Technical Note

Patellar Tendon Graft Anterior Cruciate Ligament Reconstruction Technique With Suture Tape Augmentation

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Abstract: Suture tape augmentation for repair and in combination with reconstruction with grafts has been described for multiple procedures. To date, no description of a patellar tendon graft anterior cruciate ligament reconstruction with an augmented graft has been published. This Technical Note details a technique we developed to incorporate a cross-linked suture tape into a patellar tendon graft.

The use of suture materials to augment knee, elbow, and ankle ligament procedures has been recently described. Biomechanical studies have shown that they provide additional strength.[1-4] One of the most common procedures performed in orthopaedics is reconstruction of the anterior cruciate ligament (ACL), with more than 100,000 performed annually in the United States.[5] Despite significant advances in surgical technique and physical therapy, graft rupture and inability to return to sports are still significant issues.[6] Techniques have been described for reinforcing soft-tissue grafts with a suture tape material.[1,7] We present a technique for ACL reconstruction in which a patellar tendon graft augmented with a cross-linked suture tape is used. A cortical button is used for fixation on the femoral side. Either a button or an interference screw plus a suture anchor can be used for the tibial side fixation. The unique aspect of the technique is the graft preparation, which, to our knowledge, has not been previously described.

Methods

This technique can be used with either a patellar tendon autograft or allograft. Other items that are used in this graft augmentation are a FiberLoop suture with a straight needle, a FiberTape suture, and the Bone-Tendon-Bone TightRope (all products from Arthrex, Naples, Florida) (Fig 1). There are multiple options for fixation on the tibial side, all of which can be used with this technique. Our current preference is to use an interference screw along with a SwiveLock anchor (Arthrex). The surgeon or assistant will also want to have available the following equipment: 9-mm oscillating saw blade, Stryker Total Performace System (TPS) or power unit, rongeur, needle driver, suture scissors, 1.5-mm drill bit, and drill.

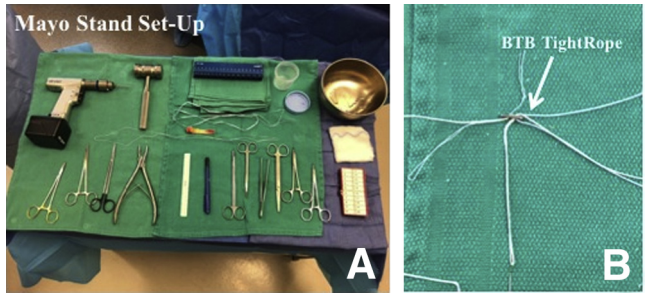

Fig 1. Materials for this graft preparation. (A) Materials, instruments, and supplies needed for this graft preparation technique. (B) FiberLoop suture, FiberTape suture, and Bone-Tendon-Bone TightRope button (Arthrex). (BTB, bone-to-bone.)

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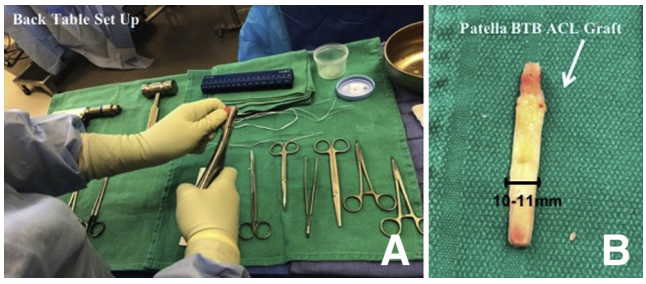

Fig 2. Shaping the bone plugs of the graft. (A) The bone plugs are shaped with a rongeur. (B) Graft after preparation is complete. The bone plugs are approximately 10 × 18 mm, and the tendon length is 35 mm. (ACL, anterior cruciate ligament; BTB, bone-to-bone.)

