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Arthroscopic double bundle ACL reconstruction using a bone patellar tendon bone—gracilis tendon composite autograft: a technical note

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Abstract The authors devised an alternative arthroscopic double bundle ACL reconstruction technique using a bone patellar tendon bone (BPTB)–gracilis tendon composite autograft. One tibial and two femoral tunnels were used to reconstruct two bundles of anterior cruciate ligaments (ACL) [an anteromedial bundle (AM) and a post-erolateral bundle (PL)]. BTBB was fixed in the tunnels produced on the isometric points of the tibia and femur using the conventional technique. The gracilis tendon was then fixed in a PL tunnel produced using the outside-in technique. The authors consider that the devised technique based on a combination of autogenous bone patellar bone graft and gracilis tendon, can minimize tunnel widening post-operatively, allow easier revision should the reconstructed ACL fail, and also provides an alternative means of restoring rotation stability.

Keywords Anterior cruciate ligament · Double bundle reconstruction · Bone patellar tendon bone—gracilis tendon composite autograft

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Introduction

Recently, several double bundle anterior cruciate ligament (ACL) reconstruction techniques have been devised for the anatomical restoration of knee stability [1, 2, 4, 7–13, 15–19]. These techniques vary and opinions are divided regarding graft type, fixation method, and the need for graft bundle tensioning. Allogenic grafts and hamstring tendons have both been used for double bundle ACL reconstruction [1, 13, 15, 18], Of fixation methods, one tibial and two femoral [7, 9, 10], two tibial and two femoral [4, 12, 15–19], and three tibial and two femoral tunnel techniques [13] have been reported. However, potential complications associated with tunnel numbers and tunnel enlargement due to hamstring tendon or allograft tendon positioned within increased numbers of tunnels should be considered [5, 14]. Here, the authors introduce an alternative double bundle technique that utilizes autogenous rather than allogenous grafts, and bone blocks of grafts positioned in both tibial and femoral sides to minimize post-operative tunnel enlargement, and facilitate revision if necessary.

Surgical technique

Graft harvesting and preparation

A 7- to 8-cm long longitudinal skin incision is placed on the distal side of the patella, extending distally to provide adequate exposure, and a bone patellar tendon bone (BPTB) autograft of the following dimensions is harvested; a trapezoidal shaped bone plug on patella of width 9 mm, length 25 mm, and depth 10 mm, and a bone plug on tibia of width 10 mm, length 25 mm, and depth 10 mm. In addition, through the distal portion of an incision, gracilis

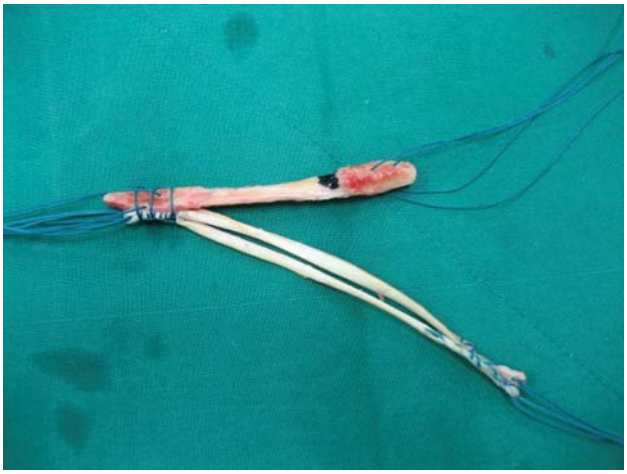

Fig. 1 A 9 mm sized bone plug, which will be combined with a folded gracilis tendon, was carefully prepared to allow it to easily pass within the anticipated 11 mm tibial tunnel, and the folded gracilis tendon was sutured to the cortical side of the 9 mm wide bone plug with Ethibond 2-0

tendon is harvested and folded, The folded gracilis tendon is then firmly attached to the cortical side of the 9 mm wide bone plug with Ethibond 2-0 and carefully prepared to allow it to pass easily within the anticipated 11 mm tibial tunnel (Fig. 1).

