The Knee 18 (2011) 382–386

Contents lists available at ScienceDirect

The Knee

Analysis of Revision Anterior Cruciate Ligament Reconstruction according to the combined injury, degenerative change, and MRI findings

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ARTICLE INFO

Article history:
Received 10 February 2010
Received in revised form 12 October 2010
Accepted 1 November 2010

Keywords:
Knee
Anterior Cruciate Ligament (ACL)
Revision
Results
Magnetic resonance imaging

ABSTRACT

The purposes of this study were to analyze the results of revision ACL reconstruction, and to determine the effects of pre-revision combined injuries, degenerative changes, and post-revision magnetic resonance imaging (MRI) findings on clinical results.

Forty patients (41 operations) were enrolled in this study. Clinical results and stabilities were evaluated. Radiological results were evaluated using Fairbank scale. For the subgroup analysis, Fairbank scale and preoperative combined injuries were used. Follow-up MRIs were also available for 31(75.6%) patients and we searched for relations between MRI findings and clinical results.

Significant improvements in subjective, objective scores ($p<0.0001$), and stability ($p<0.0001$) were observed between pre-revision surgery and final follow-up results. In the subgroup analysis according to the degenerative change, the mild group achieved better clinical results than the severe group ($p=0.015$ and 0.035, respectively). In the subgroup analysis according to the combined injuries, no significant difference was observed between 2 groups in terms of final follow-up Lysholm and IKDC subjective scores ($p=0.083$ and 0.085, respectively). No relation was found between clinical or stability results and MRI findings ($p=0.26\sim0.99$).

Our results show that the severities of combined injuries were not correlated with clinical results, but the severities of degenerative changes were correlated with clinical results and that results were better in the no or mildly degenerated group. We also found that MRI is helpful for evaluating revision ACL, but that no relation was found between clinical or stability results and MRI findings of the graft after revision surgery.

1. Introduction

Successful revision surgery requires a methodical and organized approach to identify and correct all potential causes of failure. Many factors affect the success of ACL reconstruction, including preoperative laxity of the knee, the integrity of secondary restraints, the status of articular and meniscal cartilage, the graft material and the surgical technique used, postoperative rehabilitation and the compliance, motivation, and expectations of the patient [1,2]. Of these factors, preoperative combined injuries and degenerative changes are uncontrollable, and thus, we questioned whether these factors are correlated with the outcomes of revision surgery.

MRI is used to evaluate the ACL after reconstruction and many studies have described various MR appearances of grafts and commented on the variable accuracy of MRI for assessing graft insufficiency [3–10]. However, few reports have been issued on the relationship between the results of revision surgery and MR appearances. As compared with primary surgery, complex signal intensities may be observed after revision surgery, because of the presence of the previously reconstructed graft.

The purposes of this study were; (1) to report clinical, stability, and radiological results, (2) to correlate results with the severities of preoperative combined injuries, and with the pre-revision status of degenerative changes, and (3) to correlate MRI findings with clinical and stability results.

2. Materials and methods

2.1. Study design and demographics

This is a retrospective study. There were 50 operations conducted between January 1997 and June 2004. However, only 41 operations done on 40 patients out of 50 operations were available for follow-up examinations. Patients followed up more than three years were included in this study. However, patients who had combined collateral ligament surgery or major surgeries such as meniscal allograft transplantation were excluded. We were not able to follow-up on six knees because we lost contact. Three knees were excluded because they had additional collateral ligament reconstructions. Thus, there were 36 men and seven women and of average age 32 years (range, 21 to 55) at time of revision. Mean time from primary ACL reconstruction was

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doi:10.1016/j.knee.2010.11.001

59 months (range, 6 to 216) and the mean follow-up period was 76 months (range, 42 to 118).

Graft selection was individualized based on factors, such as, age, activity level, economic status, previous surgery, and surgeon's preference [11]. We prefer to use a double-loop semitendinosus and gracilis autograft because we have obtained better results in terms of ligamentization using this technique based on our 2nd look arthroscopy series [12]. However, a bone patellar tendon bone (BPTB) allograft is used for athletes because of rapid bone-to-bone healing and an Achilles allograft is used in cases of tunnel widening due to the additional bone graft with remnant bone. Thirty eight primary ACL reconstructions (92.6%) have been done by other surgeons in other hospitals using 10 Achilles allografts, seven BPTB allografts, eight BPTB autografts, five artificial ligaments, four Achilles autografts and three hamstring autografts. The remaining three patients were our own cases, who underwent reconstruction with a BPTB autograft. Fourteen (34%) knees underwent revision reconstruction with previously unharvested ipsilateral autogenous hamstring tendons. Eighteen (44%) received BPTB allograft and nine (22%) an Achilles allograft.

