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Arthroscopic Posterior Cruciate Ligament Reconstruction Using LARS Artificial Ligament: A Retrospective Study

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Background. **The aims of this study were to analyze the preliminary clinical effects of arthroscopic reconstruction of posterior cruciate ligament (PCL) using Ligament Advanced Reinforcement System (LARS) artificial ligament. It is hypothesized that LARS artificial ligament is a safe and effective choice for PCL reconstruction, providing good knee stability.**

Materials and Methods. **Forty-one patients who underwent PCL reconstruction using LARS artificial ligament were enrolled in this retrospective study. Average age at time of surgery was 34 y (range, 23–57 y). Average time from injury to surgery was 15 d (range, 5–45 d). Average follow-up period was 44 mo (range, 36–54 months). Follow-up examinations included the Lysholm Knee Score and the International Knee Documentation Committee (IKDC) score.**

Results. **The average Lysholm knee score was 64.9 ± 8.8 preoperatively (range, 47-75) *versus* 92.1 ± 3.3 three years after operation (range, 79–100). Thirty-six of 41 patients (88%) showed good or excellent results at final assessment. The final IKDC score at 3 y postoperatively rated as normal in 21 patients (51%), nearly normal in 17 patients (42%), abnormal in three patients (7%).**

Conclusions. **The results shows that LARS artificial ligament appears to be an effective device for PCL reconstruction leading to good ligamentous stability and knee function. Long-term follow-up should be performed to confirm the durable stability of the knee and the tolerance of the knee to the LARS artificial ligament.**

Key Words: **posterior cruciate ligament; reconstruction; arthroscopy; artificial; ligament advanced reinforcement system; retrospective study; LARS.**

INTRODUCTION

The posterior cruciate ligament (PCL) acts as the primary restraint against posterior translation of the tibia on the femur at nearly all positions. PCL also provides secondary resistance to varus and valgus of the knee. One study shows that PCL injury represents about as many as 3.4% to 20% of all knee ligament injuries [1]. Some authors thought that PCL injury can heal on its own, and believed that conservative treatment was better [2]. However, others recommended surgical reconstruction because of degenerative changes of the affected knee with pain and functional disability [3, 4]. Currently, conservative treatment, including protected weight-bearing and quadriceps muscle rehabilitation, is recommended for most isolated PCL injuries (grades I and II) [5]. Early PCL reconstruction is generally recommended for more severe grade III (tibial plateau displaced posterior to the femoral condyle between 10 and 15 mm) or grade IV (posterior displacement greater than 15 mm) PCL injury [3, 6]. Symptomatic severe posterior knee instability and multiple ligament injuries were also the indications for PCL reconstruction.

The ideal choice of graft tissue is controversial. The results of PCL reconstruction using autografts and allografts are acceptable and reproducible [7]. Currently, the bone-patellar tendon-bone (BPTB) and hamstring autografts are the most commonly used grafts. However, the phenomenon of ligamentization occurs in the successfully reconstructed human cruciate ligament between 6 mo to 1 y after operation, being slowly revascularized and presenting most histologic and functional properties [8, 9]. In addition, donor site morbidity was also reported for autograft reconstruction [10, 11], which may negatively affect recovery after PCL reconstruction. Disease transmission should also be considered for allograft reconstruction. These situations stimulated

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interest in the use of artificial ligament to replace PCL. In recent years, arthroscopically assisted PCL reconstructions with the use of artificial ligaments have become an alternative to traditional procedures using autografts and allografts. Through this technique, artificial ligament is used replacing PCL. Recent reports have shown satisfactory clinical results of PCL reconstruction using artificial ligaments [12, 13].

From June 2005 to December 2006, we performed PCL reconstruction using Ligament Advanced Reinforcement System (LARS artificial ligaments; Arc-Sur-Tille, France) in 41 patients with PCL ruptures in our hospital. The aims of this study were to explore the operative techniques and preliminary clinical effects of arthroscopic reconstruction of PCL using LARS artificial ligament. We hypothesized that LARS artificial ligament is a safe and effective choice for PCL reconstruction, providing good knee stability.

