Review Article

Anatomical femoral tunnel creation: outside-in versus anteromedial portal

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Abstract: If tunnels are created in the anatomical anterior cruciate ligament (ACL) attachment areas, the graft is able to mimic the orientation of the native ACL without impingement to the femoral notch or posterior cruciate ligament (PCL), leading to successful ACL reconstruction. This article describes the exact location of the ACL femoral attachment area and its landmarks based on histological study, the rationale behind creating anatomic tunnels, and a description of how to create anatomic tunnels during ACL reconstruction.

Keywords: Anatomical anterior cruciate ligament femoral attachment area (anatomical ACL femoral attachment area); landmarks; anatomical tunnels; outside-in approach; inside-out approach

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Introduction

It is mandatory to create tunnels in the anatomical attachment areas of the anterior cruciate ligament (ACL) for successful ACL reconstruction. This makes it possible for the graft to mimic the orientation of the native ACL without impingement to the notch or posterior cruciate ligament (PCL). In this section, we describe the exact location of the ACL femoral attachment area and its landmarks based on histological study, the rationale behind creating anatomic tunnels, and how to intraoperatively/arthroscopically identify the area, and some tips to create the anatomical tunnels.

ACL femoral attachment area and rationale of creating anatomic tunnel(s)

Iwahashi *et al.* histologically demonstrated that the direct insertion of the ligament to the femur is located as a crescent-shaped fovea at superior-posterior margin of the lateral wall of the intercondylar notch, and provided the area on 3D CT image by reconstituting the oblique-axial CT sections (1). Thus, the femoral insertion area of crescent shape has the following landmarks: the resident's/lateral intercondylar ridge, anteriorly; proximal cartilage margin, superiorly; posterior cartilage margin, posteriorly (2,3) (*Figure 1*).

It is our strong recommendation to create the tunnel aperture(s) inside the attachment area with thicker cortex not only to make the aperture(s) robust but to precisely mimic the orientation of the native ACL (4). Thus, we do not create a single big round tunnel of 10 mm or greater which destroys border of the attachment area or resident's ridge, but a single rectangular tunnel or two continuous round tunnels inside the area (3,5-8).

Set-up, portals and exposure of the femoral attachment area

The distal thigh is kept horizontal using a leg holder with the calf hung down with gravity. In addition to the routine anterolateral (AL) and anteromedial (AM) portals, the far anteromedial (FAM) portal is created

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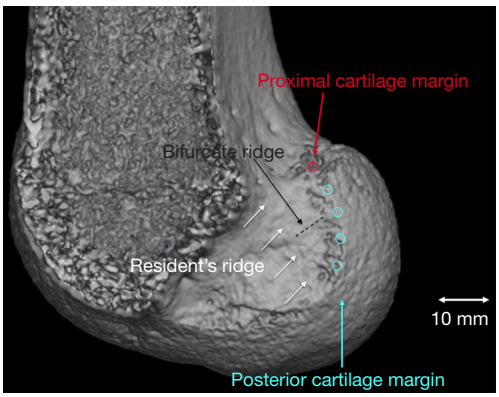

Figure 1 ACL femoral attachment area of the right knee shown on 3D CT. There are three landmarks to identify the area: the resident's ridge, proximal cartilage margin, posterior cartilage margin. ACL, anterior cruciate ligament.

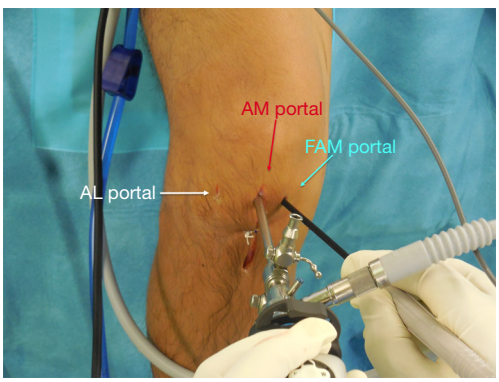

Figure 2 Three arthroscopic portals: AL portal, diagnostic; AM portal, for viewing; FAM portal, for instruments. AL, anterolateral; AM, anteromedial; FAM, far anteromedial.

