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Anatomic double-bundle ACL reconstruction using a bone–patellar tendon–bone autograft: a technical note

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Abstract This article describes an original arthroscopic double-bundle anterior cruciate ligament (ACL) reconstruction technique using a bone–patellar tendon–bone autograft. A rectangular patellar bone block, with a double strand patellar tendon, and a double tibial bone block is harvested. The femoral anteromedial tunnel is made using an all-inside technique by the anteromedial portal. The femoral posterolateral (PL) tunnel is created with an outside-in technique, with a 30° divergence between both tunnels. A single tibial tunnel is drilled, the graft is then passed through the tibial tunnel, and the bundles are separately tensioned and fixed with three bioabsorbable interference screws. The femoral AM bone block is fixed by the anteromedial portal, the tibial bone block is then fixed in an oblique manner in order to mimic the ACL orientation with the knee at 30° of flexion. The femoral PL bone block is fixed at the end with the knee in full extension.

Keywords Anterior cruciate ligament reconstruction · BPTB graft · Double bundle · Arthroscopy

Introduction

Conventional single-bundle anterior cruciate ligament (ACL) reconstructions have demonstrated good global clinical outcomes [4]; however, several undesirable side effects such as knee pain [5] or persisting knee instability [10] have also been documented. Recently, better knowledge of ACL anatomy and function has led to the development of new reconstruction techniques utilizing a double bundle concept.

Biomechanical studies have shown that double-bundle ACL reconstruction may achieve a better restoration of the normal biomechanics of the knee and therefore better control of the rotation [1].

Various surgical techniques for double-bundle reconstruction have been developed. These techniques differ in terms of the graft type [2, 6, 9, 15], the number of tibial tunnels [2, 6, 9, 15], and the fixation method [6, 9, 15, 16]. Hamstrings, quadriceps tendon, hamstrings associated with bone–patellar tendon–bone have been described [2, 6, 15]. To our knowledge, there is no technique in the current medical literature demonstrating bone–patellar tendon–bone (BPTB) autograft for double-bundle reconstruction, despite the fact that this type of graft is frequently used for single-bundle ACL reconstruction. This study focuses on an original double-bundle ACL reconstruction technique using a BPTB graft with one tibial and two femoral tunnels.

Surgical technique

A medial incision beginning at the distal aspect of the patella is made. The incision extends distally from 7 to 8 cm long to provide sufficient exposure. The anterior soft tissue is dissected and a trapezoidal shaped bone block is harvested from the patella with a small oscillating saw. The block should have the following characteristics: 20 mm long and 12 mm in diameter.

The tendon has a width of 12 mm and is split in situ into two strands (7 and 5 mm, respectively). A rectangular

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tibial bone block is harvested with the same characteristics as that of the patellar block. Following the tendon strands, the tibial bone block is split in situ, before harvesting, in order to avoid any breakage of the blocks. These blocks are intended to the femoral anteromedial (AM) and posterolateral (PL) bundle, respectively. The graft is calibrated in order to pass easily within an 11-mm tibial tunnel. The 2 blocks are calibrated separately to fit their femoral tunnel diameter, 7 mm for the AM tunnel and 6 mm for the PL tunnel (Fig. 1).

Standard anteromedial and anterolateral portals are used. The knee is flexed at 120°. A 5 mm over the top femoral pin guide is introduced through the anteromedial portal. The AM femoral tunnel is positioned at 10:30 o'clock for a right knee and at a 1:30 o'clock position for a left knee. The AM tunnel is drilled over the pin with a 7-mm diameter headed reamer to a depth of 30 mm.

The knee is flexed at 90°. A 6-mm diameter posterolateral tunnel is drilled by an outside-in technique using a specific femoral guide (Phusis, St Ismier, France). This guide has an offset of 8 mm from the center of the AM tunnel (Fig. 2). A small incision (1 cm) is made over the lateral side of the epicondyle and the iliotibial band is dissected before the guide is inserted. The PL tunnel position is at 2:30 o'clock for a left knee and at 9:30 o'clock for a right knee. A space of just over 1.5 mm is left between the tunnels in order to avoid tunnel bridge breakage. The usual PL tunnel length is between 30 and 40 mm.

The tibial tunnel is made using the same method as the single-bundle technique [11]. By use of a standard tibial guide, a single 11-mm tibial tunnel is created.

The graft is routed from the tibia to the femur with the bone block for the PL and AM bundles in their respective femoral tunnel.

First, through the anteromedial portal, the bone block for the AM bundle is fixed with a 5.5 × 20-mm bioabsorbable interference screw, with the knee at 120° of flexion.

