Knee Series
Technique Guide

Triple Bundle ACL Reconstruction Using the Smith & Nephew ENDOBUTTON® CL Fixation System

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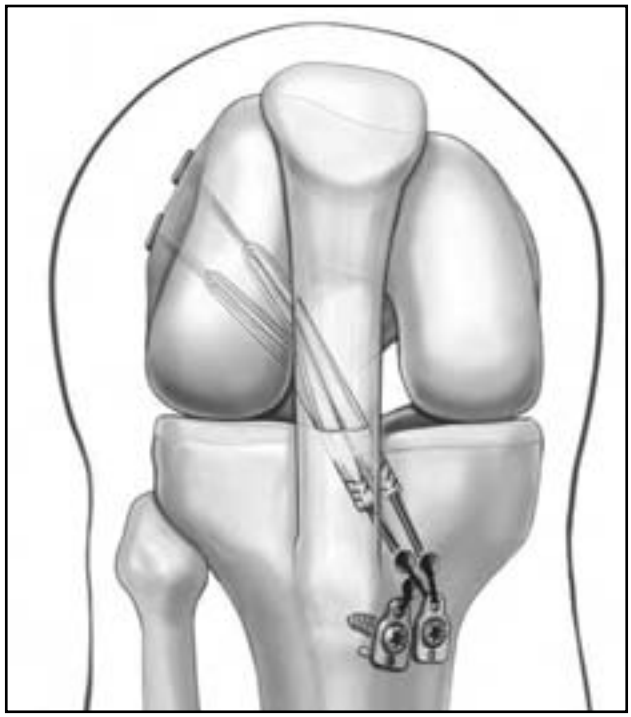

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Introduction

The natural ACL fans out to form a crescent-like footprint on the femur and an elongated, triangular one on the tibia, and can be seen as three bundles: anteromedial (AM), intermediate (IM) and posterolateral (PL) (Figure 1). Norwood and Cross describe that the anteromedial bundle contributes to anterolateral stability, the intermediate adds to anterior and anteromedial stability, and the posterolateral assists in posterolateral stability. Amis and Dawkins expand on that to show that each bundle contributes to anterior stability based on the flexion angle.

Traditionally, ACL reconstruction has focused on restoring one or two anterior bundles (AM and/or IM) under the concept of isometric graft placement. Dr. Konsei Shino established the triple bundle ACL reconstruction technique using two double-looped semitendinosus tendons to closely mimic the original three bundles of the natural ACL. Using the advanced instrumentation co-developed by Smith & Nephew Endoscopy, Dr. Shino believes this novel technique can facilitate the graft remodeling thanks to an increased graft-tunnel contact area, as well as a biomechanical function that is close to that of the natural ACL.

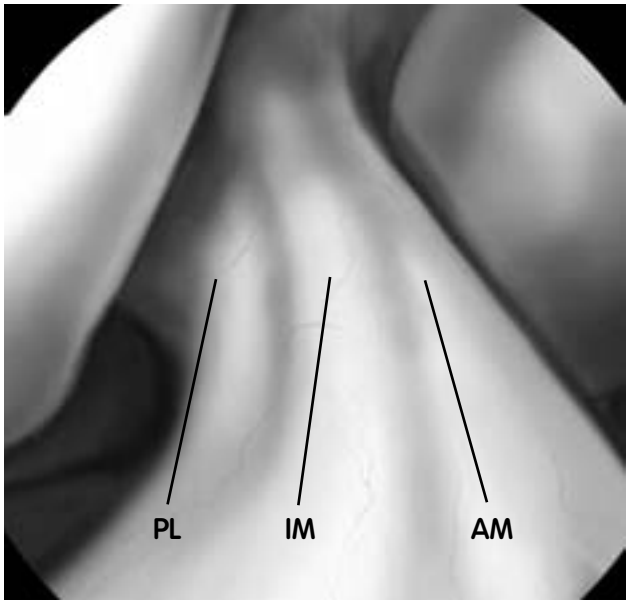

Figure 1. An arthroscopic view of the normal ACL.

