

## Original article

# Cruciate ligament reconstruction using LARS artificial ligament under arthroscopy: 81 cases report

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**Keywords:** anterior cruciate ligament; posterior cruciate ligament; arthroscopy; artificial ligament; LARS

**Background** There are many different materials used for ligament reconstruction. Currently, autograft, allograft, and artificial ligaments are used in the reconstruction. The objective of this study was to explore the clinical result of cruciate ligament reconstruction under arthroscopy.

**Methods** Eighty-one cases were reconstructed with the LARS ligament under arthroscopy, including 43 cases of anterior cruciate ligament (ACL) injury, 20 cases of posterior cruciate ligament (PCL) injury, and 18 cases of ACL combined with PCL injuries of the knee. The follow up period was 10 to 49 months. The International Knee Documentation Committee (IKDC) and Lysholm knee score scales were used for functional evaluation. We examined the anterior and posterior stability of the knee with KT-1000.

**Results** According to the Lysholm knee function score scale, the average preoperative score of (44.6±1.4) increased to a postoperative score of (82.8±2.5) in the ACL group and from (46.6±2.3) to (80.8±2.0) in the PCL group. In the ACL combined with PCL injury group, the preoperative score increased from (45.2±1.2) to (85.5±2.3). According to IKDC score standards, in ACL group we evaluated 19 cases as C and 24 cases as D, preoperatively, and postoperatively 27 cases as A, 14 cases as B and two cases as C. In the preoperative PCL group, we had 11 cases defined as C and nine cases as D that resolved to 12 cases as A, seven as B and one case of C in postoperative evaluation. In the ACL combined with PCL injury group we defined four cases as C and 14 as D during preoperative scoring. These patients had postoperative grades of six cases as A, 10 as B, and two cases as C. All of the results have statistical significance.

**Conclusions** ACL, PCL, or combined ACL and PCL reconstruction using the LARS ligament under arthroscopy is a minimally invasive, safe and effective method to treat cruciate ligament injuries of the knee. Clinical results are satisfactory in the short term.

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Different methods have been suggested for the treatments of cruciate ligament injuries and the options of materials for the ligament replacement differ. The reconstruction of the cruciate ligament using autogenous patellar tendon or semitendinosus muscle is most common, but there are some drawbacks.<sup>1-4</sup> The complications are mainly related to the harvesting of the graft and include limitation of organization sources, they can easily break or come loose in the early stage of rehabilitation, and it would be inappropriate to get complete motion early. Using allograft tendon has risk of immune rejection, knee infection, and the possibility of the spread of the disease such as hepatitis C or AIDS. The use of synthetic material for ligament replacement was proposed in the 1980s.<sup>5-12</sup> Poor results and high rates of failure were reported and the material became less popular.<sup>13,14</sup>

Improved surgical techniques and new materials designs, providing a more anatomical form of reconstruction, may offer better results. The LARS artificial ligament (Ligament Advanced Reinforcement System; Surgical Implants and Devices, Arc-sur-Tille, France) has been reported to be a suitable material.<sup>15-17</sup> The LARS artificial ligament has satisfactory torsional fatigue resistance, and is more resistant to wear and tear than older artificial

ligaments.<sup>16</sup> The open knitting structure of the ligament in the joint, with holes 30–50 μm in diameter, permit tissues to grow into them, increasing the viscoelasticity of the ligament, reducing abrasion between fibers, preventing desquamation and degradation, and it has good biocompatibility.<sup>15,18</sup> The use of artificial ligaments which avoid these complications may offer an alternative treatment. We performed arthroscopic reconstruction of the cruciate ligament using LARS artificial ligaments in 81 patients and evaluated the clinical outcome and patient satisfaction.

## METHODS

### Patients

From August 2004 to April 2008, 81 patients underwent arthroscopic LARS ligament reconstruction, including 43 cases of ACL injury: 31 males and 12 females presenting 19 left knees and 24 right knees. There were 20 cases of PCL injury: 16 males and four females presenting nine

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left knees and 11 right knees. Eighteen cases had an ACL injury combined with PCL injury: 16 males, two females, presenting five left knees and 13 right knees. The mean age at the time of surgery was 27.5 years old (17 to 48 years old). Motor vehicle accidents caused 17 cases, 11 were from heavy pressure and 53 patients had sports injuries. All patients were diagnosed before surgery by MRI examination and physical examination.

