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Can Hamstring Tendons be Used as Autografts in Peroneal Tendon Reconstruction? A Cadaveric Study

Peroneal Tendon Rekonstrüksiyonunda Otogreft Olarak Hamstring Tendonları Kullanılabilir mi? Kadavra Çalışması

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ABSTRACT

Aim: Tendon transfers and autografts can be used in the reconstruction of chronic peroneal tendon tears. This cadaveric study aimed to evaluate the use of autograft hamstring tendons to reconstruct peroneal tendons in terms of diameter suitability.

Materials and Methods: In this study, 13 hamstring tendons (gracilis, semitendinosus) without macroscopic injury and degeneration from the lower extremity of 13 fresh frozen cadavers were harvested and measured by standard methods. Then, peroneal tendons (peroneus longus, peroneus brevis) of the same cadavers were harvested and measured by standard methods. Tendon diameters were measured from the middle region of the tendon using a digital micro-caliper. After the measurements were completed, the thickness of the hamstring tendons and both peroneal tendons were statistically evaluated.

Results: The mean age of the cadavers included in the study was 74.07±12.25 (minimum: 51, maximum: 94) years, and the mean body mass index was calculated as 25.38±6.07. There was no statistically significant difference by gender in the evaluated tendon diameters ($p>0.05$ for each). A positive correlation was found between hamstring tendons (gracilis and semitendinosus) and peroneus longus and brevis tendons in terms of size ($p<0.01$ for each). In addition, in the measurement of the mean tendon diameter from the middle region, the mean diameter of the semitendinosus tendon was found to be closer to the mean diameter of the peroneal tendons.

Conclusion: In the reconstruction of chronic peroneal tendon rupture, the semitendinosus tendon's being used as an autograft for both peroneal tendons might be more appropriate according to the evaluation of the tendon diameter from the middle region.

Keywords: Peroneal tendon, peroneal tendon reconstruction, hamstring autograft

ÖZ

Amaç: Kronik peroneal tendon yırtıklarının rekonstrüksiyonunda tendon transferleri ve otogreftler kullanılabilir. Bu kadavra çalışmasında peroneal tendonların rekonstrüksiyonu için otogreft hamstring tendonlarının kullanımının çap uygunluğu açısından değerlendirilmesi amaçlandı.

Gereç ve Yöntem: Çalışmada 13 (4 kadın, 9 erkek) taze donmuş kadavra alt ekstremitesinden otogreft olarak 13 adet makroskopik yaralanması ve dejenerasyonu olmayan, hamstring tendonları (gracilis, semitendinosus) standart yöntemler ile elde edildi ve ölçüme alındı. Ardından aynı kadavraların peroneal tendonları (peroneus longus, peroneus brevis) standart yöntemler ile elde edilerek ölçüme alındı. Tendon çap ölçümleri tendonların en kalın olduğu orta bölgesinden dijital mikro kumpas yardımıyla yapıldı. Ölçümler sonucunda hamstring tendonları ile her iki peroneal tendon kalınlıkları istatistiksel olarak değerlendirildi.

Bulgular: Çalışmaya dahil edilen kadavraların yaş ortalaması 74,07±12,25 (minimum: 51, maksimum: 94) yıl iken vücut kitle indeksi ortalaması 25,38±6,07 olarak bulundu. Çapları değerlendirilen tendonlar ile cinsiyet arasında istatistiksel olarak anlamlı bir fark bulunmadı (her biri için $p>0,05$).

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Hamstring tendonları (grasilis ve semitendinosus) boyutları ile, peroneus longus ve brevis tendonları arasında pozitif bir korelasyon mevcuttu (her biri için p<0,01). Ayrıca tendon orta çap değerlendirmesi sonucuna göre semitendinozus tendon çap ortalamasının peroneal tendonların çap ortalamasına daha yakın olduğu tespit edilmiştir.

Sonuç: Kronik peroneal tendon yırtıklarının rekonstrüksiyonunda otogreft olarak, her iki peroneal tendonun rekonstrüksiyonu için semitendinozus tendonunun kullanılması tendon orta çapları değerlendirmesine göre daha uygun olabileceği kanaatine varıldı.

Anahtar Kelimeler: Peroneal tendon, peroneal tendon rekonstrüksiyonu, hamstring otogreft

INTRODUCTION

Problems associated with the peroneal tendon constitute an essential part of posterolateral ankle complaints and are often associated with anatomical abnormalities that predispose to chronic lateral ankle instability[1]. Peroneal tendon disorders can be encountered clinically as tendinitis, chronic tenosynovitis, subluxation, wear, longitudinal fissures, partial tears, and complete tears[2,3]. One study reported that only 60% of peroneal tendon disorders could be diagnosed correctly at the first clinical examination[4]. Although the exact prevalence of peroneal tendon tears in the general population is unknown, it has been reported that 11-38% of the samples were ruptured in cadaver studies. Left untreated, these disorders can cause persistent lateral ankle pain and significant functional disability[5,6].

