Technical Note

Quadrupled Semitendinosus Anterior Cruciate Ligament Reconstruction Without the Use of Tourniquet and Minimal Instrumentation: The "Double D" Technique

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Abstract: The hamstring tendons are among the most common autografts used for anterior cruciate ligament reconstruction. Typically, the ipsilateral knee's gracilis and semitendinosus tendons are harvested. More recently, studies have described the use of just 1 of the tendons (the semitendinosus [ST]) in a tripled or quadrupled configuration, particularly in all-inside reconstructions. Instead of using a double gracilis and ST, a quadrupled ST tendon allows for a graft with enough diameter to more closely mimic the natural anterior cruciate ligament while lowering the likelihood of graft rupture. The use of tourniquets has been reported to increase the risk of complications, particularly deep vein thrombosis. This Technical Note describes an anterior cruciate ligament reconstruction performed with a quadrupled ST, without the use of a tourniquet, and with only the reamers and a tibial guide as surgical instrumentation.

The 2 most commonly used autografts for anterior cruciate ligament (ACL) reconstruction are the patellar tendon and the hamstring tendon.[1] Quadrupled semitendinosus (ST) has been described as an all-inside method with a cortical button.[2,3] Theoretically, sparing the gracilis tendon could offer the benefit of preserving the knee's deep flexion strength.[4] This can result in quicker recovery and better prospects of returning to play at the same level.[1-3] In contrast, the ST tendon is wider than the gracilis tendon. A larger-diameter graft is produced by a quadrupled ST than by a doubled ST—gracilis composite.[5,6] This is crucial, since it has been determined that hamstring graft size poses a danger of rupture when the diameter is less than 8 mm.[6] A recent study showed that ACL reconstruction performed without a tourniquet resulted in a significantly reduced incidence rate of deep venous thrombosis and significantly less bleeding from drains.[7,8] The use of a tourniquet during ACL reconstruction has also been hotly disputed.[7,8] Using this surgical approach, we describe ACL reconstruction performed with a quadrupled ST, without the use of a tourniquet, and with only the reamers and a tibial guide as instruments (Table 1).

Surgical Technique (With Video Illustration)

Patient Preparation and Positioning

After subarachnoid anesthesia, clinical tests are performed to ensure knee stability, and before positioning, an injection with a vial of mepivacaine 2% 10 mL (Carbosen; Galenica Senese Srl, Siena, Italy) and 0.3 mg/mL of adrenaline (SALF SpA, Cenate Sotto, Italy) is performed at the level of the pes anserinus and intra-articular region. If there were no particular contraindications, a gram of tranexamic acid (Bioindustria L.I.M., Novi Ligure, Italy) was injected intravenously.

The patient is placed in the supine position on the operating table with lateral support at the level of the thigh and a foot roll positioned to stabilize the leg at 90° of knee flexion (Fig 1). The injured leg is prepared and draped using the surgeon's preferred method, and then appropriate landmarks are palpated and marked.

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Table 1. Advantages and Disadvantages of the "Double D" technique

Advantages	Disadvantages
No use of a tourniquet	ST tendons shorter than 24 cm may not be visible in the tibial tunnel
Preservation of gracilis and strength in flexion	
Only tibial guide use for the procedure (except reamers)	
Greater diameter graft compared with double gracilis–ST graft	
Cheap technique	
Good visualization during all the procedure	
Real fit femoral tunnel	

ST, semitendinosus.

Semitendinosus Harvesting

There are important anatomical landmarks for the ST autograft harvest. First, the tibial tubercle and the posteromedial cortex of the proximal tibia should be identified. A midpoint between these 2 landmarks can usually be found when the pes anserinus is palpated under the skin. The incision should be made from this midpoint directed downward, longitudinally, and between 2 and 4 cm (Fig 2). Due to local injection, hemostasis is not necessary. At this point, dissection of soft tissue is performed until the pes anserinus can be exposed and visualized.

