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Single bundle ACL reconstruction with peroneus longus tendon graft: 2-years follow-up

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ABSTRACT

Background: Peroneus longus tendon autograft resembles hamstring tendon's biomechanical strength. Thus, peroneus longus is a potential graft in reconstructive orthopaedic procedures. However, there was few study in evaluation of peroneus longus usage in ACL reconstruction. This study aimed to quantify the clinical outcome and donor site morbidity in ACL reconstruction using peroneus longus tendon autograft.
Methods: Patients who suffered isolated ACL injury were enrolled and underwent isolated single bundle ACL reconstruction using peroneus longus autograft. Functional score (IKDC, Modified Cincinnati, and Tegner-Lysholm score) were assessed at pre-operative and 2-years after surgery. Graft diameter was measured intraoperative. Donor site morbidities were assessed with thigh circumference measurement and ankle scoring using AOFAS and FADI. We also measured serial hop test.
Results: Seventy-five patients fulfilled inclusion criteria. Peroneus longus graft diameter was 8.38 ± 0.68 mm. There was significant difference between pre and 2-years post-operative functional score in IKDC, Modified Cincinnati, and Tegner-Lysholm score. Mean of AOFAS was 98.93 ± 3.10 and FADI was 99.79 ± 0.59 with no significant decrease of thigh circumference, and good serial hop test result.
Conclusion: ACL reconstruction with peroneus longus autograft has excellent functional score in IKDC, Modified Cincinnati, Tegner-Lysholm score at 2-years follow up with the advantages of greater graft diameter, less thigh hypotrophy, good serial hop test result, and excellent ankle function based on AOFAS and FADI score.
Level of evidence: Level 2, Prospective Cohort Study.

1. Introduction

Anterior Cruciate Ligament (ACL) reconstruction is a common ligament reconstruction to restore functional knee stability. However, the site of graft harvesting is vulnerable to have donor site complications. There was a lot of graft selection, include hamstring tendon, bone-patellar tendon-bone (BPTB), synthetic graft. The BPTB graft is still considered to be the gold standard graft in reconstruction.[1] BPTB's biomechanical strength is similar to native ACL. BPTB allows early-active-safe-rehabilitation without an increased risk of graft failure and has good long-term result.[1,2] However, BPTB has potential morbidity to the site of graft harvesting include patellofemoral pain, loss of motion, and patellar fracture.[3] Thus, some orthopedic surgeons try to use peroneus longus tendon as a graft. Peroneus longus tendon autograft is nowadays used in some orthopaedic procedures including deltoid ligament reconstruction[4] and Medial Patellofemoral Ligament (MPFL) reconstruction.[5] Peroneus longus has synergistic function with peroneus brevis.[6]

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Some previous studies reported the usage of peroneus longus tendon as an autograft in ACL reconstruction with good clinical outcome and minimal donor site morbidity, but other studies did not concur due to donor site morbidity.[7] Phatama et al., in 2017 reported there is no difference between peroneus longus and hamstring tendon tensile strength.[8]

The purpose of this study is to evaluate the functional outcome and donor site morbidity of single bundle ACL reconstruction using peroneus tendon graft. This study considers the usage of peroneus longus tendon autograft as a graft of choice in ACL reconstruction.

2. Materials and methods

This study is cohort retrospective with consecutive sampling of ACL reconstruction patients in October 2015 until June 2016. The diagnosis of ACL rupture was established based on anamnesis, physical examination and Magnetic Resonance Imaging of the injured knee. The inclusion criteria was isolated ACL ruptured patient at age 18–45 years old. Exclusion criterias were associated ligament injury, chondral damage, meniscal injury, fracture around the knee, and presence of pathologic condition in the lower extremity or an abnormal contralateral knee joint.

A total of 75 patients gave informed consent to be enrolled in this study and underwent single bundle ACL reconstruction using peroneous tendon graft in RSUP Dr. Soeradji Tirtonegoro, Klaten. The functional scores (International Knee Documentation Committee (IKDC), Modified Cincinnati, Tegner-Lysholm score) were recorded before the surgery. The post operative evaluation was performed at two years after the surgery to finish the rehabilitation protocol and obtain the peak function after ACL injury. We recorded functional scores (IKDC, Modified Cincinnati, Tegner-Lysholm score), ankle functionial score (The American Orthopaedic Foot & Ankle Society (AOFAS) score and Foot and Ankle Disability Index (FADI) score), serial hop tests (single hop test, triple hop test, cross over hop test, time hop test), thigh circumference difference of bilateral femoral region at 10 cm and 20 cm form upper pole of the patella.

