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Tensile strength comparison between hamstring tendon, patellar tendon, quadriceps tendon and peroneus longus tendon: A cadaver research

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ABSTRACT

Knee ligament injury is a frequent occurrence. Ligament reconstruction using tendon graft is the best therapy recommendation in the case of severe knee ligament injury. Tendon graft that is oftenly used are hamstring tendon, patellar tendon (BPTB), quadriceps tendon and peroneus longus tendon have been proposed as tendon graft donor. Biomechanically, tensile strength from tendon graft is the main factor that greatly contributes to the success of ligament reconstruction procedure. Numerous researches have been done to calculate tensile strengths of hamstring and patellar tendon, but there has not been a research done yet on the comparison of the tensile strengths of peroneus longus tendon, hamstring, patellar tendon and quadriceps tendon. This research will strive to record the tensile strengths of peroneus longus tendon, hamstring, patellar tendon and quadriceps tendon as well as their comparison. Population of this research is 6 cadavers that have met the exclusion and inclusion criterias. From population above, 48 samples are retrieved and further divided into 4 groups. 12 samples for quadriceps tendon group, 12 samples for hamstring group, 12 samples for peroneus longus tendon group and 12 samples for patellar tendon group. Tensile strength measurement will then be done on each tendon by clamping both ends of examined tendon, then pulled on one side until tendon ruptures. Results are then read with a tensile tester. Tensile strength of peroneus longus tendon is not significantly different in comparison to hamstring tendon ($p > 0,05$). Whereas when compared to patellar and quadriceps tendons, peroneus longus and hamstring tendons have tensile strengths that are significantly higher ($p < 0,05$). Peroneus longus tendon have the highest tensile strength in comparison to the other three, followed by hamstring, quadriceps, and patellar tendons respectively.

1. Introduction

Muscles, tendons, and ligaments are soft tissues that often get injured. Injury frequently happens during exercise but daily activities may also cause injuries. Sprain, strain, and contusion, as well as tendinitis and bursitis are soft tissue injuries that happens most often. This type of injury may have a long recuperation time, even though given a proper handling.[1] According to general population data, prevalence of knee injury is 500 to 400.000.[2] There are operative and non-operative therapy choices for cases of multiple ligament injury.[3] Operative actions are divided into two, repair and reconstruction. Ligament reconstruction with tendon graft.[4]

As of now, multiple ligament reconstruction and on the knee have been done frequently that an alternative choice for donor tendon is required for such procedures.[4] There are three main modalities for autografts: hamstring tendon, bone-patellar tendon– bone (BPTB), and quadriceps tendon.[4] As of now, quadriceps tendon grafting is currently considered as a second choice

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even though clinical studies have shown good results and low donor morbidity rate.[1] Another choice for autograft that can be considered as a new alternative is the peroneus longus tendon. Studies have shown that the peroneus longus tendon does not have an effect on walking disorder does not affect ankle stability, meaning it may be used as a choice for autograft in ligament reconstruction procedures.[1]

Mechanically, tensile strength of tendon graft is a factor that greatly contributes to the success of ligament reconstruction. Lengthening of tendon does not only depend on the amount of force it receives, but also how long the force acts on it. This dependency on time can be described through two phenomena, Creep (tissue lengthening dependency on time when given constant tension) and Stress relaxation (observed decrease in stress in response to the same amount of strain generated in the tissue).

Tendon is also strain-rate dependent, where increase in mean lengthening will result in a more rigid tendon. Different anatomical locations, biomechanical environments, and biochemical environments will have different biomechanical properties as well.[6] Numerous researches have been done to calculate tensile strengths of hamstring and patellar tendon. From previous researches, it is known that tendons from flexor muscles and upper and lower extensor have a higher Young Modulus and ultimate tensile stress in comparison to tibialis dan peroneus tendons.[7] Extensor muscles tendons' tensile strength is higher than that of flexor muscles tendons', even though difference in value is not statistically significant.[8] From the comparison of tibialis tendon and peroneus tendon, the highest to lowest ultimate stress value is owned by peroneus longus tendon, tibialis anterior and tibialis posterior respectively. And from these results it is given that there is no significant difference between each tendon.[9]

However, there is no research done yet on the comparison of peroneus longus tendon, hamstring, patellar tendon and quadriceps tendon. This research will strive to uncover the tensile strengths of peroneus longus tendon, hamstring, patellar tendon and quadriceps tendon as well as their comparison.

1.1. Research methods

This research is an experimental research that is performed to find out the tensile strengths of hamstring tendon, patellar tendon, quadriceps tendon and peroneus longus tendon.

Population of this research is 6 cadavers from Forensic Medicine Installation Dr .Saiful Anwar, Malang. From population above, 48 samples are retrieved and further divided into 4 groups. 12 samples for quadriceps tendon group, 12 samples for hamstring group, 12 samples for peroneus longus tendon group and 12 samples for patellar tendon group. Collection of hamstring tendon, patellar tendon, quadriceps tendon and peroneus longus tendon will be done to each cadaver.

Tensile strength measurement will then be done on each tendon by clamping both ends of examined tendon, then pulled on one side until tendon ruptures. Results are then read with a tensile tester in Machine Laboratory of Technical Faculty Brawijaya University.

