



# Peroneus Longus Tendon Regeneration after Anterior Cruciate Ligament Reconstruction with Magnetic Resonance Imaging Evaluation

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## Abstract

**BACKGROUND:** Peroneus longus graft can be recommended as a superior graft over hamstring in anterior cruciate ligament (ACL) reconstruction. There are many studies concerning hamstring tendon regeneration, but there are few studies on the regeneration of the peroneus longus tendon after ACL reconstruction.

**AIM:** This study aimed to investigate whether regeneration of the peroneus longus tendon occurs after ACL reconstruction with magnetic resonance imaging.

**METHODS:** Twenty-five patients underwent ACL reconstruction with donors from the peroneus longus tendon by the same operator and were followed 12 months later with bilateral crural magnetic resonance imaging (MRI) for comparison of the donor and healthy peroneus longus tendon areas. Regeneration was assessed at 5 cm, 10 cm, and 15 cm from the ankle joint.

**RESULTS:** The average age 30.4 (18-38) years old. There were 17 right and 8 left knees involved in this study. The interval between surgery and MRI was 1 year. The average regeneration presentation was located in the distal part (5 cm from the ankle joint) 66.78%, medial part (10 cm from the joint) 63.2%, and proximal part (15 cm from the ankle joint) 67.53%. There was no significant difference in the presentation of proximal, medial, and distal areas while there was a significant difference between age and regeneration of the proximal area,  $p < 0.05$  ( $p = 0.047$ ). Tissue regeneration was tendinous and it appeared smaller in the place where the tendons grew.

**CONCLUSION:** Regeneration of the peroneus longus tendon occurred after ACL reconstruction at a 1-year follow-up according to MRI.

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## Introduction

Anterior cruciate ligament (ACL) is one of the few ligaments in the knee that is often injured in sports and accidents. The incidence of ACL rupture is higher in women than in men. ACL reconstruction is a common surgical procedure for ACL rupture in active people. The purpose of ACL reconstruction is to restore knee stability, relieve pain and instability symptoms, and return the patient to daily activities [1]. There are several graft choices used in ACL reconstruction, one of which is the peroneus longus tendon graft [2]. Peroneus longus autograft is an effective and safe graft as an alternative to ACL reconstruction [3]. In biomechanical studies, there are similarities in tensile strength between the hamstring and peroneus longus tendon [4]. Rhatomy *et al.* in their study confirmed

that the peroneus longus graft can be recommended as a superior graft over hamstring in a single bundle ACL reconstruction because the peroneus longus has a graft with a larger diameter, less hypotrophy, and better ankle function compared to hamstring tendons [5]. Otis *et al.* in his study explained the peroneus longus muscle is an evertor muscle that is less effective than the peroneus brevis. Nevertheless, the ankle function for eversion is still good at the donor site [6]. Morbidity at the donor site of peroneus longus was reported to occur within 1 year after surgery. It can be in the form of sensory, tissue, and structural problems, so ankle muscle rehabilitation after surgery is required [7]. Mervyn *et al.* reported regeneration of the hamstring tendon after ACL surgery in the form of growth at a location near the anatomic position which was functional [8]. Regeneration in gracilis and semitendinosus tendons also occurs distally from the

joint line [9]. Magnetic resonance imagery (MRI) can be a parameter to assess the regeneration of peroneus longus tendon grafts in ACL reconstruction [10], [11]. Accordingly, a deeper study of the regeneration of the peroneus longus graft in ACL reconstruction is needed. This study aimed to investigate whether regeneration of the peroneus longus tendon occurs after ACL reconstruction with MRI.

## Materials and Methods

Twenty-five patients underwent single-bundle ACL reconstruction using peroneus longus tendon graft between June and December 2018. We analyzed the cohort prospectively for this study. The inclusion criteria for the patients were ACL rupture without other ligament rupture, meniscus intact, and there is no cartilage defect. Those with other ligament rupture, meniscal injury, chondral lesion, any deformity of the lower limb, or associated fracture in the lower extremity were excluded from the study. We diagnosed ACL rupture through clinical assessment (Lachman test, anterior drawer test, or Lelli test), and MRI.

All subjects were informed about their knee condition and treatment procedures. All the arthroscopic procedures were done by one experienced surgeon. Patients received a comprehensive clinical assessment and radiological examination before their operation and MRI 1 year follow-up to evaluate the regeneration of peroneus longus.

For the first part of this study, MRI was performed to see the regeneration of the peroneus longus in the 12 months after ACL reconstruction. The patient underwent MRI on both legs at 12 months postoperatively, then the areas were compared between the donor and healthy sites. Crural MRI was made from the ankle joint to the knee joint. MRI was assessed in 3 axial sections, which were proximal (15 cm from the ankle joint), medial (10 cm from the ankle joint), and distal (5 cm from the ankle joint). All patients were operated on by the same orthopedic doctor, then they were rehabilitated with a standard brace. This study was approved by the medical and health research ethics committee with reference number KE/FK/FK/210/2018.

