Technical Note

Triple Hybrid Tibial Anterior Cruciate Ligament Graft Fixation

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Abstract: Optimal graft fixation in anterior cruciate ligament reconstruction is critical. Several direct and indirect methods of graft fixation exist, each with advantages and disadvantages. This Technical Note describes a tibial hybrid anterior cruciate ligament graft fixation technique combining direct and indirect fixation methods, including autologous bone augmentation of the drill tunnel using cancellous bone fragments.

Optimal graft fixation in anterior cruciate ligament (ACL) reconstruction (ACLR) is critical but remains one of the most easily adjustable factors affecting postoperative outcomes. The primary aim of graft fixation is to provide stability of the graft within the bone tunnel until graft-to-bone incorporation is accomplished. Optimal graft fixation minimizes graft elongation, longitudinal ("bungee effect") and transverse ("windshield wiper") graft movement, as well as influx of synovial fluid into the bone tunnel by maximizing strength, stiffness, stability, and durability.[1] Optimizing femoral and tibial graft fixation might allow for faster and more aggressive rehabilitation protocols.

Several direct and indirect methods of graft fixation have been described, including cortical button, interference screws, cross pins, staples, washers, or hardware-free press-fit fixation. Nevertheless, the optimal technique remains a matter of debate, as each option has advantages and disadvantages

The purpose of this Technical Note is to describe a tibial ACL graft-fixation technique combining direct and indirect fixation methods including autologous bone augmentation using cancellous bone fragments. The aim of this technique is to maximize stability and promote graft incorporation while minimizing tunnel widening.

Surgical Technique (With Video Illustration)

Patient Positioning

The described technique is a substep of ACLR and is independent of the positioning of the patient. We recommend positioning the patient in the personally desired position on the operating table. Our preferred position is supine with the ability to flex and extend the knee between 0° and 130°. After intraoperative examination, a well-padded tourniquet is placed around the proximal thigh. The lower extremity is thereafter prepped and draped according to standard sterile routine.

Graft Choice and Preparation

This technique can be performed with all graft options, but all-soft tissue autografts and allografts as well as those with a soft-tissue tibial end (eg, bone–quadriceps tendon) are the preferred option. For this Technical Note, an autologous hamstring tendon graft was used. After freeing the graft from muscle tissue, the femoral site is armed according to personal preference and routine. The authors prefer an adjustable loop cortical button fixation. The tibial end is armed using a No. 2 suture (FiberWire, Arthrex,

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Table 1. Pearls and Pitfalls of Triple Hybrid Tibial Anterior Cruciate Ligament Graft Fixation

Pearls	Pitfalls
Fully expose and clearing of the tibial opening to facilitate graft and cancellous bone fragment insertion	Insufficient tibial tunnel exposure and cleaning complicates the insertion of the graft as well as the bone
For optimal fixation and graft incorporation a tibial bone tunnel of at least 35 mm length is recommended.	A too-short bone tunnel can limit graft and bone incorporation
Place the suture button in such a way that it closes the entrance of the tibial tunnel and prevent the autologous cancellous bone or bone chips from falling out	An extracortical suture button is not recommended in patients who are lean because of possible skin irritation.
A cortical bone bridge can be used in lean patients to minimize skin irritation from the cortical button	

Naples, FL) in Krackow stitch technique. Total length of the graft must be between 55 and 65 mm.

Tibial Tunnel Placement

Up to the point of tibial tunnel drilling, routine arthroscopic examination and ACLR is performed. If not already performed for hamstring autograft harvesting, an approximately 3-cm long skin incision is placed at the anteromedial tibia at the location where the tibial bone tunnel is desired. Blunt dissection is performed until reaching the anteromedial tibia. Care should be taken not to injure the medial collateral ligament, pes anserinus, or infrapatellar branch of the saphenous nerve.

A drill guide set to 60° is used for anatomical tibial tunnel placement and, thus, a 2.4-mm K-wire is inserted. Note: For optimal fixation it is recommended that the length of the tunnel is more than 35 mm (Table 1).