A single experienced knee surgeon operated all patients. Patients laid in supine position under regional anesthesia. Tourniquet was applied in the thigh and inflated without elevation and exsanguination. Standard anterolateral and anteromedial portal were made. Diagnostic arthroscopy for ACL rupture was performed and followed by peroneus longus tendon harvesting.

Peroneus tendon harvesting was done in ipsilateral leg. The incision location was marked at 2–3 cm above and 1 cm behind the lateral malleolus. The incision was made through the skin, subcutaneous tissue, and superficial fascia. Peroneus longus and peroneus brevis tendon were identified. See Fig. 1. The location of tendon division was marked at 2–3 cm above the level of lateral malleolus. Distal part of the peroneus longus tendon was sutured with end-to-side suture. See Fig. 2. Peroneus longus tendon was stripped proximally using tendon stripper until ±4–5 cm below the fibular head to avoid peroneal nerve injury. See Fig. 3 and Fig. 4.

The intercondylar notch was cleared from fibrous tissue to facilitate good visualization during preparation of the tunnels. ACL fibers were preserved as a reference for graft insertion. The femoral tunnel and the tibial tunnel were drilled independently. Graft tendon was implanted and tensioned using graft tensioner to prevent graft loosening in the future. Graft tendon fixation proceed using graft fixation in femoral side with button (XO *Button*®, Conmed© USA) and using graft fixation in tibial side with bio absorbable screw (Bioscrew®), Conmed© USA).

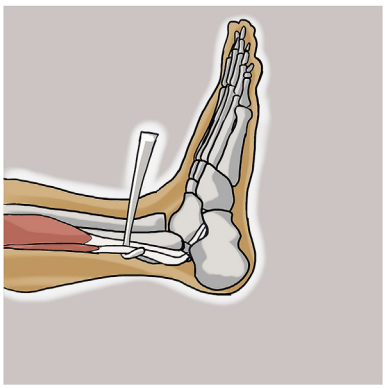

Fig. 1. Identification of peroneus longus and peroneus brevis tendon.

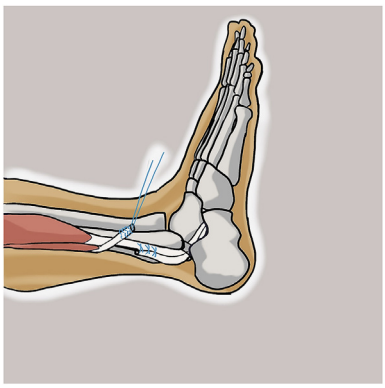

Fig. 2. Tenotomy of peroneus longus tendon.

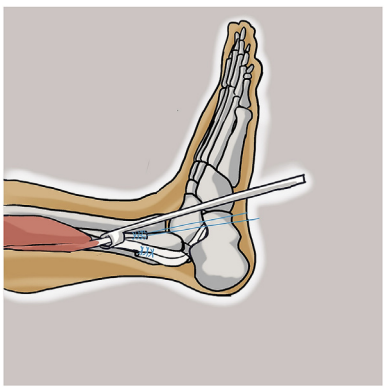

Fig. 3. Harvesting peroneus longus tendon with tendon harvester.

2.1. Rehabilitation

Patients were treated with the ACL rehabilitation program. Patients were trained to exercise the injury site leg using partial weight bearing until 3-weeks post-surgical procedure. Patients were allowed to full weight bearing. Knee extension was began immediate after surgery. Knee flexion was started from 0 to 90° (increased gradually) until 3 weeks post-surgery with subsequent full flexion. The patient was allowed to jog after 2 months. Patients allowed to return for sport activity after passing functional outcome test and serial hop test at 6 months. The test consist of evaluation of knee stability based on anterior drawer test, lachmann test, and serial hop test.

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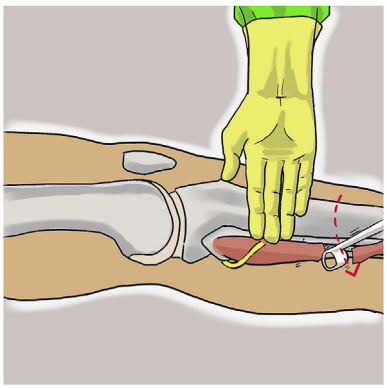

Fig. 4. Marked the end of peroneus longus tendon harvest at three fingers bridge below the tip of fibular head.

2.2. Post-operative evaluation

Post-operative functional outcome and donor site morbidity were recorded two year after surgery. A single orthopaedic surgeon, outside from surgical team, was examined and interviewed all the patients. We recorded IKDC, Modified Cincinnati, Tegner-Lysholm score, AOFAS score, FADI score, measured thigh circumference of donor site, and compared to the contralateral healthy side, and also recorded serial hop test. This study was approved by ethics committee Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada with protocol number KE/FK/1387/EC/2019.