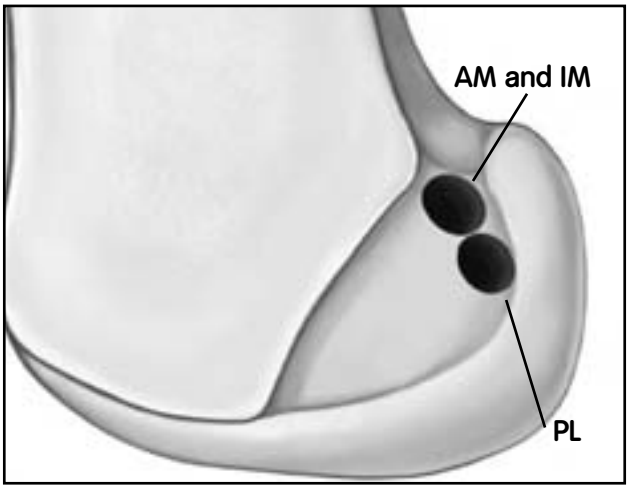

Figure 2. Tunnel locations in the femoral footprint of the right knee.

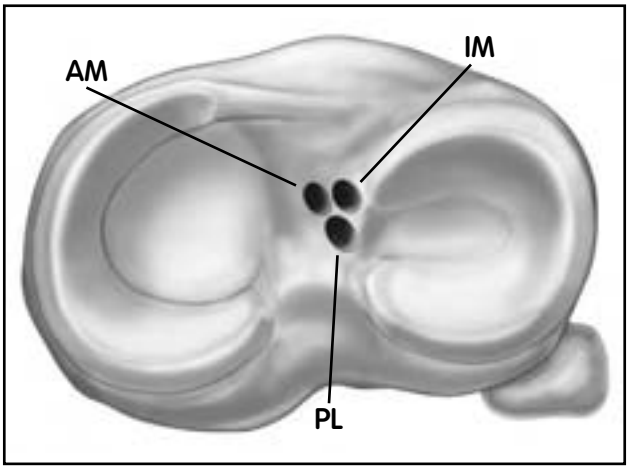

Figure 3. Tunnel locations in the tibial footprint of the right knee.

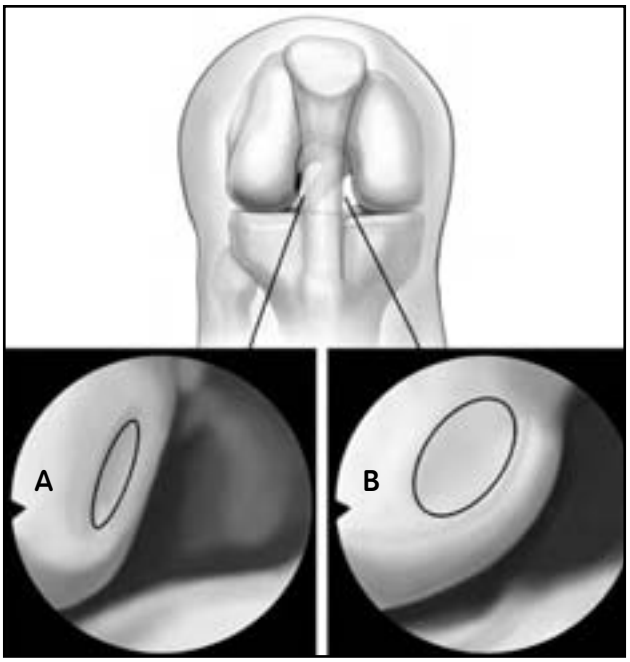

Figure 4. Arthroscopic views of the femoral footprint in the right knee through the anterolateral portal (A) or through the anteromedial portal (B).

Technique and Instrument Development

When developing the technique, a key question was whether to place two or three tunnels in the femoral footprint. Dr. Shino worked with Smith & Nephew Endoscopy to develop the necessary instrumentation and technique, which center on an outside-in drill guide and the use of only small drill bits (up to 6 mm).

Dr. Shino found that placing the two femoral tunnels using a drill guide applied 45° to the femoral axis in the frontal plane resulted in an elongated oval aperture where each tunnel met the femoral footprint. The elongated apertures of the tunnels eliminated the space available for a third tunnel to be used for the intermediate graft (Figure 2). As a result, the two femoral and three tibial tunnel (Figure 3) technique was adopted as a practical choice.

An oblique arthroscope in the AM portal provides an excellent view of the tunnel placement in the femoral footprint (Figure 4). Since it is much easier to observe the femoral footprint through the AM portal than it is through the anterolateral portal[8], an anterolateral entry femoral aimer was designed.

