Anatomic transtibial single-bundle anterior cruciate ligament reconstruction: a new surgical technique

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Objective

Many surgeons perform anatomic anterior cruciate ligament (ACL) reconstruction through the anteromedial portal due to the difficulty in reaching the anatomic femoral insertion through the transtibial technique. A number of authors have described technical modifications to the transtibial technique to improve and restore the native femoral tunnel obliquity. In this work we present a new technique to reach the native femoral footprint in anatomic single-bundle ACL reconstruction through the transtibial tunnel with the aid of new instruments.

Materials and methods

From September 2009 to October 2010, 80 consecutive ACL reconstruction surgeries were performed following a prospective study design. The mean patient age was 31 years (range, 18–45 years); there were 72 male patients and eight female patients. The guide pin was inserted in the femoral footprint through the tibial tunnel with a special arthroscopic manipulator and\or pusher. Radiographic evaluation was carried out by measuring the femoral tunnel orientation in anteroposterior view in plain radiographs. Using computed tomography, the angle of femoral tunnel was measured in coronal and sagittal cuts, and the distance of the tunnel from posterior wall was measured. Clinical evaluation was performed with the IKDC scores.

Results

The mean angle of the femoral tunnel orientation with reference to the bicondylar line was 52.1° (range, 40°–60°). The average clock position was that of 10 O'clock. In the computed tomographic evaluation the femoral entry point at the sagittal view was 1–2 mm. The mean distance of the tunnel from the articular surface in the coronal views was 4 mm. The mean IKDC scores had increased from 55.5±18.0 to 76.8±15.3 postoperatively.

Conclusion

With the aid of the arthroscopic manipulator and\or the pusher, the anatomic footprint of ACL insertion site could be reached through the transtibial tunnel drilling technique.

Keywords:
anterior cruciate ligament, manipulator, technique, transtibial

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Introduction

The main function of the anterior cruciate ligament (ACL) has been accepted as being the principal restraint against anterior tibial displacement for years. More recently, the important role of the ACL in rotatory stability of the knee has been put forth [1–3]. It acts against combined rotatory loading of internal tibial and valgus torques. Consequently, the manner in which surgeons reconstruct the ACL has changed according to new findings [4,5].

There are two major techniques for creating the femoral tunnel. One is drilling through the tibial tunnel [transtibial technique (TTT)], and the other is drilling through the anteromedial portal (anteromedial portal technique) [6].

A number of authors have described technical modifications to the TTT to improve femoral tunnel obliquity and restore the native femoral tunnel obliquity and the native ACL footprint [7–9].

In this work we study a modification of the TTT to reach the anatomic footprint of the femoral insertion of the ACL with the aid of newly designed arthroscopic instruments.

Materials and methods

From September 2009 to May 2011, 80 consecutive ACL reconstruction surgeries were performed by two senior surgeons according to a prospective study design. The mean patient age was 31 years (18–45 years); ther e were 72 male patients and eight female patients. Inclusion criterion was the presence of primary ACL injury with or without meniscal tears. Exclusion criteria were as follows: combined posterior cruciate ligament injury; lateral collateral ligament injury; posterolateral rotatory instability or fracture around knee; no previous knee ligament surgery; and no malalignment.

Surgical technique

After induction of anesthesia, patients were placed supine on the operating room table, prepared, and draped in the usual manner, with the knee hung freely at 90° of flexion. A standard anterolateral portal was established as the viewing portal. A low anteromedial portal was then established as the working portal. Insertion of the aimer through this portal allows the aiming arm to easily rotate, and this allows the guidewire trajectory that is slightly more horizontal relative to the lateral wall of the notch. After diagnostic arthroscopy and treatment of the associated injury, clearing of the lateral wall of the notch by shaver and notchoplasty is preformed if needed. Hamstring graft harvesting and preparation was preformed.

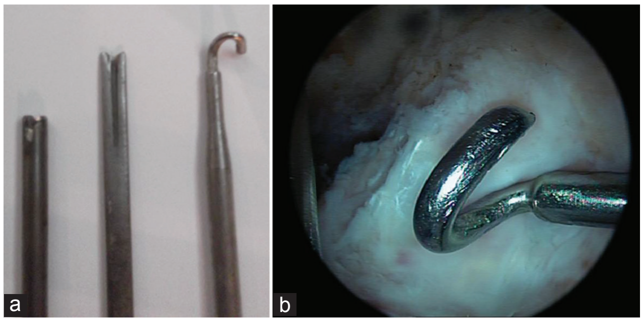
Tibial tunnel preparation was carried out by setting the tibial tunnel ACL guide at 55° from the horizontal plane and 25°–30° from the sagittal plane, with the intra-articular exit point of the guide pin directed 5 mm lateral to the medial tibial spine. At 2 mm posterior to the anterior horn of the lateral meniscus, the external starting point was placed at the anterior border of the medial collateral ligament insertion fibers to allow for oblique orientation of the aiming device. The guidewire was inserted, and an expanded head reamer with the same diameter of the prepared graft was used to drill the tibial tunnel.