Although there is no standard protocol in treating peroneal tendon disorders, conservative treatment or surgical treatment are among the options. Surgical treatment is preferred, especially when conservative treatment is not sufficient, such as tears and tendon subluxations[7].

Although tubularization and primary repair can be applied in acute partial tears, chronic tendon injuries require different treatment methods such as tendon transfers, tendon lengthening, allograft reconstructions, or synthetic graft reconstruction[8-10].

It has been reported that satisfactory results were obtained with allograft in peroneal tendon repair[10]. However, allograft tendon transfer is accompanied by several concerns such as tissue compatibility, sterilization, disease transmission, and cost[11]. A study has reported that hamstring autografts are an excellent option in peroneal tendon repair; while providing a biomechanical advantage for the patient, it results in better outcomes biologically than allograft reconstruction[12].

This cadaveric study aims to evaluate the compatibility of semitendinous and gracilis tendon autografts in terms of tendon size in peroneal tendon reconstruction.

MATERIALS AND METHODS

Ethics committee approval was given to the Medical Research Evaluation Board (ATADEK) study with the date 09.07.2020 and the decision number 2020-15/12. This anatomical study included 13 unpaired fresh frozen cadaver legs (four females, nine males) stored at +4 C. No evidence of skin incision, scar tissue, external deformity, or trauma was observed around the knee and ankle in any of the legs. The mean preservation time from death to dissection was one month. Preoperative ankle range of motion (ROM) was measured with a goniometer, and ankle movements were regular. Exclusion criteria included significant osteoarthritis (>Stage 3), ligament damage at the medial or lateral ankle, and damage to the hamstring tendons. Hamstring tendons were harvested in the supine position while peroneal tendon dissections were performed in the prone position. The width of the peroneal tendons was measured using calipers at three regions standardized in each tendon, and mean values were used. The same person performed all dissections to eliminate inter-observer variability.

Hamstring Tendon Preparation

An anteromedial approach harvested hamstring tendons. A standard release followed by a closed scraper was used to harvest the gracilis and semitendinosus tendons after they were identified at the tibial attachment sites. Following graft preparation and cleaning from adherent muscle and adipose tissue, a load of 89 newtons was applied to each doubling tendon for 15 minutes, and each tendon diameter was measured with a digital micro-caliper (Neiko 01407A Electronic Digital Caliper, Neiko Tools, China) with a resolution of 0.1 and a precision of 0.02 mm. The thickness was measured from three different points of each sample, and the mean value was recorded[13,14].

Peroneal Tendon Preparation

Peroneal tendons were harvested by palpation, followed by a retro-malleolar posterolateral approach. A standard release followed by a closed scraper was used to harvest the peroneus longus and peroneus brevis tendons. Following graft preparation and cleaning from adherent muscle and adipose tissue, a load of 89 newtons was applied to each doubling tendon for 15 minutes, and each tendon diameter was measured with a digital micro-caliper (Neiko 01407A Electronic Digital Caliper, Neiko Tools, China) with a resolution of 0.1 and a precision of 0.02 mm. The thickness was measured from three different

points of each sample, and the mean value was recorded[13,14].

Statistical Analysis

SPSS v20 program was used for data evaluation. The Shapiro Wilk-W test was used to determine the conformity of the data to the normal distribution. Variables are given as mean±standard deviation or frequency (percent). The normality t-test or Mann-Whitney U test was used to compare continuous variables. Correlation between tendon diameters from the middle region and peroneal tendons was evaluated with the Pearson correlation test. The significance level was accepted as $p<0.05$.

RESULTS

Of the 13 cadavers included in the study, 9 (69.23%) were male, and 4 (30.76%) were female, with a mean age of 69.07±10.35 (minimum: 51, maximum: 94) years. The mean body mass index of the cadavers was calculated as 23.38±6.47 (Table 1). There was no statistically significant difference by gender in the evaluated tendon diameters ($p>0.05$ for each) (Table 2).

The mean tendon diameters were 5.65±0.66 mm, 4.22±0.37 mm, 6.56±0.49 mm, and 5.22±0.33 mm for semitendinosus, gracilis, peroneus longus, and peroneus brevis, respectively. A positive correlation was found between hamstring tendon (gracilis and semitendinosus) diameters and peroneus longus and brevis tendon diameters ($p<0.01$) (Table 3).

