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Effects of pre-operative knee laxity on clinical outcomes after partial anterior cruciate ligament reconstruction

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ABSTRACT

Background: The effects of retaining residual bundles on surgical outcomes has not been observed, so we evaluated the effects of preoperative knee laxity on clinical outcomes after partial anterior cruciate ligament (ACL) reconstruction for partial ACL rupture in this study.

Purpose: To evaluate the effects of preoperative knee laxity on clinical outcomes after partial anterior cruciate ligament (ACL) reconstruction for partial ACL rupture.

Methods: The data of 47 patients, who had partial ACL rupture and underwent partial ACL reconstruction, were retrospectively analyzed. According to preoperative kneelax arthrometer and pivot shift test, the 47 patients were divided into group A (kneelax arthrometer ≤5 mm and pivot shift test <II grade, n = 26) and group B (kneelax arthrometer >5 mm and/or pivot shift test ≥II grade, n = 21). The minimum follow-up duration lasted 2 years. The clinical outcomes were evaluated using IKDC (International Knee Documentation Committee) scoring systems, Lysholm knee scoring scale, Tegner activity rating, Lachman test, Pivot shift test and the kneelax arthrometer.

Results: The function and stability examinations for the affected knee joint were significantly improved in both groups after partial ACL reconstruction as compared with preoperative ones (all $P < 0.01$). There were no significant differences in the post-operative Lysholm and Tegner scores, Lachman and Pivot shift test results between both groups (all $P > 0.05$). However, there were significant differences between the two groups in terms of the post-operative IKDC scoring system and kneelax arthrometer examination result (all $P < 0.05$).

Conclusions: In the patients with partial ACL rupture, the mechanical strength of the remnant ligament has significant influence on the therapeutic effects of partial reconstruction. The patients with kneelax arthrometer >5 mm and/or pivot shift test ≥II grade still have anterior instability in the affected knee after partial reconstruction.

1. Introduction

The anterior cruciate ligament (ACL) consists of two functionally separate and distinct bundles: anteromedial (AM), and posterolateral (PL) [1,2]. Although the two bundles together maintain knee stability, there is a slight difference in their biomechanics, which is due to their different anatomical positions. The AM bundle mostly controls anterior translocation of the tibia at >45° flexion. The PL bundle is non-isometric and more oblique, and plays a fundamental role in rotational stability between 0 and 30° flexion [2]. This means that one bundle can be easily damaged under a specific condition, leading to partial ACL rupture. It has been reported that partial ACL tears occur in 10–28% of ACL ruptures [3–7].

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Surgical treatment is often required because of the persistence of symptomatic instability after the ACL has been partially injured, especially in the young who have high functional demands [8,9]. There are three surgical methods for treatment of partial ACL rupture: single-bundle reconstruction, double-bundle reconstruction, and partial reconstruction. The traditional single-bundle reconstruction allows 61–67% of patients with ACL rupture to have normal International Knee Documentation Committee (IKDC) scores [10]. Single-bundle reconstruction can effectively restore anterior–posterior knee stability, but cannot restore rotational stability [11,12]. Double-bundle reconstruction shows marked therapeutic effects on knee-rotational stability [12].

Various recent Level I and II studies have indicated that, compared with single-bundle reconstruction, double-bundle reconstruction obtains better short-term clinical therapeutic effects because it is equivalent to the former in restoring anterior–posterior knee stability and can also achieve better knee-rotational stability [13–17]. However, in partial ACL rupture, double reconstruction requires disruption of the intact fibrous bundle (AM or PL), which contains mechanoreceptors [18–20], and abundant vasculature [21–23]. Therefore, partial reconstruction has gradually become used in patients with partial ACL rupture because it preserves the intact or less-damaged bundle during ACL reconstruction, which improves clinical results, due to its biological advantages. Although there are many studies on the treatment of partial ACL rupture with partial reconstruction, little research on its biomechanics has been conducted.