MATERIALS AND METHODS

Patients Demographics

The Institutional Review Board on Human Studies of our hospital approved this study. All the patients enrolled signed written informed consent before the study. From June 2005 to December 2006, PCL reconstructions with LARS artificial ligament were performed on 59 patients with symptomatic rupture of PCL. Eight patients with additional anterior cruciate ligament (ACL) ruptures and six patients with combined posterolateral corner injuries were excluded. Four patients who could not complete the final follow-up were also excluded. Forty-one patients followed-up at least 3 y were enrolled for analysis. The flow chart of patient selection is illustrated in Fig. 1. Patient demographic characteristics are summarized in Table 1. There were 25 males and 16 females, and the mean age at the time of reconstruction was 34 y (range, 23–57). The average time from injury to surgery was 15 d (range, 5–45 d). Arthroscopic PCL reconstruction was performed on 37 patients (90%) before 3 wk after injury, four patients (7%) between 3 wk and 3 mo after injury. In all the patients, arthroscopic PCL reconstruction with LARS artificial ligament was performed. During the arthroscopic examination, 29 patients were found to have intact menisci and 12 had associated meniscal lesions. The additional injuries were treated accordingly. Traffic accident occurred in 31 patients (75.5%). Ten patients sustained injuries from sports activities (24.5%) (Table 2).

Preoperatively, the diagnosis of PCL rupture was confirmed by clinical examination, magnetic resonance imaging (MRI), and arthroscopic examination. All the PCL reconstructions were performed by the same surgeon using the same operative technique.

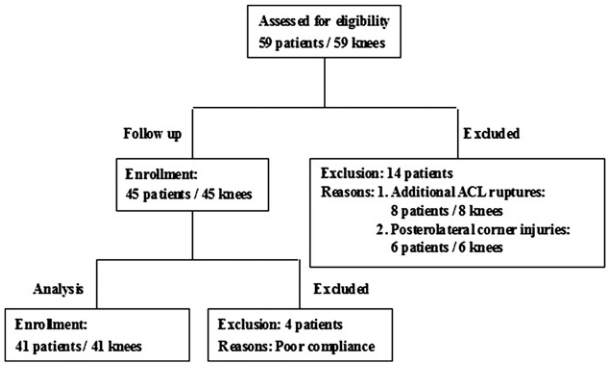

FIG. 1. Flowchart of patient selection: eight patients were excluded for additional ACL ruptures, six patients were excluded for combined posterolateral corner injuries, and four patients were excluded for poor compliance.

TABLE 1

Patient Demographic Characteristics of PCL Reconstruction Using LARS Artificial Ligament

Patient number	41
Age at operation (y)	34 (range, 23–57)
Gender	
Male	25 (61%)
Female	16 (39%)
Affected knee	
Right	22 (54%)
Left	19 (46%)
Associated procedures	
None	29 (70%)
Menisectomy	8 (20%)
Meniscal repair	4 (10%)
Time from injury to operation	
<3 wk	37 (90%)
3 wk to 3 mo	4 (10%)
>3 mo	0 (0%)
Follow-up time (mo)	44 (range, 36–54)

Graft

The graft used for PCL reconstruction is PCL LARS artificial ligament, which is made of polyethylene terephthalate. LARS (Ligament Augmentation and Reconstruction System, Dijon, France) is a system of artificial ligament devices used for reconstructions from PCL and ACL reconstruction to Achilles tendon and acromioclavicular repairs. PCL LARS artificial ligament is composed of intra-articular potion and extra-articular portion (Fig. 2). Designed to mimic the normal structure of natural PCL, the intra-articular longitudinal fibers resist fatigue and allow fibroblastic in-growth. The extra-articular woven fibers provide strength and resistance to elongation.

There are two kinds of ligaments: PC60 and PC 80. PC80 has more fibers than PC60 in the intra articular portion. We used the PC80 for all the 41 patients.

