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ORIGINAL ARTICLE

Activity-related outcome in anterior cruciate ligament reconstruction with synthetic ligament advanced reinforcement system

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Abstract

Background: Arthroscopic anterior cruciate ligament (ACL) reconstruction with ligament advanced reinforcement system (LARS) had revealed good results with low complication and failure rate in series of studies. The specific candidates for ACL reconstruction with LARS are still unknown anyway. The purpose of this study is to evaluate the activity-related outcome in ACL reconstruction using LARS ligament.

Methods: A total of 43 unilateral arthroscopic ACL reconstructions with LARS were collected and divided into two groups: group A (preinjury Tegner score ≥ 6, n = 20) and group B (preinjury Tegner score < 6, n = 23). We had analyzed the stability of knee and functional outcome with a minimum of 2-years follow up.

Results: All patients were aware of improvement over the knee stability immediately after ACL reconstruction with LARS. The functional outcome of knee was improved in both groups by analysis with the Lysholm score and modified International Knee Documentation Committee (IKDC) score. The postoperative grading of the knee examination form of modified IKDC grade showed no statistical difference in both groups.

Conclusion: Arthroscopic ACL reconstruction with LARS was encouraged as an alternative option even in high sports demand patients.

Keywords: Anterior cruciate ligament injury; Anterior cruciate ligament reconstruction; Polyethylene terephthalates

1. INTRODUCTION

Anterior cruciate ligament (ACL) injury is a common medical issue in different patient age groups. Numerous surgical methods of ACL reconstruction have been reported. Among the grafts that had been used in series of studies and reviews, bone-patellar-tendon-bone (BPTB) and hamstring tendon (HT) autograft or allograft are the two most commonly used materials with excellent clinical results.[1–7] Owing to the disadvantages in allograft, including tissue reaction, the risk of disease transmission, and delayed revascularization, in addition to the harvest procedure inherent in autograft, which may delay knee recovery,[1,8–11] the interest in synthetic material was piqued in ligament reconstruction. In the 1980s, many synthetic materials and biologic tissue augmentation were proposed for ACL synthetic replacement, including carbon fiber, Dacron, Gore-Tex, Leed-Keio, and the Kennedy augmentation device, respectively. However, because of the high mechanical failure and complication rates, the enthusiasm for synthetic materials waned gradually[12–15] and artificial ligament was rarely used in ACL reconstruction. With the improvement of surgical techniques and understanding of the anatomy and biomechanics of the ACL, the ligament advanced reinforcement system (LARS; Surgical Implants and Devices, Arc-sur-Tille, France), a new artificial ligament, has been reported as a good choice for ligament reconstruction.[16–18] Several clinical studies in ACL reconstruction using the LARS artificial ligament revealed good results with low complication and failure rates in the short or mid-term.[19–24] However, a recent case series reported a high mechanical failure rate of artificial ligament.[25] The activity-related clinical outcomes in ACL reconstruction with LARS are still unknown. The purpose of this study was to evaluate the activity-related outcome in ACL reconstruction using the LARS ligament.

2. METHODS

Between September 2003 and June 2011, 43 unilateral arthroscopic ACL reconstruction procedures using the LARS ligament were performed by the same orthopedic surgeon. ACL rupture was diagnosed on the basis of clinical examination and magnetic resonance imaging findings. The inclusion criterion was symptomatic ACL rupture with normal contralateral knee stability indicated for arthroscopic ACL reconstruction. Patients who experienced multiple ligament injuries, previous ACL reconstruction, previous knee surgery, or outerbridge grade 3 or 4 chondral lesion were excluded. In this study, we completed the

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postoperative rehabilitation protocol and regularly contacted the patients. All the patients had a minimum of 2 years of follow up, and none were lost to follow up. The patients were fully informed of the disease details and surgical procedures, including the advantages and disadvantages of the procedures. Then, the patients selected their treatment procedure in accordance with their preference. Written informed consent was obtained from each patient.

