Knee Surg Sports Traumatol Arthrosc (2007) 15:1023–1027
DOI 10.1007/s00167-007-0336-6

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Double-bundle anterior cruciate ligament reconstruction using two different suspensory femoral fixation: a technical note

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Received: 28 February 2007 / Accepted: 12 March 2007 / Published online: 12 May 2007

Abstract We describe a novel double-bundle reconstruction method for ACL deficient knee. Grafts are tibialis allograft for AMB (anteromedial bundle) and semitendinosus autograft for PLB (posterolateral bundle). Femoral fixations are done by Bio-TransFix for AMB and EndoButton for PLB. Tibial fixations are done by Bio-interference screw for AMB at 60–70° knee flexion and secure the PLB and remnant AMB graft simultaneously onto anteromedial aspect of tibia at 10–20° knee flexion with spiked washer and screw. With our technique, graft lengths are not restricted and we provide strong femoral and tibial fixation if it is compared with previous techniques.

Keywords Anterior cruciate ligament · Double bundle · Anatomic reconstruction · TransFix fixation

Introduction

Traditionally, anterior cruciate ligament (ACL) reconstruction techniques have focused on reconstruction of one portion of the ACL–AMB (anteromedial bundle). However, the ACL consists of two functional bundles and some limitations are proposed on using single-bundle reconstructions [18, 19]. With femoral fixation, it is well known that corticocancellous suspensory fixation is better than cortical suspension [12]. Therefore, we introduce a novel anatomic double-bundle ACL reconstruction using two different femoral suspensory fixation systems.

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Surgical procedure

Graft havest and preparation

For harvesting the semitendinosus graft and drilling the tibia tunnels, a longitudinal incision of about 3 cm is marked on the anteromedial tibia at the midpoint between the anterior tibial crest and the posteromedial tibial border, just adjacent and distal to the tubercle. Grafts' free ends are sutured with No. 5 Ethibond (Ethicon, Somerville, N) for about 3 cm length. Once the femoral tunnel length of PLB is determined, the corresponding EndoButton loop (Smith & Nephew, Andover, MA) is attached so that at least 20 mm of the tendon graft rests in femoral tunnel.

Diagnostic arthroscopy and preparation for reconstruction

The patient is placed in supine position and general or spinal anesthesia is induced. The end of the operating table is lowered so that the patient's knee can be flexed to 90°. The arthroscope is introduced via the anterior portals and the intraarticular structures are examined. The AM (anteromedial) portal is made more medial and inferior in its placement. A meniscus surgery is performed when needed. The torn ACL is debrided and native footprint of intercondylar notch and tibial eminence help in the correct anatomic tunnel placement. Notchplasty was performed minimally and we mark again the femoral footprint.

PL tunnel formation and Guide pin insertion for AMB

First, we create a tibial tunnel for PLB. We hold the knee 90° flexion and insert the ACL guide (Acufex Microsurgical, Mansfield, Massachusetts, 1988) at an angle of 55° via AM portal and point the guide tip to the most posterolateral aspect of footprint with considering graft diameter. The tunnel is made 45° obliquely from vertical line in coronal plane. Then the guide pin is advanced to anterior distal corner portion of femoral footprint with considering graft diameter and which is similar to the point previously identified by Yasuda et al. [19] (Fig. 1). Tibial exit point usually located at just anteromedial portion of LMPH (Lateral Meniscus Posterior Horn) insertion and femoral entry point is located at anterior distal corner of ACL footprint. Once the pin is in an acceptable position, the tunnel is drilled upto the far cortex with a 4.5 mm EndoButton drill and the depth of the tunnel is measured. The tunnel is usually measured from 35 to 40 mm and we ream the inner tunnel to 25–30 mm length using 6 mm reamer. After that, guide wire for AMB is positioned in a more anteromedial aspect on the tibial footprint with an ACL guide at an angle of 45 . Then the guide pin is advanced to proximal posterior portion of footprint, which is located 5 mm anterior from over-the-top position and mild

