Incidence of the Remnant Femoral Attachment of the Ruptured ACL

Jocelyn Wittstein MD, Maria Kaseta MD,
Robert Sullivan MD, William E. Garrett MD, PhD

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Abstract The presence of remnant tibial and femoral attachments of the ruptured ACL has been described in the literature but the femoral remnant has not been well described as a landmark for tunnel placement during reconstruction. We reviewed operative reports, pictures, and videotapes from 111 ACL reconstructions to determine the incidence of a remnant femoral stump. Patients were divided into two groups: Group A included patients treated from January 2006 through September 2006 ($n = 63$) when the presence of the femoral footprint was documented retrospectively and Group B included patients treated from September 2006 through June 2007 ($n = 48$) when the presence or absence of the femoral footprint was documented prospectively. In Group A, there were 48 of 58 (83%) patients with a visible stump and 10 (17%) patients in whom we could not verify the existence of the stump. In Group B, 43 of 44 (98%) patients had a visible stump on the lateral femoral wall that was adequate as a guide for femoral tunnel placement. The native femoral footprint is seen in most cases of ACL reconstruction and can be used for guidance during femoral tunnel preparation.

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Each author certifies that his or her institution has approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research.

J. Wittstein (✉), M. Kaseta, R. Sullivan, W. E. Garrett
Division of Orthopaedic Surgery, Duke University Medical
Center, 821 Kenmore Road, Chapel Hill, NC 27514, USA
e-mail: witts002@mc.duke.edu

Introduction

An estimated 75,000 to 100,000 ACL reconstructions are performed annually in the United States [22]. The goal of these procedures is to restore the anatomy and function of the native ACL. Improper graft placement is believed to be a major cause of failure in current ACL reconstruction techniques, with femoral tunnel malposition cited as a common error [2, 5, 6, 9, 14, 19–21]. The most common technical error is anterior placement of the femoral tunnel, resulting in increased graft tightness in flexion and excessive strain on the graft [5]. Placing the femoral tunnel too vertical (at 11 o'clock rather than 10 o'clock) in the coronal plane in the notch is another common mistake, which results in decreased resistance to rotatory loads [13, 17].

Remnants of the tibial insertion of the ACL have been used as guides for tibial tunnel placement to restore the native anatomy [10]. Using the native attachment may limit such problems as graft impingement resulting from anterior placement of the tibial tunnel [1]. Additionally, placing the tibial tunnel too lateral or medial can result in impingement on the lateral femoral condyle or PCL, respectively [15].

To determine the likelihood of being able to use the femoral remnant footprint as a guide to tunnel placement, we determined the incidence of the remnant femoral attachment on the lateral wall of the notch after ACL rupture as seen during arthroscopic reconstruction.

Materials and Methods

We retrospectively studied 111 patients undergoing ACL reconstructions from January 3, 2006, through May 31, 2007. The patients were divided in two groups. Group A ($n = 63$) included patients operated on from January 3,

2006, through September 19, 2006, when the existence of the femoral footprint in the notch was retrospectively documented from a review of operative reports, pictures, and videotapes. Group B ($n = 48$) included patients operated on from September 28, 2006, through May 31, 2007, when the presence of the ACL femoral footprint was prospectively documented intraoperatively. There were no differences between Groups A and B in terms of gender, age, and time to surgery from injury. There were 71 male and 40 female patients with an average age of 27.8 years (range, 13–56 years). The right knee was affected in 60 patients and the left in 51. We excluded five patients in Group A and four in Group B with previous ACL reconstructions. After excluding patients with revisions, 58 patients remained in Group A and 44 in Group B. Surgery was performed an average of 6.4 months after injury (range, 0.5–96 months). There were two chronic injuries (treated greater than 1 year after injury) in Group A and one in Group B. One patient in Group A could not specify the time of injury. Approval for this study was obtained from our institutional review board before proceeding with this research.

In Group A, we performed arthroscopic reconstruction of the ACL after diagnostic arthroscopy and notchplasty. We retrospectively reviewed operative reports, pictures, videotapes, and patient charts. Operative reports were reviewed specifically for a statement by the surgeon that the native ACL stump was visible. In cases where the surgeon did not state whether the femoral stump was identifiable, intraoperative arthroscopy photographs and videotapes were reviewed to further elucidate whether the stump was present. In Group B, a thorough arthroscopic evaluation was performed, before notchplasty and ACL reconstruction, in which the intercondylar notch was inspected to carefully identify any remaining ACL fibers at the femoral attachment site. As in Group A, all knees in Group B were positioned in 90° flexion with the leg hanging over the edge of the operating table with a lateral post. All arthroscopies were performed with a 30° arthroscope. In addition to a standard diagnostic arthroscopy, the posterior aspect of the joint was observed routinely by placing the arthroscope through the notch such that the posterior aspect of the lateral femoral condyle was seen. In all cases, inferomedial, inferolateral, and superomedial portals were used.