Next, the distal pes anserinus is lifted with a small "L"-shape incision, dissecting first the superficial sartorial fascia that covers the tendons. As the ST tendon is detached from the bone, try to preserve the gracilis insertion as best as possible. Find the division between the ST and gracilis. It is easier to identify their division from underneath. There is an overlap between them that can make it challenging. Once you split between them with scissors, find 1 or 2 attachments that the ST tendon might have to the medial gastrocnemius (Fig 3). Next, the tendon is extracted using an open stripper (Concept 8750 Tendon Harvester; Conmed Linvatec, Largo, FL). This kind of stripper, performed before proximal detachment, allows for a tendon long enough to be quadrupled. After proximal detachment, it is important to harvest the ST from the tibia, taking as much tendon as possible.

Fig 1. The patient is positioned in the supine position without a tourniquet, with lateral support at the level of the thigh and a foot roll positioned to stabilize the leg at 90° of knee flexion. The red circle shows how the tourniquet is not even placed for safety so as not to interfere with the harvesting of the semitendinosus.

Fig 2. Right knee, flexed at 90°. Identification of the pes anserinus. The 2 landmarks are the tibial tubercle and the posteromedial cortex of the proximal tibia. The incision should be made from this midpoint directed downward, longitudinally, and between 2 and 4 cm. The dotted line shows the position of the incision, which should be performed oblique to avoid injury to the infrapatellar branch of the saphenous nerve.

Graft Preparation

The tendon is measured and mixed with saline and 1 g of vancomycin (Mylan, Milano, Italia). The aim is to have a tendon of at least 24 cm to quadruple it. Fold it

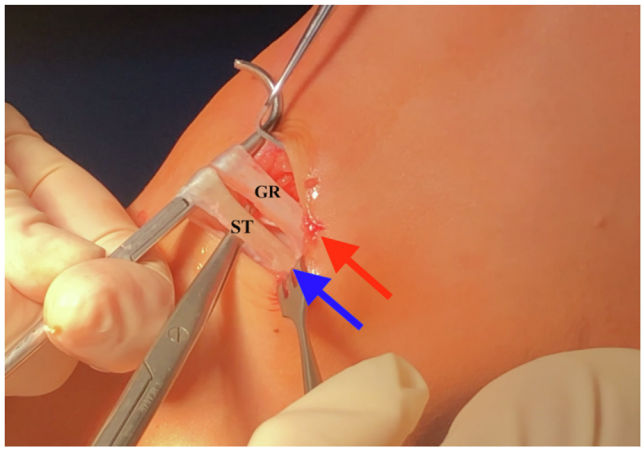

Fig 3. Right knee, medial side. Identification of the hamstrings, usually the gracilis is above and the semitendinosus below. The blue arrow shows the semitendinosus, whereas the red arrow shows the gracilis. (GR, gracilis; ST, semitendinosus.)

twice and hang it on the ULTRABUTTON device (ULTRABUTTON Adjustable Fixation Device; Smith & Nephew, London, United Kingdom). Any other suspensory device can be used. With this suspensory system, it is important only to measure the entire femoral tunnel. Finally, sutures (VICRYL 2; Ethicon, Raritan, NJ) are added to the end of the quadrupled tendon; it is then ready to be used as an ACL graft (Fig 4). The minimum acceptable length for the graft is 6 cm; otherwise, it is mandatory to tripled the ST or harvest the gracilis tendon. The graft is marked with a stitch at the same point of the half-tunnel femoral length (Fig 5).

Diagnostic Arthroscopy

High anterolateral and anteromedial portals are established. Diagnostic arthroscopy is performed, and any meniscal or chondral lesions are addressed before ACL reconstruction.

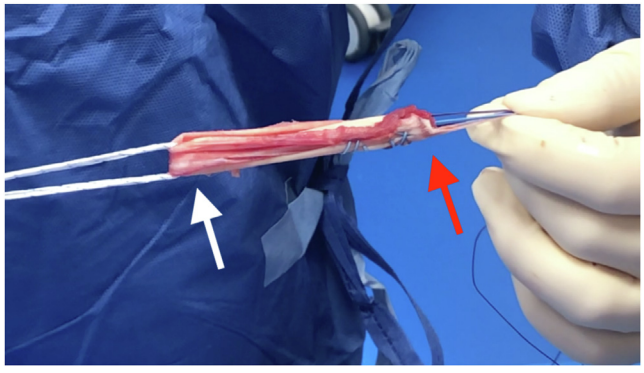

Fig 4. The semitendinosus has been quadrupled and is ready to be used as an ACL graft. The white arrow shows the proximal part of the tendon fixed with the ULTRABUTTON device, which will be fixed at the femoral side. The red arrow shows the distal part that will be fixed at the tibial side.