### Arthroscopic surgery technique

Operations were done by the same operator. Locations for the skin incision were marked at 2-3 cm above and 1 cm behind the lateral malleolus. The incision was made across the skin, subcutaneous tissue, and superficial fascia. Peroneus longus and brevis tendons were then identified. The location of this tendon was marked 2–3 cm above the level of the lateral malleolus. The distal end from the peroneus longus tendon to the

peroneus brevis tendon was sewn with end to side sutures. Peroneus longus was proximally released with a tendon stripper at 4-5 cm from the fibular head to prevent injury to the peroneal nerve.

### Statistical analysis

Statistical analysis was performed using SPSS 16.0. Distribution of the data was assessed using Shapiro–Wilk tests. Comparison of proximal, medial and distal tendon regeneration area was analyzed using ANOVA (Bonferroni test as post hoc test). The results were calculated as mean with standard deviation (SD), with  $p < 0.05$  as a significant value.

## Results

This study group consisted of 21 men and 4 women. The average age of the patients at the time of MRI was 30.4 (18–38) years old. There was 17 right and 8 left knees involved in this study. The interval between surgery and MRI was 1 year. The patients had an intact meniscus. In all patients, regeneration of the peroneus tendon varied.

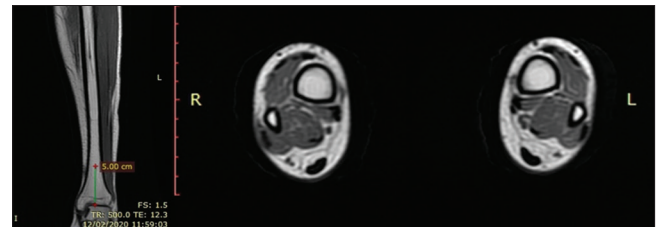


Figure 1: Magnetic resonance imaging axial view 5 cm from ankle joint

The average regeneration presentation was distal (5 cm from the ankle joint) 66.78% (Figure 1), medial (10 cm from the ankle joint) 63.2% (Figure 2), and proximal (15 cm from the ankle joint) 67.53% (Figure 3 and Table 1). Based on the Shapiro–Wilk test with ( $n = 15$ )  $p > 0.05$  (distal  $p = 0.235$ , medial  $p = 0.156$ , and proximal  $p = 0.735$ ), the data were normally distributed. Based on one-way ANOVA, sex was not significantly related to regeneration ( $p > 0.05$ ) (Table 2). There were no significant differences in the proximal, mid, and distal areas (Table 1).

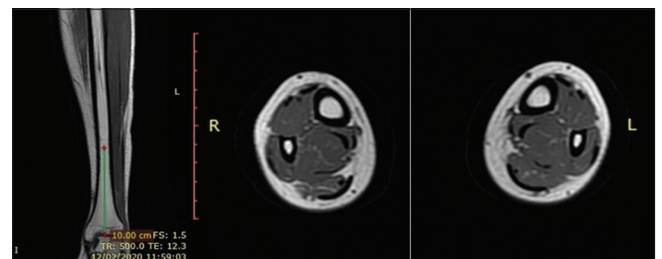


Figure 2: Magnetic resonance imaging axial view 10 cm from ankle joint

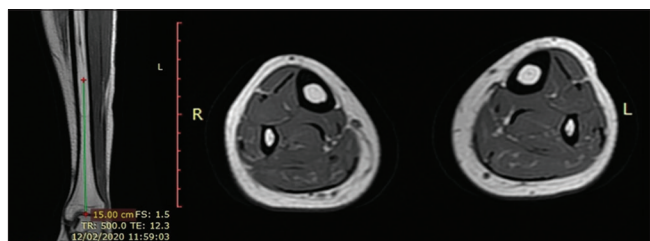


Figure 3: Magnetic resonance imaging axial view 15 cm from ankle joint

Tissue regeneration was tendinous and it appeared smaller in the place where the tendons grew (Figure 4).

Table 1: Percentage of regeneration

Location	Percentage of regeneration (mean $\pm$ SD)	p-value
5 cm (distal)	66.78 $\pm$ 1.29	0.235
10 cm (medial)	63.2 $\pm$ 1.21	
15 cm (proximal)	67.53 $\pm$ 1.84	

## Discussion

In this study, the results showed that peroneus longus tendon regeneration occurred after ACL graft reconstruction. This finding is consistent with previous research on the regeneration of hamstring tendons. Rhatomy *et al.*, in a previous study with 6 months of follow-up of the peroneus longus tendon, stated that there was no impairment in ankle stability and there were a good ROM and good outcome. Peroneus tendons are an alternative to reconstructing ligaments to prevent morbidity from donor sites in another tendon [5].