Operative Technique

After epidural anesthesia, a complete diagnostic arthroscopy was performed to identify the extent of PCL tear and evaluate the condition of intra-articular structure. Meniscus tear and cartilage lesion,

TABLE 2

Injury Mechanism in 41 Patients

Injury styles	Patients number
Motorcycle accident	20 (48.7%)
Motor vehicle accident	11 (26.8%)
Football	4 (9.8%)
Basketball	2 (4.9%)
Jump	2 (4.9%)
Fall	2 (4.9%)

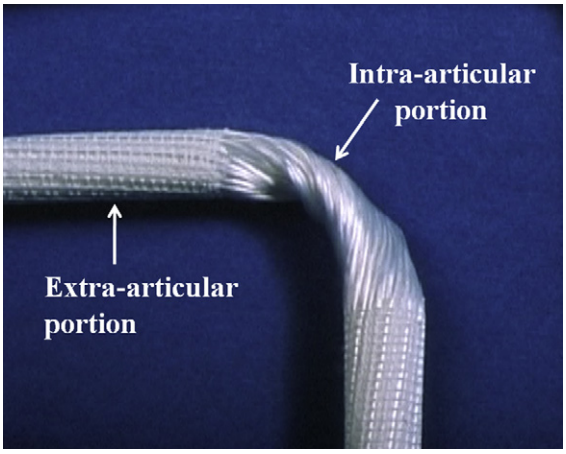

FIG. 2. PCL LARS artificial ligament is composed of intra-articular portion and extra-articular portion (Fig. 2). The intra-articular longitudinal fibers resist fatigue and allow fibroblastic in-growth. The extra-articular woven fibers provide strength and resistance to elongation.

if any, were treated. Clearance of soft tissue in the intercondylar notch gave a view of the position of the femoral isometric point. However, both stumps of the native PCL should be preserved.

The operative procedures of PCL reconstruction are shown in Fig. 3. After the PCL tear was confirmed under arthroscopy, the tibial guide was placed. The retrotibial spatula was inserted through the anteromedial incision, pushed from the inside of anterior cruciate ligament (ACL), and finally placed at the middle part of the posterior border of the tibial plateau. A fixed stem was drilled parallel to the tibial plateau to get a temporary fixation (Fig. 3A). A 6.0 mm spiculate drill bit was drilled the tibial tunnel through the cannula with the knee at 45° of flexion. The spiculate drill bit would not stop until the spatula was reached (Fig. 3B). The contact between the spiculate drill bit and the spatula must be confirmed. The spiculate drill bit was replaced by a flat-ended drill bit, which was pulled out and pushed in over and over again to remove the bony debris at the tibial tunnel (Fig. 3C). The flat drill bit was then replaced by a curved wire-passer cannula (Fig. 3D). A wire loop passed into the curved wire passer cannula and pushed through it, and finally exited out of the base of the retrotibial spatula (Fig. 3D, E, and F).

This femoral isometric point was at 40% of a line parallel to the Blumensaat line and passing the most prominent point of the posterior condyle on the lateral X-Ray [10]. The guide-wire tip was placed at this point and drilled inside-out from the intra-articular aspect of the medial condyle (Fig. 3G). Then the guide-wire was replaced by a 6.0 mm drill bit to drill the femoral tunnel (Fig. 3H). Once the femoral tunnel was drilled, a wire passer cannula was placed in femoral tunnel. Then a wire-loop and a blunt guide-wire, which would be used to lead the interference screws, were introduced.

A blood vessel forceps was introduced through the medial portal to pull the inferior extremity of the femoral wire loop out of the medial portal. The leading threads of the LARS artificial ligament were passed through the wire loops and pulled into the tunnels. When the upper braided portion of the LARS artificial ligament was pulled into the femoral tunnel under arthroscopic observation, an interference screw was driven outside-in through the guide-wire (Fig. 3I). Then the LARS artificial ligament was rotated 90° laterally around its longitudinal axis to mimic the natural ligaments. After the LARS artificial ligament was tensioned and at least 15 cyclic loads have exhibited full and easy range of motion, the tibial end of graft was fixed (Fig. 3J). Subsequent arthroscopic examination was performed to confirm proper graft placement and ensure the absence of intra-articular impingement.