2. Result

The measurements that have been done shows the following results. (Fig. 1) A normality examination is done using the Kolmogorov-Smirnov method to determine whether or not the spread of data is considered to be normal. The normality test returns with a significance value (p) of 0,221, which concludes that the data used have a normal spread of distribution (Table 1). Then the homogenization of the data obtained from the previous test is analyzed using the homogenity of variance test (Levene's test) to determine whether or not the data utilized have the same variances. Results from the tests have shown a value of significance of 0,350 which can be concluded that the data utilized have a homogeneous spread and can be used for the ANOVA test (Table 2). One Way Anova is done to test whether there is a meaningful and significant difference between each group. Based on the analysis result of ANOVA, a value of 0.000 of p for Tensile Strength, meaning there is a significant difference between each group. Which means there are significant differences in influence between groups (Table 3). To find the difference, further test is done using Tukey method, with the results as shown below (Table 4). Based on the Tukey test results, it is shown that there is no significant difference between Hamstring and Peroneus Longus groups, whereas difference between Hamstring and Peroneus Longus with Patellar dan Quadricep is significant. Patellar tendon does not have a significantly different result when compared with Quadriceps tendon.

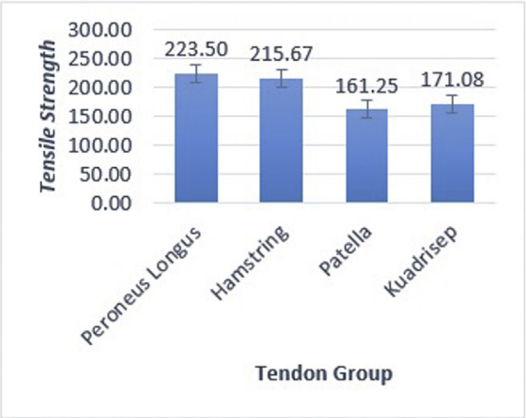

Fig. 1.

Table 1
Normality test.

		Tensile Strength
N		48
Normal Parameters[a,b]	Mean	192.8750
	Std. Deviation	29.96,922
Most Extreme Differences	Absolute	.151
	Positive	.112
	Negative	-.151
Kolmogorov-Smirnov Z		1.049
Asymp. Sig. (2-tailed)		.221

[a] Test distribution is Normal.
[b] Calculated from data.

Table 2
Test of homogeneity of variances.

Levene Statistic	df1	df2	Sig.
1.122	3	44	.350

Table 3
One way anova test.

	F	p
Tensile Strength	73,467	0,000

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Table 4
Tukey test.

Group		p	Info
Peroneus Longus	Hamstring	0.435	Significant
	Patella	0.000	Significant
	Kuadrisep	0.000	Significant
Hamstring	Patella	0.075	Not Significant
	Kuadrisep	0.000	Significant
Patellar	Kuadrisep	0.240	Not Significant

3. Discussion

Peroneus longus provides the best tensile strength as seen in several experiments. Zhao and Huangfu found that with the anterior half of the peroneus longus tendon (AHPLT) having enough length and strength to be effective as an autograft choice in ACL reconstruction.[10]

The study by Shi et al. showed that the main tensile strength of both peroneus longus tendons and hamstring tendons was four times higher than the original ACL while the main tensile strength of the double strand peroneus longus tendon was comparable to in vitro. Four-strained hamstring tendon. In their experience, they found the diameter of the double strand of Peroneus longus is usually between 8 and 9 mm and the length of the peroneus longus tendon is about 30 cm from the myotendinous junction to its insertion, making it clinically effective in width and length.[10]

In the Kerimoglu experiment also showed the maximum tensile load of one peroneus longus tendon was 1950N, although the age of the corpse they used was 70 years.[11] The tensile strength of the hamstring veins did not differ significantly as seen in the experiments Shi et al. Meanwhile there are many corruption options for ruptured anterior cruciate ligament (ACL) ligament with special consideration of injuries and certain patients that need to be made during preoperative planning. The most frequently described and used techniques for index procedures are bone-patellar-bone autograft and quadrupled, or four-strand, harmstring autograft.[10]

The Patella tendon autografts have become the most popular choice of grafts because of their strength characteristics, ease of harvest, rigid fixation, bone for bone healing and favorable clinical results.[12]

The average main tensile strength and the average stiffness of normal ACL are 1.725 N and 182 N/mm, respectively. Bone-patellar tendon graft (14 mm) has a tensile strength of 168% and almost four times normal ACL stiffness. Semitendinosus and gracilis tendons provide 70% and 49% of the reported normal ACL strength, respectively. This makes the tensile strength of the second hamstring tendon, compared to the patellar tendon graft bone.[12]

In the hamstring tendon autograft, with a medial harvest, it can damage the saphene nerve and potentially cause medial knee joint instability if the ACL rupture is accompanied by a grade III injury of the medial collateral ligament (MCL). Postoperative varus or valgus instability due to collateral ligament injury can compromise graft resistance.[10]

In a Hamstring graft, there is also a significant variability in small-diameter HT and graft is a potential risk factor for failure of ACL reconstruction. It has been recommended that the diameter of the transverse graft for reconstruction is at least 8 mm which can be difficult with Hamstring alone while maintaining sufficient length.[10]

From tensile strength results of quadriceps tendon, patellar tendon, hamstring tendon, and peroneus longus tendon, it is shown that the Hamstring and Peroneus Longus groups do not have a significant difference, but Hamstring and Peroneus Longus have a significant difference in comparison to Patellar dan Quadricep. Patellar tendon also does not have a significant difference in comparison to Quadriceps tendon.

These results help to explain that even though mean tensile strength of peroneus tendon is a little bit higher than that of hamstring, tensile strengths of both tendons are statistically similar. Whereas when compared to patellar and quadriceps tendon, peroneus longus tendon has a significantly higher tensile strength. Similar values of tensile strengths of peroneus longus and hamstring tendons show that both of them are biomechanically similar.

4. Conclusion

Tensile strength of peroneus longus tendon is not significantly different in comparison to that of hamstring tendon. Whereas in comparison to patellar and quadriceps tendons, peroneus longus tendon has a significantly higher tensile strength.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jajs.2019.02.003.

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