2.2. Surgical procedure and rehabilitation

All surgeries were performed by the senior author, with the patient under general anesthesia with a tourniquet. The surgical technique was dictated by the status of the failed primary procedure, but was similar to that used for primary ACL reconstruction [13]. Staged operations were used to treat one knee because of a dilated femoral tunnel, and three knees were reconstructed with a one-stage bone graft at a wide tibial tunnel using a residual Achilles bone or an auto iliac bone graft. The details of the technique used depended on the nature of the original graft and the abnormalities encountered [14]. Concomitant procedures were necessary in 23 (56%) of the 41 knees (Table 1).

The postoperative regimen was followed by revision technique and concomitant operations. All patients began immediate isometric quadriceps and active range-of-motion exercises. On the third day after surgery, we allowed partial weight bearing within the tolerable range. On the fourth day after surgery, an ACL brace was fitted and range of motion exercises were conducted with 15 degrees increases per week. At 4 weeks after surgery, 90 degrees of motion was allowed and at 6 weeks after surgery 135 degrees of motion was allowed. At 6 months after surgery, straight-line running was allowed and at 9 months after surgery, changing direction while running was allowed [13,14].

2.3. Assessments

In order to eliminate surgeon bias, two sports medicine fellows reviewed charts and data independently of the treating surgeon. We routinely check knee function pre- and postoperatively. Clinical evaluations were performed using Lysholm's and IKDC scores. Instability was evaluated using a KT-2000 arthrometer (Medmetric Corp., San Diego, CA) with maximal manual displacement, and using the Lachman and pivot shift tests. Standard anteroposterior and lateral plain radiographs were analyzed by a single individual. Osteoarthritis progression was evaluated using the Fairbank scale [15,16] by comparing preoperative and follow-up radiographs (Table 2) [17].

We divided the patients into two groups (the mild group – grades 0 and 1 and the severe group – grades 2, 3 and 4) according to the pre-revision state of degenerative change and compared the two groups in terms of clinical results. We also divided patients into minor and major groups according to the severity of combined injuries and also compared the two groups in terms of clinical results (Table 3). Follow-up MRIs were also evaluated in 31 (75.6%) patients, and correlations between results and MRI findings were evaluated.

2.4. Statistical methods

Statistical analysis was conducted using SPSS 13.0 (SPSS, Chicago, IL).The non-parametric Wilcoxon signed rank test and the parametric Chi-square test were used to compare results before and after surgery. The independent T test was used for the plain radiograph analysis, and the Mann-Whitney U test and the Independent T test were used for the MRI analysis. Statistical significance was accepted for p values of <0.05.

2.5. Follow-up MRI

Follow-up MRIs were also evaluated at 20.7 (8-86) months postoperatively for 31 (75.6%) patients. We have recommended to the patients who had revision surgery to get follow-up MRI to observe whether the graft was successfully maintained. The patients were informed that they could refuse to get MRI if they didn't want to. The MR imaging protocols used were as follows: proton density weighted fast spin-echo images (TR/TE 2000/20) with or without fat suppression in the sagittal, coronal, and oblique coronal planes, and fast spin-echo T2-weighted images (TR/TE 2000/80) in the sagittal coronal plane. The field of view was 14 cm, the number of expectations was 4, and the slice thickness and slice spacing were 4 and 1 mm, respectively. There were other types of image studies taken at other hospitals. Nevertheless, this was not an obstacle to the consistency of the study because magnetic resonance image evaluations were limited to the integrity and signal of ACL grafts. Two sports medicine fellows carried out all of the radiographic evaluation in consensus. All of the images were reviewed retrospectively without having any knowledge of the clinical history, symptoms, physical examinations, or the initial interpretations of the magnetic resonance images.

The MRI findings of ACL grafts were analyzed for continuity, signal intensity, sagittal and coronal diameter, morphology, and orientation [10]. Graft continuity was divided into four types: well-preserved, partial disruption (<50%), partial disruption (>50% disruption) and complete disruption. We divided into two groups based on continuity (A: >50% preserved; B: <50% preserved) and compared clinical results. Gross graft morphology was divided based on MRI determined into four types: homogenous dark signal intensity bands, longitudinal streak-increased signal intensity bands, focal-increased signal intensity, and diffuse-increased signal intensity. We divided morphology into two groups (C: homogenous or longitudinal streak-increased signal, and D: focal or diffuse-increased signal) and also compared these groups with respect to clinical results. Graft signal intensities in sagittal and coronal scans were evaluated using the following grading

Table 1
Combined operative procedures.

Combined procedures	Number of procedures
Partial medial menisectomy	7
Partial lateral menisectomy	6
Subtotal medial menisectomy	3
Medial meniscal repair	7
Lateral meniscal repair	2
Posterolateral capsule repair	1
Posterolateral corner repair	1
Microfracture	2
Loose body removal	2

Table 2
Radiographical results (modified Fairbank scale).

Grade		Preoperative	Last f/u
0	No change	18	15
1	Flattening of femoral condyles	16	15
2	Osteophytes	4	6
3	Narrowing of joint space	3	5
4	Osteoarthritis	0	0