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Tunnel position following posterior cruciate ligament reconstruction: An *in vivo* computed tomography analysis

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ABSTRACT

The success of posterior cruciate ligament (PCL) reconstruction is dependent on appropriate tunnel placement. Computed tomography (CT) provides detailed images of intra-articular osseous anatomy. The objective of this study was to analyze by CT the position of femoral and tibial tunnels relative to intra-operative goals following arthroscopic-assisted PCL reconstruction. Nineteen patients who underwent single-bundle PCL reconstruction were evaluated 16 months post-operatively. Each underwent a CT scan and tunnel locations were identified in the coronal, sagittal, and axial planes. The coronal plane tibial tunnel location was within 5 mm of the intra-operative goal (48% of the total tibial plateau width from the medial border of the plateau) in 16 patients (84%). The sagittal plane tibial tunnel location was within 5 mm of the intra-operative goal (the middle of the posterior half of the retrospinal surface) in 14 patients (74%). In the sagittal plane, the femoral tunnel location was within 5 mm of the intra-operative goal (10 mm from in the distal articular margin of the medial femoral condyle) in 15 patients (79%). In the notch, the femoral tunnel was between 10:30 and 11:30 for left knees or between 12:30 and 1:30 for right knees (the intra-operative goal was 11 o'clock for left knees and 1 o'clock for right knees) in 18 patients (95%). Arthroscopic PCL reconstruction results in tunnel positions near intra-operative goals. Further work is necessary to define CT-specific criteria for the assessment of PCL tunnel position.

1. Introduction

While specific reconstruction techniques vary, it is clear that accurate tunnel placement is critical when performing surgery to reconstruct the posterior cruciate ligament (PCL) [1–4]. It is therefore not surprising that numerous studies have been published documenting the anatomy of the PCL and describing intra-articular landmarks to aid in tunnel placement [5–14].

Similarly, radiographic tools have been developed to evaluate tunnel position post-operatively. These include methods based on plain radiographs [12,15,16] as well as magnetic resonance imaging [17]. While computed tomography (CT) has been used to evaluate the appearance of graft tissue following PCL reconstruction [18] and tunnel position following ACL reconstruction [19], we are aware of no studies utilizing CT to evaluate tunnel position following arthroscopic PCL reconstruction.

In spite of advances in understanding of the anatomy of the PCL and the availability of methods to evaluate tunnel position, there is very little data in the literature assessing PCL tunnel position following arthroscopic PCL reconstruction. We hypothesize that CT evaluation will demonstrate tunnels positioned near intra-operative goals following arthroscopic PCL reconstruction utilizing intra-articular and fluoroscopic landmarks.

2. Materials and methods

2.1. Patients

Between January 1, 2007, and December 31, 2008, 24 patients at our center underwent operative treatment of grade 3 PCL injuries. Nineteen of these patients (79%) were available for computed tomography evaluation of femoral and tibial tunnel placement at an average of 16 months following surgery. These patients form the study group. Two patients were unable to return for evaluation due to geographic constraints and three were lost to follow-up.

Twelve patients were treated for chronic isolated PCL deficiency. The remaining cases represented multi-ligament knee injuries that were treated acutely. These cases included three ACL/PCL/posterolateral corner injuries, two ACL/PCL injuries, one ACL/PCL/MCL injury, and one PCL/posterolateral corner injury. Acute ACL reconstruction was not performed in these patients. The PCL injury was related to a motor vehicle crash in eight cases, sports in eight cases, and activities of daily living in three cases. The average age of the 19 patients (16 male, three female) at PCL reconstruction was 29 years (range, 16 to 45 years).

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2.2. Surgical technique

All procedures were performed with the same operative technique at a single center under the supervision of the senior author. All patients underwent arthroscopic reconstruction of the PCL using a single-bundle technique [20]. No posterior portals were used. Quadriceps tendon autograft was utilized in 16 patients and quadriceps tendon allograft was utilized in three patients. The tibial tunnel was created under fluoroscopic control with the knee flexed to 90°. A 55-degree tibial PCL guide was used to place a guidewire through the tibia with a goal of exiting the retrospinal surface at the anatomic PCL insertion site: the middle of the posterior half of the retrospinal surface [10] just medial to the midline [16,21]. The femoral tunnel guidewire was placed based in intra-articular landmarks, with a goal of entering the notch at the 1 o'clock position for right knees and the 11 o'clock position for left knees. The tunnel was centered 10 mm posterior to the articular margin in accordance with previously published anatomic studies [5,11,13,22–25].

The graft was passed in a retrograde manner. Tibial fixation was performed with a resorbable interference screw backed-up with a wire and screw. A resorbable interference screw was used for femoral fixation.

2.3. Radiographic analysis

All 19 patients underwent a CT scan post-operatively with 1 mm cuts on a high resolution CT scanner (Aquilion 16, Toshiba, Zoetermeer, the Netherlands). Coronal and sagittal plane reconstructions were performed according to the same protocol in each patient.