Tunnel drilling is performed using a canulated reamer with a diameter depending on the tibial graft thickness (eg, 8 mm) (see Video 1). Autologous cancellous bone fragments and bone marrow are obtained during tunnel drilling and stored on the instrument table (Fig 1, Video 1). Note: Make sure to keep bone fragments moist.

The tibial opening is cleared of soft tissues to facilitate subsequent graft insertion. Femoral graft fixation is now performed according to personal routine.

Tibial Graft Fixation

After successful graft insertion and standardized personal femoral fixation, manual graft tensioning is performed. The knee is then cycled 10 times for graft pretensioning and suture slack removal.

With the knee in 30° flexion and the graft manually tensioned with approximately 80 N, a bioabsorbable interference screw is inserted. Subsequently, the remaining tibial bone tunnel is filled with the previously collected cancellous bone fragments and bone marrow using a pickup or surgical tool. Slight compression is performed using a bone pestle (Fig 2). Note: If insufficient autologous cancellous bone has been obtained, additional allograft bone chips can be used to fill the remaining tibial tunnel.

A standard extracortical button is now used for additional suspensory fixation. The button is placed in such a way that it closes the entrance of the tibial tunnel and prevent the autologous cartilage bone from falling out. (Fig 3) Note: In patients who are very lean, an alternative additional fixation can be used instead of the button, such as a bone anchor or cortical bone

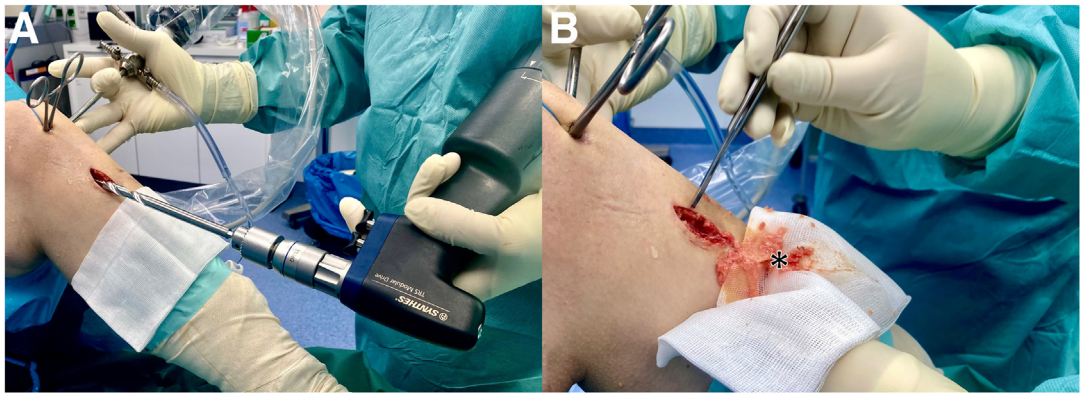

Fig 1. (A) Tunnel drilling is performed using a canulated reamer to harvest autologous cancellous bone fragments (Left knee, patient in supine position). (B) The autologous cancellous bone (asterisk) is first collected on a moist gauze.