The Smith & Nephew Anterolateral Entry Femoral Aimer with 6 mm Offset Tip (REF 7210984) (Figure 5), combined with the view of the offset tip via the AM portal, makes it possible to consistently create the femoral tunnels in the anatomical footprint without compromising the tunnel location. This outside-in approach also provides more rigid fixation with an ENDOBUTTON® CL device on the femoral cortex at the cost of adding two 1 cm incisions on the lateral thigh.

This additional fixation is a result of the femoral tunnels always meeting the femoral cortex at an angle greater than 45°. Therefore, the ENDOBUTTON CL device cannot slip into a tunnel unless the tunnel's diameter exceeds 6 mm. If the tunnel diameter does exceed 6 mm, a Smith & Nephew XTENDOBUTTON Fixation Device (REF 72200134) can be used to prevent the ENDOBUTTON CL device from slipping into the tunnel.

The Smith & Nephew Stepped Tibial Offset Guide (REF 6901105) was developed to make creating the three parallel tibial tunnels (Figure 3) faster and easier (Figure 6).

Note: In some cases it is easier to create the PL tunnel using the Smith & Nephew Anterolateral Entry Femoral Aimer without 6 mm Offset Tip (REF 6901189).

Figure 5. The Smith & Nephew Anterolateral Entry Femoral Aimer with 6 mm Offset Tip. The targeting tip of the aimer is aimed at the guide pin for the upper femoral tunnel.

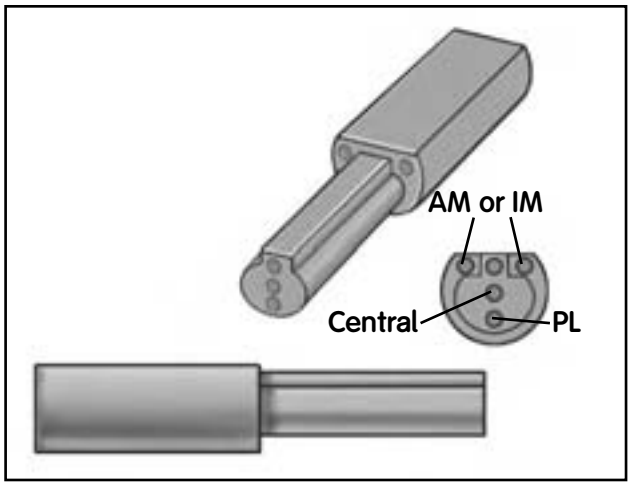

Figure 6. Stepped tibial offset guide for three tibial tunnels. The guide can also be used as an in-line offset pin guide for the two tibial tunnel technique.

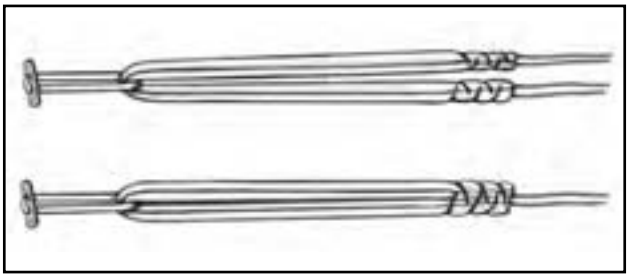

Figure 7. Prepared grafts.

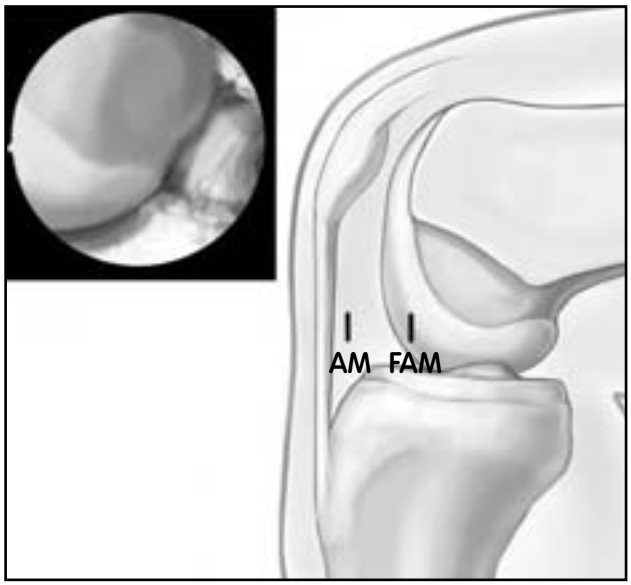

Figure 8. The FAM portal is 2–2.5 cm posterior to the standard AM portal.