2–2.5 cm posterior to the AM portal and just above the medial meniscus (*Figure 2*) (9). This portal makes it possible for instruments to get more perpendicular access to the ACL femoral attachment area on the lateral wall of the notch.

Viewing the posterior third of the lateral wall of the notch via the AM portal with a 45-degree oblique arthroscope, the fibrous tissues including ACL stump on superior-posterior half of the lateral wall of the intercondylar notch is thoroughly removed using a radiofrequency device and small curette through the FAM portal (8). Mechanical shavers are utilized only to roughly excise the fibrous tissue, leaving the subtle undulation of the bony surface around the attachment area intact. After cleaning up, the crescent-shaped attachment area is clearly delineated by the resident's ridge anteriorly, the proximal cartilage margin superiorly, and the posterior cartilage margin posteriorly (*Figure 3*). Even if the ridge could not be clearly identified, the other landmarks (proximal cartilage margin and posterior cartilage margin) could be used to assume the attachment area, as the long axis of the area or the ridge forms an angle of 31-degree to the distal femoral axis (8).

Outside-in creation of the anatomical femoral tunnel (s) (*Figure 4*)

While lateral femoral incision(s) and a drill guide are required, the outside-in technique is the gold standard for creating anatomical femoral tunnel during the anatomical ACL reconstruction for the following reasons: (I) good view

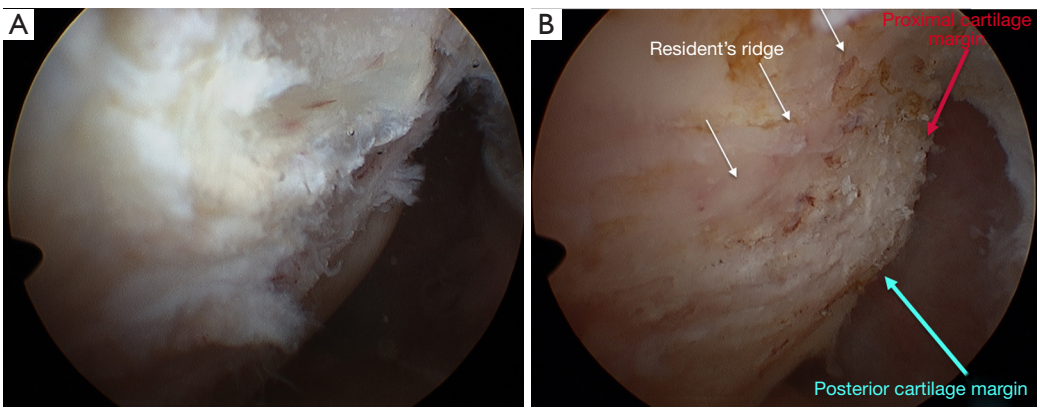

Figure 3 Arthroscopic views of the ACL femoral attachment area of the right knee via AM portal with a 45-degree oblique scope. (A) View before clearage of the fibrous tissue around the area; (B) view after clearage of the fibrous tissue around the area. The three landmarks to identify the area: the resident's ridge, proximal cartilage margin, posterior cartilage margin are visualized. ACL, anterior cruciate ligament.