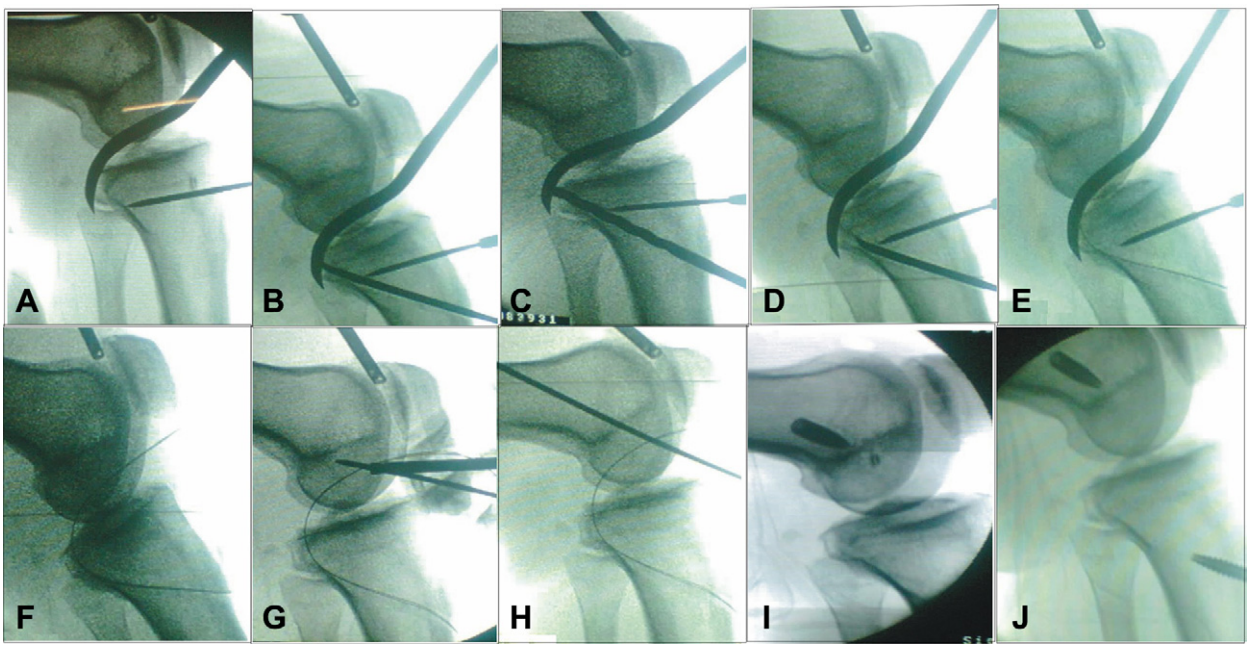

FIG. 3. The operative procedures of PCL reconstruction. (A) A fixed stem was drilled parallel to the tibial plateau to get a temporary fixation. (B) The spiculate drill bit would not stop until it reached the spatula. (C) The spiculate drill bit was replaced by a flat ended drill bit. (D) The flat drill bit was then replaced by a curved wire-passer cannula. (E) and (F) A wire loop passed into the curved wire passer cannula and pushed through it, and finally exited out of the base of the retro tibial spatula. (G) The guide-wire tip was placed at this point and drilled inside-out from the intra-articular aspect of the medial condyle. (H) The guide-wire was replaced by a 6.0 mm drill bit to drill the femoral tunnel. (I) An interference screw was driven outside-in through the guide-wire. (J) The tibial end of graft was fixed.

Rehabilitation Programs

Protective braces were not used after the operation. The isometric contraction of the quadriceps and straight-leg raises was started on the first or second postoperative day. Later, flexion and extension of the knee, from 200×/d 500×/d, was allowed as tolerated by the patients. Knee flexion was performed from 45° and increased gradually to a full knee extension within a week. Patients were instructed to walk with crutches and non-weight-bearing within 4 d after operation. Walk without crutches was allowed 3 wk after reconstruction, and normal daily activities were gradually resumed.

