Technical Note

Supplementary Tibial Fixation in Anterior Cruciate Ligament Reconstruction With Bone-Tendon-Bone Graft

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Abstract: Good to excellent results at long-term follow-up have been published for anterior cruciate ligament reconstruction with bone-tendon-bone graft. Despite improvements in fixation devices, concerns regarding the stability of graft fixation on the tibial side remain. We present supplementary tibial fixation for anterior cruciate ligament reconstruction with bone-tendon-bone graft using a transosseous technique that is simple and inexpensive and avoids the risk of symptomatic hardware.

An anterior cruciate ligament (ACL) rupture is a devastating injury that can lead to recurrent instability, chronic pain, and degenerative changes in the knee.[1] Arthroscopic reconstruction is the standard approach, but controversy remains over the most favorable graft selection.[2]

The most commonly used autografts for ACL reconstruction in the United States are bone—patellar tendon—bone and 4-strand hamstring tendon.[3] Bone-tendon-bone (BTB) autograft has historically been considered the gold standard.[4,5] Some authors have suggested that BTB autograft is the most favorable graft choice because of faster graft incorporation, a higher proportion of patients returning to preinjury activity levels, and a potentially lower risk of graft rupture.[2,6,7] However, others favor hamstring autografts because of lower rates of donor-site morbidity such as anterior knee pain and extensor strength deficits, as well as osteoarthritis.[1,6] Good to excellent results at long-term follow-up have been published for ACL reconstruction with BTB graft.[8]

Although controversy on specific advantages and disadvantages remains, clearly the most significant adverse outcome after ACL reconstruction is graft rupture with subsequent revision surgery. The weak point of fixation of the graft, most of the time, is the tibial tunnel because metaphyseal fixation is limited by lower bone density.[2]

Despite improvements in fixation devices, concerns regarding the stability of graft fixation on the tibial side remain. We present supplementary tibial fixation for ACL reconstruction with BTB graft using a transosseous technique that is simple and inexpensive and avoids the risk of symptomatic hardware.

Surgical Technique

Our surgical technique is demonstrated in Video 1. The indications are shown in Table 1, the advantages and disadvantages of the procedure are presented in Table 2, and pearls and pitfalls are summarized in Table 3.

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Table 1. Indications for Using Supplementary Tibial Fixation in ACL Reconstruction With BTB Graft

Revision surgery
Poor bone quality
1-Stage ACL revision (dilated tunnel)
2-Stage ACL revision (poor quality of grafted bone in tibial tunnel)
Interference screw size error (small screw)

ACL, anterior cruciate ligament; BTB, bone-tendon-bone.

Patient Positioning

The surgical procedure is performed with the patient under epidural anesthesia. The patient lies in the supine position with the knee flexed and the foot hanging over the edge of the bed. A tourniquet is placed as proximally as possible around the thigh. The leg is then prepared and draped in the standard sterile manner. Next, we perform an arthroscopic examination of the involved knee.

Portal Creation and Arthroscopic Examination

We begin by placing an anterolateral portal adjacent to the lateral border of the patella. The standard anteromedial portal is made under arthroscopic visualization with a spinal needle, just medial to the patellar tendon and directly superior to the anterior horn of the medial meniscus. After portal placement, we perform an arthroscopic examination of the knee, looking for associated meniscal and chondral lesions.

Graft Harvest

A midline longitudinal incision is made from the inferior pole of the patella to approximately 2 cm distal to the tibial tubercle (Fig 1, Table 4). The paratenon is split and carefully reflected off of the underlying tendon, thus allowing side-to-side repair after ACL reconstruction (Fig 2). We mark the center of the patellar tendon, and using a ruler, we make other marks, 5 mm to the left and to the right (Fig 3). Before use of the saw, 2 drill holes are made in both bone blocks using a 1.5-mm K-wire (which will subsequently be used for graft preparation). Two different saw blades, 10 mm (vertical cut) and 5 mm (horizontal cut), are used to harvest the bone plug in a trapezoidal shape (Fig 4). The osteotome can then be used to gently lever both bone plugs away from the remnant bone (Fig 5). The aim is to harvest a tibial plug (10 mm × 25 mm), a patellar bone plug (10 mm × 30 mm), and an 11-mm-wide tendon graft (Fig 6). We leave at least 10 mm of patellar tendon medially and use a high-resistance suture (No. 2 FiberWire; Arthrex). We perform bone grafting of the patellar bone plug harvest site, and we close the paratenon using No. 0 absorbable suture.