Figure 9. The anterolateral entry femoral aimer with 6 mm offset tip in use in the right knee.

Surgical Technique

Patient Preparation

Place the patient supine on an operating table with the contra-lateral limb positioned in a well-leg holder and in a flexed and abducted position. Use an arthroscopic leg holder to secure the proximal thigh and lock it into position, letting the calf hang free. It is extremely important to keep the distal third of the thigh horizontal to get a consistent and excellent arthroscopic view of the femoral footprint (Figure 4 and Figure 8 inset).

Graft Harvesting and Preparation

For autogenous grafting, harvest the entire semitendinosus tendon, including distal periosteum, through a 4 cm oblique skin incision 3–4 cm medial to the tibial tubercle. Transect the tendon into two equal halves to create two double-looped grafts 60–70 mm in length and 5–6 mm in diameter. In the case of a semitendinosus tendon 24 cm or less in length, do not transect the tendon equally. Instead, transect the tendon so that the resulting double-looped AM graft is 10 mm longer than the double-looped PL graft.

Connect an ENDOBUTTON® CL device to the loop end, and place thick polyester sutures (#3 to #5) in each free end of the graft using baseball glove or whip stitches (Figure 7). One limb of the bifurcated anterior graft will be passed into the IM tibial tunnel as the intermediate graft in inside-out fashion, while the other is introduced into the AM tunnel as the anteromedial graft.

Arthroscopic Portals

Establish the two standard anteromedial and anterolateral portals. In addition, under arthroscopic visualization[4] use a 23 gauge needle to establish the "far anteromedial" (FAM) portal 2–2.5 cm posterior to the standard anteromedial portal and just above the medial meniscus. The FAM portal provides a more perpendicular access to the original femoral ACL footprint (Figure 8).

Femoral Tunnel Preparation

Remove the residual fibrous tissues on the femoral ACL footprint via the AM portal. A notchplasty or wall plasty will not be required. Identify the reference point of the posterior margin of the lateral wall at the level of the superior margin of the inner border of the articular cartilage.

With the reference point located, introduce the anterolateral entry femoral aimer with 6 mm offset tip through the AL portal (Figure 9). Insert the 2.4 mm guide pin for the AM and IM tunnel first. Insert the guide pin from the lateral cortex to a target 5–6 mm shallow of the reference point (at 2:00 o'clock for the left knee or at 10:00 o'clock for the right knee) (Figure 10, broken arrow). Use a small skin incision of 1 cm to insert the guide pin.

Remove the femoral aimer from the AM and IM guide pin and reposition the aimer to accommodate placing the PL tunnel guide pin. Target 5–6 mm shallow and inferior to the tip of the first pin (at 3:00 o'clock for the left knee or at 9:00 o'clock for the right knee) (Figure 10, solid arrow, and Figure 11). Use a small skin incision of 1 cm to insert the guide pin.

Use a 6 mm operative cannula (REF 6901106) and a cannulated drill that matches the diameter of the grafts to overdrill the passing pins and create the tunnels (Figure 12).

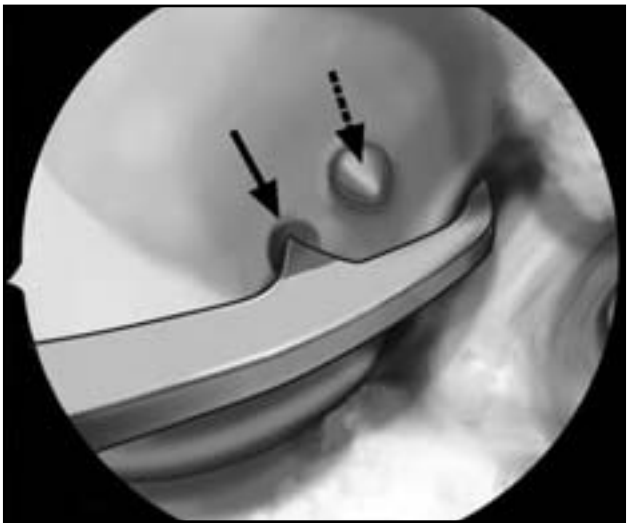

Figure 10. An arthroscopic view of anterolateral entry femoral aimer shows that the targeting tip of the aimer is aimed at the guide pin for the PL femoral tunnel (solid arrow) after insertion of the guide pin for the AM and IM tunnel (broken arrow).

