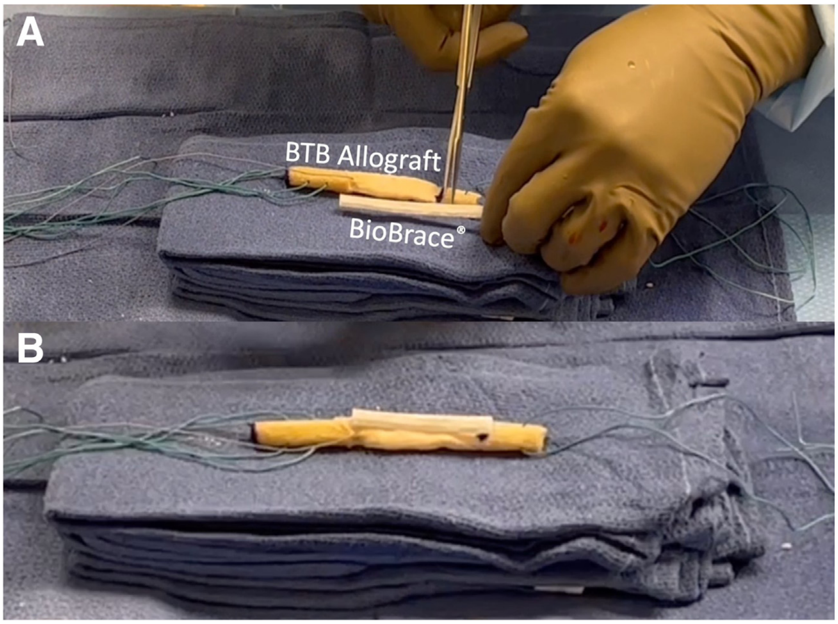

Fig 1. BioBrace graft is trimmed (A) to align with the length of the tendinous portion of the BTB allograft (B). (BTB, bone—patella tendon—bone.)

Fig 2. BioBrace secured to the bone—patella tendon—bone allograft with 4 Vicryl (Ethicon) locking loop stitches.

Fig 3. BioBrace/bone—patella tendon—bone allograft construct soaked in whole blood.

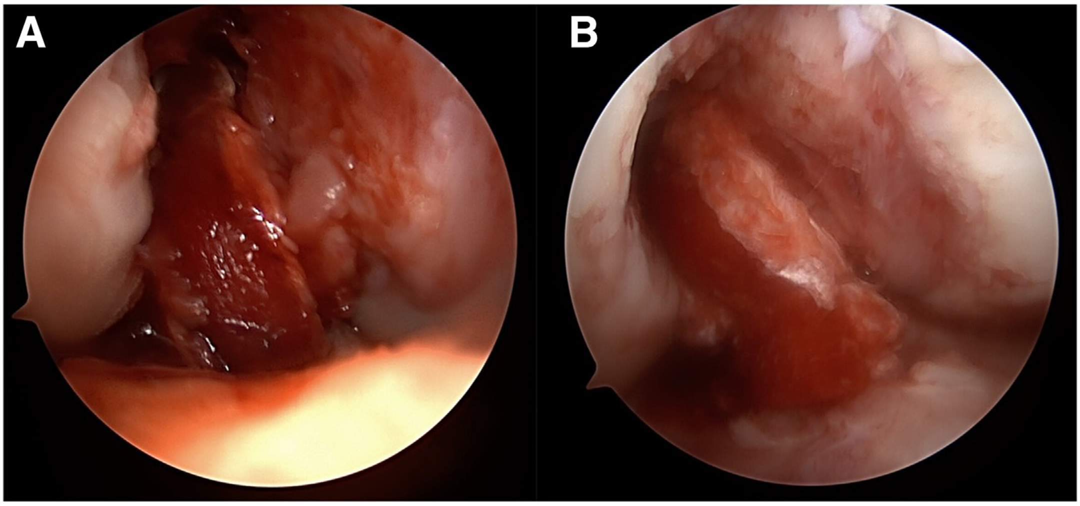

Fig 4. (A, B) Intra-articular images of the BioBrace/BTB allograft construct view of right knee viewed from anterolateral portal. (BTB, bone—patella tendon—bone.)

after ACLR. The highly porous type I collagen matrix and bioresorbable PLLA microfilaments support induction, maturation, and remodeling of new host tissue while also providing load sharing. In large animal models, BioBrace demonstrates the ability to promote a robust native healing response and the formation of naturally oriented connective tissue fibers.[6,7]

The described technique offers a quick and reliable method for BioBrace augmentation of a BTB allograft. Surgeons may consider BioBrace augmentation in autograft ACLR patients with smaller graft sizes or patients with impaired tissue quality. There are several pearls for this technique (Table 1) that may offer benefit in patients undergoing allograft ACLR when there is concern regarding allograft size, tissue quality, or healing potential. There are numerous advantages associated with BioBrace augmentation, including the fact that it uses absorbable sutures, ensuring that there will not be any retained intra-articular foreign materials (Table 2). Additionally, the graft itself reabsorbs as opposed to other techniques that employ a nonabsorbable suture material. This technology is attractive because early studies suggest that this augmentation process may lead to enhanced biologic and mechanical environment, but long-term studies are needed.

Disclosures

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: C.W.N. received financial support from the AO Foundation, Arthrex, Guidepoint Consulting, and Vericel and is a board member of the American Association of Orthopaedic Surgeons, American Orthopaedic Society for Sports Medicine, and Arthroscopy Association of North America. S.F.D. received financial support from AO North America, Arthrex, and Springer and is a board member of the American Orthopaedic Society for Sports Medicine and Arthroscopy Association of North America. All other authors (P.B., L.O.O.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Table 2. Advantages and Disadvantages of the Described Technique

Advantages	Disadvantages
Offers a time zero load-sharing strength of 141 N that can enhance the mechanical properties of the BTB allograft	Increased cost associated with the BioBrace implant
Easily reproducible surgical technique that allows augmentation without additional surgical incision or procedure	Increased surgical time associated with preparation of the BioBrace/BTB allograft construct
Can be used in autograft ACLR in patients with smaller grafts or compromised tissue quality or allograft ACLR to supplement the donor tissue	Long-term clinical outcomes are lacking at this time
BioBrace can be customized to match a variety of different graft sizes and types	Concern for mild, local, inflammatory foreign body response

ACLR, anterior cruciate ligament reconstruction; BTB, bone—patella tendon—bone.

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