The 43 patients were divided into two groups according to preinjury Tegner activity level as follows: group A, those with preinjury Tegner activity levels of ≥6 (n = 20) and group B, those with preinjury Tegner activity levels of <6 (n = 23). In group A, the mean patient age, time from injury to surgery, and follow-up duration were 23.9 years (range 17-34 years), 7.3 months (1-36 months), and 65.6 months (25-96 months), respectively. The mechanism of injury was sports activity in 17 patients (85%) and traffic accident in three patients (15%). In group B, the mean patient age, time from injury to surgery, and follow-up duration were 42.2 years (range 28-58 years), 6.3 months (1-24 months), and 64 months (24-105 months), respectively. The reason for the injury was fall in nine patients (39%), sports injury in one (4%), and traffic accident in 13 (57%). The patients' characteristics are summarized in Table 1.

2.1. Surgical technique

Routine arthroscopic examination was then performed. ACL reconstruction with LARS was undertaken following the isometric reconstruction surgical principles described earlier by Dericks.[16] The ACL stump was preserved as much as possible.[15,18] The bone tunnels were started in a standard transtibial fashion. The knee was placed at 90° flexion, and the tip aimer was set at a 55° angle through the anteromedial portal into the knee joint. The tip of the aimer was positioned 2 to 3 mm anterior to the posterior margin of the anterior horn of the lateral meniscus and slightly medial to the midline of the ACL tibial attachment site, reaming the tibial tunnel to 7 mm in width, with just 1 to 2 mm of bone bridge remaining between the tunnel and the PCL (Fig. 1), while inserting the transtibial femoral ACL drill guide from the tibial tunnel to the postcortex of the femoral condyle by using the over-the-top technique at an approximately 11 o'clock to 10:30 position in the right knee (or 1 o'clock to 1:30 position in the left knee). Then, a Kirschner wire was drilled inside-out with a 6- to 8-mm distance to the posterior wall. The femur tunnel was reamed to 7 mm with a cannulated reamer into the knee joint from the anterolateral thigh guided by the Kirschner wire. A flexible wire loop was inserted outside-in to the femoral tunnel and passed through the tibial tunnel and leaders of the LARS ligament through the loop in the wire loop. A LARS artificial ligament with 100 fibers was used for ACL reconstruction. The femoral side of the wire loop was pulled through the ligament leader thread. Pulling on them gradually introduced the ligament into the tunnel. The artificial ligament was fixed with titanium interference fit screws with blunt thread edges of 8 mm in diameter at each site (Fig. 2).

2.2. Postoperative rehabilitation

All the patients underwent the same rehabilitation program. Quadriceps isometric exercises were initiated since postoperative day 1. Immediate mobilization of the knee was authorized from 45° flexion and increased gradually to complete flexion within 4 weeks. Immediate full weight bearing was permitted according to the pain tolerance. Activities of daily living and cycling were restored from 4 weeks postoperatively. Noncompetitive sports could be resumed after 3 months, and full sports exercise was allowed after 6 months. Knee brace protection after ACL reconstruction with LARS was unnecessary for all the patients.

2.3. Clinical assessment

The subjective knee functional outcomes were evaluated on the basis of three grading scales as follows: Lysholm score; modified International Knee Documentation Committee (IKDC) scale, including the subjective knee evaluation score; and knee examination form grading system. Knee mechanical stability was determined on the basis of the side-to-side difference using the Lachman test, pivot-shift test, and KT-2000 arthrometer laxity measurement device (MEDmetric, San Diego, CA) at 30° knee flexion with a 134 N anterior drawer force. The assessments were performed by a single orthopedic surgeon.

2.4. Statistical analysis

The Wilcoxon signed-rank test was used for comparison between the two-paired data. Categorical variables, expressed as percentages, were analyzed using Yate's correction of contingency for two groups. Ordinal variables were expressed as mean ± SD (or median [range]), and the independent groups were compared using the Mann-Whitney *U* test. Significant differences were accepted for p values of <0.05. Analyses were performed using the Statistical Package for the Social Science (version 15.1 [SPSS Inc, Chicago, IL, USA]).

