The Anterior Cruciate Ligament Reconstruction with the Peroneus Longus Tendon: A Biomechanical and Clinical Evaluation of the Donor Ankle Morbidity

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Background: *The purpose of this study was to report on ankle and foot functions via the holistic evaluations using clinical examination, functional scores assessment and isokinetic tests after harvesting autogenous peroneus longus tendons for anterior cruciate ligament (ACL) reconstruction focusing on the donor site morbidity with a minimum 1-year follow-up period.*

Material and Method: *The study included 24 patients who underwent ACL reconstruction using peroneus longus autograft and endobutton fixation. Results of ACL reconstruction were assessed via physical examination. Donor site morbidity of the foot and ankle after tendon-harvesting was assessed using American Orthopedic Foot-and-Ankle Society (AOFAS) for ankle-hindfoot score and Visual Analogue Score-Foot Ankle (VAS-FA). Isokinetic testing for the ankle was performed in 10 voluntary patients after surgery.*

Results: *Mean follow-up time was 12.8 months. Regarding the latest follow-up, anterior drawer tests of ankle showed normal findings in 83.3%, and 1+ anterior laxity in 16.7% of all patients. Mean pre- and postoperative AOFAS scores were 100.0±0.0 and 96.0±9.6, respectively at 6-month follow-up ($p = 0.06$). Mean pre- and postoperative VAS-FA scores were 99.7±1.1 and 95.4±12.0, respectively at ~13-month follow-up ($p = 0.09$). At 7-month follow-up by isokinetic testing, peak torques of eversion and inversion were significantly lower on the harvested ankle compared with the contralateral ankle at both velocities (60°/second and 120°/second, $p<0.05$).*

Conclusion: *Based on overall findings in the present study, the authors could not recommend the peroneus longus tendon as the first option of donor graft for ACL reconstruction due to the several morbidities particularly in the first 12 months after the operation. However, the peroneus longus tendon may be the option after other graft harvestings for the ligament reconstruction, which needs several tendon grafts in a patient with multi-directional instability of the knee due to some specific situation such as a traumatic knee dislocation.*

Keywords: *Anterior cruciate ligament, Peroneus longus, Ankle, Morbidity*

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Nowadays, bone-patellar, tendon-bone or double-looped semitendinosus/gracilis autografts have become the most common graft choices for anterior cruciate ligament reconstruction. Other common sources of autograft include the fascia lata, iliotibial band, and quadriceps tendon with or without bone[1]. Although they have several advantages as autogenous sources, these aforementioned autografts could not be independent of the donor site morbidity. There has been increased use of allograft as an alternative graft to reduce potential donor site morbidity resulting from the harvesting of autogenous tissue[2]. Although the patellar tendon has theoretical advantages, 40-60% of patients who have undergone arthroscopic anterior cruciate reconstruction using patellar tendon autografts have anterior knee problems[3]. Recently, the quadrupled hamstring has become an increasingly popular alternative autograft, and recent reports indicate less graft harvest morbidity and improved device fixation; however, few reports of clinical follow-up findings had been issued on this modality in the early 1990s[4].

Accordingly, the author sought to find a donor site that meets the demands of kneeling,

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but with enough strength and minimal donor site morbidity. Clinical results of anterior cruciate ligament reconstruction with autogenous peroneus tendon graft have been reported[5,6]. However, these studies had no complete evaluation of ankle morbidity in terms of validated scores or other crucial finding such as the deficit of first ray plantar flexion. The purpose of the present study was to report on ankle and foot functions via the holistic evaluations using clinical examination, functional scores assessment and isokinetic tests after harvesting autogenous peroneus longus tendon for anterior cruciate ligament (ACL) reconstruction focusing on the donor site morbidity with a minimum 1-year follow-up period.

Material and Method

All patients who had been operated on with the use of ipsilateral peroneus longus tendon autograft between 2011 and 2012 were collected in this study. The inclusion criteria are patients with anterior cruciate ligamentous injury who needed ligamentous reconstruction with no previous significant ankle injury or instability. The exclusion criteria are patients who did not want to participate in this study or patients who had high level of sport activities using ankle functions such as soccer or dancer or patients with failed anterior cruciate ligamentous reconstruction. In accordance with the inclusion and exclusion criteria, consecutive series of 24 ankles in 24 patients underwent ipsilateral autogenous peroneus longus tendon harvesting for primary anterior cruciate ligament reconstruction at our institution. Of these, 5 (20.8%) of the patients agreed to undergo magnetic resonance imaging examinations, and 10 patients agreed to undergo isokinetic muscle strength testing. Medical records were retrospectively reviewed to determine each patient's age, gender, and duration of follow-up. The present study has been approved by the Ethic Committee of the Faculty of Medicine, Thammasat University.

