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ORIGINAL STUDY

Simultaneous multiple anterior cruciate ligament reconstructions using a single Achilles tendon allograft

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This study aimed to evaluate simultaneous multiple anterior cruciate ligament (ACL) reconstructions performed with a single Achilles allograft. After selection of an Achilles allograft with suitable length, the circumference of the isthmus and length of the tendinous portion were measured. The Achilles tendon was divided along its fibers into two or three strips and each strip was looped into a two-strand construct. Fifteen Achilles allografts were used for 31 ACL reconstructions in 30 subjects. The median circumference at the isthmus was 29 mm and the median length of the Achilles tendon 185 mm before and 206 mm after removal of the insertional bone block. The median difference in length before and after removal of the bone block was 19 mm. Achilles allografts with proper length consistently yielded two free tendon grafts suitable for simultaneous multiple ACL reconstruction with good short-term results.

Keywords : ACL repair ; Achilles tendon allograft ; simultaneous multiple use.

INTRODUCTION

Anterior cruciate ligament (ACL) reconstruction uses autograft or allograft as a ligament reconstruction material. Using autograft has advantages concerning disease transmission, immune reaction, incorporation time and additional medical costs, but also has disadvantages such as donor site morbidity and longer operation time (*6,8,9,10*). To avoid donor site morbidity and the possible limitations of autograft such as short length or small thickness of the autograft, allograft is becoming more commonly used, even in primary reconstruction. The results of ACL reconstructions with allograft were reportedly comparable to those with autograft in most studies (*3*).

Generally, a single allograft is used for a single ACL reconstruction. When the Achilles allograft is prepared for ACL reconstruction, a significant amount of tendon tissue, sufficient for another reconstruction, is discarded. To optimize the use of an Achilles allograft and to reduce the cost, we used a

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single Achilles allograft for multiple reconstructions. We actually have successfully used it for a simultaneous reconstruction of the posterolateral ligament complex. We decided to use a single Achilles allograft to reconstruct two ACLs, in the unusual case where one patient needs two reconstructions at the same time. The purpose of this study was to establish if thickness and length of a single Achilles allograft permitted multiple ACL reconstructions and to report our short term experience in 31 cases of simultaneous multiple ACL reconstructions with a single Achilles allograft.

MATERIALS AND METHODS

With approval of the ethics committee of National Police Hospital, this prospective case study (registered with ClinicalTrials.gov) was conducted between May 2011 and November 2011. During the study period 79 subjects were diagnosed with ACL rupture by physical examination and MRI. Of these, four subjects were treated conservatively and two refused surgical intervention. Sixteen subjects underwent reconstructive surgery unpaired, which means one Achilles allograft was used for one ACL reconstruction and the remnant was discarded. The subjects with concomitant meniscus or cartilage injuries were included. We excluded patients who required reconstruction of medial or lateral collateral ligament, or posterolateral ligament complex (*5*), patients preferring autograft for reconstruction (*10*), or did not want to participate in this study (*4*). Patients who could benefit of national reimbursement (*6*) were also excluded because in Korea reimbursement is refused when a single allograft is used for more than one recipient (one single allograft must be used for a single recipient). The remaining 32 patients were planned for reconstruction per two or three to share one allograft. When the number of patients was even, simultaneous surgery was done per two. After the explanation of the purpose and procedures of this study, informed consents were obtained.

Tissue preparation

An Achilles allograft labeled 17 cm or longer on the package was chosen. After ACL rupture was confirmed by arthroscopy, thawing and preparation of the fresh frozen allograft (at -70 ºC) started in a separate room. To ensure the allograft provided enough material for two or more reconstructions, circumference and length were checked. The circumference was measured at the narrowest part (generally 4 to 5 cm above calcaneal insertion) with the graft tied up using string or tapeline. A circumference of 26 mm or more was sufficient to obtain two free two-strand tendon grafts with a thickness of 9 mm. The bone block was removed, preserving the insertional tendon. Usually it could be separated by hand. The length of the Achilles allograft was measured before and after the calcaneal bone block was removed. Depending on the thickness of the graft, division into two or three tendon strips with a width of 6 to 7 mm was started distally and dissection continued upwards along the tendon fibers, using a No. 10 scalpel blade (Fig. 1). Attention must be paid not to transect tendon fibers significantly, knowing that the tendon fibers rotate 90° internally as they insert onto the calcaneal tuberosity (*13*). Each free tendon strip was folded into two strands to become 9 mm-thick. The length of the graft was set to be 9 to 10 cm depending on the length of tibial tunnel considering that the intra-articular portion would be about 3.5 cm (*1,7*). The free ends of each strand were whip-stitched with No. 2 Fiberwire over 30 to 35 mm (Fig. 2).