Evaluation

Evaluation was performed by single independent experienced examiner who did not attend the operations. Each patient was regularly followed up at the third, sixth, ninth mo, 1 y postoperatively, and then annually thereafter. The results of follow-up at the first, second, and third y were analyzed in this paper. The follow-up examination included the following scoring system, Lysholm score, IKDC subjective and objective forms, posterior drawer test, KT-1000 arthrometer single-leg test, and the measurement of thigh circumference.

All patients completed the subjective questionnaire, including IKDC subjective form and Lysholm scoring system, to evaluate the subjective symptoms. The Lysholm scoring system included limp, use of support, evidence of joint locking, knee instability, joint swelling, impaired ability to climbing stairs, and squat. KT-1000 arthrometer (MEDmetric, San Diego, CA) were used to evaluate the ligament laxity of the knee. The KT-1000 tests were performed in 70° of flexion with a standard force of 30 lb (134 N) to measure the total anteroposterior translation, and side-to-side difference. One-leg hop test was used for distance on the affected and normal side to evaluate the knee function. Three trials for each leg are recorded and averaged. A ratio of the affected knee to normal knee is calculated. Knee radiographs in standing anteroposterior, lateral, and Merchant's views were examined for alignment, joint space narrowing, and degenerative changes in the knee, as well as for bone tunnel enlargement. Bone tunnel enlargement was defined as the percentage of tunnel width on postoperative radiographs that exceeded width at follow-up.

A statistical analysis was performed using SPSS for Windows, ver. 11.5 software (SPSS Inc., Chicago, IL). Continuous variables, including the Lysholm scores and the KT1000, were normally distributed and were compared using the paired Student's *t*-test. Categorical data including KT1000 measurements was analyzed using $\chi 2$ test. The level of statistical significance was set as P values < 0.05.

RESULTS

Lysholm Knee Scores

The Lysholm knee scoring system was used to evaluate subjective symptoms (Table 3). The average Lysholm knee score was 64.9 ± 8.8 preoperatively (range, 47–75) *versus* 92.1 ± 3.3 3 y after operation (range, 79–100), improvement from preoperative to postoperative score was statistically significant ($P < 0$ .01). After follow-up for at least 3 y, 23 patients (56%) achieved excellent results, 16 displayed good results, the remaining two patients were graded as fair, and none had a poor result.

IKDC Subjective Evaluation

All patients rated their preoperative IKDC subjective evaluation as abnormal or severely abnormal. At follow-up of 3 y postoperatively, 39 patients subjectively rated their knee function as normal or nearly normal according to the IKDC subjective assessment. Knee function improved significantly after 3 y postoperatively, with 21 normal knees, 18 nearly normal knees, 2 abnormal knees, and 0 severely abnormal knee (Table 4).

TABLE 3

Comparison Between Preoperative and Postoperative Lysholm Knee Scores

		Postoperative		
Rating (point)	Preoperative	1 y	2 y	3 y
Excellent (95–100)	0	20 (49%)	22 (54%)	23 (56%)
Good (84–94)	0	16 (39%)	17 (41%)	16 (39%)
Fair (65–83)	17 (41%)	5 (12%)	2 (5%)	2 (5%)
Poor (<65)	24 (59%)	0	0	0
Mean ± SD	64.9 ± 8.8	91.3 ± 3.9	91.9 ± 3.8	92.1 ± 3.3
P values*	<0.01	<0.01	<0.01	<0.01

*$P < 0.01$ (paired Student's *t*-test) in comparison between preoperative and postoperative measurements.