Anatomic transtibial femoral tunnel preparation was performed using free-hand technique through the tibial tunnel. The guidewire was inserted intra-articularly through the tibial tunnel. It was pushed and manipulated with special instruments (manipulator and/or pusher) (Fig. 1a and b) designed by the senior author. The manipulator was inserted through the anteromedial portal to manipulate the guidewire from the high point to the more low anatomic point (point below the resident ridge and posterior to the bifurcate ridge without an acute bend of the wire) (Fig. 2a and b). Thereafter, the femoral tunnel was drilled, and it was measured with a depth gauge. The hamstring graft was then introduced and fixed on the femoral side, with either a bioabsorbable (hydroxyapatite/poly-l-lactic acid) screw or endobutton (Fig. 3). Tensioning the graft by cycling the knee through a range of 0°–90° flexion was performed several times. Tibial fixation was performed with a bioabsorbable screw or two spiked cobalt-chrome staples.

Postoperative rehabilitation

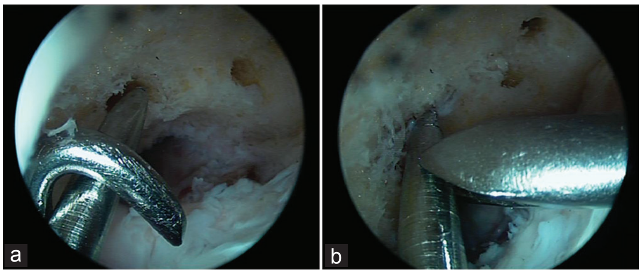
The patients followed the accelerated rehabilitation program. For the first 6 weeks, walking with crutches with partial weight-bearing was allowed with brace. Patients were encouraged to restore full range of motion of the knee as tolerated, and isometric strengthening of the quadricep muscle was carried out from the first day postoperatively. Six weeks after surgery, patients returned to performing daily activities. Noncontact sports were permitted after 3 months, and contact sports were permitted 6 months after surgery.

Figure 1



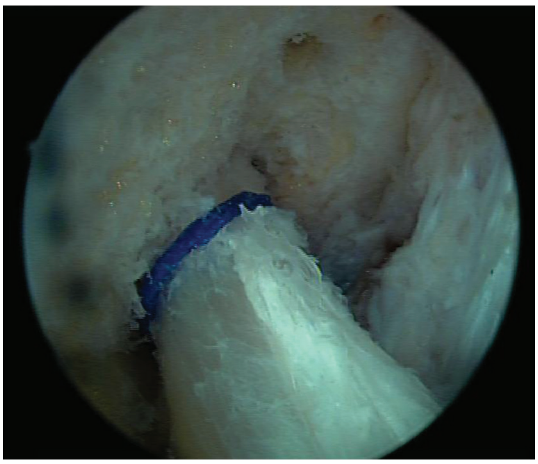
New instruments used in single-bundle ACL reconstruction. (a) Manipulator and pushers. (b) Double-angled hook. ACL, anterior cruciate ligament.

Figure 2



(a, b) Moving the wire through the drilled tibial tunnel ‘8 mm’ from 11 to 9.5 O’clock, using the manipulator or pusher intra-articularly.

Figure 3



The final position of ACL graft in its anatomic femoral tunnel site. ACL, anterior cruciate ligament.

Radiological and clinical evaluation

A postoperative radiograph was obtained for each case. In accordance with a recently described method, the femoral tunnel orientation with reference to a line tangent to the distal aspect of the femoral condyles was measured in anteroposterior view in plain radiographs [8]. Computed tomography was performed, and coronal obliquity was defined by the angle subtended between the tunnel and a horizontal axis defined by the lateral tibial plateau. Clock-face description of coronal obliquity was defined by Rue *et al.* [9], with each 30° increment from the vertical axis (12 O'clock) equivalent to one clock-face position. Sagittal obliquity was defined by the angle subtended between the tunnel and longitudinal axis of the femur.

Postoperative clinical evaluation was carried out using the IKDC score; the mean follow-up period was 18 months.

Results

Using arthroscopic depth gauge measurements, a 35 mm tunnel depth could be established in 76 cases. In the remaining four cases, only 25 mm tunnel lengths could be established because of small lateral condyles.

Using radiographic evaluation, the mean angle of the femoral tunnel orientation with reference to the bicondylar line was 52.1° (range, 40°–60°) (Fig. 4). The average clock position was that of 10 O'clock (range, 9 : 15–10 : 30).

