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In vivo evaluation of femoral and tibial graft tunnel placement following all-inside arthroscopic tibial inlay reconstruction of the posterior cruciate ligament

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ABSTRACT

Background: The arthroscopic all-inside tibial inlay technique represents a novel procedure for posterior cruciate ligament (PCL) reconstruction. However, in vivo investigations that evaluate the accuracy of this technique regarding anatomic graft tunnel placement are few. The objective of this study was to analyse the femoral and tibial tunnel apertures using computed tomography (CT) and compare these findings to recommendations in the literature.

Methods: CT scans were obtained in 45 patients following single-bundle PCL reconstruction. The centres of the tibial and femoral tunnel apertures were correlated to measurement grid systems used as a radiographic reference.

Results: The centre of the femoral tunnel aperture was located at 42.9% ± 9.4% of the total intercondylar depth and at 12.9% ± 7.2% of the total intercondylar height. The angle α for the femoral tunnel position was measured at 64.2° ± 10.0°. The centre of the tibial tunnel aperture was found at 51.8% ± 4.1% of the total mediolateral diameter of the tibial plateau. The superoinferior distance of the tibial tunnel aperture to the joint line was 9.6 mm ± 4.4 mm on frontal and 9.3 mm ± 3.4 mm on sagittal 3D-CT scans. The distance of the tibial tunnel aperture to the former physis line averaged to 0.8 mm ± 3.4 mm. Comparison to the corresponding reference values revealed no statistically significant difference.

Conclusion: Arthroscopic tibial inlay reconstruction is an efficient procedure for precise replication of the anatomical footprint of the PCL.

Level of evidence: IV, prospective case series

1. Introduction

To restore normal knee joint function and stability and to prevent premature joint degeneration the reconstruction of isolated PCL ruptures has been recommended if both subjective and objective instability are present [1–8]. A multiplicity of reports in the literature, developments in implant application and a trend towards preferably anatomical ligament reconstruction have resulted in a variety of different techniques for tibial and femoral tunnel placement. [1–5] Several authors have shown that transtibial tunnel techniques might result in inferior graft position with graft elongation, thinning and insufficiency, both impairing long-term functional results. Open PCL inlay reconstruction with quadriceps tendon autograft has therefore become widely accepted as a preferable treatment option [1–5,9]. Recently, technical innovations have facilitated an all-inside reconstruction technique utilizing a retrograde drill system to combine the benefits of the tibial inlay technique with a minimally invasive arthroscopic approach [10]. In addition, the creation of inside-out bone sockets has been recommended to minimize the constriction imposed by transtibial tunnel or arthroscopic portal orientation, decreasing the risk of fragmented intraarticular tunnel rims and reducing the risk of synovial fluid proliferation in the graft tunnel. However, reports that analyse the procedure's effectiveness and eventually its superiority in creating anatomic graft tunnel positions in vivo are lacking in the current literature. Several anatomic studies have characterized the tibial and femoral PCL footprints and provided radiographic data from either plain radiography or CT scans to facilitate both the intraoperative replication of anatomic tunnel positions and the postoperative quality validation. In addition, the necessity of imaging tools for intra- and postoperative quality validation have been noted [10–13]. The allocation of evidence for a consistent documentation of the surgical modus operandi seems to be essential. A standardized measurement grid system and a preoperatively threshold for the targeted tibial and femoral tunnel position were established according to these recommendations [14] and a comparison of the measurements results of our study of these findings was

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conducted to evaluate the hypothesis of this investigation that the presented arthroscopic tibial inlay procedure is accurate and reliable in replicating the anatomical PCL footprints.

2. Materials and methods

Between 2008 and 2012, 45 consecutive patients (33 male and 12 female) with an average age of 32.24 standard deviation 12.19 years (range, 13.94 to 57.00 years) at the time of surgery were prospectively enrolled in this study. In 23 cases the right knee and in 22 cases the left knee were involved. All patients received isolated arthroscopic single-bundle PCL reconstruction with quadriceps tendon autograft using an all-inside tibial inlay retro-construction technique. The selection of tibial and femoral tunnel entry was derived from previous investigations on a radiographic and arthroscopic reference system of the native PCL insertion areas. On intraoperative fluoroscopic images the aspired position for the tibial tunnel was at 48% of the total mediolateral diameter of the tibial plateau and 8 mm inferior from the connecting line between the medial and the lateral tibial plateau, respectively. Target position for the femoral tunnel was at 40% of the total intercondylar depth and at 13% of the total intercondylar height, respectively. The corresponding and arthroscopically visualized target position for the femoral tunnel was at 8 mm from the anterior cartilage border of the medial femoral condyle and at 3.5 mm from the intercondylar roof [14]. Exclusion criteria were traumatic bone involvement, revision surgery and combined procedures with anterior cruciate or multiple ligament reconstruction and corrective osteotomies. PCL rupture was diagnosed by clinical examination and magnetic resonance imaging in all patients.