2.3. Statistical analysis

Sample size was calculated using Lemeshow method as shown below:

$$n = \left(\frac{z}{d}\right)^2 p(1-p)$$

The proportion of patient with ACL rupture (p) was found to be around 8% in our study population. With 95% CI, and precision level of 10%, the calculation were $(1.96)^2$ x 0.08 x $(0.92)/(0.1)^2 = 28$ samples. Statistical significance was assessed at $p < 0.05$.

3. Results

During the period of study, 84 patients underwent the isolated single bundle ACL reconstruction. Nine patients were excluded because of presence of concomitant injury to the meniscus/cartilage or refusing to participate in this study. Seventy-five patients fulfilled inclusion criteria with proportion of male was 59 patients and female was 16 patients. Mean age of the patients was 26.70 ± 8.57 with range from 18 until 45 years old. Injury mechanism of the patients was motorcycle accident 6 patients, sport injury 52 patients, and others injury 17 patients. See Table 1.

3.1. Graft diameter

Diameter of the peroneus longus graft was measured and recorded intraoperative, and the result peroneus longus graft mean diameter was 8.38 ± 0.68 mm. See Table 1.

3.2. Thigh circumference

No patients had thigh hypotrophy of more than 20 mm. The mean of thigh circumference at 10 cm from upper pole of patella bone was 45.33 ± 2.66 at injury site and 46.10 ± 2.80 at contralateral site. The mean of thigh circumference at 20 cm from upper pole of patella bone was 53.41 ± 3.46 at injury site and 54.43 ± 3.36 at contralateral site. There was no difference both at 10 cm and 20 cm of thigh circumference between injury site and contralateral site ($p > 0.05$). See Table 2.

Table 1
Subjects characteristics.

Characteristics	Mean	SD	Min	Max	N
Age	26.70	8.57	18.00	45.00	
Sex					
Male					59 (78.7)
Female					16 (21.3)
Injury mechanism					
Motorcycle accident					6 (8.0)
Sport					52 (69.3)
Others					17 (22.7)
Graft diameter	8.38	0.68	6.50	10.00	

3.3. Functional outcome

Result of mean IKDC score pre-operative was 54.66 ± 14.02 and post-operative was 95.69 ± 3.35. Mean Modified Cincinnati score pre-operative was 65.45 ± 16.24 and post-operative was 93.29 ± 7.04. Mean Tegner-Lysholm score pre-operative was 67.80 ± 15.29 and post-operative was 89.70 ± 8.34. There were significant differences between preoperative and 2-year post-operative score in IKDC, Modified Cincinnati, and Tegner-Lysholm score ($p < 0.05$). See Table 3.

3.4. Donor site morbidity

Evaluation of donor site morbidity of peroneus longus tendon autograft using AOFAS and FADI score. The mean of AOFAS score of donor ankle was 98.93 ± 3.10 and FADI score was 99.79 ± 0.59. See Table 4.

3.5. Serial hop test

The mean score of single hop test was 91.41 ± 2.45. The mean score of triple hop test was 94.16 ± 2.34. The mean score of cross over hop test was 93.73 ± 2.31. The mean score of timed hop test was 93.78 ± 4.10. See Table 4.

4. Discussion

A previous biomechanical study showed no significant difference of tensile strength between the peroneus longus and four strand hamstring.[8] ACL reconstruction with peroneus longus tendon showed good result in functional outcome.[7] Diameter graft is one of the most important considerations during ACL reconstruction surgery of the knee. ACL reconstruction using quadrupled-strand hamstring autograft with a diameter equal to or larger than 8 mm decreases failure rates.[9] Grafts larger than 8 mm were found to provide a protective effect in patients aged younger than 20 year.[9] The effect of the autograft diameter to rerupture and revision rate of the reconstructed ACL of the knee has been studied intensively. Graft failure rate is higher in younger patients.[10] Patient with height less than 149 cm has potential graft size less than 7 mm and needs to augment of the graft. Other study found significant positive correlation between 1 mm increase in graft diameter, with higher KOOS score and IKDC score, and also higher revision rate with graft size of less than 8 mm.[11] In this study, we found that

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Table 2
Thigh circumference.