Surgical Technique

Patient Position

The patient is placed supine on the table. A lateral post (Shutt Universal Stress Post, Conmed, Inc., Utica, NY) is positioned 3 to 4 fingerbreadths superior to the patella. A sandbag is taped to the bed so that the foot can rest against it with the knee at 90° of flexion (for harvesting an autograft). If an allograft is being used, no sandbag is necessary. A tourniquet is placed on the upper thigh and inflated to 250 mm Hg. The leg is prepared and draped in sterile fashion.

Incision and Graft Harvest

For an autograft, an anterior midline incision is made from the inferior pole of the patella to the tibial tubercle (Video 1). A 13 × 18 mm Smillie retractor with a down curve is used for exposure of the tendon. The central third of the patella is harvested. Our preference is to take a 10- or 11-mm—wide portion of the middle of the tendon. A 9-mm oscillating saw is used to obtain an 18-mm bone plug from the patella and the tibia. An 8-mm mini Lambotte osteotome is used on the patella, and a curved ¼-inch osteotome is used on the tibia. The graft is then prepared on the back table.

For an allograft, standard anterolateral and anteromedial arthroscopy portals are made, and an incision is made on the proximal tibia for the tibial tunnel. The graft can be prepared before the arthroscopy is performed.

Graft Preparation

The surgeon or assistant can prepare the bony ends of the graft in typical fashion. Our preference is to use a rongeur to shape the femoral-sided bone plug into a cylinder (Fig 2) of 10 mm in diameter and 18 mm in length. The tibial side is prepared in a similar fashion. An oscillating saw may also be needed for preparing the bone blocks. Our preferred tendon width is typically 10 or 11 mm.

A horizontal (or medial to lateral) drill hole is made by using a 1.6-mm drill bit in both the femoral bone plug and the tibial bone plug (Fig 3). This hole should be made about one-third of the way from the end of the bone plug (two-thirds of the way from the tendon) on the femoral side and at the midpoint on the tibial side.

The FiberLoop suture is passed around the tendinous portion of the tibial end of the graft. Two to 3 passes are made through the tendon, and a Keith needle is then passed through the soft tissue on the posterior aspect of the tibial-sided bone plug (Fig 4). This will serve as a passing or shuttle suture. Passing the suture on the backside of the tibial bone plug reduces its chance of being inadvertently cut by the bone tap for the interference screw, used at the end of the procedure.

Once the FiberLoop has been passed, we make sure to cut the suture and save the Keith needle with the nitinol loop intact. We will use this needle in a subsequent step.

The Keith needle is placed through the horizontal drill hole in the femoral bone plug and maintained there as a reference. A pass with a 1.6-mm drill is made immediately beneath (closer to the tendon) and perpendicular (anterior to posterior) to the Keith needle in the horizontal drill hole (Fig 5).

After the perpendicular drill hole is made, the FiberTape suture is passed through the horizontal hole with the Keith needle used as a shuttle (Fig 6).

The Keith needle is slightly bent with a needle driver. The needle is passed from the femoral side through the substance of the tendon, parallel to the tendon fibers.

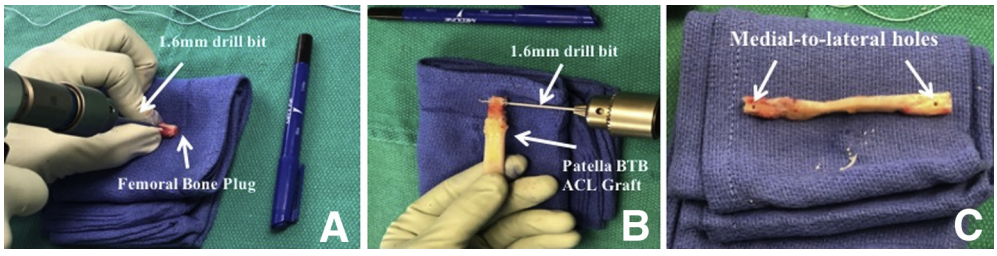

Fig 3. Making the medial-to-lateral drill holes. (A and B) The drilling of the medial-to-lateral holes in both the tibial and femoral bone plugs, respectively, utilizing 1.6-mm drill bit. (C) Overall appearance of the graft on completion of drilling the medial-to-lateral holes in both bone plugs of the graft. (ACL, anterior cruciate ligament; BTB, bone-to-bone.)