3. RESULTS

All 43 patients showed improvement of knee stability immediately after ACL reconstruction with LARS. They were allowed to return to perform their sports and work activities at the level

Table 1

Basic variable differences between groups

	Pre-inj T ≥ 6 (n = 20)	Pre-inj T < 6 (n = 23)	
Variable	**M ± SD**	**M ± SD**	***p***
Age	22.50 ± 4.48	42.22 ± 9.62	<0.0001**
Interval	9.30 ± 9.53	6.57 ± 6.44	0.564
F/U	61.7 ± 26.48	63.96 ± 30.50	0.941
Sex			
F	5 (25.0%)	11 (47.8%)	0.219[a]
M	15 (75.0%)	12 (52.2%)	
R/L			
L	7 (35.0%)	13 (56.5%)	0.269[a]
R	13 (65.0%)	10 (43.5%)	

Mann-Whitney *U* test; **$p < 0.01$.
[a]χ^2 test with Yate's correction of contingency.
Pre-inj T = preinjury Tegner activity level scale.

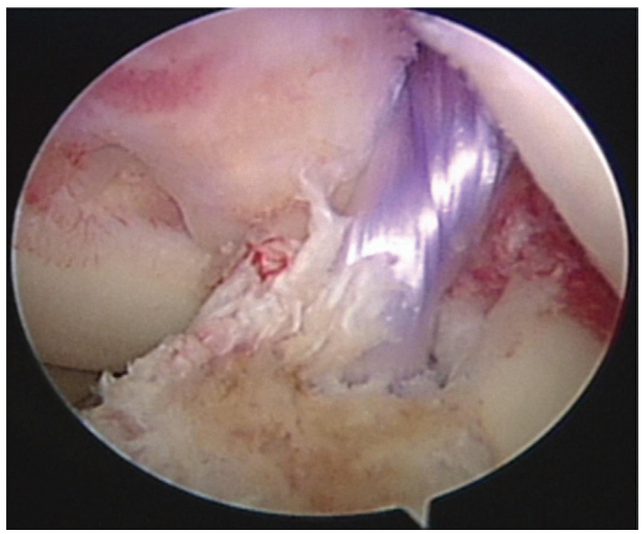

Fig. 1 The tibia tunnel of ACL reconstruction with LARS. ACL reconstruction with LARS was undertaken following the isometric reconstruction surgical principles. ACL stump was preserved as much as possible. ACL, anterior cruciate ligament; LARS, ligament advanced reinforcement system.

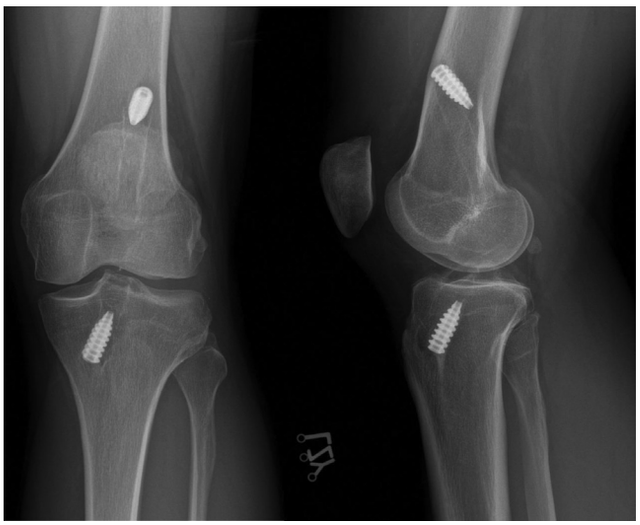

Fig. 2 The radiography after ACL reconstruction with LARS for 6 months. The LARS were were well fixed with Titanium interference screws in both femoral and tibial tunnels. ACL, anterior cruciate ligament; LARS, ligament advanced reinforcement system.

before the ACL injury only after completion of the rehabilitation course.

