Remnant preservation with tensioning can improve the clinical outcome after anterior cruciate ligament reconstruction

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Abstract

Background: Many studies exist about remnant preservation in anterior cruciate ligament (ACL) reconstruction. However, concern remains for development of a cyclops lesion during remnant preservation. To prevent this, a tensioning method has been suggested. Current study evaluated the clinical and radiologic results of remnant preservation in ACL reconstruction with tensioning compared to classical ACL reconstruction.

Methods: From January 2016 to June 2017, ACL reconstruction patients who underwent magnetic resonance imaging (MRI) 2 years postoperatively were enrolled. For comparison, all participants were divided in two groups: remnant preservation with tensioning (group R) and controls (group C). Clinically, Hospital for Special Surgery (HSS), International Knee Documentation Committee (IKDC), Lysholm scores, and incidence of symptomatic cyclops lesions were evaluated. Radiologically, signal-to-noise quotient (SNQ) and size of the synovium on MRI as well as anterior instability in Telos stress radiographs were evaluated.

Results: A total of 64 patients were enrolled (42 in group R and 22 in group C). The IKDC score in group R (70) was better than that in group C (62; \( p < 0.05 \)). One patient in group R had a cyclops lesion with clinical symptoms and arthroscopic excision was recommended. Radiologically, the SNQ, synovium area, and anterior instability on Telos radiography showed no difference between the two groups.

Conclusion: Remnant preservation with tensioning is a good option for ACL reconstruction without the development of a cyclops lesion.

Keywords

anterior cruciate ligament, anterior cruciate ligament reconstruction, remnant preservation ACL reconstruction, remnant preservation with tensioning, cyclops

Introduction

The remnant preservation method was introduced for anterior cruciate ligament (ACL) reconstruction in the early 21st century,¹⁻³ and better results have been reported in many studies.⁴⁻¹⁴ This method has merits of better maturation of the reconstructed graft,¹⁰,¹² better stability,⁴,⁵ better clinical outcome, and preservation of the proprioception of the native ACL.¹³⁻¹⁵

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Several concerns about remnant preservation remain. Previous studies reported inconsistent clinical outcomes for remnant preservation compared to standard ACL reconstruction. Furthermore, extension loss after remnant preservation ACL reconstruction was reported, and other studies reported remnant impingement and formation of Cyclops lesions. Variable methods of remnant preservation have been developed to prevent these problems, but the concerns remain.

The three methods for remnant preservation include remnant tensioning, augmentation of a selective bundle, and graft passing. In addition, method modifications include positioning the graft as “behind the remnant” and retensioning. A previous study reported that the remnant tensioning is simple and preserves more remnant; however, its method has not been developed for different femoral fixations, such as the use of an interference screw. Therefore, we modified the tensioning method to include direct suturing to the intra-articular part of the graft.

We evaluated the clinical and radiologic results of our modified tensioning method by comparing it to the classical reconstruction. We hypothesized that this modified method can result in a better clinical outcome.

**Material and method**

The protocol and design of the current study were reviewed and approved by the ethics committee of the public institutional review board (IRB approval, 2020-1203-001). Medical records and radiologic results of ACL reconstruction patients were reviewed retrospectively and compared based on the remnant preservation with tensioning.

Inclusion criteria of our study were as follows: patients who underwent ACL reconstruction at a single institution between January 2016 and June 2017; patients with no previous surgical history, including ligament reconstruction, osteotomy, or fracture; and patients who did not undergo combined surgery, such as osteotomy or other ligament reconstruction. The recommended follow-up for ACL reconstruction patients in this institution was over 2 years and included magnetic resonance imaging (MRI). Therefore, the current study included patients who were followed for ≥2 years and underwent a 2-year postoperative MRI.

**Surgical procedure and postoperative rehabilitation protocol**

Remnant preservation focused on two points: (1) protecting the remnant tissue during the reconstruction procedure, such as during tunnel reaming, and (2) tensioning the remnant tissue after reconstruction to prevent loosening of the remnant.

ACL reconstruction was performed as described previously. Briefly, the fresh frozen Allo-Achilles tendon was prepared to 10 mm in diameter. A femoral tunnel was made via the transtibial technique and the graft was fixed using a metal interference screw for the femoral side and a spike washer with screw plus a bioabsorbable interference screw for the tibial side.
After spinal anesthesia was induced, arthroscopic examination was performed via superolateral, anterolateral, and anteromedial portals. After examination and performing other meniscal or cartilage procedures, a hooked spinal needle with absorbable No. 0 polydioxanone synthetic (PDS) and Nexon sutures was passed through the ruptured ACL remnant from the anteromedial side in the posterolateral direction (Figures 1(a) and (b)). After locating the passed tip of the spinal needle, the suture was pulled by a grasper through the anteromedial portal (Figure 1(c)). A second suture was applied on the remnant tissue in the same manner. These two sutures were pulled during tunnel reaming to protect the remnant tissue (Figures 1(d) and (e)).

