Artroskopska anatomija in patoanatomija raztrganine sprednje križne vezi: klinična raziskava z vključenimi 94 bolniki

Arthroscopic anatomy and pathoanatomy of anterior cruciate ligament ruptures: clinical study with 94 patients

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Izvleček

Cilji: *Artroskopsko smo želeli določiti variacijo velikosti narastišča sprednje križne vezi (SKV) ter ugotoviti, ali ima raztrganina sprednje križne vezi različne vzorce glede na dejstvo, da je sestavljena iz dveh snopov.*

Material in metode: *V raziskavo je bilo vključenih 94 operiranih bolnikov s pretrgano sprednjo križno vezjo v obdobju od junija 2008 do junija 2009. Povprečna starost bolnikov je bila 26.7 ± 8.3 (od 16 do 48 let). Vključitvena kriterija sta bila dva: pretrganje sprednje križne vezi in čas med poškodbo in operacijo , krajši od 120 dni. Ta kriterij je bil določen, ker se je pri prejšnji neobjavljeni raziskavi pokazalo, da je 120 dni po poškodbi težko ločiti oba snopa.*

Abstract

Purpose: *To arthroscopically evaluate the size variability of the Anterior cruciate ligament (ACL) insertion sites and to determine whether there are variations in rupture patterns of the two ACL bundles.*

Material and Methods: *Ninety-four patients undergoing ACL reconstruction between June 2008 and June 2009 were included in our study. The average age of the patients was 26.7 ± 8.3 years (range, 16–48 years). Only patients with an ACL rupture less than 120 days old were included as unpublished data revealed difficulty in distinguishing between AM and PL bundles in older ACL ruptures.*

Rezultati: *Ugotovili smo, da je dolžina narastišča sprednje križne vezi na femur od 11 do 20 mm (15.9 ± 2.2). Na tibiji je dolžina od 9 do 20 mm (16.0 ± 2.1). Širina narastišča sprednje križne vezi na femur je od 6 do 11 mm (8.3 ± 1.2). Širina narastišča sprednje križne vezi na tibijo je med 6 in 12 mm (8.7 ± 1.1).*
Najpogostejši vzorec poškodbe sprednje križne vezi je bila raztrganina obeh snopov proksimalno, in sicer kar pri 74 bolnikih (78.7 %).
Zaključek: *Obe hipotezi sta bili potrjeni, kar je morda klinično pomembno pri rekonstrukciji sprednje križne vezi.*

Results: *The femoral ACL insertion site length ranged from 11 to 20 mm (15.9 ± 2.2). On the tibial side, the length of the tibial ACL insertion site ranged from 9 to 20 mm (16.0 ± 2.1). On the femoral side, the width of the ACL insertion site ranged from 6 to 11 mm (8.3 ± 1.2). On the tibial side, the width of the entire ACL insertion site ranged from 6 to 12 mm (8.7 ± 1.1).*
The most frequent injury pattern was found to be the proximal rupture of both bundles; seen in 74 patients (78.7%).
Conclusion: *Both hypotheses were confirmed, and this may be clinically relevant in anatomic ACL reconstruction.*

INTRODUCTION

The ACL consists of dense connective tissue enveloped in a synovial membrane, which places the ligament in an intraarticular but extrasynovial position (1). The bony attachment is located at the posterior part of the inner surface of the lateral femoral condyle and not, as sometimes presumed, at the roof of the intercondylar notch. From its femoral attachment, the ACL runs anteriorly, medially and distally to the tibia. Its length ranges from 22 to 41 mm and its width from 7 to 12 mm (1, 2, 3, 4). The tibial attachment is somewhat wider and stronger than the femoral attachment. It has been well described in the literature that the ACL can be divided into two major functional bundles, the anteromedial (AM) bundle and the posterolateral (PL) bundle (1, 2). These two functional bundles are named according to their insertion on the tibial side. The fascicles of the AM bundle originate at the most anterior and proximal aspect of the femoral attachment and insert at the anteromedial aspect of the tibial attachment. Conversely, the fascicles of the PL bundle originate at the posterodistal aspect of the femoral attachment and insert at the posterolateral aspect of the tibial attachment (4). Biomechanical investigations have demonstrated that the ACL fiber bundles are not isometric throughout flexion and extension. In general, the AM bundle tightens in flexion and the PL bundle relaxes, whereas in extension the PL bundle tightens and the AM bundle relaxes (4).