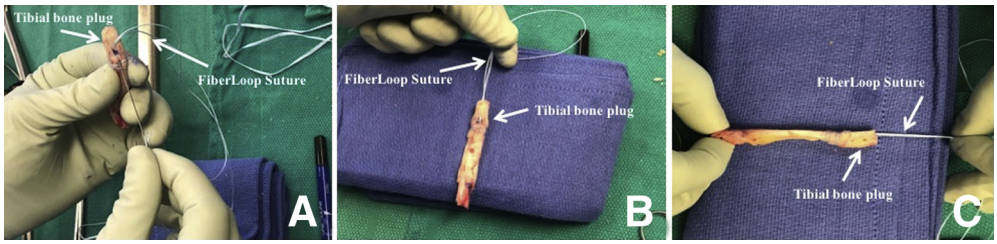

Fig 4. Placing the FiberLoop suture. (A) The FiberLoop suture is initially passed on the tibial side. (B) The FiberLoop suture should exit through the soft tissue on the posterior aspect of the bone plug. (C) Overall appearance of the graft with the FiberLoop suture on completion of this step.

The needle should enter and exit at the junction of the bone plug and the tendon (Fig 7).

The nitinol loop on the end of the Keith needle is used to shuttle the FiberTape through the tendon. This step is repeated on the other side of the tendon with the remaining limb of the FiberTape suture (Fig 8).

The ends of the FiberTape suture are then passed through the horizontal drill hole in the tibial bone plug in a crisscross fashion.

Next, the Arthrex Bone-Tendon-Bone TightRope needle is passed through the anteroposterior femoral drill hole. The loop attached to the cortical button is