Table 2: Percentage of regeneration according to sex

Location	Sex	Percentage of regeneration (mean $\pm$ SD)	p-value
5 cm (distal)	Male	67.22 $\pm$ 13.84	0.747
	Female	63.89 $\pm$ 2.38	
10 cm (medial)	Male	65.2 $\pm$ 11.54	0.102
	Female	50.18 $\pm$ 6.6	
15 cm (proximal)	Male	70.77 $\pm$ 17.23	0.081
	Female	46.47 $\pm$ 12.59	

Kerimoglu studied 12 patients who underwent ACL reconstruction using peroneus longus tendon grafts with follow-up ranging from 18 to 96 months using MRI and found that there was a regeneration of peroneus longus tendons and there was no disturbance in ankle function and exercise [11].

Rob *et al.* in his study of 22 patients who underwent MRI follow-up at the location of the hamstring after ACL reconstruction for 2 weeks, 6 months, and 12 months stated that there was a regeneration of hamstring tendons [9]. A study by Mervyn *et al.* of 225 patients who underwent ACL reconstruction with hamstring tendons and follow-up after 6 months using MRI revealed the semitendinosus and gracilis tendons could grow close to their anatomic and functional positions [8]. Nakamae in his study reported that there were 2 cases of hamstring tendon regeneration after ACL reconstruction due to re-rupture during regeneration [12].

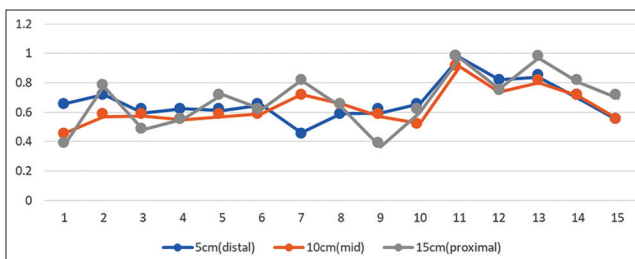


Figure 4: Difference in comparison of the peroneus longus size from donor site and peroneus longus tendon of the contralateral side

Suijkerbuijk, in a study with a systematic review of hamstring tendon regeneration, said the majority had regeneration at 50–100% in semitendinosus tendons and 46–100% in gracilis tendons 1 year after ACL reconstruction [13]. However, hamstring tendons in the elderly and smokers had reduced regeneration potential [14].

Other method to evaluate soft tissue regeneration with using ultrasonography (USG) or soft tissue biopsy. Bedi *et al.*, in their study with dynamic 12 MHz ultrasonography, assessed the ipsilateral and contralateral areas from 15 patients who underwent hamstring tendons ACL reconstruction. There was tissue growing at the site where the graft was taken, proximal retraction from the musculotendinous junction, and tissue disorganization which did not show the same physiological function as the original tendon [15]. A prospective study by Papandrea *et al.* involving 40 patients who underwent ACL reconstructions with hamstring graft tendon followed by pre- and post-operative assessment using ultrasound at 2 weeks to 24 months postoperatively showed that semitendinosus regeneration was similar to normal tendons within 18 months post-month ACL reconstructive surgery [16]. Papalia *et al.*, in a systematic review of 19 articles with a total of 400 observed patients, stated that the average soft tissue regeneration was found in 86% of hamstring tendon after ACL reconstruction and 74% from the biopsy of cases with typical histology with tendons [17].

Eriksson *et al.* stated in his study of 11 patients with 6–12 months follow-up for ACL reconstruction that regeneration of hamstring grafts was found in 8 patients using MRI 6 months postoperatively. The regeneration of the semitendinosus and gracilis tendons with the topography of the joints was normal. MRI could not be used to distinguish regeneration from tendons or scar tissue. Therefore, Eriksson conducted another study on this matter. In a subsequent study, Eriksson *et al.* conducted a study of 6 patients between 7 and 28 months after ACL reconstruction who were assessed by MRI, open surgery, and histological biopsy. There was regeneration for semitendinosus and gracilis tendons macroscopically with open surgery and histologically at 28 months follow-up [18]. The tendon resembled normal tendon in terms of appearance and tensile strength. Results obtained histologically showed that the tendon consisted of collagen structures separated

by small fibroblast cells that are uniform like normal tendons; there was an increase in the proliferation of fibroblasts and capillaries [18], [19], [20], [21].

Limitations of this study are limited subject and short-term follow-up, further study needed to prove the regeneration using dynamic sonography or dynamic MRI, and study in animal to evaluate regeneration using histology finding. In this study, MRI finding showed that regeneration of peroneus longus tendon was likely to occur within 1 year.

## Conclusion

Good peroneus longus tendon regeneration was observed on MRI after 1 year.

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### Ethical approval

The informed consent form declared that patient data or samples will be used for educational or research purposes. Our institutional review board also provided ethical approval in the form of case report with KE/FK/FK/210/2018 as the protocol number.

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