### Operative procedure

Routine arthroscopy was carried out on all patients and any minor meniscal injuries were treated.

#### PCL reconstruction

Preparation of tibia tunnel: The bend-side of the PCL guide was placed through the anteromedial portal and set at the origin of the PCL on the posteromedial border of the lateral tibial plateau. The appropriate site was between 1 and 2 cm distal to the articular margin. A guide wire was drilled through the cannula under direct arthroscopic vision via the posteromedial portal with the knee in 90° of flexion.

Preparation of femoral tunnel: The PCL femoral tunnel sites were marked through the anterolateral portal with the camera in the anteromedial (AM) portal. The anterolateral femoral tunnel site was marked at the 1 or 11 o'clock position for right and left knees, respectively. The center of the tunnel was marked with a Steadman awl approximately 6 to 7 millimeters from the articular surface. This would allow the 11-mm tunnel to abut the articular surface. The posteromedial tunnel was marked 3 to 4 millimeters from the articular surface at the 2:30 to 4 o'clock position for a right knee and at the 8 o'clock to 9:30 position for a left knee.<sup>19-21</sup> Once the tunnels were marked, sequential guide pins were placed and tapped into the marked sites. The appropriate accessories were selected according to the drill diameter. A Kirschner wire was inserted through the femur at the top of the entrance of the condylus medialis femoris for PCL (anterolateral bundle) and below the entrance (posteromedial bundle) through the anterolateral (AL) incision. The Kirschner wire should be parallel to the direction of the femur as much as possible, so that the bone tunnel will be long enough and the two tunnels should be as far away from each other as possible. We selected a LARS flat drill of 6 mm in diameter to drill the femoral tunnel along with Kirschner wire, and make two skin incisions at the corresponding parts of the inner thigh. Locate a catheter from the skin incision to the femoral tunnel (to avoid injury, do not insert the catheter intra-articular), pass the guide-wire through the catheter to the femoral tunnel, and out of the AM incision under arthroscopy.

Implanting the PCL: the reconstruction of the PCL used the Y-shaped ligament. We pull out the single-side ligament from the tibia bone tunnel wire-guided through the AM incision to the ventro-crus skin incision. Each of the double-side ligaments was guided into the femoral tunnel using a wire-guide through the AM incision to the

skin incision of the inner thigh. The artificial ligament in the tibial side was fixed using LARS titanium screws. We make an extension-flexion movement of the knee 20 times to adjust the tension of the ligament, and an interference-fit screw was inserted to fix the anterolateral bundle in a flexion position, while the posterolateral bundle was fixed in an extension position. Remnants of the artificial ligament on the tibia and the femur side are cut off. Finally, suture the incision.

#### ACL reconstruction

ACL reconstructions were undertaken following the surgical principles which have previously been described.<sup>22-25</sup> Briefly, the ACL attachment site was identified under arthroscopy; a Kirschner wire was inserted at the anteromedial part of the tibial footprint of the ACL from the anteromedial tibial cortex using the tibial aimer. Another guide wire was inserted from the lateral femoral cortex to the superoposterior portion of the femoral footprint using the femoral aimer. Each guide wire was then overdrilled with a cannulated reamer. The diameter of the drill hole was 6 mm for the tibial and femoral tunnels in all patients. The LARS ligament was then introduced into the knee joint. The artificial implant was fixed by interference-fit titanium screws with diameters of 7 and 8 mm at each site.

#### Reconstruction of the ACL combined with PCL injuries

When reconstructing the ACL combined with PCL injuries under arthroscopy, the PCL should be reconstructed first, and the tension of PCL should not affect the tension of ACL. Thus, the correction of the dislocation of the tibia will not be too excessive, and lead to hypercorrection. It must be recognized that the posterior margin of the femoral condyle should not be in front of posterior edge of the tibial plateau when the knee was in the 90° flexion position. A lateral radiograph of 90° flexion is taken to ensure the overlapping of the two condyles. The knee should be restored to the center position after PCL reconstruction and before ACL reconstruction (Figure).