2.1. Surgical technique

The surgical technique was based on inside-out drilling of tibial and femoral bone sockets using the RetroConstruction System with a specially designed retrograde drill guide set (Fig. 1, Arthrex Inc., Naples, FL, USA). Arthroscopic visualization was accomplished with 30° and 70° scopes via anteromedial, anterolateral and posteromedial portals. In addition, tunnel placement, graft passage and implant position were assessed fluoroscopically. The tibial footprint of the native PCL was located and dissected under direct arthroscopic view on the posterior tibial slope. A 12 mm tibial bone socket was created using a retrograde cutter over a previously inserted guide wire under arthroscopic and fluoroscopic visualization at the level of the previous physeal line as the required target area in accordance with the identified remnants of the native PCL. The 10 mm round abraded patellar bone block of the quadriceps tendon autograft was armed with a suture loop over a 2-hole suture button and directed intraarticular to the tibial bone socket via a passing suture which was retrieved at the anterior tibial cortex. Tibial graft fixation was achieved by tensioning and knotting the suture loop over a 4-hole suture button at the anterior tibial cortex. The femoral tunnel was created using a preformed femoral drill guide and a flip cutter which was inserted through a skin incision over the medial femoral condyle. After identification of the femoral remnants of the native PCL, the creation of the femoral tunnel was accomplished under direct arthroscopic and fluoroscopic visualization. The graft was directed into the femoral tunnel, tensioned via the reinforcement suture similar to the tibial technique and fixed with a bioabsorbable interference screw (Fig. 2). After surgery axial high-resolution computed tomography, CT scans with frontal, sagittal and volume rendered 3D reconstructions according to a standardized knee protocol were obtained on the second postoperative day on a Phillips Brilliance 64 Multislice CT-scanner (FOV 250 mm, collimation 40 × 0.625 mm, thickness of layer 1 mm, increment 0.5 mm, pitch 0.4, rotation 0.75 s, 140 kV, 200 mas, matrix 512, reconstruction 0.9/0.45 mm). CT scans were not obtained exclusively for this study but represent a standard protocol for postoperative documentation and quality validation following ligament reconstruction procedures on the knee in our institution and excluding the investigation from a mandatory ethical committee approval in accordance with local legal requirements.

2.2. Data collection

All measurements were conducted by a single observer using IMPAX EE R20 image viewer software (Agfa Healthcare, Bonn, Germany). On two orthogonal biplanar oblique CT images parallel to the bone tunnel, the intersection of the femoral tunnel aperture with the adjacent cortical bone was labelled with a marker (as previously described for the anterior cruciate ligament by Silva et al. [15]). A measurement grid

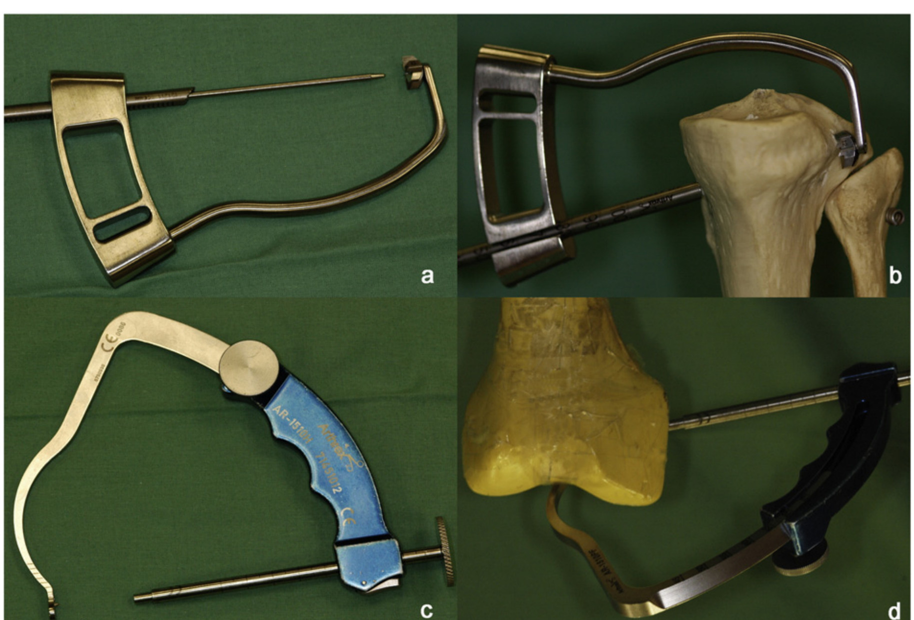

Fig. 1. The RetroConstruction System: a) Tibial drill guide with mounted cutter head for intraarticular delivery to the threaded guide wire. b) Right knee model, medial view, demonstrating the configuration of the tibial system prior to retrograde drilling process. c and d) Aspect and procedural configuration of the femoral drill guide system on the medial femoral condyle, right knee model, anterior view.