3.1. Biomechanical stability of the knee

Before operation, all the patients presented at least grade 2 laxity in the Lachman test. In group A, the side-to-side difference was improved significantly after the reconstruction surgery from 7.35 ± 0.59 mm preoperatively to 4.45 ± 2.93 mm postoperatively ($p < 0.05$), estimated using a KT-2000 arthrometer. Group B also demonstrated significant improvements, from 7.74 ± 0.69 mm preoperatively to 3.96 ± 1.22 mm postoperatively ($p < 0.05$). The patients who underwent arthroscopic ACL reconstruction with LARS in both groups regained adequate stability of the injured knee (Table 2).

3.2. Whole function of the knee

Knee function was analyzed using the Lysholm score and modified IKDC grade, which were the subjective knee evaluation score and knee examination form grade, respectively. Both scores were significantly improved after ACL reconstruction with LARS in both groups. In group A, the preoperative and postoperative Lysholm scores were 79.95 ± 7.55 and 88.70 ± 12.51, respectively ($p < 0.001$). In group B, the preoperative and postoperative Lysholm scores were 70.83 ± 7.49 and 93.35 ± 5.83, respectively, indicating a significant improvement ($p < 0.001$). Regarding the subjective knee evaluation score in the modified IKDC, the patients in group A had mean preoperative and postoperative scores of 81.55 ± 7.45 and 87.88 ± 11.72, respectively ($p < 0.05$). Meanwhile, in group B, the preoperative and postoperative scores were 67.97 ± 5.69 and 86.47 ± 5.76, respectively ($p < 0.001$). The results showed that functional benefits could be perceived in both groups after ACL reconstruction with LARS (Table 2).

The outcome variable differences between the groups showed no statistically significant difference. In the analysis of the postoperative objective grade in the knee examination form of the modified IKDC, the results showed that five patients (25%) in group A had worse results with grade C or D, while two patients (8.7%) in group B had grade C. The postoperative grade in the knee examination form of the modified IKDC showed no statistically significant difference in both groups ($p = 0.222$; Table 3).

3.3. Range of motion

All the patients achieved full range of motion recovery of the knee when compared with the contralateral side and allowed to return to perform preinjury work and sports activities after the 6-months rehabilitation course.

Table 2

Pre and postoperation variable differences between groups

	Pre-inj T ≥ 6 (n = 20)		Pre-inj T <6 (n = 23)	
Variable	**M ± SD**	***p***	**M ± SD**	***p***
Preop-Lysholm	79.95 ± 7.55	0.0004**	70.83 ± 7.49	<0.0001**
Postop-Lysholm	88.70 ± 12.51		93.35 ± 5.83	
Preop-IKDC	81.55 ± 7.45	0.0449*	67.97 ± 5.69	<0.0001**
Postop-IKDC	87.88 ± 11.72		86.47 ± 5.76	
Preop-KTlast	7.35 ± 0.59	0.0004**	7.74 ± 0.69	<0.0001**
Postop-KTlast	4.45 ± 2.93		3.96 ± 1.22	

Wilcoxon signed-rank test; *$p < 0.05$; **$p < 0.01$.
IKDC = modified International Knee Documentation Committee, the subjective knee evaluation score; Ktlast = KT-2000 arthrometer laxity measurement; Pre-inj T = preinjury Tegner score.

Table 3

Outcome variable differences between groups

	Pre-inj T ≥ 6 (n = 20)	Pre-inj T < 6 (n = 23)	
Variable	**M ± SD**	**M ± SD**	***p***
Preop-Lysholm	79.95 ± 7.55	70.83 ± 7.49	0.0006**
Postop-Lysholm	88.70 ± 12.51	93.35 ± 5.83	0.395
Preop-IKDC	81.55 ± 7.45	67.97 ± 5.69	<0.0001**
Postop-IKDC	87.88 ± 11.72	86.47 ± 5.76	0.077
Preop-KTlast	7.35 ± 0.59	7.74 ± 0.69	0.082
Postop-KTlast	4.45 ± 2.93	3.96 ± 1.22	0.317
Postop-IKDC grade			0.222[a]
C&D	5 (25.0%)	2 (8.7%)	
A&B	15 (75.0%)	21 (91.3%)	

Mann-Whitney *U* test; *$p < 0.05$; **$p < 0.01$.
[a]χ^2 test with Yate's correction of contingency.
IKDC = modified International Knee Documentation Committee, the subjective knee evaluation score; IKDC grade = modified International Knee Documentation Committee, the knee examination form; Ktlast, KT-2000 arthrometer laxity measurement; Pre-inj T = preinjury Tegner activity level scale.