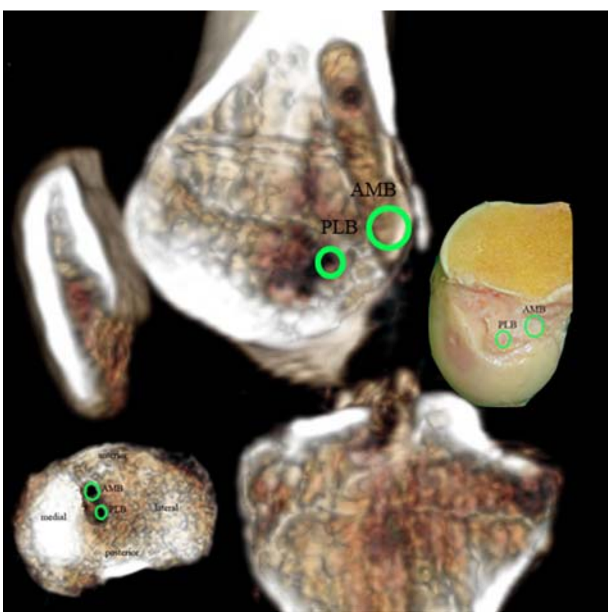

Fig. 1 Postoperative 3-dimensional computed tomograms show the tunnels that are formed at the expected positions. A picture of the lateral condyle and tibia plateau taken with a precise medial view (*AMB* anteromedial bundle, *PLB* posterolateral bundle)

mismatch of point was adjusted while reaming. This point is mildly posterior to that discussed by Yasuda et al. [19] said (Fig. 1).

AM tunnel formation and preparation for TransFix fixation

The AMB is very similar to single-bundle ACL reconstruction, and the starting point of tunnel for AMB is more anterior and central, so that an osseous bridge of approximately 1.5–2 cm remains on the tibial cortex between two pins. Tibial tunnel is located at anteromedial corner of ACL footprint with considering graft diameter. Tibial tunnel is reamed over guide pin according to the diameter of graft and a trastibial technique is used in the manner similar to single-bundle technique. The femoral tunnel of AMB is located at the posterior proximal corner of the ACL footprint with considering graft diameter (Fig. 1). The 6 mm over-the-top guide is placed on the posterior cortex of the notch between the 10:00 and 10:30 o'clock position and femoral tunnel is reamed for approximately 4 cm length for later TransFix (Arthrex, Naples, FL) fixation. TransFix tunnel hook that matches the tunnel diameter is assembled with the TransFix drill guide. The tunnel hook is inserted through the tibial tunnel and positioned in the femoral socket. The guide-pin sleeve is positioned on the skin of the lateral thigh, a small incision is made and the sleeve advanced to bone. The 5 mm broach, with depth stop collar, is drilled over 3 mm guide pin to broach cortex for the Bio-TransFix implant. Instead of graft passing wire, we use 23-gauge wire and Beath pin because of its cost and frequent breakage of original passing wire. Therefore, we remove all tunnel hooks and sleeve and reinsert the Beath pin with 23-gauge wire through previously formed hole with arthroscopic guide to be positioned at the central area of the tunnel. If the wire is positioned eccentrically, tendon breakage can occur (Fig. 2). The wire is then pulled out the tibia tunnel using probe while viewing from AL (anterolateral) portal (Fig. 3).

Graft passage

We insert the beath pin through tibia and femoral tunnel for PLB to lateral aspect of thigh. The beath pin is positioned posterior to passing wire for AMB in intraarticular location. The PLB graft is passed first and it is introduced through the tibial tunnel to the femoral tunnel using Beath pin. The EndoButton is flipped off the femoral cortical surfaces. For AMB, the midsection of the graft is positioned over passing wire with the graft-end lengths equalized. Needle holders are used to secure the free ends of the wire and to assist in graft passing.