IKDC Objective Evaluation

No patient was noted to have joint effusion. Patellofemoral crepitus with mild pain was identified in two patients. Thirty-seven were noted to have normal radiography. Two patients had joint space narrowing and two had light deterioration, who were noted with chondral damage identified at operation. Average bone tunnel enlargement at final follow-up was noted in 11 patients (27%) for tibial tunnel and nine patients (22%) for femoral tunnel. Before operation, six patients (15%) had a flexion deficit > 15° compared with the normal side. Four patients (10%) had an extension defect > 10°. After 3 y of reconstruction, 37 (90%) patients were rated as normal status, with a difference

TABLE 4

International Knee Documentation Committee (IKDC) Subjective Knee Evaluation Score Before and After Operation

		Postoperative		
IKDC grade	Preoperative	1 y	2 y	3 y*
Normal	0	17 (41%)	20 (49%)	21 (51%)
Nearly normal	0	22 (54%)	19 (46%)	18 (44%)
Abnormal	25 (61%)	2 (5%)	2 (5%)	2 (5%)
Severely abnormal	16 (39%)	0	0	0
P values*	<0.01	<0.01	<0.01	<0.01

*P values (χ^2) for rating in the normal-nearly normal *versus* the abnormal-severely abnormal rating (comparison between preoperative and postoperative data).

TABLE 5

Comparison of Posterior Displacement by KT-1000 Test Between Preoperative and Postoperative Follow-Up

Side-to-side difference (KT-1000 for IKDC rating)	Preoperative	Postoperative		
		1 y	2 y	3 y
Normal (0–2 mm)	0	28 (68%)	29 (71%)	31 (76%)
Nearly normal (3–5 mm)	0	11 (27%)	10 (24%)	7 (17%)
Abnormal (6–10 mm)	15 (37%)	2 (5%)	2 (5%)	3 (7%)
Severely abnormal (>10 mm)	26 (63%)	0	0	0
Mean ± SD(mm)	12.33 ± 2.18	2.57 ± 2.17	2.48 ± 2.06	2.38 ± 2.29
P values*	<0.01	<0.01	<0.01	<0.01

*$P < 0.01$ (paired Student's *t*-test) in comparison between preoperative and postoperative measurements.

between normal and reconstructed limbs of 3° or less at full extension or 5° or less at full flexion. Two patients (5%) were rated as nearly normal status with 3° to 5° deficit in extension. Two (5%) patients with 16° to 25° deficit in flexion were rated as abnormal status. No patient had a severely abnormal rating (an extension deficit ≥ 10° or a flexion deficit ≥ 25°).

KT-1000 arthrometer was used to evaluate ligament laxity. Evaluations of posterior displacement were performed at 30 lb (134N) with 70° of flexion preoperatively and postoperatively. Preoperatively, the average posterior displacement was 12.33 ± 2.18 mm. At a 3-year follow-up, KT-1000 examination revealed a 0 to 2 mm anterior-posterior translation in 31 (76%) patients, 3 to 5 mm anterior-posterior translation in seven (17%) patients, and more than 5 mm translation in three (7%) patients. The average posterior displacement was 2.38 ± 2.29 mm postoperatively. There was a significant difference between preoperative and postoperative evaluation ($P < 0.01$) (Table 5). Some patients were afraid to perform one leg hop test in the first attempt. However, at the 3-y follow-up, all patients were asked to perform one leg hop for 3 times, and the average distances were recorded. Thirty-six (88%) patients hopped an average distance of more than 90% compared with the normal knee in three attempts. Three (7%) patients achieved 76% to 89% of the distance achieved by their normal knee. Two (5%) patients achieved 50% to 75% of the distance achieved by their normal knee.

Finally, 15 patients (37%) were rated as abnormal and 26 patients (63%) as nearly normal according to the IKDC criteria preoperatively. Postoperatively, 21 (51%) patients were rated as normal, 17 (42%) were rated as nearly normal, and three (7%) were assessed as abnormal; none was severely abnormal (Table 6). There was a significant improvement in IKDC grade evaluation comparing between preoperative and final follow-up data ($P < 0.01$).

Complications

There was no spontaneous rupture or laxity of graft. No adverse biological reactions ever occurred, including synovitis, which suggests good compatibility *in vivo*. Two patients (5%) underwent removal of the tibial screw because of pain. One patient (2%) experienced a stitch abscess with superficial wound infections.