3.4. Complications

The mean follow-up period was 5 years. No infection, stiffness, or flexion contracture was observed during the follow up. Three patients in group A (two men and one woman) experienced mechanical graft failure. The two men were competitive basketball players and returned to their previous sports activities after 6 months of rehabilitation. They had mechanical graft failure at the fourth year of follow up and reported a "popping" sensation when they played basketball. The woman, a track-and-field athlete, encountered graft failure during the third year of follow up when she felt graft rupture when doing a quick turning motion. Although low-grade synovitis could be observed in some patients, no surgical interventions were needed for alleviation.

4. DISCUSSION

Numerous studies of arthroscopic ACL reconstruction showed low complication rates and encouraging results in the past decades. Among the materials used to reconstruct the ruptured ACL, autografts such as bone patellar tendon bone graft and HT graft were considered the gold standard.[2–6,26–28] However, with the surgical technique improvement and new material design, artificial ligament has become an interesting topic in ACL reconstruction owing to its several advantages such as immediate recovery of stability, early rehabilitation, and avoidance of sacrifice of donor-site structures. As indicated by Dericks et al.,[16] the first published report of the clinical use of LARS in ACL reconstruction, encouraging results were demonstrated in 220 cases with

a mean follow up for 2.5 years. Subsequent series of studies in artificial ligaments also showed satisfactory short- to mid-term results.[19–23] When comparing the LARS ligament with autografts (BPTB and 4SHG) in ACL reconstruction, no significant difference in clinical outcome was found.[29] Moreover, patients treated with LARS had earlier functional recovery and returned to sports activity without complications. As a consequence, more surgeons considered artificial ligaments as a possible alternative choice to autografts.

Parchi et al[23] reviewed a series of research studies on knee ligament reconstruction with the LARS ligament (ACL, PCL, and ACL + PCL), including 1245 cases with follow-up durations ranging from 3 months to 9 years, and reported 12 cases with mechanical graft failure (0.96%) and three cases with knee synovitis (0.24%) after reconstruction. Lavoie et al.[20] reported that three patients (6.4%) had failure of implant fixation and required revision surgery. Gao et al.[19] reported that three cases (1.9%) had rupture of the LARS ligament caused by sports trauma. Iliadis et al.[25] reported a mechnical failure rate of LARS of as high as 31%. In our study, three cases in group A (6.9%) were complicated with mechanical failure of the LARS, while no mechanical failure was observed in group B.

To our knowledge, no research study has evaluated which specific characteristic was more suitable for using the LARS ligament in ACL reconstruction. Whether patients with high sports demand are also suitable for ACL reconstruction with LARS is still unclear. In our study, 43 cases of ACL reconstruction with LARS showed statistically significant improvement in stability and function accompanied with a high patient satisfaction rate. The evaluation of the patient groups with different sports activity levels showed no statistically significant difference in clinical outcomes. These results may indicate that the LARS ligament can be recommended as an alternative graft option in ACL reconstruction for patients needing a fast recovery of activities of daily living and work activities, even in patients with high sports demand.

4.1. Limitations

The small number of cases was related to the weak statistical power. The major trauma mechanisms of ACL injury differed between the two groups and might have affected the clinical results. A study with larger sample size and longer follow-up period should be conducted to ensure a representative sample distribution and age groups.

In conclusion, LARS is recommended as an alternative option for arthroscopic ACL reconstruction with high success and satisfactory outcome, even in patients with high sports demand.

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