These anatomical and biomechanical considerations have recently sparked an interest in the clinical application of more anatomic reconstruction techniques (1, 5, 6). Anatomic ACL reconstruction can be defined as the functional restoration of the ACL to its native dimensions, collagen orientation and insertion sites (7). Karlsson et al. stated that for an anatomic single-bundle or anatomic double-bundle procedure, graft type, tunnel size, and graft diameter should be dictated by morphologic characteristics of the knee and native ACL anatomy of each patient (8).

Many studies have shown that the size of the ACL insertion sites is variable (2, 9, 10, 11, 12). However, these studies are limited by their relatively small sample sizes, use of cadaveric specimens, or the presence of osteoarthritic changes in patients undergoing total knee arthroplasty (13).

The first purpose of this study was to arthroscopically evaluate the size variability of the ACL insertion sites in a large series of patients. This will help to individualize the surgery regarding the single- or double-bundle surgery and graft size.

The second purpose was to determine whether there are variations in where the bundles rupture.

MATERIAL AND METHODS

DEMOGRAPHICS

Ninety-four patients undergoing ACL reconstruction between June 2008 and June 2009 were included in our study. Investigation performed at Artros Center for Orthopaedic Surgery and Sports Medicine, Ljubljana, Slovenia

The average age of the patients was 26.7 ± 8.3 years (range, 16–48 years). Only patients with an ACL rupture less than 120 days old were included, as unpublished data revealed difficulty in distinguishing between AM and PL bundles in older ACL ruptures. Exclusion criteria were previous ACL reconstruction.

OPERATIVE TECHNIQUES

The knee was prepared and draped in the standard fashion, and arthroscopic portals were established. The anterolateral portal was placed superior to the inferior pole of the patella and at its lateral border.

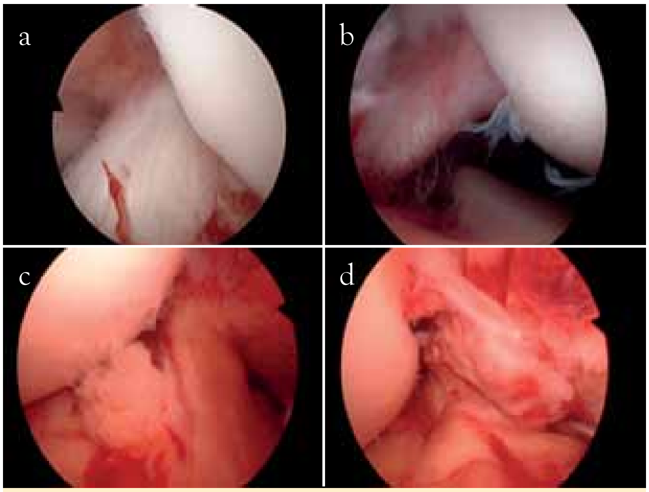

Figure 1. *ACL Bundles: a. Intact AM bundle; b. Intact PL bundle c. Ruptured PL bundle; d. Elongated PL bundle*

The anteromedial portal was placed low, just medial to the medial edge of the patella tendon to allow better visualization of the femoral insertion site, to be aligned with the major axis of the ACL insertion site and to obtain a more exact measurement. Finally, an accessory inferior medial portal was marked medial to the inferomedial portal slightly above the meniscus. Prior to assessment of the ACL, any meniscal or chondral pathology was addressed. Next, the rupture pattern of the AM and PL bundle was carefully evaluated using a thermal device. Special attention was given to the rupture pattern and remaining fibers of each bundle, and the insertion sites of the AM and PL bundle were very carefully visualized through the lateral and medial portal (Fig. 1). We then visualized and identified the bony landmarks, especially the lateral intercondylar ridge and the lateral bifurcate ridge. We marked the location of the native femoral and tibial footprint, corresponding to their positions in the native ACL. The length and width of the femoral and tibial insertion sites were measured using an arthroscopic flexible ruler (Smith & Nephew Endoscopy, Andover, MA, USA). The length was measured along the major axis of the insertion sites, and the width was measured perpendicular to it at the widest diameter of the two bundles (Fig. 2). All procedures and measurements were performed by the first author.

STATISTICS

Statistical analysis was done using the SPSS 18.0 software package (SPSS Inc., Chicago, IL, USA). Background data statistics included percentage dis-

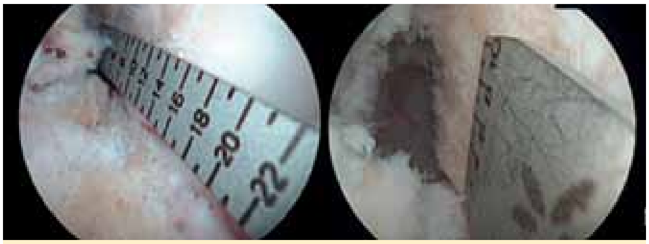

Figure 2. *Arthroscopic view of the left knee: (A) Intraoperative measurement of femoral ACL insertion site length. (B) Intraoperative measurement of femoral ACL insertion site width.*

tributions, frequency analysis, mean values and standard deviations.