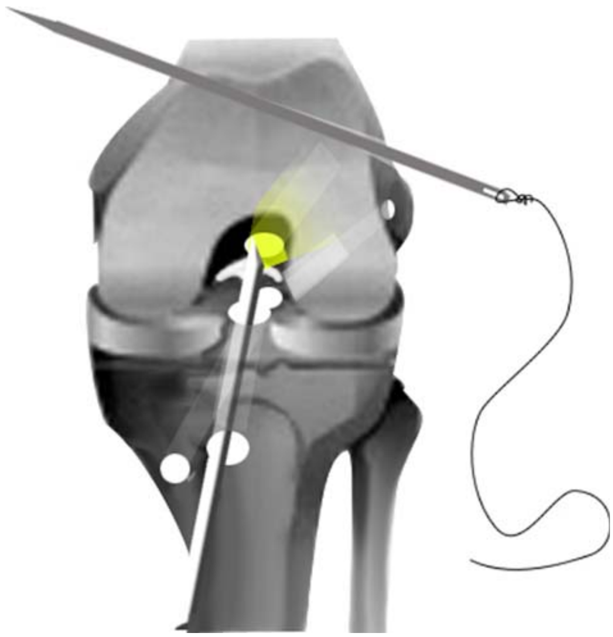

Fig. 2 The Beath pin with 23-gauge wire is inserted through previously formed hole via arthroscopic guide to be positioned central area of tunnel

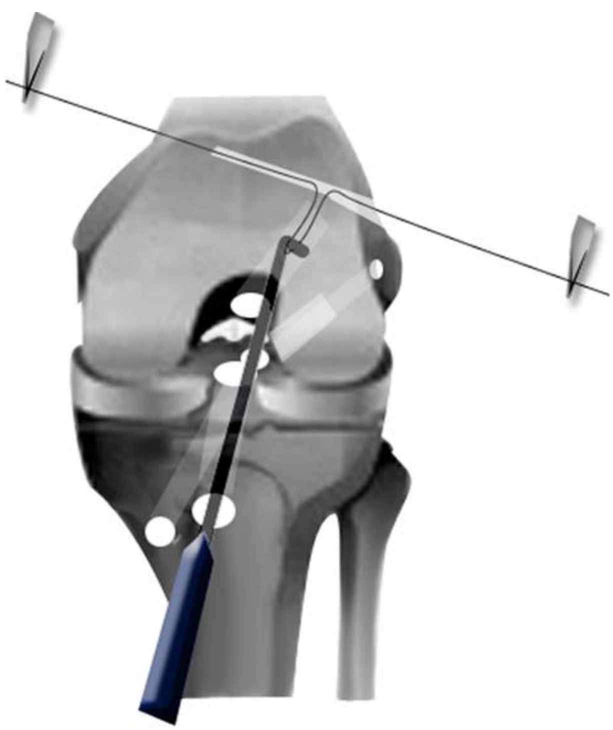

Fig. 3 The wire is pulled out the tibia tunnel using probe while viewing from AL (anterolateral) portal

Femoral and tibial sequential fixation

After graft passage, the Bio-TransFix dilator may be inserted over the wire and implant is engaged. After confirming that the grafts do not impinge on the lateral condyle of femur and cyclic loading, simultaneous tension of about 40 N to AMB and 20 N to PLB is given (Fig. 4). Tibial fixations are done by Bio-interference screw for AMB at 60–70° knee flexion and secure the PLB and remnant AMB-graft simultaneously onto anteromedial aspect of tibia at 10–20° knee flexion with spiked washer and screw (Fig. 5). Postoperatively the patient is placed in a hinged knee brace. Full-weight bearing is allowed with full extension brace. CPM is started on the second postoperative day after hemovac removal. The brace is unlocked at 1 week, and crutches are maintained for 6 weeks. We also followed standard ACL rehabilitation protocols.

Discussion

Attention has been drawn toward double-bundle technique because biomechanical analysis of the ACL showed that a double-bundle ACL reconstruction can more closely restore anteroposterior laxity and rotational stability of the normal knee than single-bundle reconstructions and numerous techniques have been introduced [2, 3, 6, 8, 9, 11, 14, 15, 19, 20]. In double-bundle reconstructions, there are many controversies over the number, position of tunnel, graft material and fixation methods [1–3, 6, 8, 9, 11, 13–17, 19, 20]. We chose the two tibial and two femoral tunnel, anatomic location, tibialis allograft and semitendinosus autograft, and two different suspensory femoral fixation in femur and one aperture fixation and simultaneous additional fixation in tibia. Yasuda et al. [19] reported a double-bundle technique that focused on the anatomic placement of the ACL. In their technique, they re-created two different bone tunnels based on their anatomic insertions on the femur and the tibia. They recommend placing the tunnel for the AMB at the 1:30 or 10:30 o'clock position at a distance of 5–6 mm from the back wall on the intercondylar notch and in an anteromedial position on the tibial footprint. The femoral tunnel for the PLB is placed at the intersection of the long axis of the insertion site of the ACL (which is directed posteriorly 30° from the long axis of the femur) and the vertical line drawn from the contact point between the femoral condyle and the tibial plateau at 90° of flexion. Our technique is similar to Yasuda's technique in that there are two separate tunnels that attempt to re-create their footprints. However, we think that the central area of AMB's femoral footprint does not coincide with Yasuda's point and we created femoral tunnel at a point 5 mm anterior from over-the-top position between the 10:00 and 10:30 o'clock position, which is also more isometric. In femoral fixation, there are three different fixation mechanisms: compression, expansion, and suspension. The last was further divided into cortical,