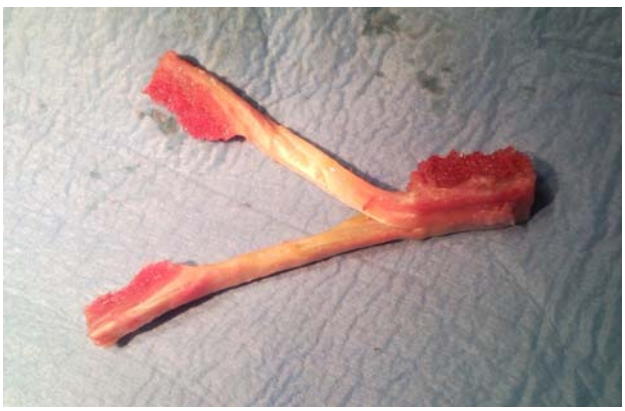

Fig. 1 Double-bundle bone–patellar tendon–bone graft

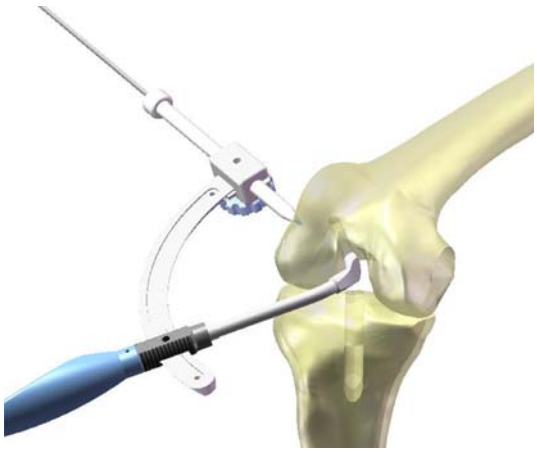

Fig. 2 Outside-in tunnel for the PL bundle

The tibial bone block is fixed as would be done in a single-bundle procedure with a 9 × 20-mm bioabsorbable interference screw and with the knee at 30° of flexion (Fig. 3). The orientation of the tibial bone block is made in an oblique, anterior to posterior manner, in order to follow the anatomy of the tibial insertion of the ACL (Fig. 4). Finally, the PL bone block is fixed by the lateral side with a 5 × 20-mm bioabsorbable interference screw with the knee in full extension (Fig. 5).

Discussion

The most important finding of this study is that it is possible to perform a double-bundle ACL reconstruction with a BPTB autograft and a separate tensioning of the bundles.

Fig. 3 Fixation of the bone block on the tibial side at 30° of flexion

Fig. 4 Arthroscopic view of the double BPTB

Fig. 5 Fixation of the PL bone block in full extension

Many ACL double-bundle reconstruction procedures have been described with different graft types: hamstrings, quadriceps tendon, composite bone–patellar tendon bone–gracilis tendon [2, 6, 7, 15].

The optimal method for double-bundle reconstruction is still controversial. Hamstring tendon grafts with two femoral and two tibial tunnels are widely used, however, an extra anatomic cortical femoral fixation is also frequently used, which can lead to problems such as tunnel enlargement [13]. Graft fixation is closer to the joint with an interference screw on a bone block end.

Significant tunnel widening has been reported with hamstring grafts rather than with BPTB grafts [3]. The choice of BPTB graft allows fixation with interference screw at both ends of the graft which, for us, is the gold-standard fixation method. The tunnel diameter is reduced and the tunnels are filled with bone in order to decrease the risk of postoperative enlargement.

On the other hand, the necessity of a large BPTB transplant raises the problem of complications at the harvesting site (pain at donor site, patellar fractures…). During the procedure, the transplant is carefully split and harvested. The tendon is not closed after harvesting to avoid postoperative patella baja.

Various surgical methods have been used in a number of tunnels: one tibial and two femoral [7, 15, 16], two tibial and two femoral [2, 9, 13], three tibial and two femoral. With two tibial tunnels it is difficult in small knees to obtain two separate tibial tunnels without cortical breakage.

Siebold [14] reported difficulties in tunnel differentiation due to the close positioning of both tibial tunnels. Yasuda et al. [16] reported that anatomic double-bundle reconstruction with one single tibial tunnel showed good biomechanical results with no significant difference compared to two tunnel procedures.

In the presented technique with one tibial tunnel, the graft is fixed in an oblique manner to mimic the arrangement of the native ACL fibers following the double bundle concept [12].

In terms of femoral tunnel placement, an outside-in fixation is an easier, safer and more reproducible procedure for the PL tunnel. The two bundles are tensioned separately and the divergence between the two tunnels is more than 30°, thereby minimizing the risk of tunnel breakage.

Moreover, this hybrid method the AM tunnel with an inside-out technique and PL tunnel with an outside-in technique, is suitable for all graft types (hamstrings, quadriceps tendon, allografts).

In relation to the thin BPTB grafts (7 and 5 mm), no study has reported a resistance to tension load. However, Mae et al. [8] have shown that each bundle strength tends to add up to a strength similar to that of a standard single bundle.

Conclusion

This original technique uses a BPTB autograft for double-bundle ACL reconstruction. We believe that bone–tendon–bone fixation allows a good primary fixation and tunnel filling after graft incorporation. The bone stock might be preserved in case of revisions. For BPTB graft users, our technique is an alternative to double-bundle reconstruction with hamstring tendons.

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