Anthropometric references for reconstruction of the anterior cruciate ligament in the anatomical position

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SUMMARY

Recent anatomical and biomechanical studies have established that the anatomical position in the reconstruction of the anterior cruciate ligament (ACL) is ideal because this position results in a lower placement of the femoral tunnels, which provides optimal biomechanical function of the graft, and because anterior translation and rotational stability are controlled. Ten femurs (five left and five right) and ten tibias (five left and five right) were dissected to analyze the various bony prominences of the lateral wall of the intercondylar fossa. Parameters were also established for the measurement of the ACL and its anteromedial and posterolateral bundles. Regarding the results in the medial wall of the lateral femoral condyle, different bony landmarks were considered, such as the distances from the bone-cartilage transition of anterior and posterior point of femoral condyle to the bifurcated ridge obtaining 7.68 ± 2.15 mm and 7.99 ± 2.15 mm, respectively. On the tibial bone we considered the length between the free edges of lateral and medial menisci, to the medial and lateral edges of anterior cruciate ligament (ACL), finding a distance of 2.5 cm + 1.20 mm. All these references during knee arthroscopy are useful to the surgeon, providing tools for the proper placement of the tunnels used in the reconstruction surgery of the ACL.

Key words: Anterior cruciate ligament – Femoral tunnels – Reconstruction of ACL – Anterior cruciate ligament bundles

INTRODUCTION

The rupture of the anterior cruciate ligament (ACL) is one of the most common pathologies in orthopedics, especially for patients who participate in sports (Fu, 1999; Griffin, 2000; Myklebust, 1997; Prodromos et al., 2007) Recent studies have reported that between 30% and 35% of patients with ACL ruptures who undergo reconstructive surgery do not return to performing at the same level of athletic activity after the surgery (Biau, 2007; Freedman et al., 2003).

The clinical results of ACL repair are not satisfactory in all patients. (Aglietti, 1997; Carson, 2004; Colosimo, 2001; Getelman, 1999; Martinek, 2002; Taggart, 2004). The principal cause of this dissatisfaction is attributed to the fact that the position of the ACL in surgical reconstruction is not optimal. (Howell, 1998; Sommer, 2000; Diamantopoulos, 2008). Originally, repairs to the ACL by arthroscopic means were not performed in the anatomical position of the ACL because of...
the technical difficulty of such approach. Currently, there is an increasing trend to position the ACL according to the anatomical insertion points of the ligament during reconstruction to obtain a better clinical outcome. Two fundamental aspects for improving the clinical outcome are a proper anatomical position when placing the graft during surgery and separate reconstruction of the anteromedial (AM) and posterolateral (PL) bundles of the ACL (Shen et al., 2007).

Previous studies have reported the anatomical positions of the tibial and femoral insertions of the ACL, as well as the positions of the AM and PL bundles (Shen et al., 2007). However, the anthropometric measures between bony and/or soft tissue reference points and the ACL have not been specifically established. These measures might assist the surgeon in correctly positioning the ACL during reconstruction.

The goal of our study was to describe the position of the ACL and to establish the necessary anatomical points of reference for the correct placement of the femoral and tibial tunnels in the anatomical position during ACL repair.

MATERIALS AND METHODS

We dissected ten femurs (five left and five right) and ten tibias (five left and five right), which were collected from the Department of Human Anatomy of the Faculty of Medicine at the Autonomous University of Nuevo León, to analyze the various bony prominences of the lateral wall of the intercondylar fossa. Parameters were also established for the measurement of the ACL and its AM and PL bundles. No cadaver presented any sign of injury or abnormality in the knee joint.

Knee preparation

The anatomical pieces were refrigerated at 4°C prior to use and were brought to room temperature 12 hours prior to their handling. To access the ACL, an incision was made in the distal part of the quadriceps tendon to retract it, and to analyze the ACL as well as its two bundles and bony prominences at 90° of flexion. To improve the visibility of the menisci and the tibial and femoral insertions of the ACL, the posterior cruciate ligament (PCL) was displaced. In addition, a transverse cut was made in the collateral ligaments.

Measurements

The perimeters of the tibial and femoral insertions of the ACL, as well as their bundles and related structures, were measured using digital Vernier calipers (TED PELLA with a millimeter scale and a margin of error of 0.01 mm), which were introduced into the joint capsule to obtain the parameters that will be discussed below. For greater ease, we proceeded to completely disinsert the ACL to obtain the measurements outside the joint. This approach achieved more exact results for this structure.