Fig. 1. — The allograft was divided into two strips along the tendon fibers.

ACL reconstruction

The diameters of the tibial and femoral tunnels were sized to fit the thickness of the graft. The tibial tunnel was made at the footprint with an angle of 45° to the tibia. The femoral tunnel was made at the footprint via the anteromedial portal with the knee flexed to 120° or more. Twenty to thirty millimeters of the looped end was inserted into the femoral tunnel via tibial tunnel and fixed with Endobutton CL (Smith & Nephew, Endover, MA, USA). After pretensioning by conducting 20 range-of-motion cycles under maximal manual load the tibial end was fixed with a 7 mm diameter 23 mm long Bioscrew (DePuy Mitek, Reynham, MA, USA) and post-tied to a washer screw or suture washer (Smith & Nephew, Endover, MA, USA) with the knee flexed at 20° (Fig. 3). When a washer screw was used the end of the graft was

Fig. 2. — Each strip was looped into a two-strand graft

set to protrude 5 to 10 millimeters out of the tibial tunnel to prevent suture cut over the sharp margin of the tibial tunnel.

Measurement of Achilles allograft

Parallel to the present study, the circumference at the isthmus and the length of the tendinous portion before and after removal of calcaneal bone block were measured in all Achilles allografts used whether the subjects were included or not. The minimum length of Achilles allografts used in patients included in this study was 17 cm. Achilles allografts for subjects not included in this study were randomly chosen from the graft bank. When the tendinous portion was long enough, i.e. 17 cm or more, the allograft was used as a two-strand graft with the technique which has been described above. When the tendinous portion was not long enough to be folded into two-strand, the graft was used as a single strand.

Assessment of outcomes

All subjects were evaluated by an orthopaedic surgeon who did not participate in the surgery. Clinical evaluation included Lachman test, pivot shift test, range of motion of the knee, and Lysholm score at the last follow-up. Radiographic evaluation was side-to-side difference (SSD). To assess the SSD, anterior stress was applied with the knee flexed to 30°. The knee was loaded 150 N using Telos stress device (Austin & Associate Inc., Fallston, MD, USA).

Statistical analysis

Statistical analysis was performed with SPSS software, version 17.0 (SPSS, Chicago, IL, USA). The correlation between circumference at the isthmus of the allograft and length was analyzed with Spearman correlation test. The significance level was 0.05.

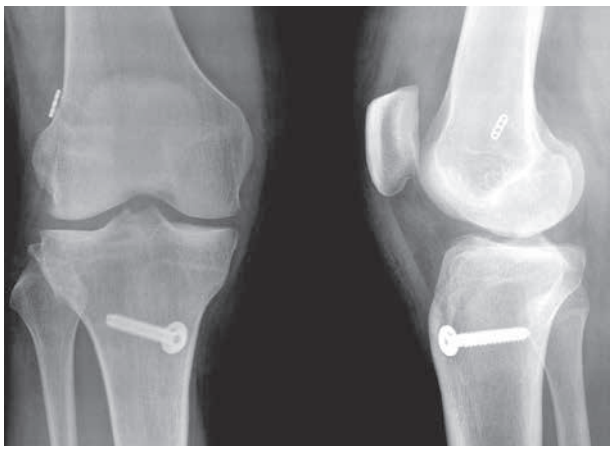

Fig. 3. — Postoperative radiographs of ACL reconstruction

RESULTS

Thirty two subjects (33 reconstructions) were recruited in this study. In 12 surgical sessions one graft served two simultaneous cases. Three times three cases were scheduled in one session, but the graft mass did only once provide enough material for three. Two subjects of these triple sessions received independently another Achilles allograft. Fifteen Achilles allografts were used for 31 ACL reconstructions in 30 subjects. Of those, one subject had revision ACL reconstruction, and another had simultaneous bilateral reconstruction. Concomitant injuries were medial meniscus tear in 2 subjects, medial collateral ligament injury in 3 subjects, and lateral meniscus tear in 1 subject. Meniscus tears were treated with partial meniscectomy and medial collateral ligament injuries were treated conservatively. The median circumference of the isthmus was 29 mm (range : 26 to 32 mm). The median length of the Achilles tendon was 185 mm (range : 171 to 216 mm) before removal of the calcaneal bone block and 206 mm (range : 189 to 233 mm) after removal of the bone block. The median difference of the length of the tendinous portion before and after removal of the calcaneal bone block was 19 mm (range : 11 to 29 mm).

