

*Full Length Research Paper*

# Arthroscopic reconstruction of anterior cruciate ligament with the remnant-preserving technique

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**The purpose of this paper was to investigate the results of arthroscopic of anterior cruciate ligament (ACL) reconstruction with the remnant-preserving technique and evaluate its clinical significance. A total of ACL injuries in 147 patients confirmed by arthroscopy, including partial disruption of ACL in 45 cases, complete disruption of ACL in 66 cases and laxity of ligament in 36 cases were included in this study. Injured bundle branches and lax ligaments were retained while ACL Ligament remnants with complete disruption were not removed. Single bundle ACL reconstruction was performed using quadrupled hamstring tendon autograft. The tendons were fixed with the Rigidfix system at the femur and with the Intrafix system at the tibia. The mean follow up was 19 months (12 to 24 months), during which the stability of knee joint was significantly increased. Lysholm knee joint function score increased from preoperative 68.6 to postoperative 94.9. Lachman test was negative in 43 cases, slightly positive in 3 cases and positive in one case. Referring to Insall's evaluation criterion on knee joint, the curative effects of knee joint were excellent in 38 cases and good in 9 cases, respectively. Arthroscopic ACL reconstruction preserving the remnants aids revascularization of the tendon transplant and recovery of proprioceptive sense, as well as the stability maintaining of knee joint.**

**Key words:** Anterior cruciate ligament, arthroscopy, reconstruction.

## INTRODUCTION

Arthroscopic reconstruction of the anterior cruciate ligament (ACL) has been the conventional treatment strategy for ACL injury. However, revascularization, tendon healing, bone tunnel healing and proprioception recovery are still the main factors influencing the curative effects of ACL reconstruction (Kim et al., 2009). Several techniques of ACL reconstruction have been introduced to improve the functional outcome and restore normal kinematics of the knee. Meanwhile, a remnant-preserving technique was developed to preserve the proprioception and to enhance the revascularization of the reconstructed ACL (Kim et al., 2009). There are three reasons to preserve these remnants: biomechanical, vascular and proprioceptive advantages for the patient. Good quality fibers work as graft protection during the healing process.

Periligamentous and endoligamentous vessels present

into the native ACL tissue may enhance the vascularization of the ACL augmentation. Mechanoreceptors still remaining in the residual ACL fibers may have proprioceptive function. The definition of remnant ACL is controversial, based on anatomy, clinical examination, instrumental laxity assessment or MRI findings. Continuous remnant ACL fibers bridging the femur and tibia, from native femoral ACL footprint to native tibial ACL footprint seem to be a good definition (indication) (Colombet et al., 2010). In this study, arthroscopic reconstruction of anterior cruciate ligament with remnants obtained satisfactory curative effects, and we report as follows:

## PATIENTS AND METHODS

### Patients

A total of ACL injuries in 147 patients treated in our department between June 2005 and June 2010 were enrolled in this study,

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including 52 cases of sports injuries, 51 cases of training injury and 44 cases of traffic accident injury. Sports injury refers to general physical exercise-induced injury while training injury refers to the damage caused by military training activities, such as Sanda fighting, 5 km cross-country, obstacle running, etc. The injured people are mainly army soldiers. The study included 109 males and 35 females with a mean age of 28 years (17 to 46 years). The main clinical manifestations included knee joint instability, pain and swelling, and these symptoms were more serious at running, going downstairs or upstairs. Physical examination showed different degrees of atrophy of quadriceps femoris, anterior drawer test was positive in 138 cases, Lachman test was positive in 138 cases and weakly positive in 9 cases. All patients were diagnosed using knee MRI to exclude combined posterior cruciate ligament injuries.

### Operative procedures

45 cases of partial ACL disruption, 66 cases of complete disruption and 36 cases of ligament laxity were confirmed by arthroscopy. The duration from injury to operation time is one week -12 years, with an average time of 9.5 months. ACL remnants in complete disruption were not removed at femoral or tibial extremities. The location of the tibial tunnel was medial and posterior to the native tibial ACL attachment point, that is, 2 mm anterior from the medial tibial spine in the extension a line starting at the free edge of the anterior horn of the lateral meniscus.

The tibial tunnel inclination was 45°, and a guide pin was drilled. A drill bit with a diameter corresponding to the tendon transplant was selected to drill the tibial tunnel over the guide of guide pin. The knee joint was flexed at 90°, and then an appropriate femoral tunnel locator was placed through the tibial tunnel. Then, each guide pin was inserted from clock 10~11 in right knee or clock 1~2 in the left knee. A drill bit equal with the diameter of tendon transplant was selected to establish a 3 cm long femoral tunnel with the guide of guide pin (Figure 1A).