We performed a limited notchplasty to better observe the stump and took intraoperative pictures of nearly all the cases in Group B (Fig. 1). The notchplasty consisted of removing just enough bone (2–5 mm) at the anterior aspect of the lateral wall of the notch to provide adequate observation of the femoral origin of the ACL during femoral tunnel placement. The femoral stump was identified based on feel during probing and appearance, which typically differed from the surrounding soft tissues. The residual stump tended to have a more bulbous appearance and to be firmly

Fig. 1A–B Observation of the residual femoral attachment of the ACL was improved after a limited notchplasty, as shown in a (A) lateral wall right knee, and a (B) lateral wall left knee.

adherent. When the femoral stump was identified, its central portion was used as a guide for femoral tunnel placement. We were not able to identify anteromedial and posterolateral femoral insertions, rather a single stump in all cases. We used an Arthrex RetroDrill (Arthrex, Inc, Naples, FL) to create the femoral tunnel, using a single-bundle technique. The retrodrill was centered on the residual femoral stump, engaged on the antegrade-placed guidewire, and then used to drill the femoral tunnel in a retrograde manner.

Results

In Group A, 48 of the 58 patients (83%) had visible stumps. In 10 cases (17%), the existence of the femoral stump

could not be verified from the operative pictures or reports. In the two cases treated greater than 1 year after injury, only one had an identifiable femoral stump. In Group B, 43 of the 44 patients (98%) had a visible ACL stump left at the native femoral footprint, which was used as a guide for femoral tunnel placement. Only one (2%) had a residual stump that was not substantial enough to be used as a guide for tunnel placement. This patient was treated 96 months after the initial injury and previously underwent arthroscopy with partial meniscectomy during which a torn ACL was identified but not reconstructed. It is possible the surgeon resected the ACL remnant to prevent impingement or to facilitate future ACL reconstruction [3].

Discussion

Improper graft placement, especially on the femur, is believed to be a major cause of failure in current ACL reconstruction techniques [2, 5, 6, 9, 14, 19–21]. Several anatomic studies showed high variability in location and dimensions of the ACL femoral attachment [4, 7, 8]. The o'clock femoral tunnel positioning technique fails to incorporate the three-dimensional characteristics of the ACL on the medial surface of the lateral femoral condyle. Considering the variability of the femoral footprint, generic o'clock femoral tunnel positions should not be used with every patient to achieve more anatomic reconstruction and restore the native function of the ACL. Some of the more common errors in tunnel placement, including anterior and vertical femoral tunnel positioning, may be avoided by using the native femoral attachment as a guide for tunnel placement. The goal of this study was to investigate the incidence of a remnant femoral attachment of the ACL and to describe its use as a landmark for femoral tunnel placement.

There are some limitations to this study. In Group A, data were collected retrospectively. The presence of a femoral stump may be underestimated owing to failure of the surgeon to report or photograph this finding. There is also potential for bias on the part of the authors who may anticipate presence of a residual femoral attachment. It is possible scar tissue or hypertrophic synovial lining could be mistaken for remnant ACL, particularly in cases where the presence of this remnant was not prospectively documented. In Group B, where data were collected prospectively, we believe it is less likely to have mistakenly identified a remnant attachment.

Several studies report different percentages of femoral ACL remnants remaining in the notch. Our results are consistent with those of Lo et al. [12], who reported only 2% of previously ruptured ACLs were absent during arthroscopic reconstruction. Zantop et al. [22] presented

pictures in which the femoral stump was visible in the notch of intraarticular rupture patterns of the ACL. In their study, two bundles were identified. In a study by Twaddle et al. [18] on knee dislocations, none of the knees had proximal avulsions whereas 19 of 53 knees had distal avulsions of the ACL. In contrast, Crain et al. [3] reported the ACL remnant in 58% of patients was healed to the lateral wall in a different site from its anatomic origin and in 42% the lateral wall was completely empty. Ochi et al. [16] noted similar findings. We suspect, based on our observations, a short stump would have been revealed at the anatomic origin of the ACL in most cases after a careful notchplasty. Failure to perform a careful notchplasty also may contribute to the difference between Groups A and B in our study.

The remnant of the femoral footprint of the ACL may be a useful landmark to aid in accurate placement of the femoral tunnel during ACL reconstruction. In a recent study by Kaseta et al. [11], more anatomic placement of the femoral tunnel was achieved using the femoral footprint as a landmark than with the over-the-top positioning guide, which resulted in femoral tunnel placement that was typically too anterior.

The ACL femoral footprint is seen in most cases of ACL reconstruction and can be used for guidance in the femoral tunnel placement. As this series included only three cases of chronic instability, it is unclear whether the femoral stump would serve as a reliable landmark in less acute settings. Additional studies are necessary to determine if use of the femoral footprint as a guide for tunnel placement results in function more closely approximating that of the native ACL.

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