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TECHNICAL NOTE

Isoanatomical bone-patellar tendon-bone single-bundle ACL reconstruction: the wedge that gives the edge!

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Abstract The purpose of the present paper is to describe the isoanatomical, single bundle, bone-patellar tendon-bone A3B-ACL reconstruction technique (A3B = Anatomical Bruderholz, Burkart, Biedert) in detail. The technical key factors and the pitfalls are highlighted. In addition, the pros and cons of the technique are discussed.

Keywords ACL reconstruction · Single-bundle technique · Isoanatomical · Patellar tendon autograft

Introduction

In the early years of arthroscopic anterior cruciate ligament (ACL) reconstruction, most authors focused more on technical convenience than restoration of the native attachment of the ACL. These were the years of the popular single-incision technique [1–3]. When it became clear that the clinical results could be improved [4], it was realized that this single-incision technique did not restore the native anatomy of the ACL. Instead of correcting this obvious mistake, opinion leaders stepped from a non-anatomical single-bundle ACL reconstruction to much more complicated double- and even triple-bundle ACL reconstruction techniques [5–7]. These techniques have been promoted in particular by the industry, as at least twofold fixation devices are needed. A tremendous effort was undertaken to prove the biomechanical and clinical superiority of the double-bundle ACL reconstruction techniques, but to date the evidence is weak [8, 9].

In the meantime, others have developed well functioning, relatively simple, reproducible, anatomical single-bundle ACL reconstruction techniques [10–15]. The principles of this technique have been proven by several anatomical and biomechanical studies [10, 16–18]. Although there is a considerable body of scientific data on the treatment of ACL lesions, the optimal surgical method still seems to be more a matter of preference than evidence [19–21].

The purpose of the present paper is to describe the isoanatomical, single bundle, bone-patellar tendon-bone A3B-ACL-reconstruction technique (A3B = Anatomical Bruderholz, Burkart, Biedert) in detail. The technical key factors and the pitfall are highlighted. In addition the pros and cons of the technique are discussed.

Technical note

Preoperative testing and positioning of the patient

Before ACL reconstruction, the ligament laxity is tested using the pivot shift and Lachman's test. The patient is positioned supine. The thigh is put in a leg holder with the lower leg hanging, and the distal femur orientated horizontally. A tourniquet is used, which is put approximately 10 cm proximally to the patella.

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Harvesting and preparation of the graft

For harvesting of the bone-patellar tendon-bone autograft, a longitudinal incision at the lateral border of the patellar tendon starting from the distal pole of the patella to a point approximately 3 cm distally to the tibial tuberosity is performed. Then, the paratenon is incised in its midline and bluntly separated from the patellar tendon. A 10-mm-wide central strip of the patellar tendon is prepared. Before harvesting of the proximal bone block, two 1.8-mm drill holes are made in the proximal corners of the block in order to avoid fracturing of the patella while harvesting the graft. The preparation of the proximal bone block (10 mm width distally, converging to 8 mm proximally, length of the block about 14 mm) is finished using an 8-mm oscillating saw and 8-mm osteotome.

The bone block and the proximal patellar tendon are armed with two resorbable sutures each (Vicryl 0, Johnson & Johnson, Spreitenbach, Switzerland). The knot is placed on the most proximal edge of the bone block. Then, the patellar tendon is excised down to the bursa just proximal to the tibial tuberosity. The surgical key factor here is that at the patellar tendon is incised using a cone-shaped metal template. The preparation of the distal bone block (10 mm wide at the tendon's side, 20 mm long, diverging distally to 13 mm width) is finished using an 8-mm oscillating saw and 10-mm osteotome, resulting in a three-dimensional conical wedge-shaped bone block. The bone block then easily enters the 10-mm femoral tunnel, and the proximal bone block interlocks with the tunnel wall leading to a safe femoral fixation of the graft.

The bone block and the distal patellar tendon are armed with two resorbable sutures each (Vicryl 0, Johnson & Johnson, Spreitenbach, Switzerland), and the distal border of the patellar tendon is marked with a blue stripe (Fig. 1). The defect of the patella and tibial tuberosity is filled with a small piece of Spongostan (Johnson & Johnson, Spreitenbach, Switzerland).

The harvest site is closed by suturing of the medial and lateral remaining patellar tendon (PDS 0, Johnson & Johnson, Spreitenbach, Switzerland).