**Figure.** The arthroscopic view after reconstruction of ACL combined with PCL injuries

#### Postoperative treatment and rehabilitation

Anti-inflammatory medication, rehydration, treatment of

swelling was continued for 3–5 postoperative days. Supervised physical therapy often began on the second or third day after surgery. About three days after surgery, starting straight leg raising exercises, 150–200 times a day, is important to strengthen the quadriceps. Active flexion and extension exercises were allowed at 2–3 weeks. Partial weight bearing on the surgically treated leg, using crutches, was allowed two weeks after surgery to strengthen the plantar flexion. Four weeks later patients started riding a fixed bike to gradually recover limb proprioception. After 4–6 weeks walking with full weight-bearing without crutches was started. Patients continue training to increase knee stability for 2 to 3 more months with increased anti-resistance strength training and proprioception training. In this period, they could return to daily work and life activities and even resume general sports. For professional athletes and other special patients, it was possible to take part in competitive sports gradually after 4 months, depending on their postoperative recovery.

### Follow-up

All the patients were followed to record the symptoms, activity and stability of the knee, the limitation of knee function in daily and sports activities, and the postoperative changes in activity. The International Knee Documentation Committee (IKDC) Ligament Standard evaluation form and the Lysholm knee function score scale were used to assess knee function. The KT-1000 examination was used to evaluate knee laxity.

### Statistical analysis

All measurements were expressed as mean and standard deviation, and non-continuous data as median with ranges given. For statistical comparisons, we used chi-squared test for all categorical data and the Student's *t*-test for unpaired groups of parametric data. A probability level of  $P < 0.05$  was considered to be statistically significant.

## RESULTS

All of the patients were followed for 10–49 postoperative months, average 29.4 months. This included 43 cases in the ACL group, 20 cases in the PCL group and 18 cases in the ACL combined with PCL group.

**ACL group:** All of the patients with symptoms of knee instability graded their knee as normal; the anterior drawer test was negative; joint function was satisfied; the range of motion was 0 to (120.0±4.5) degrees. According to Lysholm knee function score scale, the average score increased from (44.6±1.4) preoperatively to (82.8±2.5) postoperatively. The difference between the two scores was statistically significant ( $t=2.882$ ,  $P < 0.01$ ). According to IKDC score standards, we had 19 cases of C and 24 cases of D preoperatively, that resolved to 27 cases of A, 14 cases of B and 2 cases of C after treatment ( $\chi^2=8.563$ ,  $P < 0.05$ ).

**PCL group:** All patients with symptoms of knee instability graded their knee as normal. The posterior drawer test was negative with good joint function and the range of motion was 0 to (121±0.5) degree. According to Lysholm knee function score scale, the average score increased from (46.6±2.3) preoperatively to (80.8±2.0) postoperatively. The difference between the two scores was statistically significant ( $t=2.956$ ,  $P < 0.01$ ). According to IKDC score standards, 11 cases of C and 9 cases of D before surgery resolved as 12 cases of A, seven of B, and 1 case of C after treatment ( $\chi^2=9.102$ ,  $P < 0.05$ ).

**ACL combined with PCL injury group:** For all patients the anterior and posterior drawer tests were negative, and they achieved immediate knee stability after surgery. KT-1000 examination results of the knees in flexion of 25 degrees and 70 degrees were in the normal range. Radiographs were taken periodically to check the changes in knee osteoarthritis, and the overall recovery of knee function was evaluated according to IKDC and the Lysholm knee score. IKDC score standards showed improvement from preoperative scores, four cases of C and 14 of D, to 6 cases of A, 10 of B and two of C after surgery ( $\chi^2=7.996$ ,  $P < 0.05$ ). According to the Lysholm knee score, the average preoperative score of (45.2±1.2) increased to (85.5±2.3) at the latest follow-up. The difference between the two evaluations was statistically significant ( $P < 0.01$ ).

One patient experienced screw loosening during the procedure of inserting the screw into the tibia bone due to severe osteoporosis. The screw was then replaced by a larger diameter screw. The patient was advised to avoid the early postoperative activities and take anti-osteoporosis drugs. The patient showed a return of normal joint function after three months. Two patients had mild swelling in the anterior tibial area, without significant tenderness. The swelling apparently improved in response to symptomatic treatment. During the follow-up period, no ligament rupture or screw loosening occurred. All the patients went back to work after surgery, including 10 athletes who returned to the sports grounds.