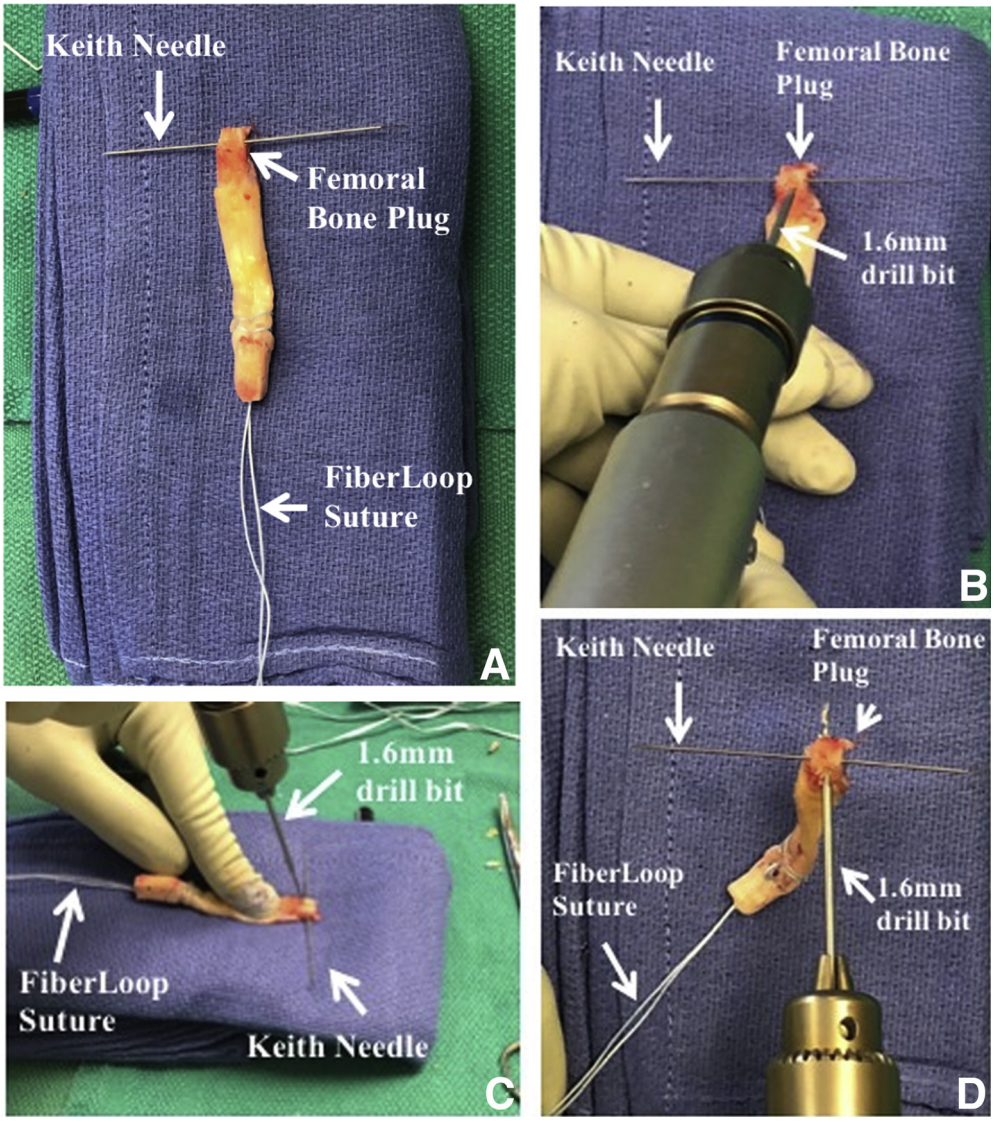

Fig 5. Drilling the Anteroposterior hole relative to the medial-to-lateral drill hole. (A) The graft shown with FiberLoop suture passed and Keith needle placed into horizontal drill hole. (B, C, and D) Another drill pass is made inferior to and perpendicular to the Keith needle, utilizing a 1.6-mm drill bit.

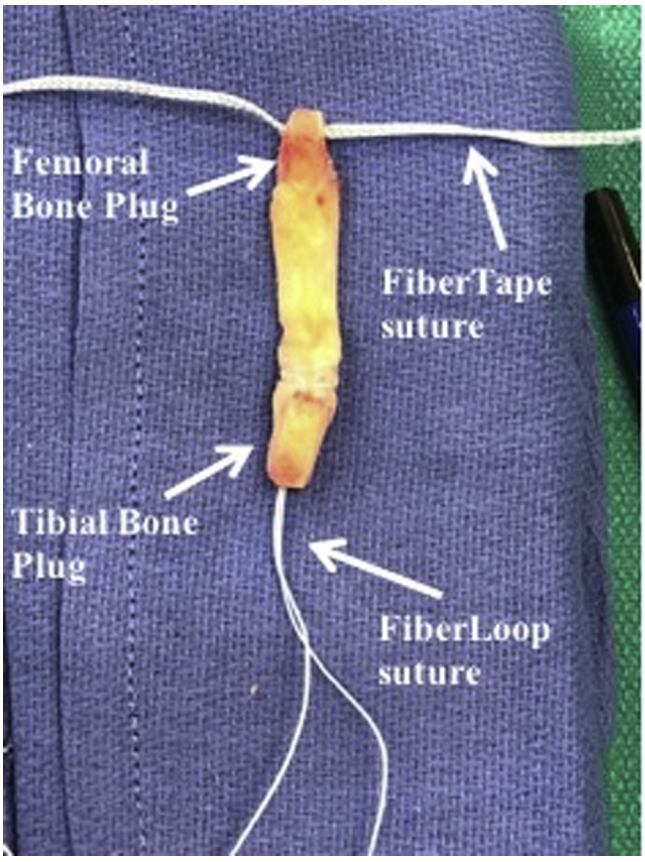

Fig 6. Passing the FiberTape suture. FiberTape has been passed through the medial-to-lateral drill hole on the femoral bone plug.

completed per the manufacturer's instructions. Once the TightRope steps are finished, an interlocking loop between the FiberTape and TightRope suture will have been created (Fig 9). The graft is now ready to be implanted.