Surgical techniques

Anterior cruciate ligament reconstruction and autogenous peroneus longus tendon harvesting were performed by one of the senior authors (Chernchujit B). To harvest the graft, the involved lower limb was placed in a supine position. Autogenous peroneus longus tendon was harvested by making an incision along the posterior border of the distal fibula, just above the superior peroneal retinaculum. The peroneus longus tendon was exposed on its posterolateral surface through the incision after carefully incising the fascia. The peroneus tendon was sutured with No. 2 of heavy non-absorbable suture and cut with a scalpel (Fig. 1A). The released proximal tendon was then performed with a tendon retriever, and it was passed through the fascial tunnel to the incision (Fig. 1B). Skin incision was closed with No. 3-0 Nylon.

Whip stitches were placed using the Bunnel criss-cross technique with a fiberwire suture (Arthrex Inc., Naples, FL). The tendinous portion was made into a 'tube' by approximating both sides of the tendon using a running suture technique with a fiberwire suture (Arthrex Inc., Naples, FL) (Fig. 2). Usually, it can be more than 4 mm in diameter of the single strand by making it in a 'tube' fashion.

After harvesting and graft preparation, the triple or quadruple peroneus longus autograft was fixed to the femoral aspect with Endobutton cortical fixation technique (Smith & Nephew, Andover, MA) and used an interference screw (Smith & Nephew) for graft fixation at the tibial aspect (Fig. 3). Each patient was encouraged to stretch the affected ankle gently and actively from first day postoperatively and to perform gentle strengthening exercises with the use of a resistance band when the patient's ankle reached a nearly full range of motion. Proprioceptive exercises were performed from 3 months postoperatively. The proprioceptive exercise level was gradually increased for 12 weeks to involve one leg standing with full weight bearing, and walking.

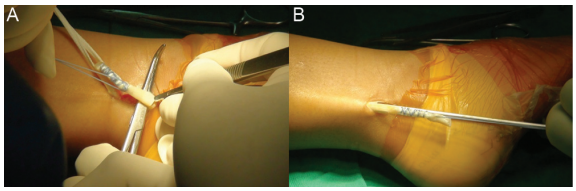

Fig. 1 A) demonstrated that the peroneus longus tendon was sutured and cut (left), B) demonstrated that the peroneus longus tendon was harvested by a tendon retriever (right).

Fig. 2 Demonstrated the peroneus longus graft after harvesting.

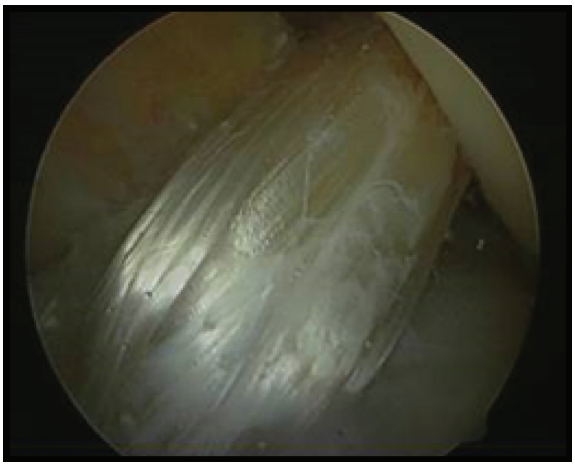

Fig. 3 The final ACL autograft via the arthroscopic anterolateral viewing portal.

Methods of evaluation

Clinical evaluations of the recipient knee

The sport medicine fellowship surgeons (Apivatgaroon A, Chaijenkit K) performed the post-operative clinical evaluations without the assessment via the knee laxity testing device (KT1000). Knee clinical outcomes were assessed consecutively using the International Knee Documentation Committee Score (IKDC)[7]. Each patient was examined for the anterior drawer test, and Lachman's test by the experienced knee surgeon (Chernchujit B) who operated all patients.