Table 3. Pearls and Pitfalls of Using Supplementary Tibial Fixation in ACL Reconstruction With BTB Graft

Pearls
Two parallel transosseous tunnels are made with a 2-mm K-wire.
The tunnels are made from the tibial groove (10 × 25 mm) to the place where the tibial tunnel begins, which should be lateral to the insertion of the patellar tendon and superior to the sartorius fascia.
We recommend a 1-cm separation between the 2 tunnels.
Through the 2 tunnels, with the aid of 2 Abbocath devices, a No. 1 Prolene suture is passed, which will serve as a transport suture to pick up the high-strength suture (No. 5 Ethibond) from the tibial plug and introduce it into the tibial groove.
Both sutures are knotted, and the knots are left in the tibial groove, where they will not cause discomfort because they do not come into contact with the skin.
Pitfalls
Suture cutting through tibial bone

ACL, anterior cruciate ligament; BTB, bone-tendon-bone.

Table 2. Advantages and Disadvantages of Using Supplementary Tibial Fixation in ACL Reconstruction With BTB Graft

Advantages
Double fixation is achieved.
The technique is simple.
The technique is reproducible.
The technique is inexpensive.
The risk of symptomatic hardware is avoided.
We leave the knots inside the tibial groove, and we do not "catch" the patellar tendon with sutures.
Reinforced dual tibial fixation increases pullout strength.
By performing knotting in the tibial groove rather than over the tendon, there is no pain in the tendon.
Disadvantages
In very weak bone, the technique could fail.
We have not performed biomechanical studies.

ACL, anterior cruciate ligament; BTB, bone-tendon-bone.

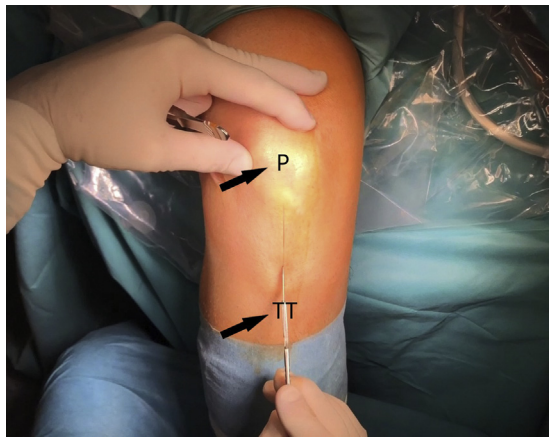

Fig 1. A midline longitudinal incision (right leg) is made from the inferior pole of the patella (P) to approximately 2 cm distal to the tibial tubercle (TT).

Table 4. Pearls Associated With BTB Autograft Harvest for ACL Reconstruction

Make a longitudinal incision from the inferior pole of the patella to approximately 2 cm distal to the tibial tubercle.
Incise and preserve the paratenon.
Use 2 different saw blades: 10 mm (vertical cut) and 5 mm (horizontal cut).
Harvest a tibial plug (10 mm × 25 mm).
Harvest a patellar bone plug (10 mm × 30 mm).
Harvest an 11-mm-wide tendon graft.
Leave at least 10 mm of patellar tendon medially.
Use high-resistance suture (No. 2 FiberWire).
Perform bone grafting of the patellar bone plug harvest site.
Perform closure of the paratenon using No. 0 absorbable suture.

ACL, anterior cruciate ligament; BTB, bone-tendon-bone.