Arthroscopy and Tunnel Drilling

An arthroscopy of the knee is performed, and all compartments are examined. Any concomitant injuries are addressed. The ACL is debrided by using a 5.0-mm arthroscopic shaver. Notchplasty is only performed in cases of a narrowed or "A-frame" type notch; otherwise, only the soft tissue is removed from the bone. Care is taken to debride back to the most posterior aspect of the femoral condyle. A small window in the periosteum is made on the proximal anteromedial tibia, and the tibial drill guide is placed in the medial portal, set at 60°. This allows for a tunnel of sufficient length to provide excellent "graft-tunnel match" and ensure that no bone from the tibial bone plug is outside the tibial tunnel once the graft is passed through and secured. A guide pin is passed through the tibial guide and into the center of the ACL insertion footprint. The guide pin is then removed, and an 11-mm reamer is passed over the guide pin. The shaver is used to remove any excess bony and soft-tissue debris around the tibial tunnel that could impede passage of the graft. A rasp is used to smooth any bony spicules within the tunnel for ease of graft passage.

The arthroscope is then transferred to the medial portal to visualize the femoral origin. The FlipCutter guide (Arthrex) is passed through the lateral portal and placed onto the center of the ACL origin. The preferred guide has a 7-mm offset that hooks onto the posterior femoral condyle. The guide handle is elevated approximately 20° from parallel to the floor and set to 105°. A small incision is made with a No. 11 blade on the lateral side of the thigh, and the drill sleeve is advanced to make contact with the lateral femoral cortex. The drill is passed through the lateral femur and will be seen entering the joint through the guide positioned at the femoral origin. Once the drill pass has been made, the sleeve and its 7-mm nipple are malleted into position, engaging into the lateral femur. The flip mechanism is engaged, and the tunnel is created by pulling back with the drill but reaming in the forward direction. The surgeon can have 1 hand on the drill and use the other

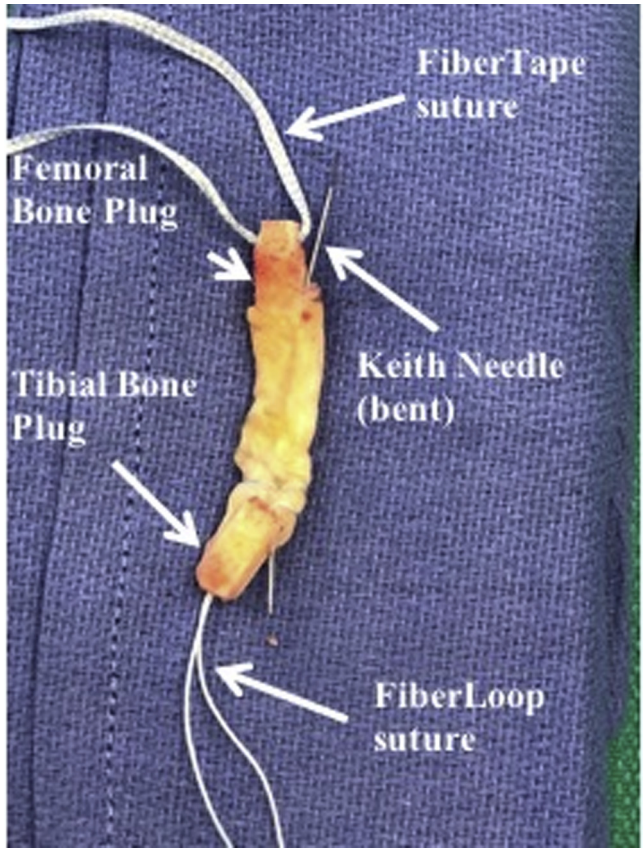

Fig 7. Placement of the bent Keith needle to show proper placement. Slightly bent Keith needle entering the tendon adjacent to the femoral bone plug and exiting adjacent to the tibial bone plug.

