Injury, Int. J. Care Injured 43 (2012) 1771–1775

Contents lists available at SciVerse ScienceDirect

Injury

journal homepage: www.elsevier.com/locate/injury

Evaluating the tibial and femoral insertion site of the anterior cruciate ligament using an objective coordinate system: A cadaver study

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ARTICLE INFO

Article history:
Accepted 3 July 2012

Keywords:
Anterior cruciate ligament
Cadaver study
Anatomic footprint

ABSTRACT

Purpose: The purpose of this study was to evaluate the tibial and femoral insertion site of the anterior cruciate ligament (ACL) using an objective coordinate system in a cadaver study in order to confirm radiological assumptions of previous investigators who identified the tibial footprint (*T*) of the ACL on *T* (5.3; 5.5) and the femoral footprint (*F*) on *F* (2.9; 3.5).
Methods: The tibial and femoral insertion site of the ACL was analysed on 30 human cadaver knee joints preserved according to the technique by Thiel. Thirty femora and tibiae were photographed under standardised methods and measured on a coordinate system twice by two examiners with respect to the ACL's footprint. We evaluated these measurements by use of the Cohen's kappa inter- and intraobserver coefficient for two observers.
Results: The photographs and tibial and femoral measurements were achieved with an almost perfect and a substantial agreement of inter- and intraobserver coefficients. Further, we could demonstrate that assumptions of anatomic points in previous radiological investigations were correct.
Conclusions: Our findings confirmed the anatomic tibial and femoral ACL footprint of a previous investigation and further the reproducibility of our coordinate system as an objective method for graft placement evaluation.

Introduction

Anatomic graft positioning is mandatory for achieving satisfying clinical results as well as anterior–posterior and rotational stability after reconstruction of the ruptured anterior cruciate ligament (ACL) with an incidence of 8.1 per 100 000 per year.[1] Previous studies have already demonstrated that intraoperative orientation should be achieved by help of the native footprint of the torn ACL.[2–6] Once misplaced on the femoral side there might occur a substantial loss of flexion and an elongated graft due to the exposure of abnormally high force on the graft tissue.[2,3,7–11] In case of a too posterior placed tibial graft it might lead to an increased anterior–posterior laxity whereas a too anteriorly placed graft will lead to impingement, notching and lack of extension.[7,10]

Previous investigators have successfully correlated anatomically placed ACL reconstructions with superior clinical outcome by using 3 dimensional computed tomography (3D CT) scans; however, this was based on radiological assumptions of the correct anatomical ACL footprint[12] with use of direct cranio-caudal tibial views and 45° internally rotated femoral views of the ACL. These assumptions detected the tibial footprint (*T*) of the ACL on *T* (5.3; 5.5) and the femoral footprint (*F*) on *F* (2.9; 3.5) using an objective coordinate system.

It is mandatory that these assumptions remain to be proven in a cadaver study with exactly the same orientation of these standardised tibial and femoral views.

The primary purpose of this study was to evaluate the tibial and femoral insertion site of the anterior cruciate ligament (ACL) with respect to an objective coordinate system in a cadaver study in order to confirm preexisting radiological assumptions. The secondary purpose was to describe the reproducibility of this measurements and the coordinate system using intra- and interobserver coefficients.

The study hypothesis was that preexisting radiological assumptions of the tibial and femoral insertion site of the ACL could be confirmed on human cadaver knees and that the method of confirmation was reproducible with respect to intra- and interobserver coefficients.

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0020–1383/$ – see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.injury.2012.07.004

Fig. 1. 30 human cadaver knees were prepared according to the technique by Thiel in order to evaluate the tibial and formal footprint of the anterior cruciate ligament (ACL).

Methods

Cadaver preparation

We studies 30 human cadaver knees, which were preserved according to the technique by Thiel[13] (Fig. 1). The anterior cruciate ligament was identified (Fig. 2) and the cruciate ligaments and the medial and lateral collateral ligaments were transected. The remaining tibial and femoral ACL were identified and the midpoint of the tibial and femoral footprint was marked with a green pen. In case of a macroscopic double bundle ACL (in 90% of cases) we chose the midpoint of these two bundles. Identification of the centre of the ACL was done by visualisation. After that we photographed the tibiae according to criteria of previously used protocols and drew the coordinate system by hand[12] (Fig. 3A and B). Next, we photographed the femora with a rotation of 45° inwards according to the same guidelines[12] (Fig. 4A). These photographs were taken twice by two observers. Thereafter, we printed the standardised photographs and identified the tibial and femoral footprint of the ACL, drew the coordinate system according to the previously published guidelines and described the endpoints with respect to the *X* and *Y* axes on tibial and femoral views (Fig. 4B). This whole procedure was performed twice by two observers in order to guarantee reliable and objective measurements by Cohen's kappa inter- and intraobservers.