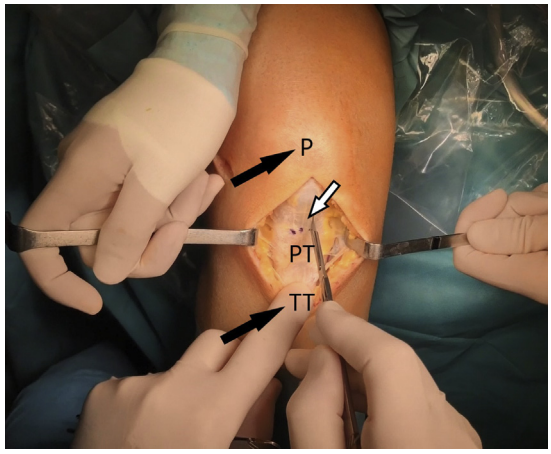

Fig 3. We mark the center of the patellar tendon (PT), and using a ruler, we make other marks, 5 mm to the left and to the right (right leg). (P, patella; TT, tibial tubercle.)

Graft Preparation

The graft is brought to the back table for measurement and preparation. The 2 bone blocks are reshaped and calibrated. Usually, the patellar bone block is placed on the femoral tunnel. A rongeur is used to remove the excess bone to allow for a 10-mm cylindrical bone block. Two No. 5 Ethibond sutures (Ethicon) are passed through the previously made holes, and these sutures will be used to pull the bone block into the tunnels later (Fig 6).

Tunnel Preparation

The technique used is a classically described technique.[9,10] If necessary, a minimal notchplasty can also be performed to open the distal femur through which the ACL graft will pass. An awl is used to mark the femoral tunnel starting point, which is the anatomic footprint of the posterolateral bundle of the native ACL. The tibial footprint of the native ACL is used for precise tibial tunnel placement. The tibial tunnel location is established with a standard tibial guide.

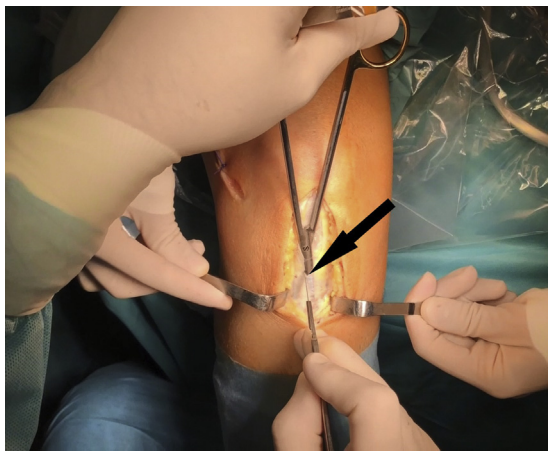

Fig 2. The paratenon is split and carefully reflected off of the underlying tendon (right leg), thus allowing side-to-side repair after reconstruction of the anterior cruciate ligament. Arrow indicates Paratenon.

The knee is now brought into a flexed position, and a Beath pin is placed through the medial portal into the starting point previously marked with an awl. It is advisable to insert the Beath pin into the medial wall of the lateral femoral condyle a few millimeters before knee hyperflexion to maintain the predetermined starting point. The knee is then hyperflexed, and the Beath pin is advanced through the lateral femoral condyle. Hyperflexion allows for appropriate femoral tunnel placement in both the coronal and sagittal planes. The Beath pin is advanced until the tip pierces the lateral thigh skin. Once the tip of the Beath pin is out of the skin and appropriate tunnel placement is confirmed, an acorn reamer is used to drill the femoral tunnel approximately 25 mm in depth. Once the femoral tunnel is created, a tunnel notcher is used to create a notch on the anterior aspect of the femoral tunnel to facilitate interference screw placement later. Next, a long polydioxanone passing suture (PDS) is placed through the eyelet of the Beath pin, and the pin is used to transfer the free ends of the polydioxanone suture across the distal thigh. After placement of the guide pin in the accurate location and confirmation, the tibial tunnel is drilled.