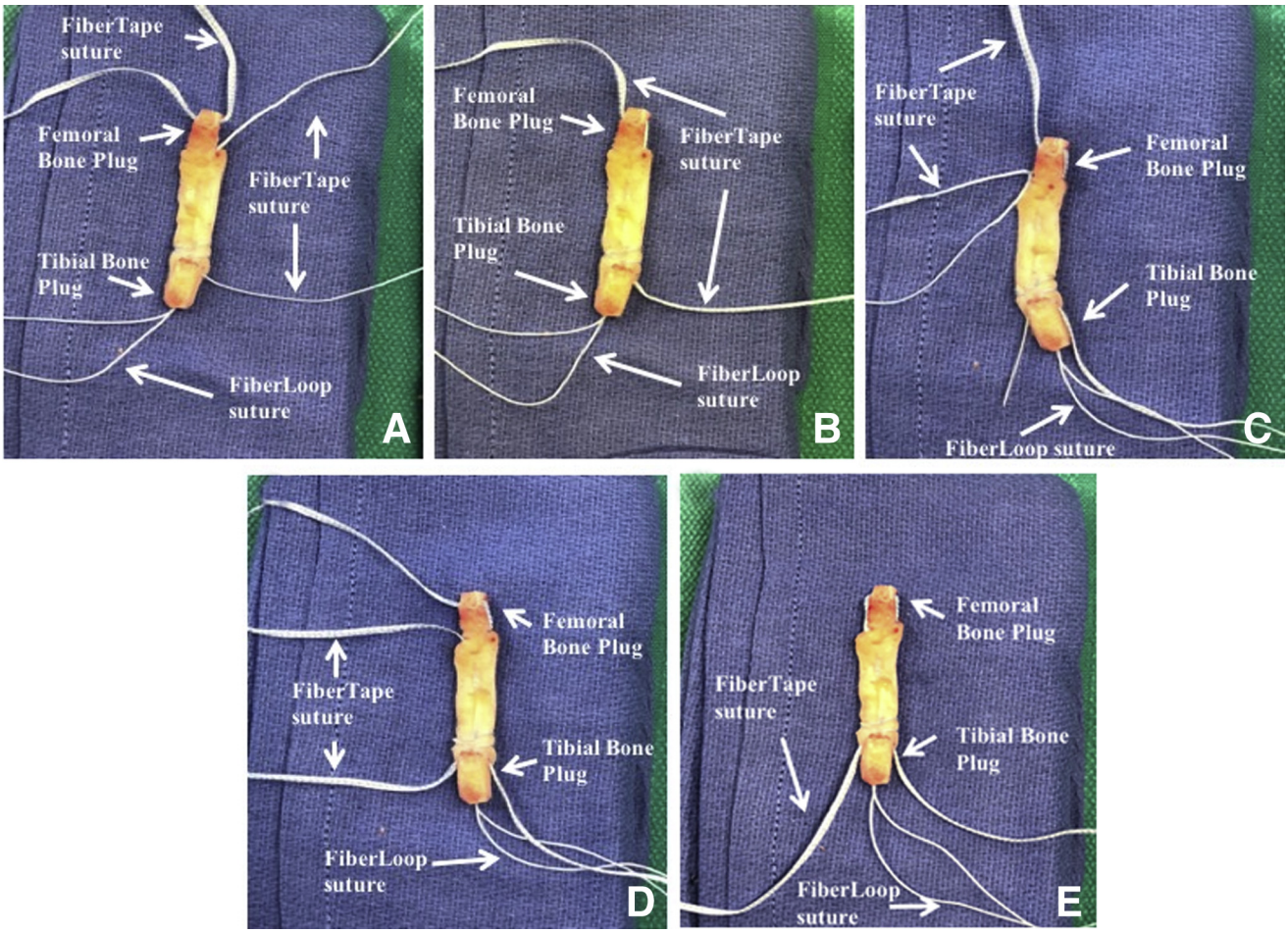

Fig 8. Passing the FiberTape suture through the bone-tendon-bone graft. (A–E) The FiberTape suture is passed parallel and within the substance of the patella tendon on each side.

hand to firmly hold the drill sleeve in place. The surgeon's thumb can be placed on the drill sleeve, and the fingers can grasp the thigh; this ensures that the drill sleeve will remain in place until the tunnel has been reamed.

The FlipCutter is again advanced into the joint, and the tip is flipped to allow for removal of the drill. At this point, a shaver can be placed in the tibial tunnel and in the joint for suctioning of any bony debris. The fluid should be turned off, and the drill should be removed. A FiberStick (Arthrex) suture is passed through the femoral drill sleeve and into the joint. A loop grasper, held upside down and advanced into the tibial tunnel, can be used to retrieve the shuttle suture with the FiberStick from the tibial tunnel.

The graft is then shuttled into position, and the button is secured on the lateral femoral cortex. A radiograph can confirm the appropriate position of the button. The white sutures of the TightRope are then toggled to pull the graft into the tunnel. The femoral bone plug sometimes must be manipulated with a probe in order for it to pass the top part of the tibial tunnel. Also, the tibial bone plug should be positioned in line with the tibial tunnel before the graft has been advanced too far.