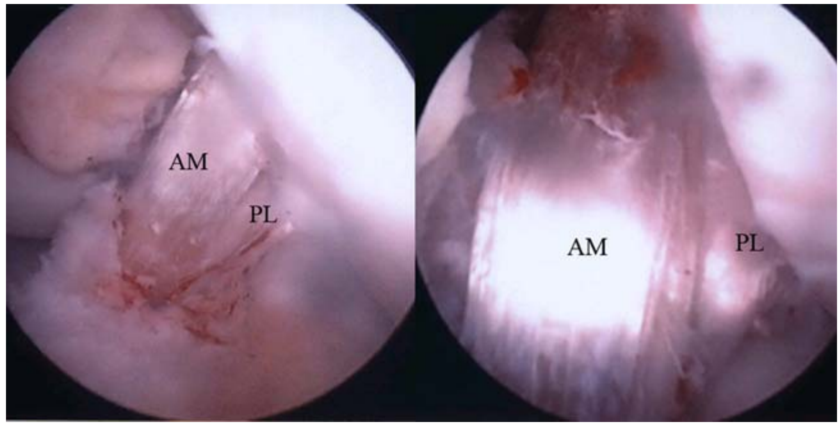

Fig. 4 The graft for AMB is seen anteriorly and PLB posteriorly. The graft's tension is changed according to flexion degrees of the knee joint

Fig. 5 Graft is fixed TransFix and Endobutton in femoral side and Bio-interference screw for AMB and with spiked washer and screw for PLB in tibial side

cancellous, and corticocancellous suspension mechanisms. TransFix implant is included with corticocancellous suspension devices and EndoButton is included with cortical suspension devices. Milano et al. [12] reported that cortical-cancellous suspension fixation achieved with transcondylar devices seemed to offer the best results in terms of graft elongation, fixation strength, and stiffness. There are many other reports maintaining that TransFix technique for ACL reconstruction has better results than other techniques using tendinous graft in strength [4, 5, 7, 10, 12]. We consider that AMB is the main bundle of ACL and must be reconstructed at the ideal position and with strong fixation. Therefore, this is the point where we positioned femoral tunnel and used TransFix femoral fixation for AMB. Tibial fixation was done by Bio-interference screw for AMB at 60–70° knee flexion and to secure the PLB and remnant AMB graft simultaneously onto anteromedial aspect of tibia at 10–20° knee flexion with spiked washer and screw. We think that it is more ideal for different bundles, which have different biomechanics. We performed abovementioned operation in 23 patients. 18 patients were followed more than 3 months and range from 4 to 18 months (average 9 months). Twenty-two patients gained satisfactory range of motion (above 130°) and showed good stability without definite Lachmann and Pivot-shift test. There were following complications. Two patients' endobuttons which were used for femoral fixation of PL bundle showed incomplete sitting on femoral cortex and one patient showed broken remnant wire in TransFix femoral fixation. Another patient showed postoperative mild infection and immediately debridement and irrigation were performed immediately. He showed grade two laxity, but his infection sign subsided luckily.

In conclusion, our technique has some advantages if it is compared with previous techniques in AM bundle femoral fixation and we can reduce the complication of TransFix fixation because we confirm the wire position if it is located centrally. We also attempt to reproduce the native insertion sites of ACL on the tibia and the femur while more closely re-creating the biomechanical function of native ACL.

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