RESULTS

The femoral ACL insertion site length ranged from 11 to 20 mm (15.9 ± 2.2) (Fig. 3). On the tibial side, the length of the total ACL insertion site ranged from 9 to 20 mm (16.0 ± 2.1) (Fig. 4). On the femoral side, the width of the ACL insertion site ranged from 6 to 11 mm (8.3±1.2) (Fig. 5). On the tibial side, the width of the entire ACL insertion site ranged from 6 to 12 mm (8.7 ± 1.1) (Fig. 6).

The most frequent injury pattern was found to be the proximal rupture of both bundles in 74 patients (78.7%).

The AM bundle was torn from the femoral side in 80 (85.1% of cases) and from the tibial side in 5 (5.3% of cases). AM mid substance tear was seen in 9 (9.5% of cases). We found no cases of AM bundle elongation.

The PL bundle was torn from the femoral side in 74 (78.7% of cases) and from the tibial side in 6 (6.3% of cases). PL was insufficient due to elongation in 4 (4.2%). PL mid substance tear was seen in 10 (10.6% of cases).

DISCUSSION

The first hypothesis of the study was that there is a large variation in ACL insertion sites between individuals. This hypothesis was affirmed, as we found the tibial insertion site to be between 16–18 mm in length (range, 9–20 mm) in 60% of patients and between 15–18 mm (range, 11–18 mm) at the femoral side in 65% of patients.

In the literature, several studies have reported the length and width of the ACL insertion sites (9, 13, 14). These studies were cadaveric studies with small sample sizes, in which the surrounding tissue was removed before measuring. Our study included a large number of patients and the measurement was done arthroscopically without removing tissue. Moreover, the study by Stijak included cadavers of an older age group than individuals in our study. It is possible that the ACL decreases in size over time and that the ACL degenerates with age (15, 16, 17).

Kopf et al. found a high variability of insertion sites on the tibia and the femur; this is the same in the