Graft Passage and Femoral and Tibial Fixation

The looped end of the shuttle suture is retrieved through the tibial tunnel with a ring grasper. The BTB

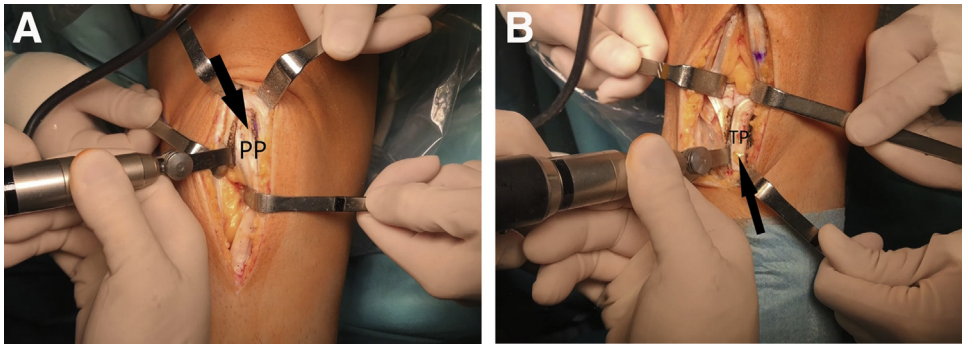

Fig 4. Two different saw blades (right leg), 10 mm (vertical cut) and 5 mm (horizontal cut), are used to harvest the bone plug in a trapezoidal shape. (A) Patellar plug (PP). (B) Tibial plug (TP).

autograft is then removed from the tensioner and brought to the operative field. Both sutures from the tibial tubercle bone plug are passed through the tibial and femoral tunnels with the passing suture (Fig 7). The cancellous portion of the graft is placed anteriorly in the femoral tunnel. Once the graft is in the appropriate position in the femoral tunnel, a nitinol wire is placed adjacent to the graft within the anterior aspect of the tunnel where the tunnel was previously notched. An interference screw is then inserted to obtain femoral fixation. For tibial fixation, we also use an interference screw.

Supplementary Tibial Fixation

For added fixation on the tibial side, we pass the free ends of the sutures from the tibial bone plug into the tibial groove. To achieve this, 2 parallel transosseous tunnels are made with a 2-mm K-wire (Fig 8). The tunnels are made from the tibial groove (10 × 25 mm) to the place where the tibial tunnel begins (the sutures are located next to the interference screw), which should be sagittally 1 cm above the superior (sartorial) border of the pes anserinus insertion and coronally 1.5 cm posteromedial from the medial margin of the tibial tubercle along the superior surface of the pes.[11]

Through the 2 tunnels, with the aid of 2 Abbocath devices (Abbocath, Abbott Laboratories, Chicago, IL), a No. 1 Prolene suture (Ethicon) is passed, which will serve as a transport suture to pick up the high-strength suture (No. 5 Ethibond) from the tibial plug and introduce it into the tibial groove (Fig 9). We recommend a 1-cm separation between the 2 tunnels (Fig 10). Subsequently, we knot both sutures, leaving the knots in the tibial groove, where they will not cause discomfort because they do not come into contact with the skin (Fig 11).

Closure

Closure of the paratenon is performed using No. 0 absorbable suture. Interrupted, absorbable subcutaneous suturing and routine skin closure follow.

Postoperative Management

Patients who undergo the described double-fixation technique follow our normal postoperative protocol after BTB grafting.

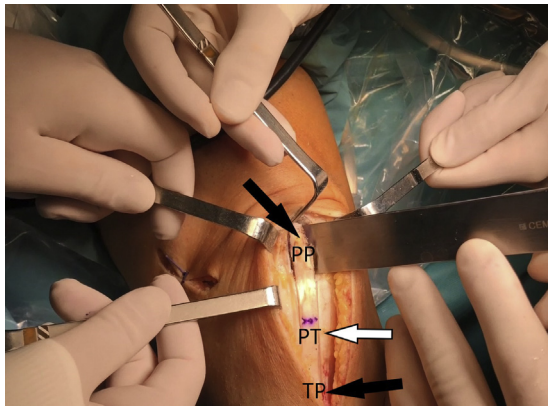

Fig 5. The osteotome is used to gently lever both bone plugs away from the remnant bone (right leg), producing the graft for final preparation. (PP, patellar plug; PT, patellar tendon; TP, tibial plug.)