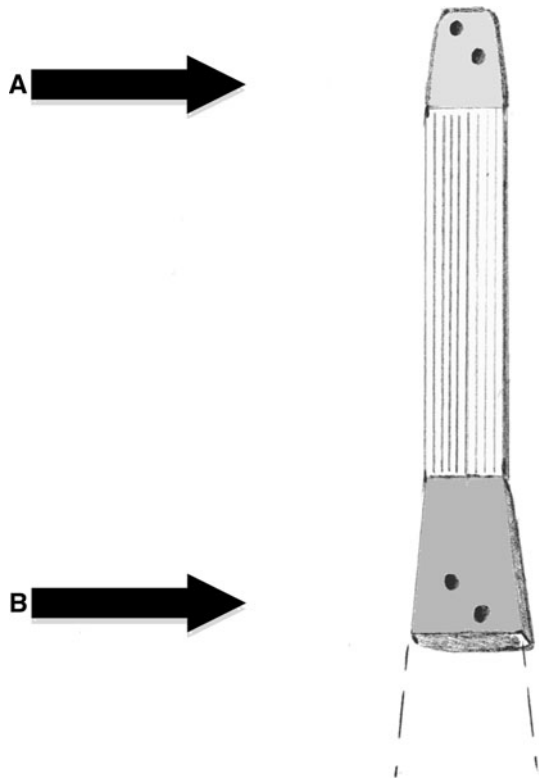

Fig. 1 Schematic representation of the prepared BPTB graft. Note the small, tapered bone block *A* originating from the patella and the wedge-shaped bigger bone block *B* originating from the tibial tuberosity, which will be tapped outside in into the cone-shaped femoral tunnel, blocking itself

Arthroscopic surgery

Femoral and tibial tunnel preparation

A high anterolateral portal in the corner between the patella and the patella tendon, and a second, low anteromedial portal is established. Then, the intercondylar notch and the tibial and femoral ACL-attachment area are cleaned using a shaver blade. It is of crucial importance to visualize the posterior attachment area of the ACL at the deep posterior femoral condyle through the medial portal, in particular the bone cartilage interface.

A second incision (approximately 3 cm long) is performed starting approximately 4 cm proximal to the lateral epicondyle. The iliotibial tract is split longitudinally anterior to the intermuscular septum. A hook is placed under the lateral vastus muscle and bluntly elevated. Then, the femoral bone is identified. The outside in aiming device (Instrumed, Luzern, Switzerland) is placed into the centre of the native ACL attachment indicating the proximal entry point of the eventual guide wire. This guide wire is introduced into the joint from proximal to distal. After verification of the desired tunnel position via the medial portal, which is quite low in the native ACL attachment, the K-wire is over drilled using a 10-mm cannulated drill bit. The PCL is protected with a curette that is placed directly in front of the intraarticular tunnel entry point; the sharp edges of the tunnel wall are debrided.

Then, the 10-mm tunnel is expanded in outside in technique using a manual mill bit (distal: 9 mm, proximal 13 mm). This step is meticulously controlled via the medial portal (Fig. 2). In this fashion, a cone-shaped femoral tunnel is created outside in, which narrows to

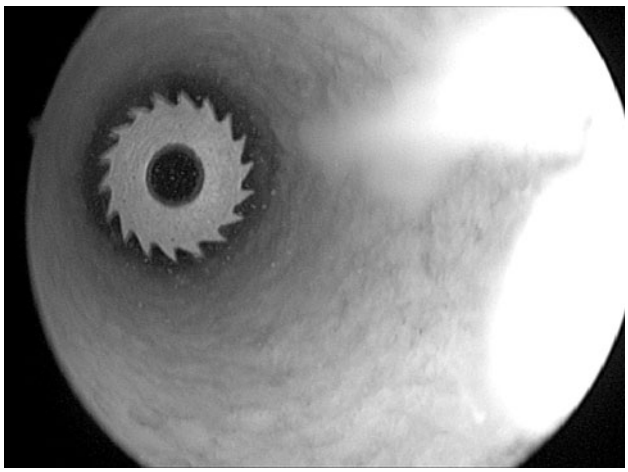

Fig. 2 The manual mill bit entering the femoral tunnel, creating the outside in *cone*-shaped tunnel. It is under constant control with the arthroscope in the medial portal viewing inside out

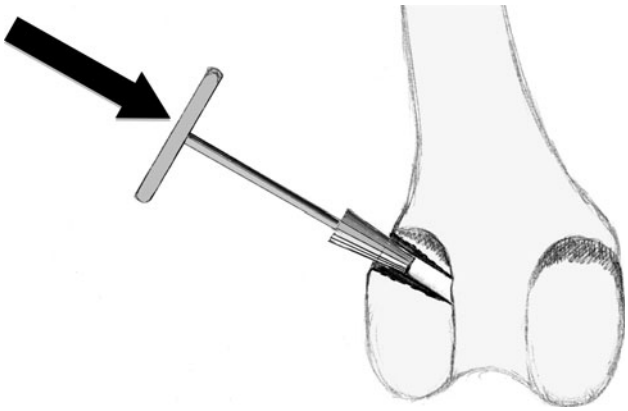

Fig. 3 Schematic representation of the creation of the *cone*-shaped femoral tunnel. The 10-mm femoral tunnel is expanded using the manual mill bit allowing for a press fit fixation of the wedge-shaped bone block in the *cone*-shaped tunnel

10 mm diameter at the former femoral attachment area (Fig. 3). The tunnel opening is almost round since the tunnel direction is virtually perpendicular to the inner bone surface. The mill bit is left in place to minimize fluid loss through the femoral tunnel.