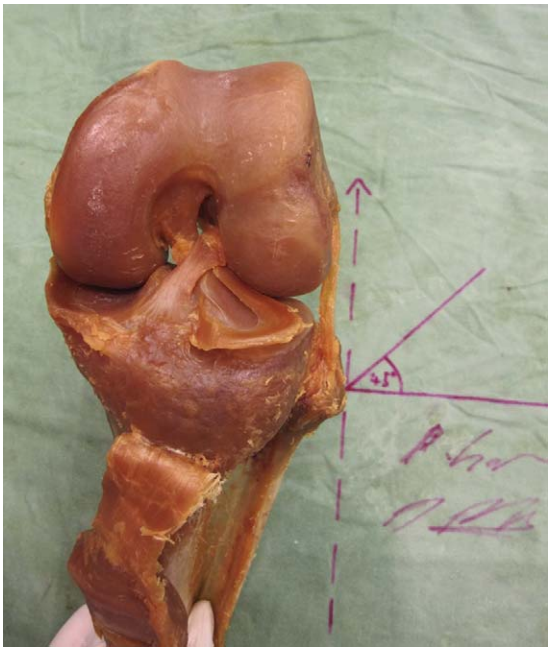

Fig. 2. This picture clearly shows the anterior cruciate ligament (ACL) of a left knee joint.

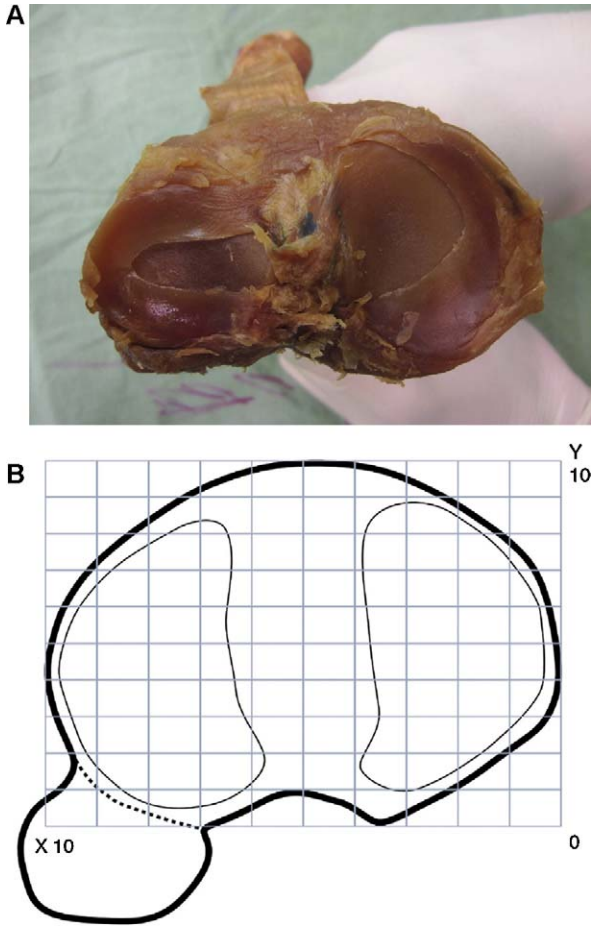

Fig. 3. (A) This picture shows the cranio-caudal tibial view in order to analyse the tibial footprint on the standardised coordinate system. (B) This sketch illustrates the standardised coordinate system with the values 0–10 from the most medial and dorsal corner to the most lateral and most anterior aspect of the coordinate system.

Construction and validation of the coordinate system

The coordinate system was drawn on the photographs as followed: the tibial insertion site of the ACL and the coordinate values were drawn and measured on a strict cranio-caudal view. The coordinate system was rated with the values zero of the *X* and *Y* axes at the postero-medial corner of a rectangular square on the tibial plateau.[12] The length and width of the plateau (square) were each rated as ten. This is illustrated in Fig. 3B. The posterior border of the facies articularis superior tibiae was set as the *X*-coordinate.[12] All of these preparations and measurements were performed twice by two observers and Cohen's kappa coefficients were evaluated.

In order to optimise the results of the intercondylar notch we rotated the cadaver knee from a strict posterior–anterior femoral view 45° internally in order to gain a better view of the intercondylar notch. This rotation was checked by a conventional