Clinical evaluations of the donor ankle

One independent fellowship-trained foot-ankle surgeon (Angthong C) performed the post-operative clinical evaluations. Ankle clinical outcomes were assessed consecutively using the Visual Analogue Scale Foot and Ankle (VAS-FA)[8], and the American Orthopedic Foot and Ankle Society (AOFAS) score[9]. The anterior drawer and talar tilt tests were evaluated comparing with the normal sides on contralateral ankles. The power of eversion and first ray plantar flexion were also examined comparing with the normal sides on contralateral ankles. Other complaints were recorded such as proximal stump irritation, numbness at the adjacent area of harvesting site.

Isokinetic muscle strength test of the ankle

A Biodex system 3 isokinetic dynamometer (Biodex Co., Shirley, NY) was used to measure isokinetic muscle strength in the ten volunteered patients who agreed to undergo examinations of bilateral ankle invertors and evertors at angular velocities of 60°/second and 120°/second. The dynamometer was used in the seated position (85 inclined back, fixed upper body, 60 bent knee, tibia horizontal), and the range of motion was from 20° in the inversion to 20° in the eversion. After two practice trials, peak torque and total work were measured at angular velocities of 60°/second (four repetitions) and 120°/second (four repetitions) angular velocities. For all measurements, the strengths of the index sides were compared with those of normal sides. All of the tests were performed by physical therapists (Nualon P, Suchao-in K).

Magnetic resonance imaging examinations

The magnetic resonance imaging (MRI) examinations of the five volunteer patients who agreed to undergo these examinations were retrospectively evaluated by one independent fellowship-trained foot-ankle surgeon. Tendon stumps were traced and recorded in each patient.

Results

Twenty-four patients had complete follow-up. There were 15 (62.5%) males and 9 (37.5%) females. The involved sides of ankle were 14 (58.3%) for right and 10 (41.7%) for left. Mean follow-up time was 12.8 months.

Clinical evaluations of the recipient knee

Regarding the latest follow-up, anterior drawer tests showed normal findings in 83.3%, while 16.7% of all examined patients had 1+ anterior laxity. The mean pre-operative and postoperative IKDC scores were 45.5±13.8 and 58.6±20.8 (p = 0.019). However, these findings were from only 5 (20.8%) patients in the study.

Clinical evaluations of the donor ankle

Mean pre-and postoperative AOFAS scores[9] were 100.0±0.0 and 96.0±9.6 respectively at 4-month follow-up (p = 0.06). Mean pre- and postoperative VAS-FA scores[8] were 99.7±1.1 and 95.4±12.0, respectively at around 13-month follow-up (p = 0.09). At around 13-month mean follow-up, the clinical tests were found that the anterior drawer tests showed normal findings in all patients; however, the evaluations of varus talar tilt found that there were normal findings in 22 (91.7%) patients, trace-laxity in 1 (4.2%) patients, and 1+ laxity in 1 (4.2%). The examinations of eversion were shown as grade V

power in 20 (83.3%) patients, while 16.7% of all examined patients had grade IV power with the muscle grading by Medical Research Council scale[10]. The examination of first ray plantar flexion found that all patients provided grade IV+ power. For the other findings, there were several complaints which were resolved in 1-6 months after the operation as ankle stiffness 2 (8.3%) patients, bulging of proximal stumps 5 (20.8%) patients, numbness (sural nerve neurapraxia) 2 (8.3%) patients, and inversion sprain of an ankle 1 (4.2%) patient.

Isokinetic muscle strength test of the ankle

At 7-month mean follow-up (range: 2.0-10.5 months) by isokinetic testing in 10 patients who had complete tests, peak torques of eversion and inversion were significantly lower on the harvested ankle compared with the contralateral ankle at both velocities (60°/second and 120°/second, $p<0.05$). Peak torque difference (% of Newton-meter (N-m)) of eversion and inversion at 60°/second were significantly decreased as 7.44 ($p = 0.008$) and 8.43 ($p = 0.001$). Peak torque difference (% of N-m) of eversion and inversion at 120°/second were significantly decreased as 12.31 ($p = 0.013$) and 10.34 ($p<0.001$). The authors performed the strength test of contralateral ankle to be the standard in each patient as compared with the harvested ankle in the postoperative phase. The strength test was not performed in the pre-operative phase.