For the tibial tunnel preparation, a tibial aiming device (Acufex, Smith & Nephew, Andover, MA, USA) is placed between the tibial spines close to the shallow border of the PCL. Then, a guide wire is introduced under arthroscopic control through the aiming device. The tunnel is expanded to a diameter of 10 mm. The tibial tunnel aperture is debrided from soft tissue with a shaver blade.

Antegrade graft introduction and femoral fixation

Shuttle sutures are inserted through the femoral tunnel, grasped with a clamp, and passed out in antegrade direction

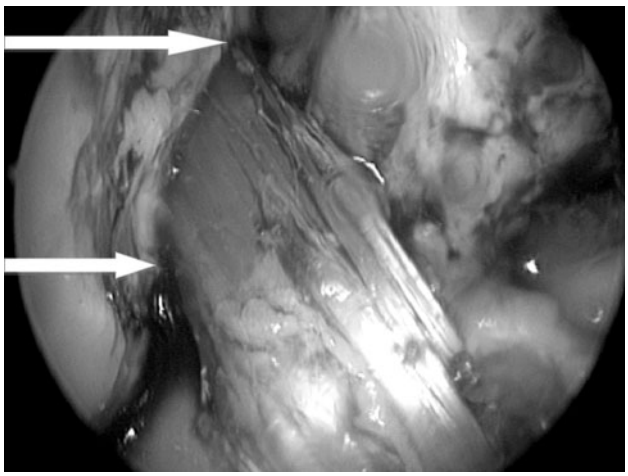

Fig. 4 The ACL graft in place. Note the high–low extension of the graft (between the two *white arrows*) mimicking the placement of the normal ACL

through the tibial tunnel. The graft is then inserted into the femoral tunnel under assistance of a probe, which helps to guide the bone block into the joint. During this maneuver, the rotation of the bone block has to be meticulously controlled. The tendon backside should face against anterior. Hence, the tendon fibers, which emerge eccentrically from the bone block, are placed as posterior as possible mimicking the round shape of the bone cartilage interface (Fig. 4).

Under constant pull on the distal sutures, the bone block is tapped into the femoral tunnel until the bone block does not move toward the joint. This is generally the case when the blue mark becomes visible at the level of the tunnel aperture. The fixation of the bone block within the femoral tunnel is checked under arthroscopic control pulling on the distal sutures.

Tibial fixation

The graft is preconditioned in 10 cycles, and the isometry of the graft is checked. In most cases, the graft will be pulled into the tibial tunnel during the last 20° of extension. The graft is then fixed in 20° of flexion using a Biocomposite interference screw (Arthrex, Naples, FL, USA). Then, the fascia and the subcutaneous layer are closed in layers on both sites.

Disadvantages of the technique

The only minor disadvantage of the proposed technique is the need for a short second skin incision on the distal lateral thigh.

Advantages of the technique

The proposed ACL reconstruction technique offers the opportunity to place the femoral tunnel in the centre of the native ACL attachment, which is lower than usually achieved in transtibial ACL techniques [22]. In addition, the femoral tunnel aperture has a circular shape with a defined diameter rather than an ovaloid shape when the drill enters the notch in a tangential direction.

In comparison with techniques where the medial portal is used for drilling of the femoral tunnel, there is no risk to damage the medial femoral condyle.

It is an easy and reproducible ACL reconstruction technique. Every step of the surgery is arthroscopically controlled, and hence, it can be routinely used in teaching hospitals.

As no fixation device is used on the femoral side, it is less costly than other described techniques. In addition, revision surgery is considered to be less difficult. The surgeon is not limited due to the initial tunnel or fixation device in placing the femoral tunnel.

Conflict of interest No benefits in any form have been or will be received from a commercial party related directly or indirectly to the subject of this manuscript.