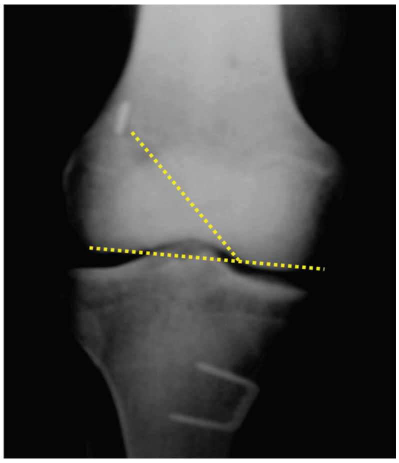
In the computed tomographic evaluation, the femoral entry point at the sagittal view in the tunnel cut where the medial tibial spine appeared was 1–2 mm (mean 1.5 mm) from the posterior wall of the femoral condyle (Fig. 5). In the coronal views the distance between the femoral entry point and the articular surface was measured at the first cut (most anterior) in which it appeared as a complete circle. The mean distance was 4 mm (Fig. 6).

The mean IKDC scores had increased from 55.5±18.0 to 76.8±15.3 postoperatively. For postoperative range of joint motion, a mean of 138.5°±5.5° was observed in 78 cases, with only two cases of limited range of motion in flexion due to defective rehabilitation program.

Discussion

The purpose of this study was to produce a nearly anatomic one-shot transtibial femoral tunnel through an easy reproducible technique.

Figure 4



Measurement of the femoral tunnel angle in plain radiograph.

Figure 5

Sagittal computed tomography at the entry of femoral tunnel showing 1–2 mm from posterior wall.

Figure 6

Computed tomographic coronal view showing the distance of the tunnel from the articular cartilage of the lateral femoral condyle.

A number of recent studies analyzing ACL tunnel position have shown that traditional, single-incision ACL reconstruction techniques may result in vertical graft orientation because of inherent technical limitations in achieving an oblique femoral tunnel [7,10,11]. The clinical result can be persistent rotational instability and a positive pivot shift examination postoperatively despite successful restoration of anteroposterior stability of the knee. As a result, current trends in ACL reconstruction include drilling a more oblique femoral tunnel to place the graft in a more anatomic position on the lateral femoral condyle and provide increased rotational stability [10–13].

Scopp *et al.* [12] showed that rotational stability in cadaveric knees is restored to normal with oblique femoral tunnel placement, and Yamamoto *et al.* [10] showed that lateral femoral tunnel placement restores rotatory and anterior translation knee stability in extension. Howell *et al.* [7] and Simmons *et al.* [13] showed a decrease in tension across the ACL graft, increased motion, and decreased posterior cruciate ligament impingement with a graft placed more horizontally in the coronal plane. In addition, some surgeons have advocated that a more lateral femoral tunnel placement favorably increases the moment arm of ACL reconstruction [11,14].

Cha *et al.* [15] recommended independent drilling of the femoral tunnel through a medial arthroscopic portal with the knee placed in hyperflexion. Preliminary laboratory studies have reported favorable femoral tunnel obliquity using this technique, although concerns regarding tunnel length, graft tunnel mismatch, and fixation methods have been reported [16]. However, another study showed that the drilling of a suboptimal vertical femoral tunnel at a clock-face position of ~11 : 30 is equally possible with the transtibial and anteromedial portal techniques and that the anteromedial portal technique is not protective against poor tunnel position [15].

Some authors have advocated that oblique femoral tunnel preparation is readily achievable with technical modifications to the conventional TTT. Howell *et al.* [7] have recommended creating a tibial tunnel at a coronal angle of 65°–70° to achieve sufficient femoral tunnel obliquity [7]. Chhabra *et al.* [17] provided guidelines to use external landmarks to achieve sufficient tibial and femoral tunnel obliquity and reported that a tibial starting point at the midpoint between the tibial tubercle and posteromedial corner achieved a coronal angle of approximately 70°. Golish *et al.* [16] reported increased femoral tunnel obliquity at the 10 : 30 position using a transtibial drilling technique with a starting point that encroaches on the anterior fibers of the medial collateral ligament. Rue *et al.* [18] effectively showed in a cadaver model that a 10 mm lateralized femoral tunnel prepared by a TTT places the graft in a location that replaces approximately half of the anteromedial and posterolateral bundle footprints. However, our technique is simple transtibial without the need for a special starting point. It has the following advantages:

(1) It is quite comfortable for surgeons familiar with the traditional TTT.
(2) The technique is quite anatomic as it succeeded in lowering the femoral tunnel and bringing the femoral fixation nearer to the joint line.
(3) Compared with the anatomic transportal method in which the drill is passed horizontally inside the knee through the anteromedial portal, the anatomic transtibial tunnel technique has other potential advantages of no violation of skin at the anteromedial portal and no violation of articular cartilage of the medial femoral condyle.
(4) It may produce a longer femoral tunnel and decrease the incidence of rupture of the posterior wall of the tunnel. This requires a further comparative study.

Conclusion

With the aid of the arthroscopic manipulator and\ or the pusher, the anatomic footprint of the ACL insertion site could be reached with the transtibial tunnel drilling technique without major change in the traditional technique, avoiding the complications of drilling the femoral tunnel through the transportal technique.

Acknowledgements

Conflicts of interest

There are no conflicts of interest.

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