Magnetic resonance imaging examinations

The MRI examinations of the five volunteer patients found that the tendon stumps were regenerated to be tendon-like fibers with attachment to the first metatarsal base in four patients. Only one patient had no regeneration. However, these findings were from only 5 (20.8%) patients in the study.

Discussion

The present study highlight the donor ankle morbidity, in patients who had the harvesting of peroneus longus, to be a donor graft for the ACL reconstruction. The clinical outcomes of ACL reconstruction using peroneus longus tendon seemed to be satisfactory regarding the evaluation of knee function. For the donor site morbidity, the authors found that there was non-significant deterioration of ankle functions via the evaluations of ankle scores as AOFAS[9] and VAS-FA scores[8]. However, the clinical evaluations at around 13-month of mean follow-up found that the varus talar tilt tests showed the laxity in 8.4% of all patients. The powers of eversion and first ray plantar flexion were deteriorated as grade IV in 16.7%, and grade IV+ in 100% of all patients, respectively. These findings revealed the direct impact of peroneus longus loss to the donor ankle function. Regarding the function of peroneus longus, its primary action is to plantar flex the first ray of the foot while plantar flexion and eversion of the foot at the ankle is the other action[11]. The primary concern of a donor ankle is the deficit of first ray plantar flexion while the patient is in the stance phase of gait[11]. The other concern is the ankle instability[6]. The authors found that the first ray plantar flexion had decreased in all patients; ankle instability was found in only one patient in first 6 months after the operation. The deficit of first ray plantar flexion may need longer term follow-up to clarify its consequences such as acquired pes planus. The functional deterioration of push-off during stance phase may be another concern from the deficit of first ray plantar flexion. This point should be of concern in the high-demand athlete who needs strong push-off strength during the stance phase of gait.

In addition to the clinical evaluations, the isokinetic testing at 7-month mean follow-up (range: 2.0-10.5 months) found that there was significant deterioration of eversion and inversion at both velocities (60°/second and 120°/second, $p<0.05$). These findings revealed the solid evidences which proposed the caution in patients who lost the peroneus longus in the first 12 months after the operation. Ankle instability may occur during this period. These patients strongly need the strengthening exercise for the ankle eversion including the propioceptive exercise to prevent ankle instability particularly in the 12 months after the operation. Therefore, the peroneus longus tendon may not be appropriate to be the first option of donor graft for ACL reconstruction due to the several morbidities particularly in first year after the surgery. This point is contrary to the conclusion of a previous study by Kerimoglu et al[5] which did not address the donor site morbidity via the isokinetic test or the deficit of first ray plantar flexion. The present study also advanced a different opinion from Nazem et al[6] which had a smaller number of patients and no data regarding the deficit of first ray plantar flexion.

Based on the present study, there were some limitations such as no data regarding pre-operative strength of the donor ankle, incomplete findings of IKDC scores or limited number of patients in isokinetic tests or a post-harvesting MRI study or short-term follow-up. However, the present study showed results,

which may be valuable information for future study with longer term follow-up and a larger number of patients.

Conclusion

Based on overall findings in the present study, the authors could not recommend the peroneus longus tendon as the first option of donor graft for ACL reconstruction due to the several morbidities particularly in the first 12 months after the operation. However, the peroneus longus tendon may be the option after other graft harvestings for the ligament reconstruction, which needs several tendon grafts in a patient with multi-directional instability of the knee due to some specific situation such as a traumatic knee dislocation.

What is already known on this topic?

Peroneus longus is able to be a tendon graft for the anterior cruciate ligament reconstruction.

What this study adds?

Donor site deformity could be occurred after the harvest of peroneus longus particularly in a year after surgery. The patients should be advised to perform the rehabilitation of their ankle muscles after surgery. Peroneus longus should not be the first option for the anterior cruciate ligament reconstruction; however, this tendon can be an alternative donor in case of the multi-directional instability which needs severally donor tendons in the reconstruction.

Potential conflicts of interest

None.