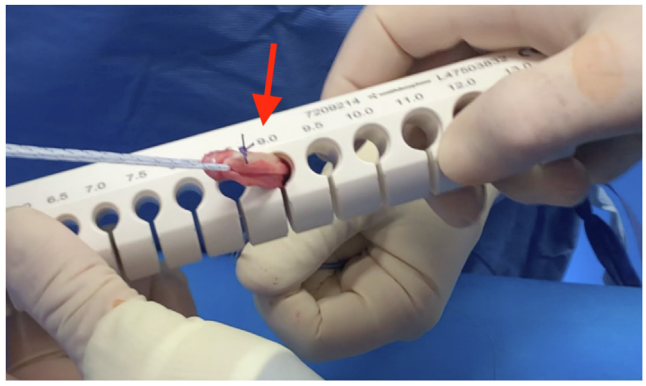

Fig 5. Measurement of the graft. With quadrupled ST, the average size is 9 mm in diameter. The red arrow shows the exact size of the graft.

Femoral Tunnel

After assessing the integrity of the other structures, preparation of the femur is started. With a 4.5-mm shaver (DYONICS; Smith & Nephew), the medial aspect of the lateral femoral condyle is prepared to visualize anatomic ACL insertion. As a single-bundle technique, we performed the tunnel in a midpoint between the anteromedial and posterolateral bundle footprint. After femoral preparation, a far medial portal is created. With the knee flexed at 90°, a 7-mm reamer is introduced from the far medial portal to reach the desired anatomic femoral insertion. With this reamer, we can check that there is no contact with the medial femoral condyle, avoiding iatrogenic chondral lesions. Once the desired position has been reached, holding the reamer at the desired point, the assistant flexes the knee up to 120°. If the reamer should move during knee flexion, it is mandatory to repeat the passage. With the knee at 120° and the reamer at the desired point, a Kirschner wire is introduced through the reamer to reach the lateral cortex of the femur. At this point, the 7-mm reamer is removed, and unlike the other techniques, we proceed with the half-tunnel creation (usually with a quadrupled semitendinosus, the diameter is at least 9 mm). This allows a true 9-mm tunnel to be milled; otherwise, if it were milled after the 4.5-mm reamer, it could flake out and create a much larger tunnel than 9 mm. The size of the femoral half tunnel is usually 20 to 25 mm (Fig 6). After this step, the 9-mm drill is removed, and the 4.5-mm drill is used to mill the entire femur up to the lateral cortical; if the technique has been performed correctly, the complete femoral tunnel should be 35 to 40 mm. Once the femoral tunnel was completed, a transport wire (VICRYL 2; Ethicon) was pulled out of the skin at the femoral level.

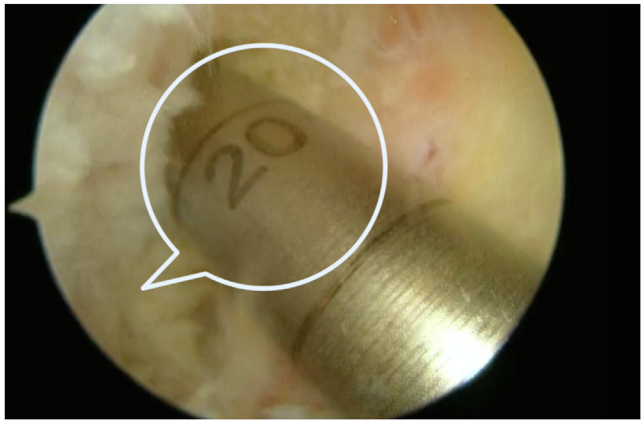

Fig 6. Arthroscopy view from anterolateral portal, with 30° arthroscope; right knee. The white circle highlights the desired size for the half tunnel into the femoral condyle (20 mm) performed with the 9-mm reamer.