Figure 11. The anterolateral entry femoral aimer repositioned to place the pin for the PL tunnel.

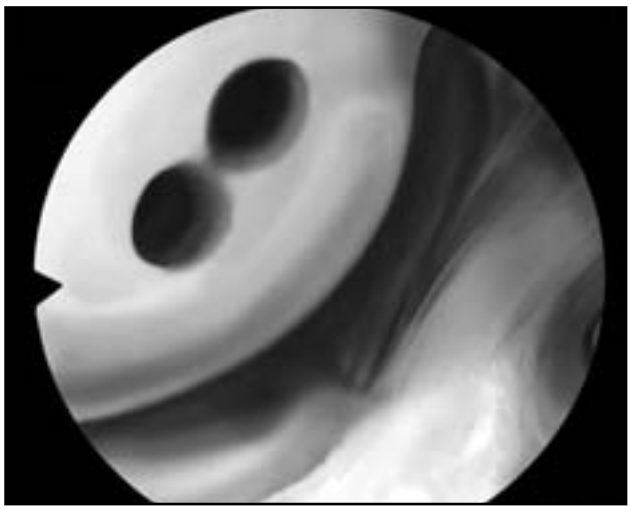

Figure 12. Two continuous femoral tunnels in the footprint of the right knee.

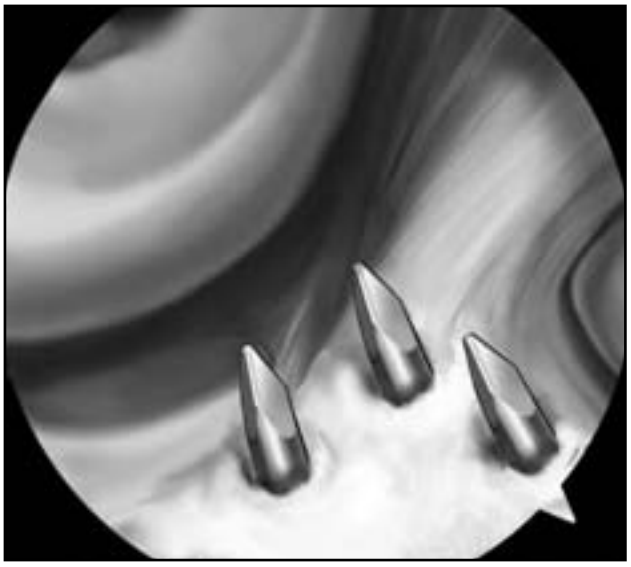

Figure 13. An arthroscopic view of the tibial footprint through the AM portal. Note three parallel guide pins forming an isosceles triangle. The distance between the two anterior pins is 7.5 mm, while that between each anterior pin and the posterior wire is 7 mm.

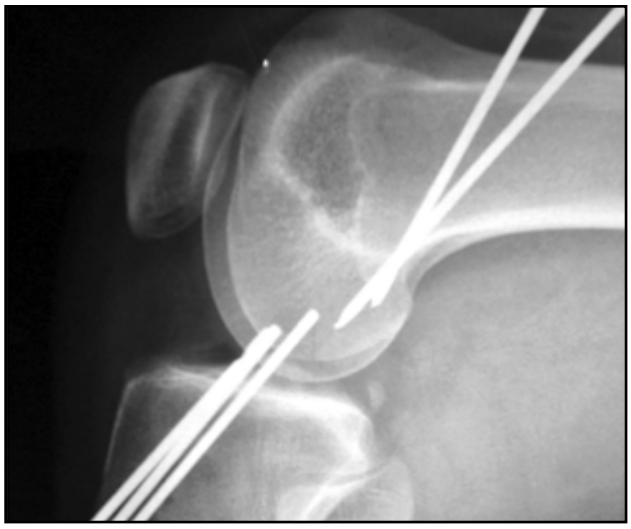

Figure 14. A lateral radiograph showing the location of the guide pins in the femur and the tibia.

Tibial Tunnel Preparation

Use the a Smith & Nephew ACUFEX® Director ACL Tibial Aimer (Elbow Aimer REF 7205518 or Tip Aimer REF 7205519) to insert a central passing pin from a point approximately 3 cm medial to the medial border of the tibial tubercle to the center of the footprint at an angle of 45° in the sagittal plane and 20–25° to the tibial axis in the frontal plane.