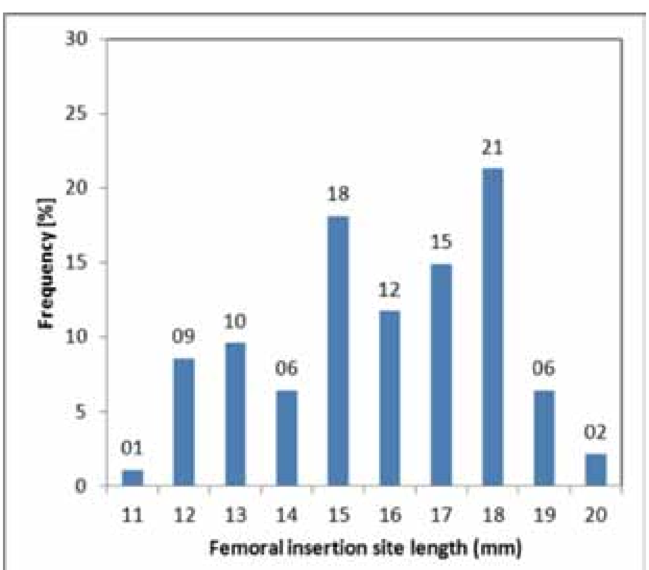

Figure 3. *Distribution of the femoral insertion site length.*

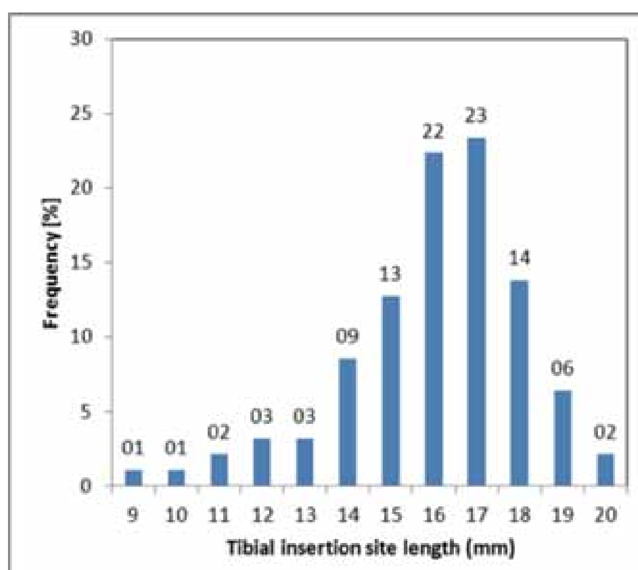

Figure 4. *Distribution of the tibial insertion site length.*

present study (18). They measured the anteromedial (AM) and posterolateral (PL) bundles instead of the whole insertion site, as we did in our study (18).
An important consideration for accurately measuring the size of the ACL insertion sites is the ability to properly identify the insertion sites. Soft tissue remnants of the ACL stumps, rupture pattern, and anatomical landmarks such as the lateral bifurcate and intercondylar ridges of the femur have been shown to be critical components for defining the native ACL anatomy. Recent publications have recommended single-bundle ACLR instead of a double-bundle ACLR in cases where the ACL insertion site is less than 14 mm in length (19). Furthermore, the size of the ACL insertion sites may influence the size of the graft and thus the graft choice, as certain grafts may limit the ability to restore the native insertion site size. In cases of larger insertion sizes, bigger grafts may be needed to adequately restore the size of the native insertion sites (18) and improve the functional results of ACL reconstruction.

The second hypothesis in our study was to determine if there are variations in rupture patterns between the two bundles. This hypothesis was also affirmed, as we found that in 74% of all cases both bundles were ruptured on the femoral side. PL was insufficient due to elongation in 4.2%, but we have no cases of AM bundle elongation. The different ACL arthroscopic rupture patterns of the AM and PL bundles offer a possibility that different mechanisms produce different rupture patterns.

Our study has a limitation in that we did not measure and include intercondylar notch size, which may be an important factor in ACL rupture and reconstruction.

CONCLUSION

The size of the ACL insertion site and clarification of the ACL rupture pattern seems to be relevant for planning future ACL surgery.

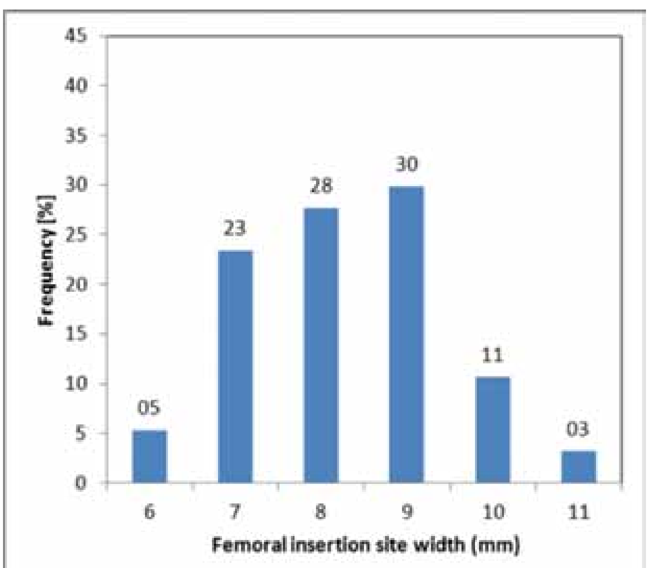

Figure 5. *Distribution of the femoral insertion site width.*

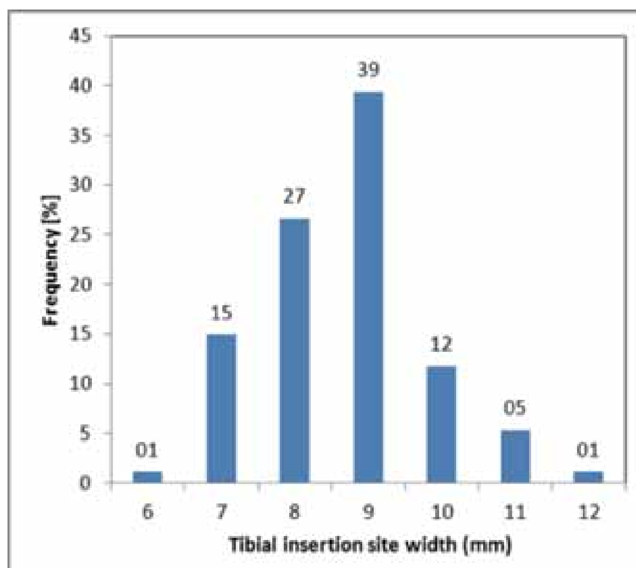

Figure 6. *Distribution of the tibial insertion site width.*

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