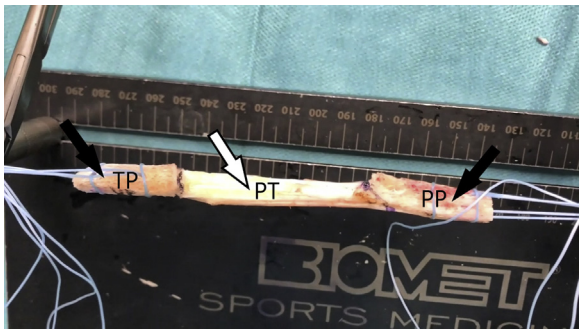

Fig 6. The aim is to harvest a tibial plug (TP) (10 mm × 25 mm), a patellar bone plug (PP) (10 mm × 30 mm), and an 11-mm-wide tendon graft (right leg). We leave at least 10 mm of patellar tendon (PT) medially and use a high-resistance suture (No. 2 FiberWire).

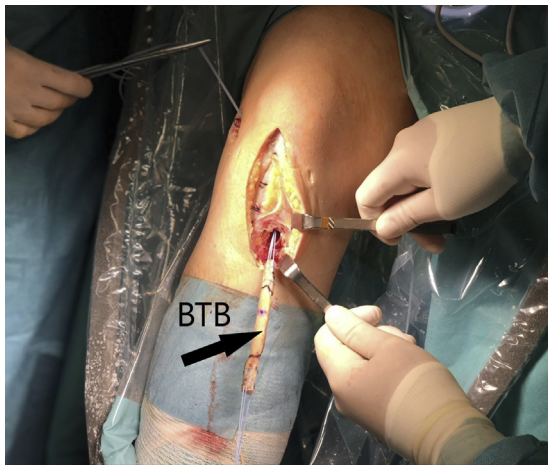

Fig 7. For bone-tendon-bone (BTB) graft placement, both sutures from the tibial tubercle bone plug are passed through the tibial and femoral tunnels with the passing suture (right leg).

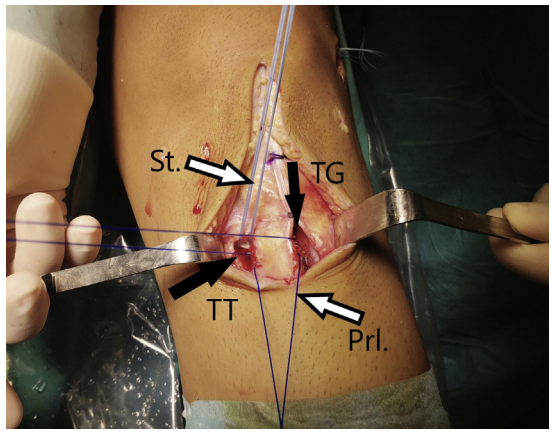

Fig 9. A No. 1 Prolene suture (Prl) is passed through the 2 tunnels with the aid of 2 Abbocath devices; this will serve as a transport suture to pick up the high-strength suture (St) (No. 5 Ethibond) from the tibial plug and introduce it into the tibial groove (TG) (left leg). (TT, tibial tunnel.)

Discussion

Supplementary tibial fixation in ACL reconstruction with BTB graft has been previously described by Abeyewardene et al.[12] using quadriceps tendon–patellar bone autograft and by Wilding et al.[13] using a bone-tendon-autograft technique. However, both groups used suture anchors. In comparison with these authors, we present a technique that is less expensive because no new implants are needed and that avoids the risk of symptomatic hardware. It should be noted that we leave the knots inside the tibial groove and we do not "catch" the patellar tendon with sutures. There are other alternatives for performing double tibial fixation, including screws and anchors. However, all these alternatives increase the cost and the risk of symptomatic hardware.

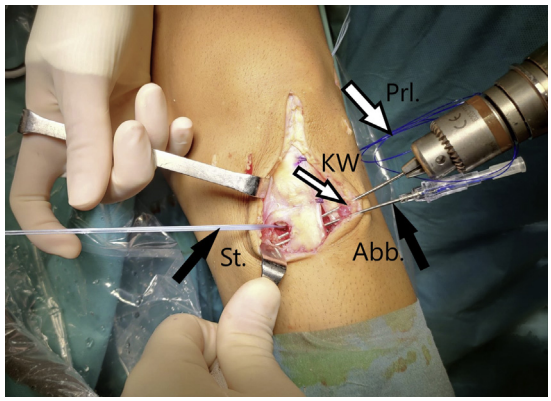

Fig 8. Two parallel transosseous tunnels are made with a 2-mm K-wire (KW) (left leg). The tunnels are made from the tibial groove (10 × 25 mm) to the place where the tibial tunnel begins (the sutures are located next to the interference screw), which should be lateral to the insertion of the patellar tendon and superior to the sartorius fascia. (Abb, Abbocath; Prl, Prolene suture; St, high-strength suture.)