Use a 10 mm endoscopic drill bit to overdrill the central passing pin and break through superficial tibial cortex. Pass the central guide tunnel on the Smith & Nephew Stepped Tibial Offset Guide (Figure 6) over the central passing pin and insert the guide slightly into the tibial cortex.

With the stepped tibial offset guide in place, insert a second passing pin, the PL passing pin, parallel to the central passing pin. Take care that the PL parallel pin is on the plane 20° to the sagittal plane or along the line from the anterior horn of the medial meniscus to the posterior horn of the lateral meniscus.

Place the third pin for the IM tunnel and the forth pin for the AM tunnel into the anterior part of the footprint. Remove the central pin; the remaining three pins should form an isosceles triangle with a side of 7.0–7.5 mm (Figures 13 and 14).

Drill the three tibial tunnels with a drill bit that matches the grafts' diameters. Usually, the two anterior tunnels for a single strand graft are enlarged up to 5 mm in diameter, while the posterior tunnel for a doubled graft is expanded up to 6 mm.

Note: If a two tibial tunnel preparation is preferred, use the stepped tibial offset guide to insert the third guide pin for the anterior doubled graft in line with the central and posterior pins. Remove the central pin and drill the two tunnels to the same diameter.

PL Graft Passage

Use a 2.7 mm passing pin through the AM portal to insert a passing suture through the PL femoral tunnel. Use grasping forceps to retrieve the sutures through the PL tibial tunnel.

Pass the PL looped graft with the ENDOBUTTON® CL device leading the graft through the posterior tibial tunnel and into the PL femoral tunnel. Flip the ENDOBUTTON device to affix the graft to the femur. Insure at least 12.5 mm of the graft is inside the femoral tunnel.

AM Graft Passage

Attach the ENDOBUTTON passing sutures for the bifurcated anterior graft (AM and IM grafts) to a 2.7 mm passing pin. Use the FAM portal to insert the passing suture through the AM and IM femoral tunnel. Pull the AM and IM graft through the femoral tunnel, but not flip the ENDOBUTTON device at this time.

Introduce the free ends of the graft into the joint. Use a suture retriever to pull the IM graft into the IM tibial tunnel. Reposition the suture retriever and use it to pull the AM graft into the AM tunnel (Figure 15). Flip the ENDOBUTTON device to affix the AM and IM grafts to the femoral cortex.

Optional: Excise the residual stump at the tibial footprint to ease graft passage.

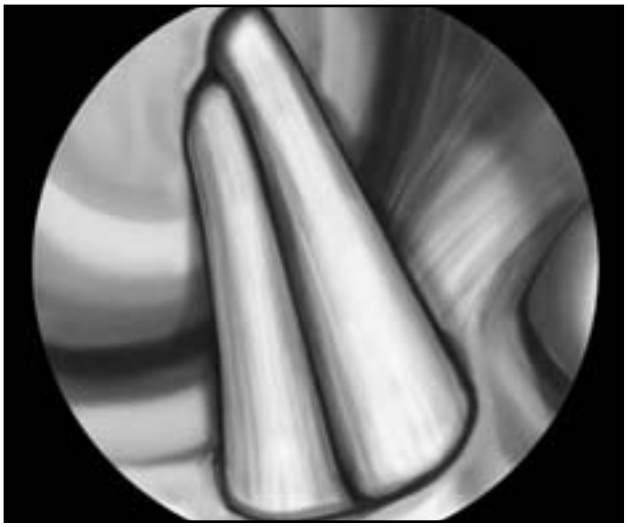

Figure 15. An arthroscopic view through the AM portal of an anatomic triple bundle hamstring graft in the right knee. Note that the tibial footprint is almost filled with the grafts, and that the AM graft is located superior to the IM graft in the femoral tunnel.