DISCUSSION

Krause and Brodsky[15] are the first authors to present a classification system that guides the treatment of rare irreparable peroneal tendon tears. According to their definition, in cases where more than 50% of the tendon is affected, tendonesis can be performed on the remaining healthy tendon after segmental resection. Although tendonesis is a simple procedure, there is insufficient evidence for its clinical results. In some studies, it has been stated that tendonesis applied after an irreparable tear will not provide the normal tension of the peroneal tendons effectively and can be repaired with allograft and autograft reconstruction[12,16]. In 2010, Ousema and Nunley[17] published the first successful results of allograft reconstruction of the peroneus brevis in a series of 4 cases. Again, Mook et al.[10] reported successful clinical results in a retrospective series of 14 patients who underwent peroneal tendon reconstruction

Table 1. Anthropometric features of cadavers

Age (years)	**Min-Max (median)**	**51-94 (76)**
	Av.±SD	**69.07±10.35**
Gender, n (%)	Male	9 (69.23)
	Female	4 (30.76)
Side, n (%)	Left	4 (30.76)
	Right	9 (69.23)
BMI	Min-Max (median)	19-39 (26)
	Av.±SD	23.38±6.47
Weight (pound)	Min-Max (median)	70-240 (155)
	Av.±SD	153.33±50.40
Size (inch)	Min-Max (median)	60-77 (65)
	Av.±SD	64.33±8.40

Min-Max: Minimum-maximum, Av.: Average, SD: Standard deviation, BMI: Body mass index

Table 2. Distribution of mean tendon diameters by gender

	Semitendinosus	Gracilis	P. longus	P. brevis
Male	5.74±0.71	4.29±0.39	6.62±0.56	5.24±0.38
Female	5.45±0.45	4.06±0.29	6.42±0.30	5.16±0.18
p	0.49	0.31	0.51	0.68

Table 3. Correlation between the diameter from the middle region of hamstring tendons and the diameter from the middle region of peroneus tendons

	Peroneus longus		Peroneus brevis	
	r	p	r	p
Semitendinosus	0.97	<0.001	0.84	<0.001
Gracilis	0.84	<0.001	0.83	<0.001

with a peroneal or semitendinosus allograft. However, in the study of Mook et al.[10], only the semitendinosus tendon was used, and no comparison was made with gracilis. Literature for peroneal tendon reconstruction with autograft is rare. In 2018, Ellis and Rosenbaum[12] were the first authors to describe the surgical technique for reconstructing the peroneus brevis with semitendinosus autograft without any clinical consequences. In this study, the compatibility of the diameter of the autogenous hamstring tendons in peroneal tendon reconstruction was evaluated with a cadaveric study.

A positive correlation was found in the study between the diameter from the middle region of the semitendinosus and gracilis tendons and the peroneus tendons. In addition, it was determined that the mean diameter of the semitendinosus tendon was closer to the mean diameter of the peroneus longus and peroneus brevis tendon. In another study, hamstring autograft was used to reconstruct the superior peroneal retinaculum injured in chronic dislocations, although not directly for peroneal tendon repair[18]. Many studies report that hamstring tendons are used primarily for anterior cruciate ligament repair, and good results are obtained[19-21]. In another study comparing hamstring tendons, it was shown that semitendinosus is superior to gracilis both in cross-sectional area width and biomechanics[22]. Zhao and Huangfu[23], in a biomechanical study in which they compared the peroneus longus anterior half with the hamstring tendon for use as autograft, showed that the endurance of the peroneus longus anterior half (7.8 N/mm) was similar to that of the semitendinous endurance (8.6 N/mm) but higher than the gracilis endurance (4.1 N/mm). In our study, semitendinosus was measured wider than gracilis in terms of tendon width. A closer value was found in the comparison of semitendinosus and peroneal tendon diameter measurements. In our study, the width of the semitendinosus tendon was more significant than the width of the gracilis. The diameters of semitendinosus and peroneal tendons were almost similar. In 2019, Nishikawa et al.[24] reported successful results with a short follow-up in their series of 3 cases where they performed peroneus brevis reconstruction with semitendinosus autograft. However, research on the use of hamstring autografts for peroneal tendon repair is minimal.

Study Limitations

Like most laboratory studies, this research has methodological limitations. First of all, the compatibility of the tendons was evaluated only by measuring the diameter. The lack of biomechanical comparison with autograft after reconstruction is one of the limitations of our study. Secondly, the cadavers used in the study are of advanced age, and the number of cadavers is low. The fact that the cadavers were fresh frozen was an advantage.

CONCLUSION

Gracilis tendon diameter was found to be smaller than those of the peroneus longus and peroneus brevis tendon, and the semitendinosus autograft is considered to be a more suitable option for peroneal tendon reconstruction in terms of diameter compatibility. There are still not enough studies on this subject. There is a need for biomechanical studies and clinical studies with long-term follow-up on the use of hamstring tendons as autografts in peroneal tendon reconstruction.

Ethics

Ethics Committee Approval: The study were approved by the Mehmet Ali Aydınlar University of Ethics Committee (protocol number: ATADEK-2020/5, date: 09.07.2020).

Informed Consent: Retrospective study.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: M.K., B.Y., Concept: D.P.K., B.Y., Design: M.K., E.D.Ç., E.N.K., Data Collection or Processing: D.P.K., E.N.K., Analysis or Interpretation: N.K., Literature Search: M.K., E.N.K., Writing: M.K., E.N.K.

Conflict of Interest: No conflict of interest was declared by the authors.

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