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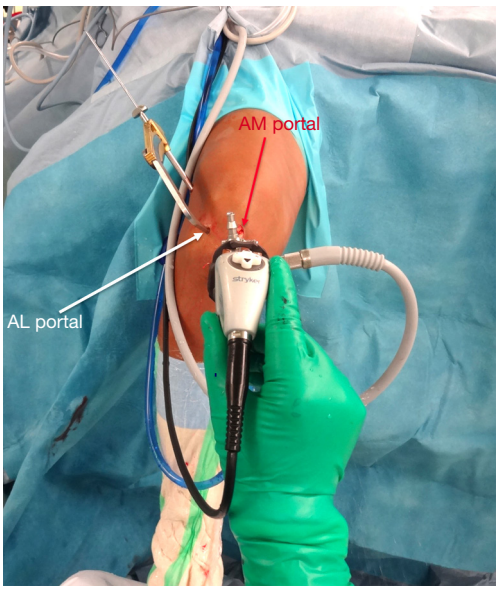

Figure 4 Outside-in technique for femoral tunnel creation. A guide pin is inserted in outside-in fashion through the drill guide via AL portal. AL, anterolateral.

is consistently obtained on the ACL femoral attachment site while drilling; (II) there is no risk to damage the articular cartilage of the medial femoral condyle; (III) no deep knee flexion is required.

Two continuous femoral tunnels for hamstring tendon graft

Only the suspensory fixation devices are recommended for secure fixation using the outside-in technique, because these devices can sit on the harder distal femoral cortex, and because the tunnels are longer with this technique.

After exposure of the ACL femoral attachment area, the area is transversely divided into two portions: upper proximal portion for the AM graft and lower posterior portion for the posterolateral (PL) graft. The centers of the two parts are marked with an awl with the AL-entry femoral guide (Smith & Nephew # 6901189 or 7210984) through the AL portal, two guide pins are drilled from the lateral cortex to the marked centers through small skin incisions of 1 cm in length.

The two pins are over drilled with cannulated drill-bits of diameter matched with the grafts' diameter in outside-in fashion through a 7 mm skin-muscle protecting cannula (*Figure 5*). With a retrograde drill, the over drilling can be performed in inside-out manner.

A single rectangular tunnel for a 10 mm wide bone-patellar tendon bone-graft

This approach is especially recommended for the knee with passive flexion of less than 140° to avoid blowout of the tunnel. Viewing the ACL femoral attachment area via the AM portal, two points are marked with a 5 mm distance in the center of the attachment area along its long axis to the resident's ridge using RF device or a micro-fracture awl. A central guide pin is drilled through a small lateral femoral incision into the center of the area from the lateral femoral cortex with the antero-lateral entry femoral guide (Smith & Nephew # 6901189, or 7210984) via the AL portal. An 11 mm skin protection cannula is installed over the guide pin via 2-cm lateral femoral incision. With the aid of a 10 mm In-line Offset Drill Guide, two guide pins are drilled parallel to the central pin along the long axis of the attachment area or the resident's ridge that forms an angle of 31° to the femoral axis (8). After the central pin is removed, two guide pins are over-drilled with 5 mm drill-bit. With the dilator of 5 mm × 10 mm (Smith & Nephew, # E0014050-2) from the lateral femoral cortex, the two drill holes are dilated into one rectangular tunnel in outside-in fashion (*Figure 6*).

Inside-out creation of anatomical femoral tunnels

While the lateral femoral incision(s) and a drill guide are not required, extreme knee flexion is mandatory to create the anatomical tunnels in an inside-out fashion (*Figure 7*). As the exit(s) of the created tunnels on the femoral cortex tends to go posterior and distal, the technique is disadvantageous for cortical fixation with suspensory fixation devices which requires harder cortical bones for secure fixation. Thus approach may not be recommended for creating two continuous femoral tunnels for hamstring tendon graft.