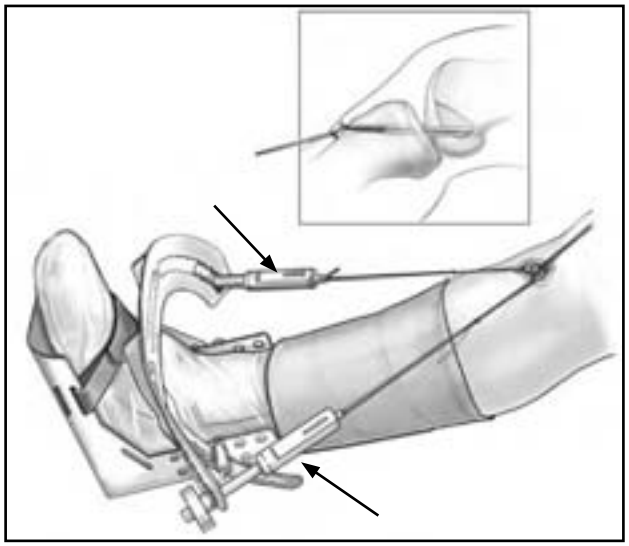

Figure 16. Graft fixation using DSP under tension of 30–40 N after femoral fixation at 15–20°. Note the tensioners (arrows) installed to the tensioning boot, which is bandaged to the calf.

Figure 17. A posterior-anterior radiograph at 45° showing fixation hardware. Note the ENDOBUTTON• devices' secure placement on the femoral cortex and the DSPs and screws installed in the tibia.

Tibial Fixation

Extra-tunnel suture fixation is preferred because only the semitendinosus tendon that provides two double-looped grafts of 6–7.5 cm length is harvested (Figure 16, inset). (If the gracillis tendon is harvested as well, a soft tissue interference screw or staple can be used). The author's choice is the MEIRA Double Spike Plate (DSP), which makes it possible to fix the grafts with predetermined tension[9].

Note: At the moment, the DSP is available only in Japan through Smith & Nephew Endoscopy, Japan. For countries outside Japan, a simple technique of tying sutures around a screw post and applying tension is recommend.

Manually tension the PL graft sutures as a whole and tie them to a small DSP. Tension the two anterior graft sutures (AM and IM) and tie them both to another DSP. Tie the tensioning sutures, distally connected to the two DSPs, to the tensioners mounted on a metal shell boot. The boot is affixed to the tibia with a bandage (Figure 16).

Apply a recommended 0.5 MPa of stress as the initial tension to the graft. To achieve this apply 10–15 N to each tensioning suture, based on the diameter of the graft. Once the tension is applied, move the knee through a passive flexion and extension movement several times. Retighten the tensioning sutures by repetitive manual pulling. After the tension stops dropping following load relaxation, maintain the knee at 15–20° under tension for an additional two minutes. Fix each graft with DSPs and two cancellous screws (Figure 17).

A final evaluation of the implanted graft confirms a notchplasty was not needed, as the anatomically-placed grafts never impinge against the roof or the wall of the intercondylar notch (Figure 18).

Figure 18. An arthroscopic view through the AM portal of the grafts in extension. Note that the graft is impingement-free and the entrance of the intercondylar notch is not prepared or widened.

Postoperative Rehabilitation

The knee is rehabilitated in a non-accelerated and controlled manner based on the following:

(1) an arthroscopic reconstruction results in minimal surgical invasion, therefore there is very little chance of developing arthrofibrosis following surgery;

(2) there is a dramatic change of the femoral tunnel angles at the femoral insertion site during range of motion exercise, aggressive flexion-extension movement prior to the graft incorporation into the drill hole might result in partial rupture or damage of the graft ("windshield wiper effect").

Postoperatively, splint the knee with an Aircast® Cryo/Cuff® in 10–15° flexion for a week. Partial weight bearing is allowed at 2–3 weeks, followed by full weight bearing at 4–5 weeks, when full extension is permitted. Jogging is recommended at 3 months. Return to strenuous activity is not allowed until 6 months postoperatively.

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Ordering Information

To order the instruments used in this technique call +1 800 343 5717 in the U.S. or contact your authorized Smith & Nephew representative. Some of these instruments are Made to Order (MTO) and have longer production times.

Instrumentation

REF	Description
7205518	ACUFEX® Director ACL Elbow Aimer
7205519	ACUFEX® Director ACL Tip Aimer
6901106	6 mm Operative Cannula (MTO)
7210984	Anterolateral Entry Femoral Aimer with 6 mm Offset Tip (MTO)
6901189	Anterolateral Entry Femoral Aimer without 6 mm Offset Tip (MTO)
6901105	Stepped Tibial Offset Guide (MTO)

Additional Instruction

Prior to performing this technique, consult the Instructions for Use documentation provided with individual components — including indications, contraindications, warnings, cautions, and instructions.

Courtesy of Smith & Nephew, Inc., Endoscopy Division

Caution: U.S. Federal law restricts this device to sale by or on the order of a physician.

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