Femoral references

The bony references that were considered include the lateral wall of the intercondylar fossa: a) the lateral intercondylar ridge, b) the bifurcated ridge, c) the posterior point of the femoral cartilage, and d) the anterior point of the femoral cartilage. The lateral intercondylar ridge is an elevation that is located in the lateral wall of the femoral condyle and that is used as a reference for the placement of the femoral tunnel because this ridge demarcates the anterior edge of the ACL. The bifurcated ridge is a bony reference that runs perpendicular to the lateral intercondylar ridge with the knee flexed at 90°, and marks the sepa-
ration between the AM and PL bundles of the ACL. The posterior point refers to the posterior bone-cartilage transition area of the lateral wall of the intercondylar fossa with the knee flexed. The anterior point corresponds to the anterior bone-cartilage transition area of the lateral wall of the intercondylar fossa with the knee flexed (Fig. 1).

**Tibial references**

The tibial bony references that were considered were the traces left by the ACL at the site of removal from its tibial insertion. The distance between the anterior edge of the tibia and the anterior and posterior edge of the ACL trace was measured. Similarly, cartilaginous references, such as the menisci and the lateral and medial edges, were determined. To measure the menisci, the two edges were accounted for using a) the “free edge”, which is in close relation to the midline of the knee, and b) the “capsular edge”, which is located proximal to the joint capsule (Fig. 2).

**RESULTS**

**Femoral parameters**

**Lateral intercondylar ridge.** This ridge was observed in all of the knees that were dissected at 90° of flexion; an average length of 18.35 mm (±3.09 mm) was measured.

**Bifurcated ridge.** The bifurcated ridge was palpated and observed in all of the knees that were dissected. The average length of the bifurcated ridge was 6.96 mm (±1.76 mm). Table 1 shows the results of the anatomical points of reference in the intercondylar fossa.

**Parameters of tibial insertion of the ACL**

**Anterior edge of the tibia.** The average length between the anterior edge of the tibia and the anterior edge of the trace left by the ACL was 11.00 mm (±2.20 mm). The average length between the anterior edge of the tibia and posterior edge of the trace left by the ACL was 25.01 mm (±4.17 mm).

**Menisci.** An average length of 25.01 mm (±4.17 mm) from the free edge of the lateral meniscus to the lateral edge of the ACL was measured. The average length from the free edge of the internal meniscus to the medial edge of the ACL was 24.99 mm (±3.11 mm). Table 2 shows the results of the anatomical points of reference and ACL on the tibia.

**Parameters of the ACL**

The length of the femoral insertion of the ACL and length of the tibial insertion of the ACL (Table 3) were considered as well as each of the measurements for the previously separated AM (Table 4) and PL bundles (Table 5).

**DISCUSSION**

This study morphometrically describes the ana-
Table 5. The posterolateral bundle length of the ACL

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<thead>
<tr>
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<th>Length</th>
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<tbody>
<tr>
<td></td>
<td>Ti</td>
<td>FI</td>
</tr>
<tr>
<td>Average</td>
<td>5.34</td>
<td>7.56</td>
</tr>
<tr>
<td>SD</td>
<td>1.38</td>
<td>1.24</td>
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Ti, Tibial Insertion; FI, Femoral Insertion; CP, Central Portion; SD, Standard Deviation. *Millimeter scale (mm)
between the edges of the menisci and internal and external edges of the ACL on the tibia is 2.5 cm ± 1.20 mm; these measurements constitute an additional tool for the correct location of the ACL on the tibia. In addition, the study quantitatively shows the diameter of the ACL at its tibial and femoral insertions, as well as the diameter of the AM and PL bundles at the femoral and tibial insertion sites.

Ziegler et al. (2011) used the centers of the ACL as well as the AM and PL bundles for the quantitative description of the insertion of the ACL in the tibia. We decided to use the edges of the ACL at its tibial insertion site as opposed to the center and its bundles, because we believe that the surgeon, when deciding between this approach or the tunnel approach as the technique to use, needs to keep the safe area of insertion in the visual field of the arthroscope and establish the margins that must not be crossed by the insertion.

This research confirmed what was described by Ziegler et al. (2011), who stated that the AM bundle is found anterior and covers the PL bundle, and that insertion of the AM bundle in the tibia has the form of a comma. When the knee is flexed at 90°, the portion of the ACL that is observed is the AM bundle. The insertion of the PM bundle at the tibia is 5.23 mm (±1.03), and it consists of a small thinning in the medial portion and increases by more than 2 mm at its femoral insertion. These results are important in surgery, because the surgeon should be aware of this discordance in diameter between the points of insertion.

The results obtained in this study assist in improving the position of the ACL placement during arthroscopic reconstruction, regardless whether with a double tunnel or a conventional single-tunnel technique is applied by always seeking the anatomical position as a central reference during reconstructive surgery of the ACL. By improving the placement of the tunnels, better functional results are obtained, and errors in ACL reconstruction are minimized.

REFERENCES


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