Using the transtibial technique and intra-articular reamer application method in our previous study, the tibial and femoral tunnels were reamed.27 After reaming, the passed sutures were pulled through the tibial tunnel by a grasper (Figure 2(a) and (b)). After the guide pin was pulled down through the tibial tunnel, the two sutures were passed through the proximal end of soft part of the Allo-Achilles tendon from medial to lateral directions (Figure 2(c) and (d)). After passage of the graft and femoral fixation by a metal interference screw, the remnant and graft sides of the two sutures were pulled simultaneously from the intra-articular to anteromedial portals (Figure 2(e) and (f)). Then, tibial fixation was applied with a spike washer with screw plus a bioabsorbable interference screw on the tibial tunnel. After all fixation was performed, the remnant was tensioned to the graft directly by tying the two sutures (Figure 2(g) and (h)). At the end of the reconstruction, graft coverage by the remnant was checked quantitatively as in the previous study.5 After irrigation, suction drainage, and suturing, a compressive dressing and cylinder splint were applied.

The suction drain and cylinder splint were removed on postoperative day 2. Then, continuous passive range of motion and straight leg elevation exercises were started with an ACL hinged brace for 2 months. Tolerable weight-bearing and crutch ambulation were permitted 2 weeks postoperatively. For patients without remnant preservation, the same operative procedures without remnant preservation were performed and the same postoperative rehabilitation protocol was applied.

**Outcome evaluation and statistical analysis**

The clinical and radiologic outcomes were evaluated 2 years post-operation. The clinical outcome was checked by the Hospital for Special Surgery (HSS), Lysholm, and International Knee Documentation Committee (IKDC) subjective scores. Telos stress radiographs and MRI were obtained to evaluate the anterior stability, graft maturation by signal-to-noise quotient (SNQ; Figure 3(a) and (b)), and development of a cyclops lesion. The latter was assessed by the incidence of a patient who underwent removal of a cyclops lesion and quantitative evaluation that measured the area of synovium anterior to the reconstructed graft and remnant on the oblique sagittal view using the free region of interest (ROI) tool (Figure 3(c) and (d)).
Based on the post hoc power analysis via a two-sided hypothesis to obtain a power of 0.8 and a significance level of 0.05, 62 participants or more were considered adequate for the detection of significant differences in the postoperative IKDC score between the two groups. Statistically, the Mann–Whitney U test was conducted to compare outcomes between the remnant preservation (group R) and control (group C) groups. All statistical analysis used SPSS 12.0 (SPSS Science, Inc., Chicago, IL, USA) and $p < 0.05$ was considered statistically significant.

Table 1. Demographics (range).

|                  | Group R | Group C | p value* |
|------------------|---------|---------|----------|
| N                | 42      | 22      | >0.05    |
| Age, years       | 33 (18–57) | 39 (20–61) | >0.05    |
| Sex, M:F         | 37.5    | 18.4    | >0.05    |
| Height, cm       | 174 (154–186) | 171 (150–171) | >0.05    |
| Weight, kg       | 78 (53–115) | 72 (50–92)    | >0.05    |
| BMI              | 25.4 (19.5–34.7) | 24.6 (19.0–29.8) | >0.05    |
| Trauma-to-surgery interval, days | 18.3 (2–98) | 11.3 (1–47) | >0.05    |

BMI, body mass index.

*Mann–Whitney U test, $p < 0.05$, statistically significant.

Results

Of the 64 patients enrolled in our study, 42 underwent remnant preservation with tensioning (group R) and 22 underwent the classical method without remnant preservation (group C). The demographics of two groups are illustrated in Table 1. Coverage at reconstruction was 7.1 in group R and 1.9 in group C (statistically significant difference). Clinical and radiologic results are shown in Table 2. Clinically, the HSS, IKDC, and Lysholm scores were 95, 70,
and 81, respectively, in group R, and 92, 62, and 79, respectively, in group C (statistically significant difference only in IKDC score). One patient in group R had complaints of flexion contracture with pain at extension, and he underwent excision of a cyclops lesion 2 years postoperatively (Figure 4). One patient in group R and three in group C showed no graft on postoperative MRI and revisional ACL reconstruction was recommended. Radiologically, SNQ, anterior instability on Telos radiography, and synovium area were 0.30, 2.1 mm, and 12.3 mm², respectively, in group R, and 0.43, 1.9 mm, and 12.4 mm², respectively, in group C. There was no statistically significant difference between the two groups.

