The Knee 23 (2016) 412–419

Contents lists available at ScienceDirect

The Knee

Transportal femoral drilling creates more horizontal ACL graft orientation compared to transtibial drilling: A 3D CT imaging study

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ARTICLE INFO

Article history:
Received 24 October 2015
Received in revised form 8 February 2016
Accepted 22 February 2016

Keywords:
Anterior cruciate ligament
Reconstruction
Transportal
Transtibial
3D CT

ABSTRACT

Background: The principle of anatomic anterior cruciate ligament (ACL) reconstruction is to create a femoral and tibial tunnel that resembles the insertion of the native ACL. Anatomic reconstruction leads to a more horizontal graft orientation that provides more rotational stability.

The aim of this study is to investigate the best method to achieve anatomical reconstruction of femoral insertion of the ACL and thus, a more horizontal orientation of the ACL. We compared tunnel position and orientation between transportal femoral drilling technique and transtibial technique.

Methods: Thirty-two patients were included. Post-operative CT scans were obtained and femur, tibia and ACL tunnels were reconstructed. The position and orientation of tibial and femoral tunnels were quantified using the quadrant method, and femoral tunnel length, ellipticity and posterior wall breakage were assessed. We also investigated clinical outcome.

Results: Analyses show that transportal drilled femoral tunnels were situated significantly lower than transtibial drilled tunnels ($p < 0.0001$), resulting in a significantly more horizontal oriented ACL in the transportal group in coronal ($p < 0.0001$) and sagittal plane ($p = 0.01$). No differences were observed in depth of femoral tunnel position ($p = 0.44$). Femoral tunnel length was shorter in the transportal group ($p = 0.01$) with a more ellipsoidal femoral aperture ($p = 0.01$). There were no differences between both groups in tibial position. There were no differences in clinical outcome measure between the transportal and transtibial groups.

Conclusion: This study indicates that transportal drilling of the femoral tunnel leads to a more horizontal graft orientation of the ACL, without differences in clinical outcome.

1. Introduction

Anatomic placement of the anterior cruciate ligament (ACL) is considered to result in more physiologic knee kinematics [1] compared to non-anatomic ACL reconstruction. The principle of anatomic ACL reconstruction is to create a femoral and tibial tunnel that resembles the footprint of the native ACL in terms of location, size, aperture, resulting in the functional restoration of the ACL to its native dimensions and collagen orientation [2]. Traditionally, non-anatomic ACL reconstructions were found to be only successful in restoring anteroposterior stability, but not rotational stability, resulting in a positive pivot shift [3,4]. Drilling of the femoral and tibial tunnels at native ACL insertion sites is considered a key factor to establish a more horizontal orientation that provides anteroposterior and rotational stability, and to prevent impingement of the graft against the intercondylar notch or posterior cruciate ligament (PCL) [5].

Both transportal (TP) and transtibial (TT) drilling methods are widely used to drill the femoral tunnel. Some authors mention that the TP method gives a higher chance for post-operative rotational stability due to a more horizontal, and thus more anatomical, graft placement [6–8]. However, clinical studies are inconclusive regarding this theory: a recent systematic review by Chalmers was not able to clearly demonstrate these differences in tunnel position, nor did they find differences in clinical outcome [9].

The aim of this study is to determine the best method to achieve anatomical reconstruction of the femoral insertion of the ACL and thus, a more horizontal orientation of the ACL. We investigated the TP femoral drilling technique used at AZ Monica Antwerp and compared it with the TT technique by performing measurements on accurate CT-based 3D models and by assessing clinical outcome.

2. Patients & methods

2.1. Study population

We performed an observed power analysis for type I errors (wrongly rejecting the null-hypothesis) but not for type II errors (wrongly

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http://dx.doi.org/10.1016/j.knee.2016.02.014
0968-0160/

retaining the null-hypothesis). The observed power is very good for all significantly different parameters between TT and TP (data not shown). To evaluate the reliability of 'non-significant' results, we calculated the 95% CI, meaning that we can be 95% sure that this interval contains the true (mean) averaged measurement. These calculated intervals were low (data not shown), indicating that the comparison of the TP and TT measurements is not underpowered.

Thirty-two patients undergoing ACL reconstruction at AZ Monica Hospitals, Antwerp, Belgium were randomly selected and asked to participate in this study. All patients gave their informed consent. Sixteen patients underwent a TP reconstruction (nine males, seven females, aged 34.4 ± 10.0 years), sixteen patients underwent a TT reconstruction (nine males, seven females, aged 34.3 ± 9.9 years). TP reconstructions were performed by three surgeons (TL, PD and KCL) while TT reconstructions were all performed by one surgeon (PD). The selection of the technique was based on surgeon preference; no randomization was performed. Average followup time was 55 months.