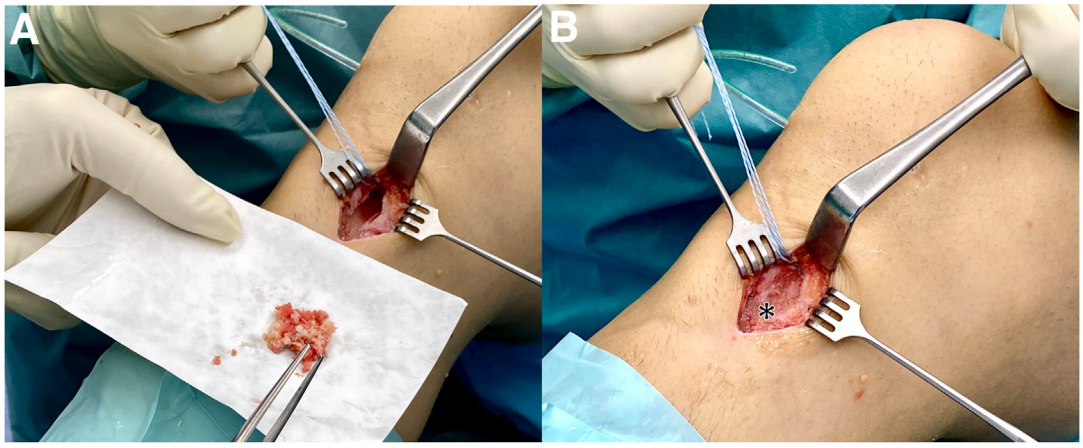

Fig 2. (A) Harvested cancellous bone (asterisk) is used to fill the tibial tunnel after insertion of the graft and interference screw. Additional allograft spongiosa can be used if insufficient autologous spongiosa was obtained (Left knee, patient in supine position). (B) Using a bone pestle, the cancellous bone is slightly compressed within the bone tunnel (asterisk) until an even surface is obtained.

bridge. ACLR is now finalized in a standard personalized manner. A postoperative radiographic image of the final construct is shown in Figure 4.

Discussion

The advantages of the presented technique for tibial graft fixation in ACLR are 2-fold: first the combination of direct (interference screw) and indirect fixations (suspensory button) provides a strong and stiff double fixation, minimizing the risk of graft slippage, longitudinal and transverse graft movement, as well as influx of synovial fluid into the bone tunnel. Second, due to the addition of autologous (and possibly allogenous) cancellous bone, bone tunnel widening might be reduced. In addition, there is no bone gap between the distal end of the interference screw and the cortical bone of the tibia, which presumably facilitates graft incorporation and may also minimize widening of the bone tunnel.

The primary aim of graft fixation is to provide stability of the graft within the bone tunnel until graft-to-bone incorporation is achieved. Optimal graft fixation maximizes strength, stiffness, stability, and durability while minimizing graft elongation, longitudinal and transverse graft movement, as well as influx of synovial fluid into the bone tunnel, which is believed to delay graft incorporation and increase the risk for tunnel enlargement.[2] Despite advancements in graft-fixation methods, the fixation point remains the weakest link in the graft-to-bone interface and is therefore crucial to the success of ACLR.

Several different graft-fixation methods exist. Direct methods include absorbable and nonabsorbable interference screws, cross pins, staples, washers, or hardware-free press-fit fixation, whereas indirect devices include fixed or adjustable suspensory cortical button fixation. Each option offers specific advantages and disadvantages. Although suspensory fixation

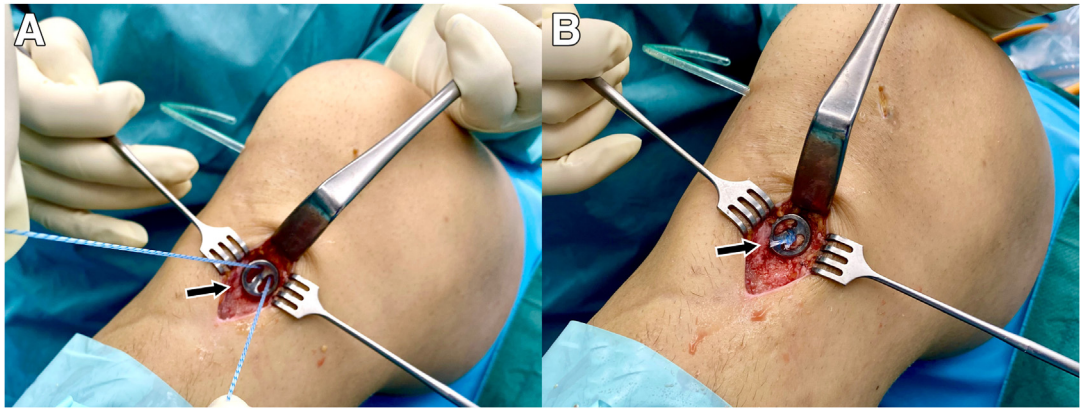

Fig 3. (A) An extracortical button (arrow) is used for additional suspensory fixation and placed in such a way to close the entrance of the tibial tunnel and prevent the autologous cartilage bone from leaking out (B) (Left knee, patient in supine position).