TABLE 6

International Knee Documentation Committee (IKDC) Objective Knee Evaluation Score Before and After Operation

IKDC grade	Preoperative	Postoperative		
		1 y	2 y	3 y
Normal	0	22 (54%)	23 (56%)	21 (51%)
Nearly normal	0	17 (41%)	16 (39%)	17 (42%)
Abnormal	15 (37%)	2 (5%)	2 (5%)	3 (7%)
Severely abnormal	26 (63%)	0	0	0
P values*	<0.01	<0.01	<0.01	<0.01

*P values (χ^2) for rating in the normal-nearly normal *versus* the abnormal-severely abnormal rating (comparison between preoperative and postoperative data).

DISCUSSION

Treatment of PCL tears is controversial. Isolated PCL injuries traditionally have been treated with nonoperative treatment, and initial short-term postoperative reports for such patients indicate relatively good function. Patel *et al.* [14] studied 57 patients with isolated PCL injuries treated with nonoperative treatment and reported that 53% had an overall Lysholm score result of excellent and good, while the Tegner activity level decreased from 7 preoperatively to 6.6 postoperatively. However, long-term follow-up studies have shown a high incidence of osteoarthritis [2, 14]. Arthroscopic posterior cruciate ligament reconstruction has recently become more common, producing satisfactory results of IKDC of A or

B (range, 81% to 97%) for the majority of patients after adequate surgical principles and techniques [10, 15–17].

The choice of graft tissue for PCL reconstruction is controversial. Autograft and allograft are recommended [10, 15–17]. There are also some issues that should be considered with the use of allograft, such as availability, price, risk of disease transmission (HIV, hepatitis), tissue quality, and graft incorporation [18]. The bone-patellar tendon-bone (BPTB) autograft is widely used for PCL reconstruction because of its graft-healing potential [19, 20]. However, this technique still has some inherent limitations. BPTB autograft may not be strong enough to adequately substitute for the PCL. Besides, reconstruction with the use of BPTB autograft takes the risk of donor site complications, such as tenderness over the bony defects, anterior knee pain, and problems with kneeling [18]. Donor site morbidity seemed to be less with the use of hamstring tendon autograft for PCL reconstruction. However, like other autografts and allografts, hamstring tendon autograft has to undergo revascularization, cell proliferation, and remodeling to complete 'ligamentization', which takes nearly one year and is prone to collapse and loosening during this course. This has provoked the interest in finding a suitable artificial ligament substitute.

Due to the advantages of no donor site morbidity compared with autografts and no potential disease transmission compared with allografts, the artificial material for ligament reconstruction was recommended in the 1980s. However, the enthusiasm for these implants gradually waned because of the intermittently reported problems, mainly referring to the high device failure rate and reactive synovitis [21, 22]. The LARS ligament was taken as a new generation of artificial ligament owing to its special design, and there were no serious problems following ACL and PCL reconstruction with it reported in the current literature [3–6].

In the 1980s, artificial ligaments were widely used because of the advantages of no risk of disease transmission compared with allografts and no donor site complications compared with autografts. However, artificial ligaments were finally given up because of high incidence of failure and complications. The failure was not only due to the poor surgical techniques and the wide indication, but also the improper material of artificial ligament. Some surgeons gave up the use of artificial ligament completely. However, others tried to study what can be done to improve. They thought that the material of artificial ligament should have better mechanical and biological properties.

The LARS ligament was taken as a new generation of artificial ligament because of its special design and excellent biological properties. LARS artificial ligament is made of polyethylene terephthalate. It has been improved both in mechanical and biological properties. The PCL LARS artificial ligament is composed of the intra-articular and extra-articular portions. To mimic the native ligament, the intra-articular portion of the LARS ligament is made of longitudinal, parallel, and totally independent fibers without transverse or crossing components, and this structure resists fatigue and allows fibroblastic in-growths [21]. In other words, this structure allows the cellular and connective tissue to grow into the LARS ligament [21]. The extra-articular woven fibers provide strength and resistance to elongation. Reconstruction with LARS ligament gives promising results and satisfying outcomes [12, 13].