	Injury site					Contralateral site					Significancy
	Mean	SD	Min	Max	Normality	Mean	SD	Min	Max	Normality	
10cm thigh diameter	45.33	2.66	41.00	53.00	0.011	46.10	2.80	41.50	54.50	0.173	0.096
20cm thigh diameter	53.41	3.46	47.00	62.00	0.200	54.43	3.36	47.50	63.00	0.200	0.619

Table 3
Functional outcome.

	Pre-operative			Post-operative			Significancy
	Mean	SD	Normality	Mean	SD	Normality	
IKDC	54.66	14.02	0.200	95.69	3.35	0.001	0.000
Modified cincinnati	65.45	16.24	0.026	93.29	7.04	0.000	0.000
Tegner-lysholm	67.80	15.29	0.000	89.70	8.35	0.000	0.000

Table 4
Donor site morbidity and serial hop test.

	Mean	SD	Min	Max	Normality
FADI	99.79	0.59	98.10	100.00	0.000
AOFAS	98.93	3.10	90.00	100.00	0.000
Single hop	91.41	2.45	88.00	96.00	0.000
Triple hop	94.16	2.34	90.00	98.00	0.000
Cross over hop	93.73	2.31	90.00	98.00	0.000
Timed hop	93.78	4.10	88.00	98.00	0.000

mean of peroneus longus tendon graft diameter was more than 8 mm. This result indicates that peroneus longus autograft is potential choice for ACL reconstruction and minimizing risks of rerupture incidence in the future.

There are some donor site morbidity using hamstring graft, including thigh hypotrophy and hypoesthesia or anesthesia subjective feeling caused by injury of infrapatellar branch of saphenous nerve. Thigh hypotrophy due to hamstring (semitendinosus and gracilis) tendon harvesting results in decreased hamstring strength, especially in deep flexion angles. The hypotrophy of the hamstring also results in quadriceps – hamstring imbalance which results in imbalance of knee dynamic stability.[12] Injured leg is usually smaller than uninjured leg in hamstring tendon usage as ACL reconstruction graft.[13] The suggested reason why our study has similar thigh circumference between injured site and uninjured site is because of the peroneus longus as a graft for ACL reconstruction. According to the research result, peroneus longus graft does not interfere the thigh diameter in injured leg.

Our study showed excellent result in IKDC score, Modified Cincinnati, and Tegner-Lysholm score. Khajotia et al. stated improvement in IKDC score in 6 months post ACL reconstruction using peroneus longus tendon with mean score 83.53.[14] Kerimoglu et al. showed good result in mean Lysholm score 83.7 in ACL reconstruction with usage of peroneus longus tendon as a graft.[7] Peroneus longus tendon is preferred because of there is no extension or flexion loss and no patellofemoral pain in patients.[7]

A previous study by Angthong et al. mentioned possible donor site morbidity using peroneus longus tendon, including decreased peak torque eversion and inversion, decreased ankle function, and concern of ankle stability.[15] However, in this study found the contradicting result with the previous study. We found that the function of donor ankle was excellent after harvesting peroneus longus tendon according to ankle functional test based on FADI and AOFAS score. This probably because donor ankle has intact peroneous brevis. Previous studies mentioned that peroneus brevis is a more effective evertor of the ankle, which will maintain ankle eversion function after harvesting of peroneus longus tendon.[6] Further study could be directed in measurement of ankle stability and power, and correlate it with functional score after harvesting of peroneus longus tendon.

Our study resulted excellent score in single hop test, triple hop test, cross over hop test, and timed hop test. Serial hop test is a predictive test to consider the ACL injury patients when they can return to sport.[16]

This study has some limitations. The cohort is too small and no evaluation for stability and range of motion. Thus making it difficult to evaluate objectively. However, the bias was minimized with using a single surgeon, the same rehabilitation protocol and operative technique. The two-years follow up in this study also a shortcoming, and further study could be directed in further evaluation of ACL reconstruction with peroneus longus autograft. Objective measurement of ankle evertor strength also could be used to evaluate donor site morbidity of peroneus longus harvesting, and its relationship with ankle functional score can be evaluated.

5. Conclusion

Single bundle ACL reconstruction with peroneus longus tendon autograft had excellent functional outcome (IKDC, Modified Cincinnati, Tegner-Lysholm score), minimal donor site morbidity, excellent serial hop test result, and no difference in thigh circumference. Peroneus longus can be consider as potential graft of choice in ACL reconstruction.

Data availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcot.2019.09.004.

List of abbreviations

ACL	Anterior Cruciate Ligament
BPTB	Bone-Patellar-Tendon-Bone
MPFL	Medial Patellofemoral Ligament
IKDC	International Knee Documentation Committee
AOFAS	American Orthopedic Foot and Ankle Score
FADI	Foot and Ankle Disability Index

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