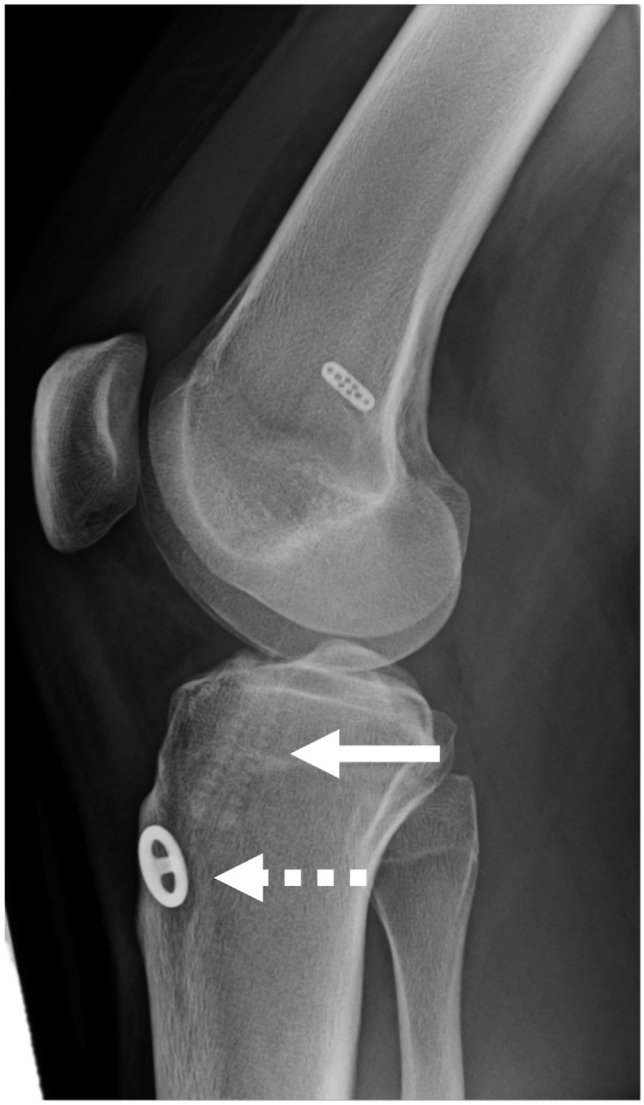

Fig 4. Lateral postoperative radiograph showing the final construct with interference screw (solid arrow) and extracortical button (dashed arrow).

allows the possibility of a thicker graft with greater graft-to-bone contact area,[3-5] graft elongation as well as longitudinal and transverse movements appear to be lower when an interference screws is used.[4,6,7] Hardware-free press-fit techniques have been reported, showing promising outcomes comparable with traditional techniques with low rates of tunnel enlargement.[8-10] In terms of subjective patient-reported outcomes, recent meta-analyses showed no differences.[9,11-13]

In this tibial fixation technique for ACL grafts, the interference screw is placed as close as possible to the joint surface to minimize graft motion within the tunnel. To minimize bone tunnel widening and facilitate graft incorporation, the remaining bone tunnel is filled using the autologous cancellous bone fragments or bone chips. Finally, an additional extracortical fixation is performed for additional fixation. Triple hybrid tibial anterior cruciate ligament graft fixation is an ACL tibial graft fixation that may provide strong tibial fixation with minimal bone tunnel enlargement.

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