A targeting bar of with equal diameter with the tunnel was inserted into the femoral tunnel. Two interlocking holes were drilled in the femur to fix the graft using Rigidfix pins. The tendon graft passed through the tibial or femoral stump, and the reconstructed ligament was covered with ligament remnants in a sleeve-like fashion (Figure 1B). In single bundle branch ACL injuries, the stump of the disrupted bundle as well as the lax ligament bundle branch was retained. In significant laxity of the ACL (Figure 1C), the tendon graft passed through the femoral or tibial attachment points and overlapped or twisted with original ligament (Figure 1D). The ACL was reconstructed with an autologous single bundle branch of quadrupled hamstring tendons.

Ligament was inserted into tibial tunnel by drawing the guide pin out from the anterolateral surface of the thigh. After accurate positioning, two absorbable pins were inserted into the interlocking holes and through the transplanted tendons. After 20 times of knee joint flexion and extension at the traction of ligament at femoral extremities, the ligament was fixed by Intrafix system.

The tension and stability of reconstructed ligament was checked. If there was impact and friction at knee extension intercondylar notchplasty was performed. In the early stages after operation, the injured lower limb was protected with orthosis, and functional exercises were performed according to rehabilitation program.

### Statistical analyses

All data were expressed as mean  $\pm$  standard deviation and analyzed by SPSS 13.0 software. Group comparison was performed with *t* test and *P* < 0.05 was considered statistically significant.

## RESULTS

All patients were followed up for a mean period of 19 months (12 to 24 months), and stability of knee joint was significantly increased. Lysholm knee joint function score was significantly increased from preoperative ( $68.6 \pm 5.1$ ) to postoperative ( $94.9 \pm 0.9$ ) (*P* < 0.05). Lachman test was negative in 43 cases, weakly positive in 3 cases and positive in one case. Referring to Insall's evaluation criterion on knee joint curative effects, curative effects of knee joint were excellent in 38 cases and good in 9 cases, respectively. All subjects in this study re-obtain the ability of daily work and life or gradually resume movement level before sports injury. Quadriceps femoris was obviously atrophic in early stage after operation. After training for a period of 6 to 12 months, knee joint function gradually restored to normal level. One year later, there was no significant difference in the proprioceptive sensation of knee joint between two sides, and the stability of knee joint was significantly increased, and Marshall score (Liu, 2008) special for knee ligament injury was 45.8.