Noyes et al. reported that partial ACL rupture could develop complete rupture in 38% of patients [24], whereas Fruensgaard and Johannsen described that this condition might occur in 51% of patients [25]. Partial ACL rupture could develop complete rupture because nutrient vessels are blocked, due to trauma and inflammation, resulting in residual ligament necrosis and rupture [26]. Li et al. believed that the residual intact bundle suffers continuous abnormal stress, as it plays a role in maintaining knee stabilization after the other bundle has become damaged, so it gradually loosens [27]. Therefore, it is worth investigating whether the residual ligament plays a role in restoring the affected knee's stability after partial ACL rupture and partial reconstruction together with a graft.

In the current study, according to pre-operative knee laxity (mechanical condition of the residual ligament), the patients who had partial ACL rupture and received partial ACL reconstruction were divided into two groups. Postoperative knee function and stability were compared between the two groups, in order to provide clinical guidance for the treatment of partial ACL tears.

2. Patients and methods

All study methods were approved by the Ethics Committee of Shengjing Hospital of China Medical University. All the subjects enrolled into the study gave written informed consent to participate.

2.1. Patient data

Sixty-three patients with partial ACL tear were treated between 2005 and 2013. All of the patients in this study suffered knee trauma with mild or moderate swelling and pain, and complained of inability to resume their previous level of activity because of instability in the affected knee joint. As proposed by Yoon et al., indications for partial ACL reconstruction include: (1) positive physical examination (anterior or rotatory instability); (2) a visible tear on magnetic resonance imaging (MRI); and (3) a relatively intact bundle during surgery (the most important point) [28]. Sixteen cases were excluded that had multiple ligamentous injuries (posterior cruciate ligament, corner injury, medial collateral ligament injury that required surgical repair or reconstruction); histories of revision surgery and previous surgery around the affected knee; combined fracture of the affected lower extremity; and associated injury in the contralateral knee. Thus, a total of 47 patients were enrolled in the current study.

In 28 cases, the lesion involved the AM band of the ACL; whereas in the remaining 19 cases, it involved the PL band. Of the 47 cases, 31 were men and 16 were women, with a mean age of 25.7 years (range 17–51). The affected knee was on the left in 19 cases and on the right in 28 cases. The interval between injury and surgery ranged from one week to 22 months. According to the pre-operative anterior or rotatory instability, the 47 cases were divided into Group A (Kneelax arthrometer ≤5 mm and pivot shift test <Grade 2, n = 26) Monitored Rehab Systems B.V., The Netherlands and Group B (Kneelax arthrometer >5 mm and/or pivot shift test ≥Grade 2, n = 21) (Table 1).

2.2. Surgical technique

One senior surgeon performed all surgical procedures. After adequate anesthetization, the Lachman and pivot shift tests were performed pre-operatively in the operating room, and knee laxity was also evaluated using a Kneelax arthrometer (30° flexion and 132 N). A preliminary diagnostic arthroscopy was then performed via standard anterolateral and anteromedial portals. A partial ACL rupture was visually confirmed, and the quantity and quality of the remaining fibers were subsequently assessed through palpation and anterior drawer test at 20° flexion for residual PL following AM band injury, and 70° flexion for residual AM following PL band injury. Meanwhile, the condition of all the relevant anatomical structures was evaluated and any associated meniscus or cartilage injuries were identified. The meniscal lesions were treated by partial meniscectomy or meniscal suture, and the cartilage lesions by debridement. Damaged synovium was debrided, while the ligament remnant at its attachment point was preserved. The intact anteromedial or posterolateral bundles were carefully maintained during the procedure.

The semitendinosus was carefully harvested and transected at the original length with a tendon stripper, and then folded into two or three strands to allow the semitendinosus graft to reach a diameter of six millimeter. In this study, the mean diameter of the two-strand or three-strand semitendinosus graft was 6.3 ± 1.5 mm (range 6.0–7.0). Both sides of the graft were sutured by interlacing sutures for three centimeters using no. 1 absorbable sutures. Depending on the size of the graft, a tibial tunnel was drilled, using a six-millimeter or seven-millimeter cannulated reamer, along the original incision for tendon removal after placement of a guide frame with the inner

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