Notch preparation and tunnel preparation

The bone of intercondylar notch is minimally debrided using a burr. In terms of tibial tunnel preparation, the procedure used for tibial tunneling is identical to that used during the conventional single bundle technique. The size of the tibial tunnel is identical to the size of the combined bone block and gracilis tendon, i.e., it is 11 mm in diameter. For femoral tunnel preparation, a tunnel of anteromedial bundle (AM) of width 10 mm and depth 25 mm is made using a transtibial technique, and is positioned at the 11-o'clock orientation for the right knee or at the 1-o'clock orientation for the left knee. The femoral tunnel of the post-erolateral bundle (PL) is made using an outside-in technique using an ACL guide, as previously described [1]. A 2 to 3 cm skin incision is made over the lateral epicondyle of the femur and the iliotibial band is further dissected. The tip of the ACL guide is located 5–7 mm superior to inner margin of the lateral meniscus posterior horn in 90° of flexion. The guide pin is inserted from just posterior and proximal to the lateral epicondyle to the intra-articular PL point. The PL tunnel is drilled using a 4.5 mm cannulated reamer along the guide pin. The distance between the two tunnels should be more than 4 mm to avoid tunnel breakage. A wire loop is then introduced

Fig. 2 A wire loop was introduced into the joint from the outer cortex of the PL tunnel

into the joint from the outer cortex of the PL tunnel (Fig. 2).

Graft passage and fixation

The BPTB bone block for the AM femoral tunnel is first introduced. With the bone block positioned within the joint, a grasper is introduced into the joint to catch the wire loop behind the bone block. The wire loop passes out of the tibial tunnel as shown in Fig. 3. The gracilis tendon for the PL bundle is introduced through the tibial and femoral tunnels using the wire loop, and the bone block within the joint is then advanced and inserted within the femoral tunnel (Fig. 4). The bone block in the AM femoral tunnel is fixed with bioabsorbable interference screw, and then the bone block in the tibial tunnel is also fixed with a bioabsorbable interference screw with the knee in 10–20° of flexion. Finally the gracilis tendon in the PL femoral tunnel is fixed using a 7 mm diameter interference screw through a small lateral skin incision with the knee in full extension (Fig. 5). Post-operatively, the patient is placed in a hinged knee brace. Full weight-bearing is allowed with the knee

Fig. 3 The BPTB bone block for the AM femoral tunnel was first introduced, and with the bone block positioned within the joint, a grasper was introduced into the joint behind the bone block to catch the wire loop, which was then withdrawn from the tunnel

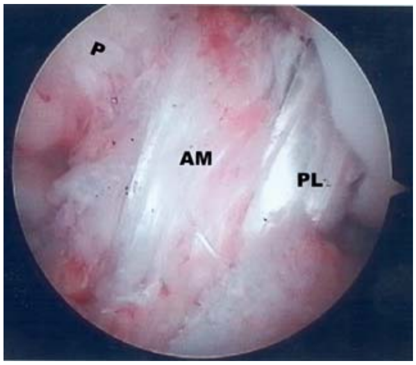

Fig. 4 The gracilis tendon for the PL bundle was introduced through the tibial and femoral tunnels using a wire loop, after then, the bone block within the joint was advanced and inserted within the femoral tunnel (P, PCL)

locked in extension. During the first post-operative week, CPM (continuous passive motion) is gradually increased to 90° of flexion. Subsequently, range of motion is increased to full flexion.

Discussion

Recently, ACL reconstructive procedures have focused on the endoscopic reconstruction of the anteromedial (AM) bundle and the posterolateral (PL) bundle of the ACL using a variety of graft choices and fixation options [1, 2, 4, 7–13, 15–19]. In terms of the graft materials used for double bundle ACL reconstruction, allografts, and hamstring autografts have become more useful, because of their greater lengths and strengths [3]. However, allograft implantation has its disadvantages, e.g., slower incorporation, potential bacterial contamination, and most importantly the possibility of disease transmission. Nevertheless, allograft tendons have been shown by several studies to provide an acceptable alternative to autograft tissue, in terms of clinical outcome. Therefore, we decided to use autografts rather than allografts.