Tibial Tunnel

The knee is placed again at 90° of flexion. The tibial ACL guide is set at 55° and then introduced through the anteromedial portal (ACUFEX DIRECTOR; Smith & Nephew). It is positioned over the ACL footprint, and a guidewire is inserted. The tibial tunnel is established, starting with a 6-mm reamer and then upsizing to a 9-mm reamer once the position is confirmed. A shaver is then introduced into the tibial tunnel to debride the aperture of the tunnel. The transport wire is retrieved from the tibial tunnel with a grasper.

Graft Passage

At this point, the graft is introduced into the transport wire and passed through the tibial and femoral tunnels. Care must be taken to ensure that the femoral tunnel is truly fit, so the passage should be checked through the arthroscope to avoid exiting the system from the skin (Fig 7). After femoral fixation, the graft is fixed to the tibia using a bioscrew one size larger than the tunnel (BIOSURE; Smith & Nephew) with the knee flexed at 10° and in the posterior drawer position. After tibial fixation, the ACL was checked to ensure proper tension, and intraarticular and along-ST harvesting

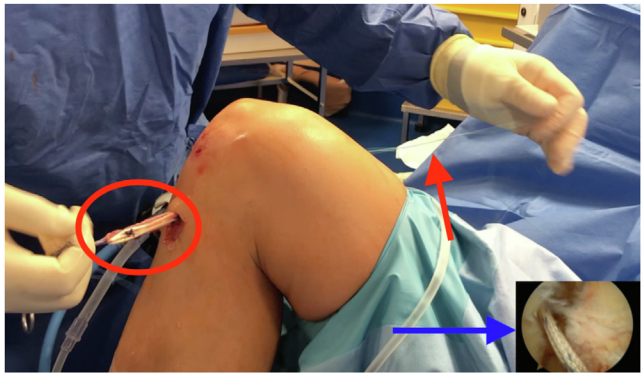

Fig 7. Right knee. The graft is introduced into the transport wire and passed through the tibial and femoral tunnels. The passage is checked by the arthroscope from the anterolateral portal (blue arrow). The red arrow shows the wires of the ULTRABUTTON device exiting from the femoral tunnel, whereas the red circle shows the graft passing through the tibial tunnel.