As a control group, 31 randomly chosen Achilles allografts for ACL reconstructions were used in this study. The median circumference at the isthmus and length of tendinous portion before and after removal

Table I. — Measurements of Achilles allograft : control group

	Median value (mm)
Circumference at the isthmus	30 (range : 26 to 34)
Length before removal of bone block	190 (range : 150 to 240)
Length after removal of bone block	196 (range : 166 to 260)
Difference in length before/after bone block removal	14 (range : 6 to 29)

of calcaneal bone block are presented in Table I. The number of allografts whose length after removal of the bone block was more than 180 mm, which was long enough for two-strand graft for ACL reconstruction, was 26 out of 31 (83.9%). All the randomly chosen allografts had 26 mm or more circumference at the isthmus, which might be thick enough for two two-strand grafts with the thickness of 9 mm for ACL reconstruction. There was a positive correlation between circumference and length of the allograft after removal of the bone block ($r = 0.602$, $p < 0.001$). There was no correlation between the length of the tendon before removal of the bone block and difference of the tendon length between before and after removal of the bone block ($r = 0.201$, $p = 0.139$).

Clinical outcomes

All the included subjects were followed up for at least one year. The Lachman test was negative in 30 subjects and 1+ in one subject. The pivot shift test was negative in 30 subjects and 1+ in one subject. Full range of motion of the knee was recovered except in one subject who showed an extension deficit of 5°. Mean Lysholm score was 93.7 ± 3.7. Mean SSD (anterior translation of the affected knee minus translation of the healthy knee) was 1.2 ± 1.4 mm.

DISCUSSION

This study shows that multiple cruciate ligament reconstructions can be performed using a single Achilles allograft with good short-term results. Achilles tendon is one of the most popular allografts for ACL reconstruction (*2,12*). Using Achilles tendon as an allograft for ACL reconstruction in some specific conditions is reimbursed by national health insurance scheme in South Korea. In a cruciate ligament reconstruction, the Achilles tendon is generally used as a single strand with a bone block on its end (*11,14,15*). However, the remaining tendon allograft material in isolated ACL reconstructions is considerable and is discarded. The thickness of the tendinous portion of the prepared graft is usually less than that of the bone block (*4*) necessitating larger femoral and tibial tunnels, which is not desirable when it comes to revision surgery. Finally the bone block may fracture during insertion, pretensioning or fixation of the graft into the tunnel. We therefore used Achilles tendon allografts without bone block. After removal of the bone, the length of Achilles tendon was between 189 and 233 mm in this study, which was long enough to be folded into a two-strand graft. The minimal length of selected allografts was 170 mm to allow folding in a two-strand graft. In this study about 16% of the randomly chosen Achilles allografts were shorter than 180 mm after the bone block was removed.

The thickness of the Achilles allograft is usually not specified on the package. This study demonstrated that there was a positive correlation between the length and the circumference of the graft, which would be helpful to select the graft. The circumference at the isthmus in our samples was 26 mm or more and in practice two or three 9 mm-thick free tendon grafts filling perfectly both tunnels could be prepared with all Achilles allografts of at least 17 cm length.

Achilles tendon fibers rotate as they insert onto the calcaneal tuberosity (*5,13*). At the level of the calcaneal tuberosity, the posterior (superficial) part of the tendon is formed by the medial head of the

gastrocnemius muscle, and the anterior (deep) part of the tendon by the lateral head of the gastrocnemius muscle. The fibers from the soleus muscle are located in the anteromedial part of the Achilles tendon. We divided the allograft into two or three bundles starting at the calcaneal end and further following the course of the tendon fibers.

This study has some inherent weaknesses. There may be a concern about the strength of the graft, since there are no specific data on the sections used. Also the number of cases is rather small and evidence must be confirmed by further experience. The follow-up is short, and comparative preoperative data were not recorded.

The described technique may not be applicable when the number of ACL reconstructions performed is small and does not allow to organize simultaneous reconstructions. However, this technique may also be an excellent option for bilateral ACL reconstructions and multiple reconstructions in one patient.

For patients who need allograft reconstruction, the cost and limited supply are real barriers to their use. Multiple use of each graft can be an option to address these issues.

CONCLUSIONS

A single Achilles allograft with a minimum total length of 17 cm consistently yielded two free tendon grafts for ACL reconstruction with good short-term results and is therefore capable of procuring enough graft material for simultaneous multiple ligament, bilateral or simultaneous ACL reconstruction in different patients.

There was a positive correlation between circumference and length of the allograft.

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