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การประเมินทางชีวกลศาสตร์และคลินิกของข้อเท้าจากการนำเอ็นเพอโรเนียสลองกัสมาใช้เป็นเอ็นทดแทนสำหรับการบูรณสภาพของการบาดเจ็บของเอ็นไขว้หน้าของข้อเข่า

ชญานิน อ่างทอง, บัญชา ชื่นชูจิตต์, อดินันท์ อภิวัฒน์การุญ, กรกฤษณ์ ชัยเจนกิจ, ปุญญาณัฐ นวลอ่อน, กนกนันทร์ สุเชาว์อินทร์

วัตถุประสงค์: *การศึกษานี้ทำเพื่อรายงานหน้าที่การทำงานของเท้าและข้อเท้าผ่านการประเมินทางคลินิกและชีวกลศาสตร์ หลังจากการนำเอ็นเพอโรเนียสลองกัสมาใช้เป็นเอ็นทดแทนสำหรับการบูรณสภาพของการบาดเจ็บของเอ็นไขว้หน้า*

วัสดุและวิธีการ: *การศึกษานี้ได้ทำการประเมินผู้ป่วยที่ได้รับการนำเอ็นเพอโรเนียสลองกัสมาใช้เป็นเอ็นทดแทนสำหรับการบูรณสภาพเอ็นไขว้หน้าจำนวน 24 ราย การประเมินผลการรักษาของการบูรณสภาพเอ็นไขว้กระทำด้วยการตรวจร่างกาย สำหรับการประเมินหน้าที่การทำงานของเท้าและข้อเท้ากระทำโดยประเมินผ่านคะแนนเท้า-ข้อเท้า [American Orthopaedic Foot-and-Ankle Society (AOFAS) for ankle-hindfoot score, visual analogue scale foot and ankle (VAS-FA) score] รวมทั้งการประเมินทางชีวกลศาสตร์ในผู้ป่วยอาสาสมัคร 10 ราย*

ผลการศึกษา: *ระยะเวลาเฉลี่ยในการติดตามอาการ คือ 12.8 เดือน สำหรับการติดตามอาการล่าสุดพบว่า การตรวจข้อเท้าเลื่อนทางด้านหน้า (anterior drawer test) บอกถึงผลปกติใน 83.3% และมีการหย่อน 1+ : 16.7% ของผู้ป่วยทั้งหมด ค่าเฉลี่ยของคะแนนเท้า-ข้อเท้า AOFAS ก่อนผ่าตัดและหลังผ่าตัดเท่ากับ 100.0±0.0 และ 96.0±9.6 ตามลำดับ ที่ระยะเวลา 6 เดือนในการติดตามอาการ ($p = 0.06$) ค่าเฉลี่ยของคะแนนเท้า-ข้อเท้า VAS-FA ก่อนผ่าตัดและหลังผ่าตัดเท่ากับ 99.7±1.1 และ 95.4±12.0 ตามลำดับ ที่ระยะเวลาประมาณ 13 เดือนในการติดตามอาการ ($p = 0.09$) การประเมินทางชีวกลศาสตร์พบว่ากำลังการบิดเท้าออกนอก (eversion) และเข้าใน (inversion) ของข้างที่ได้รับการผ่าตัดที่การเคลื่อน 60 องศา/วินาที และ 120 องศา/วินาที นั้นมีค่าต่ำกว่าข้างตรงข้ามอย่างมีนัยสำคัญ ($p<0.05$)*

สรุป: *จากผลการศึกษาในงานวิจัยนี้ทำให้ทราบว่า เอ็นเพอโรเนียสลองกัสไม่สามารถเป็นตัวเลือกแรกสำหรับการใช้เป็นเอ็นทดแทนสำหรับการบูรณสภาพของการบาดเจ็บของเอ็นไขว้หน้า เนื่องจากมีผลเสียต่อข้อเท้าที่นำเอ็นดังกล่าวมาใช้หลายอย่างโดยเฉพาะอย่างยิ่งในช่วง 12 เดือนแรกหลังผ่าตัด อย่างไรก็ตามเอ็นเพอโรเนียสลองกัส อาจเป็นตัวเลือกสำรองหลังจากใช้เอ็นจากบริเวณอื่น ๆ ไปแล้ว เช่น ในกรณีผู้ป่วยที่มีข้อเข่าหลุดและมีการขาดของเอ็นหลายเส้นซึ่งต้องใช้เอ็นมาผ่าตัดทดแทนจำนวนมาก เป็นต้น*