Various fixation methods have been used, e.g., one tibial and two femoral or two tibial and two femoral, or three tibial and two femoral tunnel techniques, with several fixation methods have been used, e.g., the Endobutton, Endopearl, and transfemoral fixation systems. Today, the two femoral and two tibial bone tunnel technique is popular, because close to each other at the ACL footprint, and because it requires a hamstring tendon autograft [2, 11, 12, 14]. However, this method has additional potential complications, e.g., revision might be more difficult and more frequent, and post-operative tunnel enlargement caused by hamstring or allograft tendons positioned within more tunnels might also be more frequently encountered [6, 14]. In patients with ACL deficient knees that were treated with

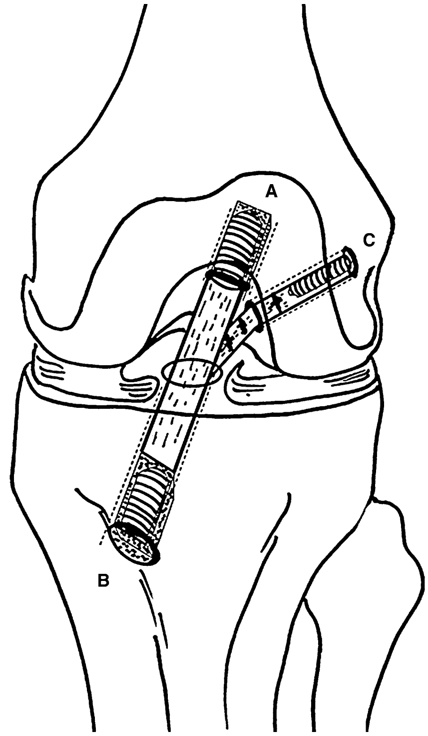

Fig. 5 The bone block in the AM femoral tunnel was fixed with a bioabsorbable interference screw (**a**), and then the bone block in the tibial tunnel was fixed with another bioabsorbable interference screw with the knee in 10–20° of flexion (**b**). Finally the gracilis tendon in the PL femoral tunnel was fixed with a 7 mm diameter interference screw through a small lateral skin incision with the knee in full extension (**c**)

a four stranded semitendinosus and gracilis graft rather than a BPTB graft, significant tunnel widening was reported [5]. Moreover, in Siebold's report [14], a 4-tunnel double-bundle hamstring autograft ACL reconstruction showed significant tibial and femoral bone tunnel enlargement on MRI 1 year post-operatively, when significant bone tunnel communication was observed on the tibial side. Using our technique, the number of tibial tunnels is reduced to one tunnel, and the two reconstructed bundles are within the knee joint. Several authors have reported a new technique involving two femoral tunnels and one tibial tunnel with various results [7, 9, 10]. In addition, using our technique, BPTB with a bone block at the both ends of graft was applied to minimize post-operative tunnel enlargement. In terms of the fixation method on the femoral side, the AM bundle was fixed with an interference screw using an inside-out technique, and the PL bundle was fixed using an outside-in technique. As was previous reported [1], we also believe that the outside-in technique used for the PL bundle is technically easier and a more effective means of restoring rotational stability; moreover, we believe that it reduces the risk of bony bridge fracture at the apertures of both femoral tunnels during screw fixation. The limitation of devised technique is that it involves the use of the hamstring tendon and the BPTB tendon, and thus, increases the risk of graft site morbidity. However, complications associated with graft site morbidity were not encountered when the technique devised by Hara et al. was used, which involved a double bundle method that utilized a combination of bone patella tendon bone and semitendinosus tendon [8]. We believe that the sarorius and semitendinosus tendons will function well and that graft site morbidity can be minimized if the gracilis tendon alone is harvested. After an average 9 months follow-up in the ten patients treated using this technique, the preliminary post-operative clinical results showed no definite laxity and the total arc of motion above 135°. At the radiological examination, tunnel widening was not observed at both the femoral and tibial tunnel site. There were no complications associated with our technique. However, in order to demonstrate the clinical significance and safety of this technique, long-term clinical and radiological studies as well as a biomechanical study will be needed.

In conclusion, this technique based on a combination of autogenous bone patellar bone graft and gracilis tendon can minimize the level of tunnel widening post-operatively, allow an easier revision should the reconstructed ACL fail, and provide an alternative means of restoring the rotation stability. Thus, we consider that our technique presents an alternative method for double bundle ACL reconstruction.

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