Table 2. Clinical and radiologic results (± standard deviation).

|                      | Group R       | Group C       | p Value*      |
|----------------------|---------------|---------------|--------------|
| Arthroscopy          | Coverage      | 7.1 ± 1.7     | 1.9 ± 2.1    | 0.000°       |
| Clinical outcome     | Lysholm       | 94.9 ± 6.5    | 92.4 ± 9.2   | >0.05        |
|                      | IKDC          | 70.2 ± 12.6   | 61.7 ± 9.3   | 0.028°       |
|                      | HSS           | 80.9 ± 16.4   | 78.8 ± 14.6  | >0.05        |
| Cyclops              | Surgery, N    | 1             | 0            | >0.05        |
|                      | Area, mm²     | 12.3 ± 19.7   | 12.4 ± 17.9  | >0.05        |
| Radiologic outcome   | Telos difference, mm | 2.1 ± 3.0   | 1.9 ± 3.2    | >0.05        |
|                      | Graft failure, N | 1           | 2            | >0.05        |
|                      | SNQ           | 0.30 ± 0.30   | 0.43 ± 0.49  | >0.05        |

IKDC, International Knee Documentation Committee; HSS, Hospital for Special Surgery; SNQ, signal noise quotient. 

* p < 0.05, statistical significance. 
*Mann–Whitney U test.

Figure 4. A case of cyclops lesion. A male 23-year-old patient in group R complained of discomfort in full extension. (a) At MRI 2 years postoperatively, a large cyclops lesion was identified and arthroscopic excision was recommended. (b) At arthroscopy, the large cyclops lesion (asterisk, dotted line) was found and (c) excised carefully. (d) After one more year, follow-up MRI showed no cyclops lesion and a good graft signal and the symptom had resolved.
Discussion

We compared the modified method of remnant preservation with tensioning to classical ACL reconstruction. The results demonstrated a better clinical outcome in the group with remnant preservation. This method is a good option for ACL reconstruction.

Remnant preservation results in a better clinical outcome after ACL reconstruction. Some earlier studies reported that remnant preservation had no better clinical outcome than the classical reconstruction method. However, recent reports including meta-analyses showed a better clinical outcome. Our current study showed a statistically significant difference in IKDC subjective score. In the Lysholm and HSS scores, although there was no significant difference, the mean scores were better in group R. Considering the ceiling effect of the Lysholm and HSS scores, our current study demonstrated that remnant preservation with tensioning was better than the classical method regarding clinical outcome.

The merit of this preservation method may be the amount of the preserved remnant. Remnant preservation is beneficial in preserving proprioception of the native ACL and graft maturation, including synovialization, and the amount of preserved remnant is known as the important factor. Although our study did not show a significant difference in graft maturation on follow-up MRI, this method preserved more remnant and provided better coverage, as in the previous studies.

Improved remnant preservation may be due to two technical points of this modified tensioning method, traction and suture. This method may preserve more remnant by traction during the procedure as in the previous study, and prevention of loosening or fraying of the remnant postoperatively. More of the remnant can be preserved. The coverage in the current study was better in group R. Furthermore, compared to the previous study without tensioning, the mean coverage in the current study was 7.1/9, which was larger than the 5.6/9 reported in the previous study. Considering the positive effect of the amount of remnant on outcome, this tensioning method may be better than other methods.

The greatest concern of this method will be development of a cyclops lesion, because the excessive remnant is located in front of the reconstructed graft. Ahn et al. [2, five] reported MRI demonstrating a cyclops lesion after a similar method was performed. They identified more tissue in the remnant preservation, but there was no clinically significant occurrence of a cyclops lesion. Our study showed similar results. A similarly sized synovial hypertrophy was observed in both groups and only one patient in group R underwent excision of a cyclops lesion. Our results showed that this tensioning method can preserve more remnant without development of a cyclops lesion.

There were limitations in our study. First, this was a short-term, not randomized, and small-sized study. Second, there were no data at preoperative clinical scoring. Third, selection bias in the results may exist. Fourth, it was only a comparison between this tensioning remnant preservation method and classical ACL reconstruction, not between remnant preservation with or without tensioning. However, our study demonstrated a better clinical outcome than the classical ACL reconstruction without remnant preservation and there was no difference in the occurrence of a cyclops lesion, which is the major concern of remnant preservation. The selection bias, due to exclusion of patients who underwent ACL reconstruction but were not followed up over 2 years, should have affected both groups; thus, the bias was compensated. These findings showed the probability of our remnant preservation with tensioning to be a better option in ACL reconstruction.

Conclusion

Remnant preservation with tensioning is a good option for ACL reconstruction without the development of a cyclops lesion.

Declaration of conflicting interests

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