Once the graft is securely in position, a final radiograph is obtained to confirm that the button is secured against the lateral femoral cortex. A posterior drawer tension is applied to the knee and an interference screw (typically a 10 × 23 mm screw) is placed in the tibial tunnel. The tails of the FiberTape are then secured to the tibia with a 4.75-mm swivel lock anchor.

Postoperative Care

Sterile dressings are applied, and the patient is placed in a hinged knee brace locked in extension. The patient can bear weight as tolerated. Our rehabilitation protocol begins the next day with an early emphasis on motion. The patient will then progress through criteria-based phases of rehabilitation. Return to activities is based on the time it takes for the graft to be incorporated into the tunnels, ligamentization of the graft, satisfactory subjective test scores, and physical examination findings. Finally, the patient must demonstrate return of strength and neuromuscular control with a

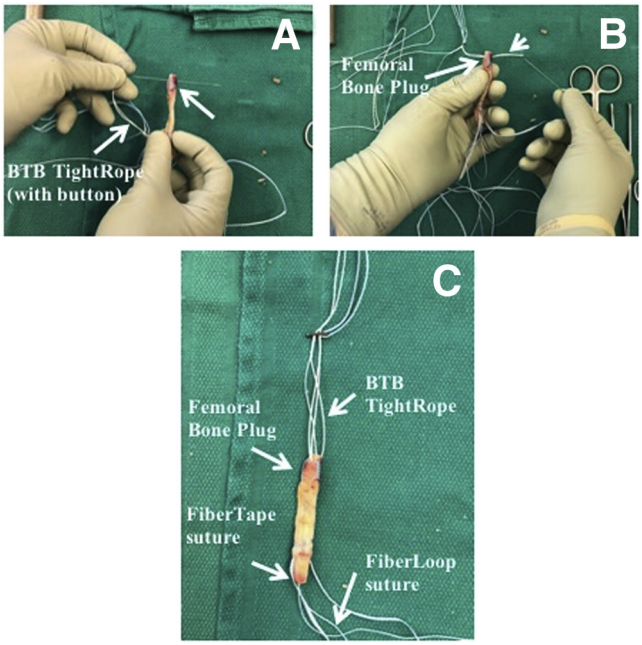

Fig 9. Completing the graft preparation. (A and B) The Bone-Tendon-Bone TightRope is passed through the anteroposterior drill hole in the femoral side bone plug. (C) The graft preparation is completed with the Bone-Tendon-Bone TightRope button, FiberTape suture, and FiberLoop suture in place as described. (BTB, bone-to-bone.)