It is ideal for PCL reconstruction using LARS artificial ligament in acute phase. Use of LARS artificial ligament for chronic PCL tears is not acceptable only if used with autografts. Unlike the anterior cruciate ligament, posterior cruciate ligament has a spontaneous healing capacity. Thus, artificial ligaments were used as a tutor for PCL healing in acute phase, guiding the physiologic repair and limiting elongation of the healed ligament by preventing the posterior laxity induced by the rupture [22]. The prominent properties of LARS artificial ligament are high resistance of fatigue and fibroblast friendly, which allow the fibroblastic in-growths. As for patients who were treated with LARS artificial ligaments, fibroblast and osteoblast-like cells grow into the LARS artificial ligament. The cells adhere to the fibers and build a piece of capsule around them [21]. So the stumps of the ruptured PCL should be preserved.

To avoid complications, simplify the reconstruction procedure, and spare autograft and allograft material, we performed 41 PCL reconstructions using LARS artificial ligament. In this study, 38 of 41 patients (93%) were rated as excellent and good results according to Lysholm knee score 3 y postoperatively. According to IKDC subjective knee evaluation score, 39 patients (96%) rated their knee function as normal or nearly normal, with 21 knees normal and 18 nearly normal knees.

Postoperative limitation in ROM may be a problem of PCL reconstruction. Wu *et al.* [23] reported 4 of 22 patients had ROM problems after PCL reconstruction with Quadriceps Tendon Autograft. Chen *et al.* [10] reported 18 of 57 patients with postoperative limitation in ROM after PCL reconstruction using hamstring tendon autograft. In this series, after 3 y of reconstruction, 37 (90%) patients were rated as normal status, and two patient (5%) were rated as nearly normal status with 3° to 5° deficit in extension and two (5%) patients with 16° to 25° deficit in flexion were rated as abnormal status. The results showed statistically significant improvement ($P < 0.01$).

For ligament laxity, 39 patients (95%) revealed less than 5 mm as measured by KT-1000 arthrometer tests. The average posterior displacement was 12.33 ± 2.18 mm preoperatively *versus* 3.38 ± 2.29 mm

postoperatively, There was a significant difference between preoperative and postoperative evaluation ($P < 0.01$). Significant improvement in laxity could be achieved with this technique.

Numerous studies have reported that PCL injury is associated with an increased incidence of degenerative changes in the knee, primarily involving the medial, patellofemoral, and lateral compartments, in that order. This rate increased with duration of injury, severity of ligament laxity, and length of follow-up time. In this study, only 2 (10%) patients showed stage I degenerative change according to the Ahlbäck classification at the last postoperative visit.

The instability resulting from PCL tears generally produces joint degenerative changes of the knee, including the medial, patellofemoral, and lateral compartments [24]. The incidence is correlated with severity of ligament laxity and the time from injury to reconstruction. In this series, two patients had joint space narrowing and 2 had mild deterioration.

The overall IKDC outcome showed excellent, only 3 of 41 patients (7%) presented with abnormal knee function. The robust result was perhaps due to the early rehabilitation. Li *et al.* [12] reported PCL reconstructions using LARS artificial ligament in 21 patients with a minimum 2-y follow-up. In the overall IKDC ratings, 19 of 21 patients were rated as normal or nearly normal, which was similar to the result of our study.

CONCLUSION

Reconstruction of PCL tear using an artificial ligament is a controversial topic; thus conclusions should be made prudently. After follow-up for more than 3 y, the outcomes analyses of Lysholm and IKDC scoring systems revealed satisfactory results. The posterior laxity is significantly improved. Thus, LARS artificial ligament appears to be an effective device for PCL reconstruction, leading to good ligamentous stability and knee function. PCL reconstruction using artificial ligament spares tendon tissue and will not result in any donor site complications. Results appear to be stable with time. However, the follow-up is relatively short, and long-term follow-up should be performed to confirm the durable stability of the knee and the tolerance of the knee to the LARS artificial ligament.

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