High-strength sutures are used for double tibial fixation. We routinely use these sutures for BTB autograft to ensure more secure graft passage and to ensure the necessary traction for graft fixation. We recommend double tibial fixation in situations in which the risk of tibial fixation failure is increased: revision surgery, poor bone quality, 1-stage ACL revision (dilated tunnel), 2-stage ACL revision (poor quality of the grafted bone in the tibial tunnel), and interference screw size error (small screw).

We have performed no biomechanical studies or high-level evidence studies statistically analyzing whether the described technique represents a real increase in tibial fixation. However, we have performed more than 100 cases and have not yet encountered any failures.

The gold standard for BTB fixation is the interference screw.[10] However, patients in whom screw fixation is unsatisfactory may benefit from our technique. In conclusion, supplementary tibial fixation in ACL reconstruction using BTB graft with osteosutures is a simple, inexpensive, and reproducible technique that potentially decreases the risk of further complications and failure.

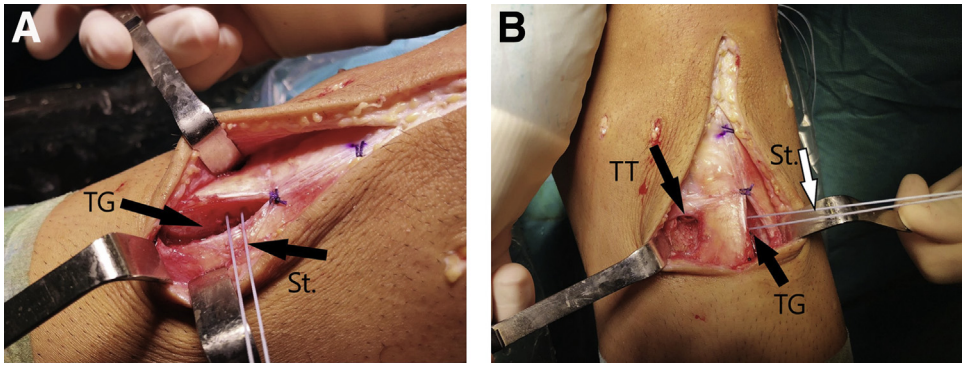

Fig 10. (A, B) We recommend a 1-cm separation between the 2 tunnels (left leg). (St, high-strength suture; TG, tibial groove; TT, tibial tunnel.)

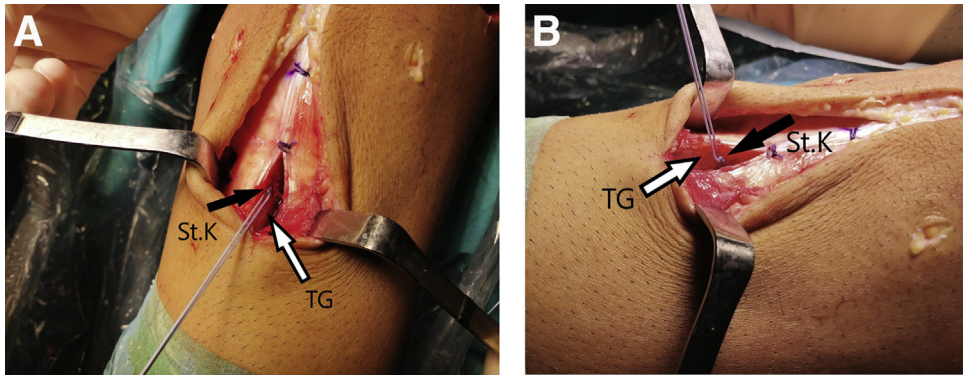

Fig 11. (A, B) Both sutures are knotted (StK), and the knots are left in the tibial groove (TG), where they will not cause discomfort because they do not come into contact with the skin.

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