Rectangular tunnel for a 10 mm wide bone-patellar tendon bone-graft or bone-quadriceps tendon graft

Two points are marked with a 5 mm distance in the center of the attachment area along its long axis to the resident's ridge using RF device and a micro-fracture awl. With the knee deeply flexed over 140° while viewing with the arthroscope via AM portal (*Figure 7*), two guide pins are drilled from the marked points to the lateral

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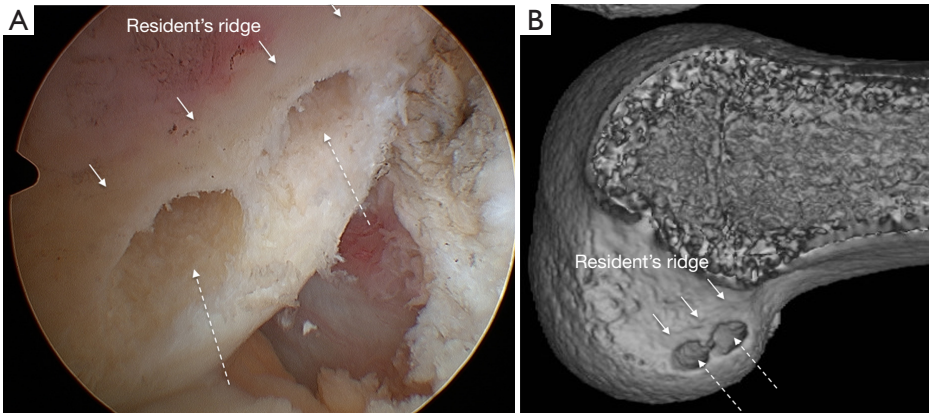

Figure 5 Two femoral tunnels created inside the attachment areas for hamstring tendon graft (dotted arrows). (A) Arthroscopic view through the anteromedial portal; (B) apertures on 3D CT image.

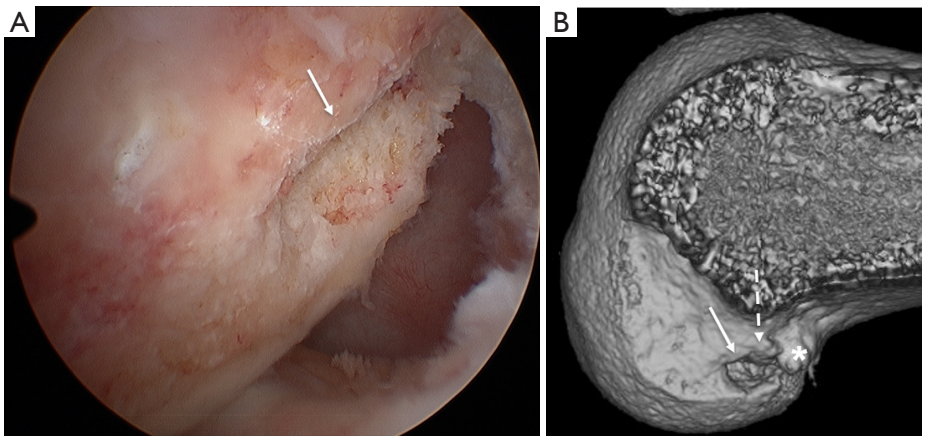

Figure 6 A rectangular femoral tunnel created inside the attachment areas for a BTB graft (solid arrow). (A) Arthroscopic view through AM portal; (B) aperture on 3D CT image. *, note the bone plug (dotted arrow) fixed with the interference screw. BTB, bone-patellar tendon bone; AM, anteromedial.

Figure 7 Inside-out creation of anatomical femoral tunnels. Note the knee is extremely flexed. The arthroscope is introduced via AM portal, while the drill is inserted through FAM portal. AM, anteromedial; FAM, far anteromedial.

femoral cortex via the FAM portal, and then over-drilled with a 5 mm cannulated acorn drill-bit. The created continuous two parallel round holes are dilated into one parallelepiped socket with the 5 mm × 10 mm cannulated dilator.

Summary

As the femoral ACL attachment area is located far back in the lateral wall of the notch, it is not easy to consistently create anatomical femoral tunnel(s), while it is mandatory for success in ACL reconstruction. Surgeons should be aware of the exact location of the attachment area and precise technique to create the tunnel inside the area.

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