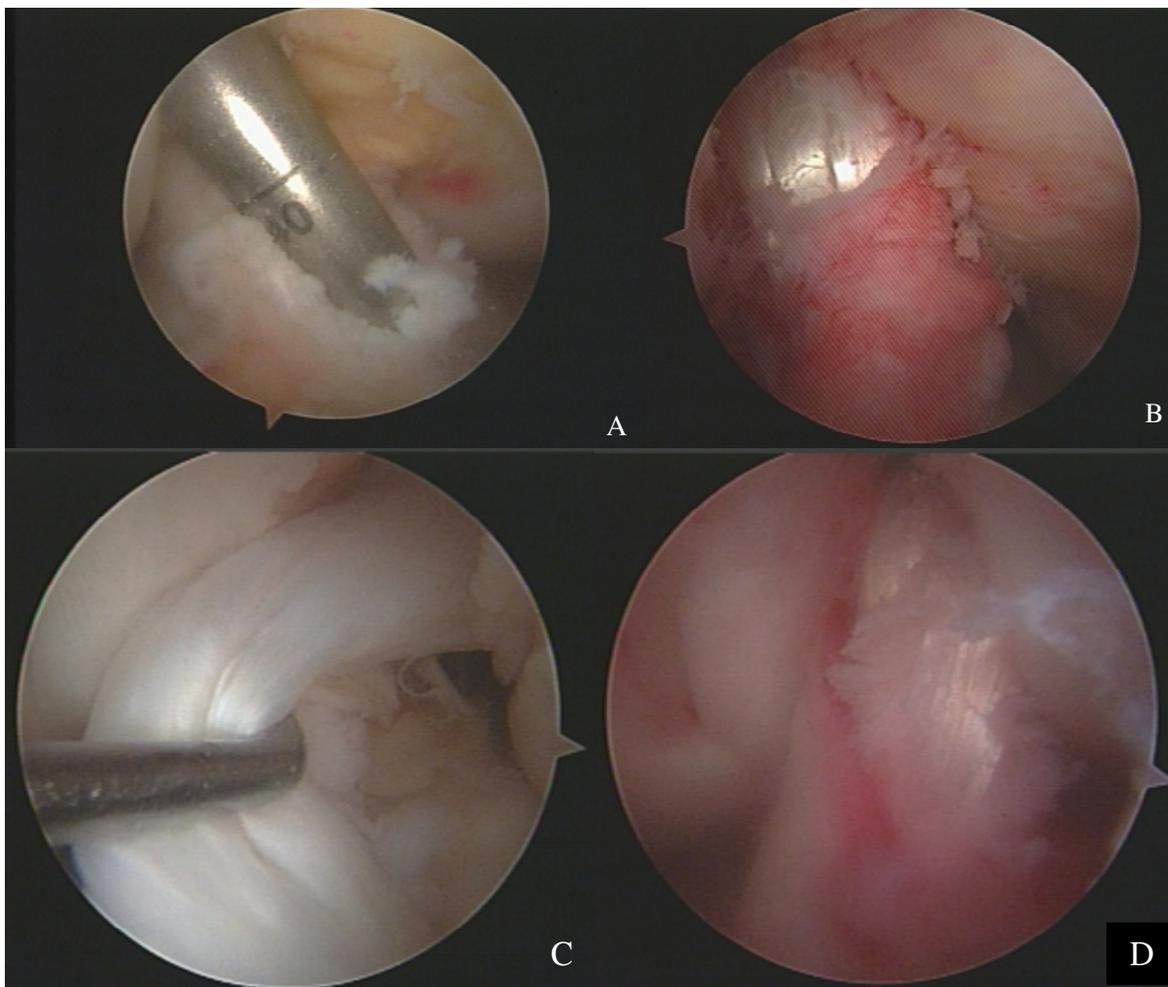
## DISCUSSION

### Conception and methods of arthroscopic ACL reconstruction with remnants

Anterior cruciate ligament injury may include complete disruption, partial disruption and ligament laxity. After complete disruption of the ACL, the preventive function on tibia anterior translocation is lost. The ACL must be reconstructed to re-obtain the stability of knee joint. During operation, ACL remnants were not removed at femoral or tibial attachment sites. The tendon transplant was reconstructed through the tibial or femoral stumps, and the reconstructed ligament was covered with ligament remnants in a sleeve-like fashion. Single bundle ACL injury is also known as partial disruption of the ACL. Regardless of medial or lateral bundle injury location, the residual bundle is lax, and thus these bundles are also slightly injured. Therefore, reconstruction of a single bundle cannot sufficiently maintain the stability of the knee joint, and two ACL bundles must be reconstructed. Although arthroscopy showed nearly an uninjured cruciate ligament in some cases, they were significantly lax, and thus the ligaments were injured in varying degrees. These lax ligaments may be tightened by radiofrequency, but the long-term effects are not satisfactory. In this study, ACL reconstruction can obtain better curative effects.

### Significance of arthroscopic ACL reconstruction with remnants

Fiber and synovium at the tibial attachment site is the



**Figure 1.** A 3 cm-long femoral tunnel was drilled at the 11'o clock position in the right knee through the tibial tunnel (A), the transplanted tendon was covered with ligament remnants in sleeve-like fashion (B), the anterior cruciate ligament is obviously lax (C) and the tendon graft is passed through the femoral or tibial attachment points and overlapped or twisted around the original ligament (D).

main blood supply source of the ACL, while the remaining blood supply is derived from the infrapatellar fat pad and the synovial blood vessels. Therefore, if ligament remnants are removed in ACL reconstruction, the reconstructed ACL is completely stripped of blood supply, which is not conducive to the ingrowth of nerve fibers and revascularization of transplanted tendons. Otherwise, ACL reconstruction with remnants can ensure that the reconstructed ACL is sufficiently covered with ligament and synovial tissues, which is conducive for revascularization the graft (Lee et al., 2006). Tsuda's studies (Tsuda et al., 2001) reveal that there are many kinds of mechanoreceptors such as Ruffini corpuscles, Pacinian corpuscles and Golgi bodies in ACL fibers, and these mechanoreceptors are closely related with the proprioceptive sense of knee joint. Mechanoreceptor excitement can improve the stability of the knee by

activating neuromuscular reflexes. The retained bundle branches and stump fibers are conducive to the ingrowth of mechanoreceptors in transplanted tendons and the restoration of proprioceptive sense of knee joint. Besides, excessive removal of ligament remnants in ACL reconstruction may result in excessive synovial fluid leakage in the bone tunnels, affecting the healing of bone and ligament. The retained ligament remnants and synovial membrane can seal the bone tunnels (Lee et al., 2008; Surendran et al., 2007). Ento-ectad interface screw is not conducive to the prevention of synovial fluid in bone tunnels. Indirect fixation away from articular surface such as the use of button door-shaped screws leads to "bungee jumping effect" due to the vertical motion between transplanted tendons and bone tunnels and "windshield wiper effect" due to horizontal motion. The fixation segment of Rigidfix horizontal nailing fixation

system is near the anatomical insertion of ACL, which is conducive to the prevention from vertical and anteroposterior displacement, and expansion of bone tunnels (Liu et al., 2009). Besides, Rigidfix horizontal pin fixation system can promote the healing of bone and tendons due to the close contact of tendons and bone tunnels, and effectively prevent joint fluid into bone tunnels (Ahn et al., 2007).

Rigidfix horizontal pin fixation system is a more ideal fixation in ACL reconstruction (Musil et al., 2005). Arthroscopic reconstruction of ACL with the remnant preserving technique may enhance the revascularization and cellular proliferation of the graft, to preserve proprioceptive function, and to be able to acquire anatomic placement of tendon graft.

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