References

1. Howell SM (1998) Principles for placing the tibial tunnel and avoiding roof impingement during reconstruction of a torn anterior cruciate ligament. Knee Surg Sports Traumatol Arthrosc 6(1):S49–S55
2. Howell SM, Clark JA (1992) Tibial tunnel placement in anterior cruciate ligament reconstructions and graft impingement. Clin Orthop 283:187–195
3. Reat JF, Lintner DM (1997) One-versus two-incision ACL reconstruction. A prospective, randomized study. Am J Knee Surg 10(4):198–208
4. Lohmander LS, Ostenberg A, Englund M, Roos H (2004) High prevalence of knee osteoarthritis, pain, and functional limitations in female soccer players twelve years after anterior cruciate ligament injury. Arthritis Rheum 50(10):3145–3152
5. Fu FH, Ranawat A (2007) Tensioning in double-bundle ACL reconstruction. Arthroscopy 23(9):1027; author reply 1027-1028
6. Shino K, Nakata K, Nakamura N, Mae T, Ohtsubo H, Iwahashi T, Nakagawa S (2005) Anatomic anterior cruciate ligament reconstruction using two double-looped hamstring tendon grafts via twin femoral and triple tibial tunnels. Op Tech Orthop 15:130–134
7. Siebold R, Dehler C, Ellert T (2008) Prospective randomized comparison of double-bundle versus single-bundle anterior cruciate ligament reconstruction. Arthroscopy 24(2):137–145
8. Kanaya A, Ochi M, Deie M, Adachi N, Nishimori M, Nakamae A (2009) Intraoperative evaluation of anteroposterior and rotational stabilities in anterior cruciate ligament reconstruction: lower femoral tunnel placed single-bundle versus double-bundle reconstruction. Knee Surg Sports Traumatol Arthrosc 17(8):907–913
9. Meredick RB, Vance KJ, Appleby D, Lubowitz JH (2008) Outcome of single-bundle versus double-bundle reconstruction of the anterior cruciate ligament: a meta-analysis. Am J Sports Med 36(7):1414–1421. doi:10.1177/0363546508317964
10. Arnold MP, Verdonschot N, van Kampen A (2005) ACL graft can replicate the normal ligament's tension curve. Knee Surg Sports Traumatol Arthrosc 13(8):625–631
11. Bernard M, Hertel P, Hornung H, Cierpinski T (1997) Femoral insertion of the ACL. Radiographic quadrant method. Am J Knee Surg 10(1):14–21
12. Deehan DJ, Pinczewski L (2002) How I do it: Endoscopic anterior cruciate ligament reconstruction using a four strand hamstring tendon construct. J R Coll Surg Edinb 47:428–436
13. Dye SF, Cannon WD Jr (1988) Anatomy and biomechanics of the anterior cruciate ligament. Clin Sports Med 7(4):715–725
14. Garofalo R, Mouhsine E, Chambat P, Siegrist O (2006) Anatomic anterior cruciate ligament reconstruction: the two-incision technique. Knee Surg Sports Traumatol Arthrosc 14(6):510–516
15. Gill TJ, Steadman JR (2002) Anterior cruciate ligament reconstruction the two-incision technique. Orthop Clin North Am 33(4):727–735, vii
16. Loh JC, Fukuda Y, Tsuda E, Steadman RJ, Fu FH, Woo SL (2003) Knee stability and graft function following anterior cruciate ligament reconstruction: Comparison between 11 o'clock and 10 o'clock femoral tunnel placement. Arthroscopy 19(3):297–304
17. Markolf KL, Hame SL, Hunter DM, Oakes DA, Zoric B, Gause P, Finerman GA (2002) Effects of femoral tunnel placement on knee laxity and forces in an anterior cruciate ligament graft. J Orthop Res 20:1016–1024
18. Scopp JM, Jasper LE, Belkoff SM, Moorman CT 3rd (2004) The effect of oblique femoral tunnel placement on rotational constraint of the knee reconstructed using patellar tendon autografts. Arthroscopy 20(3):294–299
19. Duquin TR, Wind WM, Fineberg MS, Smolinski RJ, Buyea CM (2009) Current trends in anterior cruciate ligament reconstruction. J Knee Surg 22(1):7–12
20. Hospodar SJ, Miller MD (2009) Controversies in ACL reconstruction: bone-patellar tendon-bone anterior cruciate ligament reconstruction remains the gold standard. Sports Med Arthrosc 17(4):242–246
21. Kopf S, Musahl V, Tashman S, Szczodry M, Shen W, Fu FH (2009) A systematic review of the femoral origin and tibial insertion morphology of the ACL. Knee Surg Sports Traumatol Arthrosc 17(3):213–219
22. Arnold MP, Kooloos J, van Kampen A (2001) Single-incision technique misses the anatomical femoral anterior cruciate ligament insertion: a cadaver study. Knee Surg Sports Traumatol Arthrosc 9(4):194–199