The entry point of the tibial tunnel into the joint was determined using sagittal and coronal CT images. Every measure was made based on the center of the tunnel entry point into the joint. In the coronal plane, the medial–lateral location of the tibial tunnel entry point was measured relative to the medial border of the tibial plateau. The medial–lateral diameter of the tibial plateau was measured on the same cut. Tunnel position was considered to be as expected if it fell within 5 mm of the goal described above (Fig. 1). In the sagittal plane, the distance from the tibial tunnel entry point to the posterior border of the tibia was measured along the retrospinal surface as well as the total length of the retrospinal surface. Tunnel position was considered to be as expected if it fell within 5 mm of the goal described above (Fig. 2).

The entry point of the femoral tunnel into the joint was then determined using sagittal and axial CT images. In the most lateral sagittal cut including the medial femoral condyle, the distance from the center of the femoral tunnel to the distal border of the condyle was measured. Tunnel position was considered to be as expected if it fell within 5 mm of the goal described above (Fig. 3). In the axial plane cut corresponding to the center of the tunnel entry point into the notch, a line was drawn through the center of the tunnel and parallel to the posterior border of the condyles. A clock face was then placed in the notch with the 9 o'clock and 3 o'clock positions fixed at the base of the notch and the axis connecting 9 and 3 o'clock parallel to the posterior border of the condyle. The 10 and 11 o'clock positions were added to the clock face and the position of the center of the tunnel was assessed to the nearest 0:15. Tunnel position was considered to be as expected when it fell between the 10:30 and 11:30 positions on the clock face (Fig. 4).

Plain radiographs were obtained to assess posterior laxity pre-operatively and at follow-up. Laxity was assessed on kneeling lateral views relative to the contralateral side [26].

2.4. Statistical analysis

Summary statistics (mean and standard deviation) were determined for each measurement. Tunnel position was compared to the intra-operative goal using paired *t*-tests. Pre- and post-operative radiographic laxity measurements were compared utilizing paired *t*-tests.

3. Results

3.1. Radiographic analysis of tunnel location

The mean width of the tibial plateau was measured to be 74.2 ± 6.4 mm. The mean entry point of the tibial tunnel into the joint in the coronal plane on post-operative CT was significantly more medial than the intra-operative goal (Table 1). However, the tunnel was

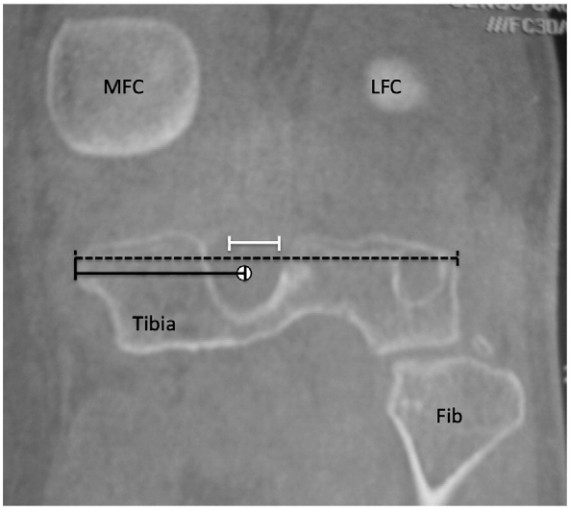

Fig. 1. A coronal plane computed tomography image of a left knee following arthroscopic posterior cruciate ligament (PCL) reconstruction. The centre of the entry point of the PCL tibial tunnel into the joint is noted with a white dot. The distance from the centre of the tunnel to the medial border of the tibial plateau was measured (solid black line), as was the total width of the tibial plateau in this plane (dashed black line). The white line denotes the expected medial–lateral position: placement of the tunnel within 5 mm of a point 48% of the way across the plateau from the medial border. The medial (MFC) and lateral (LFC) femoral condyles, tibia, and fibula (Fib) are labeled.

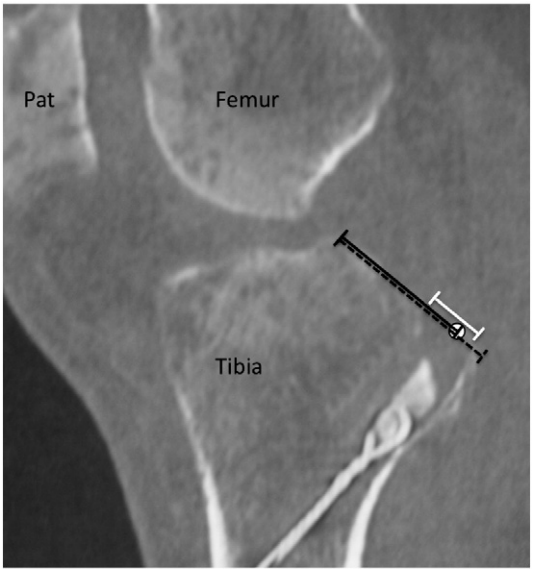

Fig. 2. A sagittal plane computed tomography image of a left knee following arthroscopic posterior cruciate ligament (PCL) reconstruction. The centre of the entry point of the PCL tibial tunnel into the joint is noted with a white dot. The distance from the centre of the tunnel to the posterior border of the retrospinal surface was measured (solid black line), as was the total length of the retrospinal surface (dashed black line). The white line denotes the expected antero-posterior position: placement of the tunnel within 5 mm of the centre of the posterior half of the retrospinal surface. The femur, tibia, and patella (Pat) are labeled.