## DISCUSSION

The LARS artificial ligament has been used in Europe for many years, and it was introduced into China from 2004.<sup>26,27</sup> Nau et al<sup>28</sup> reported their experience between 1996 and 1998 comparing the ACL reconstructed using the LARS artificial ligament with the bone-patellar tendon-bone autograft. They reported that the LARS artificial ligament group did not have complications, especially that they did not develop acute synovitis. There was no significant difference in stability between knees in the LARS artificial ligament group and bone-patellar tendon-bone group. Ligament reconstruction using LARS artificial ligaments can avoid material-related complications compared with autologous and allogeneic grafts. With a short surgical time, patients can take part in

early activities after surgery.

Trieb et al<sup>18</sup> reported that biopsies taken from the LARS artificial ligament six months after implantation and examined by histochemistry found fibroblast growth into the ligament *in vivo* and *in vitro*. Additionally, osteoblast-like cells also grow into the ligament *in vitro*. The cells adhere to the fibers and build a capsule around them. These findings are consistent with the high biocompatibility of the LARS ligament. *In vivo* the ligament was completely connected by the surrounding tissue. Although the biological compatibility of the LARS ligament seemed encouraging, the mechanical properties and tissue engineering possibilities still required further evaluation.

Compared with autologous tendon and allogeneic tendon, the LARS artificial ligament has excellent biomechanical properties. It can provide immediate stability for the knee after reconstruction, allow the early function recovery, correct dislocation motion, and it avoids complications of autologous or allograft materials.<sup>29,30</sup> The LARS artificial ligament has been used in Europe for 15 years and satisfactory clinical results have been reported.<sup>16,31</sup> Therefore, LARS artificial ligament is considered to be a safe and ideal artificial ligament for young patients demanding an immediate return to the sports ground, particularly athletes with cruciate ligament injuries.

We report a total of 81 patients who underwent ligament reconstruction with the LARS artificial ligament, and we believe that it is a mature and reliable operation. The present study had a good short-term results of immediate postoperative knee stability, especially for professional athletes engaged in sports. Ten athletes in this series returned to the sports grounds and, although our patients were followed for up to 42 months, there was no ligament loosening, fracture, or screw loosening. The short-term results of this study were satisfactory, but the follow-up period was only 10 to 49 months, and results are still needed from long-term follow-up. In future it should be compared with other methods, including autogenous graft or allogeneic graft.

Relevant skills and attention are as follows: (1) MRI should be carefully analyzed before surgery and combined with physical examination to make sure of ligament injury to avoid missed diagnosis. In some cases the preoperative diagnosis of ligament injuries was inconsistent with what was revealed under arthroscopy. We commonly prepared both anterior and posterior artificial ligament and corresponding tools before beginning. (2) It should be emphasized that the femoral isometric point is much more important, and that the room for error is far less than on the tibial side. The ACL reconstruction should not be too high or it will result in limited extension and knee pain as well as the impingement of intercondylar fossa which easily leads to artificial ligament breakage and wear. (3) The mechanical

stimulation receptors of the ligaments convey the articular location information to the central nervous system and can adjust the tension of the ligaments. Damage to ligament innervation will result in less control of the joint. Lost control of the joint lead to uneven weight-bearing and repeated minor ligament trauma that lead to premature fatigue. So the existence of a ligament stump can play an important, protective role with an artificial ligament. (4) Any fractured bone in the operation tunnel should be full removed by drilling, thereby preventing the ligament from breaking due to repeated friction. The existence of sharp edges in the bone tunnel can lead to collateral damage. (5) The artificial ligament should be left or right twisted appropriately before the fixation of the screw to reproduce the natural orientation of the anatomical ligament fibers, and to reduce fatigue under torsion when the knee goes from flexion to extension. (6) The direction of the femoral tunnel should be well designed, and you should prevent the screw from entering the patella capsule through the femoral tunnel during the operation. (7) Free fibers of the ligament should be 1 mm inside the femur bone tunnel to reduce friction. (8) Violent manipulation during the operation may lead to fracture of the ligament traction line and cause the guide pin be broken or bent. (9) Because acute cruciate ligament injury is often combined with joint capsule injury, it is necessary to reduce perfusion pressure as far as possible and to avoid intraoperative and postoperative swelling and compartment syndrome.

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