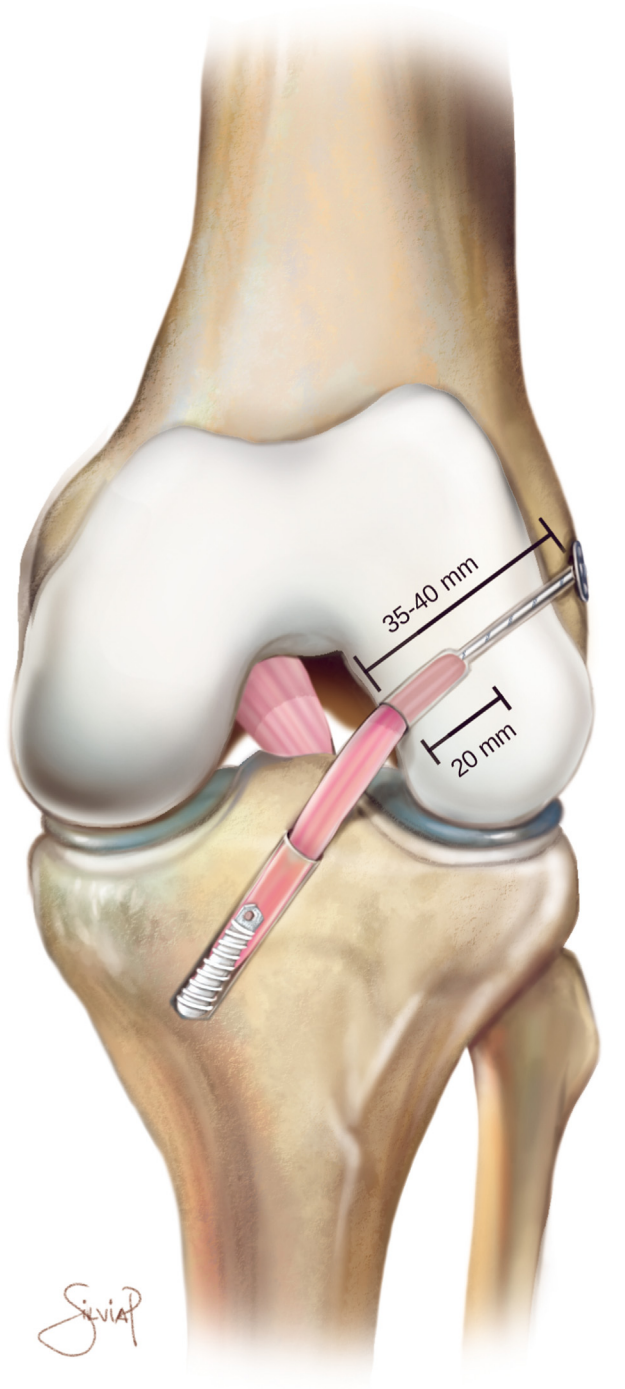

Fig 8. Final fixation of the graft with a cortical button in the femur and interference screw in the tibia. Anterior view of a left knee. The mean half-femoral tunnel is 20 mm, while the complete femoral tunnel is approximately 35-40 mm.

Table 2. Tips and Tricks for the "Double D technique"

An oblique skin incision is used for graft harvest. This avoids injury to the infrapatellar branch of the saphenous nerve.
If no assistant is present, when you have to flex the knee up to 120°, you can use your knee to push the feet of the patient, keeping the knee in external rotation
Check from the anteromedial portal the complete passage of the suspensory system through the femoral tunnel
Use a VICRYL 2 suture for the graft and as wire transport
Always harvest the ST proximally first and then distally. This can ensure a right tendon length
For tibial fixation, use screw one size larger than the tunnel
Soak the graft in the vancomycin
Do not place a tourniquet, even for safety. This may interfere with ST harvesting
Do not remove all the muscle from the graft. The muscle can help in graft healing due to high vascularization
Always ream before the half tunnel and then with the 4.5-mm reamer for the femoral preparation

ST, semitendinosus.

tranexamic acid administration (2 vials) was performed (Fig 8). Tips and tricks of the surgical technique are reported in Table 2.

Postoperative Rehabilitation

Postoperative rehabilitation began with brace-free, full weight-bearing, and progressive range-of-motion exercises. No restriction of range of motion is indicated. Early rehabilitation focuses on maintaining full extension and quadriceps activation exercises. Return to sports is allowed at 4 months for nonpivoting sports, 6 months for pivoting noncontact sports, and 8 months for pivoting contact sports.

Discussion

This technique has the main advantage of avoiding the use of a tourniquet by performing an intra- and peri-articular injection of mepivacaine and adrenaline to avoid bleeding.

According to recent studies, the incidence of deep venous thrombosis in tourniquet-aided ACL reconstruction surgeries can range from 6.6% to 41.2%.[7,8] Several concerns have been reported because ACLR without the use of a tourniquet might increase the length of the procedure.[7,8] For this, the injection with mepivacaine and adrenaline, as reported in our technique, dramatically improves the quality of the field-of-view and procedure. Furthermore, the proper use of an irrigation pump can limit intra-articular hemorrhage and secure an operating visualization—even without the use of a tourniquet.

Another advantage reported with our technique is the elective use of semitendinosus, preserving the gracilis. The addition of gracilis harvest to an isolated ST harvest for ACL reconstruction results in statistically significant differences in isokinetic and isometric hamstring strength as well as patient-reported outcomes.[3]

A clinical study suggested that an additional harvest of gracilis negatively affected knee flexion isokinetic torque at low angular velocity.[9] In addition, it is less expensive than the all-inside and outside-in techniques. Only the reamers and tibial guide are used, and using 1 screw and 1 suspensory system is inexpensive and easily reproducible.

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