2.2. Surgical technique

All patients underwent single bundle ACL reconstructions. An ipsilateral hamstring autograft was harvested prior to arthroscopy. Tibial tunnel was drilled using a tibial guide (Acufex, Smith & Nephew, Mansfield, MA) set at 50° in a similar manner in both groups with the anterior 1/3 length of the old ACL foot print as the anatomic reference. No specific adaptations of the tibial tunnel position were done in the TT group. In the TT group, drilling of the femoral tunnel was performed using an offset guide with the knee at 90° flexion. In the TP group, the femoral tunnel was placed at the height of the posterior synovial fold. The depth was determined by first measuring the sagittal length of the lateral femoral wall. The posterior edge of the notch and the distance to the articular cartilage were used as anatomic references. Then a small entrance was created just posterior from the midpoint (45%) with the knee still in 90° flexion. For final drilling of the femoral tunnel, the knee was flexed at 120° and the positioning was done free hand.

2.3. Clinical outcome

Clinical outcome was assessed using self-reported patient outcome scores such as the validated Knee injury and Osteoarthritis Outcome Score (KOOS) for pain, symptoms, average daily activities, sporting activities and quality of life [10]. Function and symptoms were also recorded with questions based on the IKDC questionnaire [11] (questions one, five, seven, eight, 10), Visual Analog Scale, and rates of rerupture, resumption of sporting activities and patient satisfaction were assessed. Patients were not aware of the type of technique that was used for their reconstruction and can therefore be considered as blinded for their assessment.

2.4. 3D CT analysis

Post-operative CT scans were obtained for all patients using the same scanning protocol (knee in extension; Siemens Sensation 64; slice thickness, 0.750 mm; slice increment, 0.400 mm; 120 kV, 153 mA). Based on these CT scans, the femur, tibia and ACL tunnels were reconstructed with 3D medical image processing software (Mimics 17.0, Materialise, Leuven, Belgium). In each reconstructed ACL tunnel a cylinder was fitted and the inertia axes of the cylinders were created. The insertion of the ACL graft was represented by the

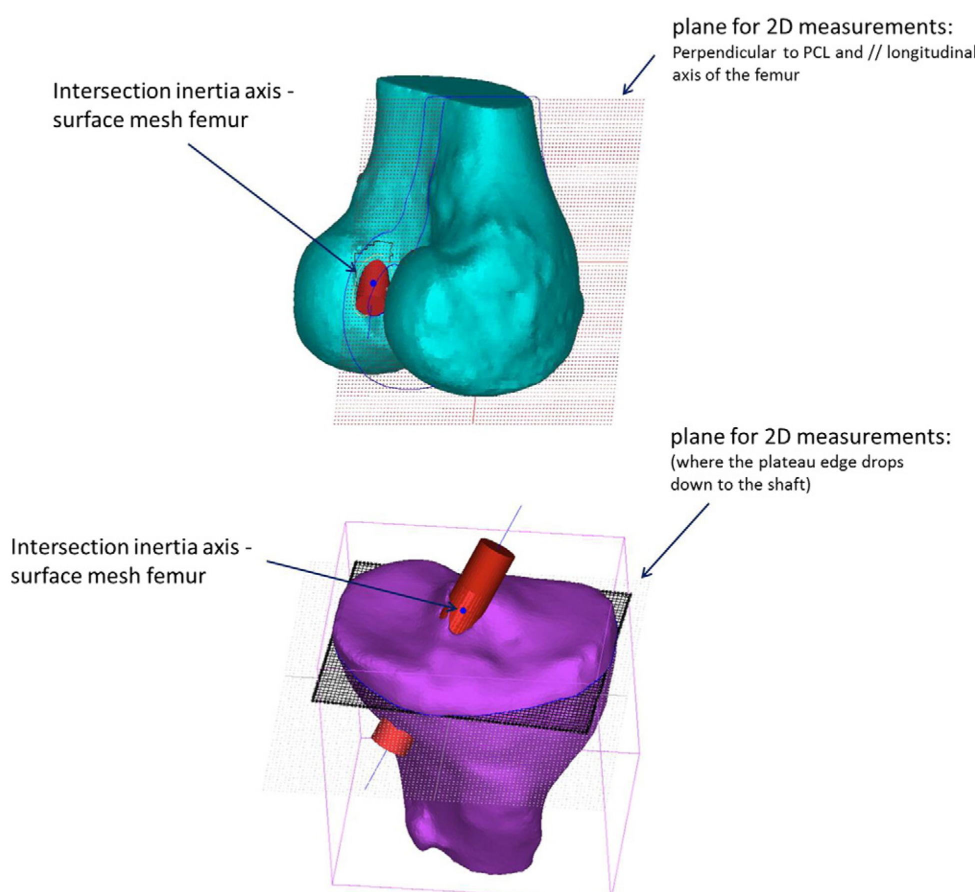

Figure 1. Conversion of tibia and femur 3D reconstruction into 2D plane for further analysis (PCL: posterior cruciate ligament).