series of videotaped movements before it is determined that a safe return to higher level activities is possible. This is followed by a reintegration to sport schedule with a progressive increase in activity and workload.

Discussion

A large volume of literature on ACL reconstruction exists; and recent studies have focused on graft choice, tunnel placement, and even preservation of the native ligament.[8,9] We have developed a technique to augment the preparation of a patellar tendon graft using a cross-linked high-strength suture tape material.

We have noted several risks and concerns in using this graft technique, despite the fact that rotator cuff repair has been performed with this same suture material for several years without any reported adverse reactions.[10] Although synthetic materials have been successfully used in ACL surgery,[11] it is not established that the suture material used in our preparation will have no effect on the knee joint. It is possible that any suture that remains within the joint could cause a recurrent effusion or other reaction. We created a way to have the suture entirely within the substance of the graft (Table 1), but time will tell whether there is any subset of patients who may have a reaction to it. We have not observed this in our patients so far.

An additional concern is what effect, if any, the suture could have on the properties of the graft. It is possible that it could have a negative effect on the ligamentization process that is characteristic in ACL reconstructions. This has not been a complication noted in other applications of the suture tape, but it has also not been specifically studied with a patellar tendon autograft or allograft. No biomechanical testing has been performed to evaluate where the grafts could fail when they do, which would in turn illustrate potential weaknesses in the construct. Finally, there is concern that the addition of the suture tape material and its fixation may overconstrain the graft, causing stress shielding. Noonan et al.[4] evaluated soft-tissue grafts augmented with suture tape and found that this load-sharing configuration bypasses any stress-shielding effect. Further study will reveal whether this is also true for an augmented patellar tendon graft.

Table 1. Pearls and Pitfalls to Preparation of Bone-Tendon-Bone Graft for Anterior Cruciate Ligament Reconstruction With Suture Tape Augmentation

Step	Pearl	Pitfall
2 — Drilling the medial/lateral hole	Make sure it is about one-third of the way from the end of the graft	If the drill pass is made too close to the end, it is possible to pull the suture through the bone plug, especially with an allograft.
3 — Cutting the FiberLoop	The Keith needle on the FiberLoop serves as the perfect shuttle for passing the FiberTape.	Make sure to cut the suture and not the nitinol loop on the Keith needle.
5 — Drilling the anteroposterior hole	Leave the Keith needle in the horizontal hole.	Misfiring on the placement of the femoral drill holes will take away the opportunity to complete the augmentation.
8 — Passing the suture within the tendon	Place a slight bend in the Keith needle. Pass the needle through the tendon before the suture is put through the nitinol loop, then pull the suture through the tendon, with just the thin portion of the suture in the loop.	Needle is harder to pass accurately while straight. FiberTape suture is difficult to pass if the wider portion of the suture is in the nitinol loop.
10 — Crisscross sutures through the tibial bone plug	Use the Keith needle to pass the FiberTape, taking care not to pierce the suture when passing the 2nd limb.	Piercing the suture will not allow the 2nd limb to pass.

Ultimately, we were seeking an augmentation to the graft that would increase its mechanical load to failure, and specific testing will determine whether it does and whether it is statistically significant.

Our efforts to improve ACL surgery are focused on development of ways to increase the rate of return to sport and reduce the chance of a repeat injury. We would further like to decrease the time to return, if this were possible. Additional study will be needed to determine whether this graft preparation can be of benefit in any of these categories.

Acknowledgment

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