Anatomical and biomechanical characteristics of fibularis longus tendon used for cruciate ligaments reconstruction

Nguyen Hoang Quan, Nguyen Manh Khanh

Viet Duc University Hospital

Corresponding author:
Nguyen Hoang Quan,
Viet Duc University Hospital
40 Trang Thi Street, Hoan Kiem District, Ha Noi City
Mobile: +84866 868 917
Email: hoangquan9987@gmail.com

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Abstract

Introduction: Arthroscopic reconstruction of the cruciate ligament of the knee becomes routine with modern techniques and special instruments. However, the source of materials for this procedure has always been an eternal issue that affects the surgeons decision. The two peroneal tendons on the lateral side of the lower leg have the same function of plantar flexion and foot eversion. The fibularis longus tendon has been used for reconstruction such as the lateral collateral ligaments of the ankle or the Achilles tendon.

Patients and methods: Descriptive cross-sectional study on twenty fresh cadavers were selected randomly for taking the fibularis longus tendon at the Department of Anatomy of the University of Medicine and Pharmacy, Ho Chi Minh City from January to July, 2022. Specimens with intact leg to lower knee segment were not crushed, well preserved and had never been used in previous studies.

Results: Fibularis longus tendon length was 29,25 ± 2,1cm; the distances from fibularis longus tendon to deep fibular nerve and superficial fibular nerve was 71.1±8.63mm respectively, no split (longitudinal tear) was observed, the maximum tensile strength was 1170,4 ±203N, the maximum length of rupture 14,29 ± 3,88 mm.

Conclusion: There was no split of fibularis longus tendon. Also no sign of impact on adjacent anatomy structures was found. The maximum tensile strength was equivalent to other grafts, such as the Hamstrings and patellar tendons. Its a potential source for arthroscopic reconstruction of the cruciate ligament

Keywords: knee arthroplasty, fibularis longus tendon, grafts, Hamstrings tendon

Introduction

Knee injury is quite commonly occurred due to sport or traffic accidents because it is constantly under pressure of the bodys weight. The anterior cruciate ligament (ACL) helps preventing anterior translation of the tibial plateau on the femur and also abnormal rotation, while the posterior cruciate ligament (PCL) prevents posterior translation of the tibia and it also has function during knee motion.

Knee arthroscopy for cruciate ligament reconstruction has become a routine with advanced techniques as well as modern instruments. However, choice of graft is always one of the main concerns for surgeons especially in multi-ligaments reconstruction or repair.

Hamstring tendon has always been the first choice for grafting; however substitutes are plenty such as: patellar tendon, allograft (Achilles tendon), synthetics graft.

The fibularis longus and brevis tendons have the same function of plantar flexion and foot eversion. However, the fibularis longus tendon has been more used for reconstruction such as the lateral collateral ligaments of the ankle or the Achilles tendon. There are plenty researches on fibularis longus biomechanic [6,7], use of fibularis longus in knee ligaments reconstruction in general [8] and in knee cruciate ligament in specifics [9,10]. These researches come to the same conclusion that the use of fibularis longus does not affect ankles function [11].

Therefore, we conducted this research aimed to assess the anatomic and biomechanical characteristics of fibularis longus tendon for knee cruciate reconstruction.

Materials and methodology:

Subjects:

Twenty intact below-knee (BK) limb specimens were randomly chosen from the fresh cadavers at the Department of Anatomy– University of Medicine and Pharmacy, CHMC. These specimens were processed and preserved in good condition and not involved in any previous researches.

Methodology:

Descriptive cross-sectional study.

Research variables:

Tab. 1. Research variables

Variables	Type
Location and morphology	Quantitative
Fibular retinaculum	Quantitative
Length	Qualitative
Accessory bands	Binary
Distance to lateral sural cutaneous nerve	Quantitative
Distance to deep peroneal nerve	Quantitative
Relationship with superficial peroneal nerve	Qualitative

Instruments:

Scapel, Metzenbaun scissors, Kelly hemostatic forceps, toothed and non-toothed forceps, needle holder.

Measuring tool for mechanical force.

Ruler (mm), pen, color pencil.

Tendon stripper, sizing.

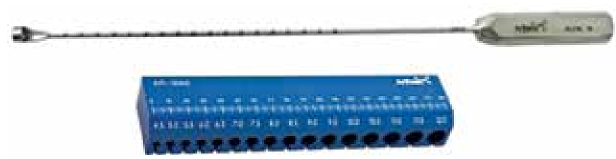

Fig.1. Tendon stripper and sizing

Procedure:

Lateral dissection of specimens and note the anatomy characteristics.

Identify anatomy landmarks: tip of the lateral malleolar, head of the fibular. The incision spans from the head of the fibula to the tip of the malleolar.

Dissection: superficial and deep.

Find and expose the superficial/deep peroneal nerve and lateral sural cutaneous nerve, fibularis longus muscle.

Dissect through the deep fascia to expose and release the fibularis longus tendon. The tendon is harvested with closed stripper.

Data collection and analysis:

Tendon length: measuring from tip of the lateral malleolar to the muscle-tendon junction. This is a quantitative variable which measured in mm.

Accessory bands if any.

Relationship of the tendon with superficial peroneal and lateral sural cutaneous nerve.

Information are collected in designed form and camera.

After harvesting the tendon, it was prepared with 4-strand technique for measuring the length (the required length for ACL about 60mm and PCL about 70mm). Quantitative variable, unit: mm.

The skin was incised along the stripper from the tip of the lateral malleolar to the head of the fibula.

Identify the tip of the stripper and deep peroneal nerve. Measure the distance. Quantitative variable, unit: mm.

Identify damage to surrounding tissue.

Assessment of effect of the method was based on the integrity of the dissected tendons (lateral dissection of leg after harvesting the tendon and detection of anatomy damage such as nerve damage).

Good: The tendon maintains its integrity or has minor abrasion that does not affect the grafts size.

Fair: damage to the tendon less than 1/2 its width.

Poor: Damage to more than 1/2 of the tendon length.

Maximal Strength: quantitative variable, measured by force impact to rupture the tendon, in N.

Maximum length when starting rupture : mm

Results

After having analysis on 20 specimens, the following results collected such as: tendon length measured from tip of the lateral malleolar to its insertion on the head of the fibular shown in the tab1.[1]

Tab. 2: Fibularis longus tendon length

Description	Length (cm)	MIN	MAX
Fibularis longus	29,25 ± 2,1	26	33

Comment: Mean length was 29,25 ± 2,1, min was 26 and max was 33 therefore, if the tendon underwent 2-strand technique, the graft length was about 13cm and its 7,31cm for 4-strand technique.

Fig.2: Fibularis longus tendon length

Morphology: the muscle origins at the head of the fibula to its upper third then transforms to tendon only.

Pathway: From the head of the fibula to tip of the lateral malleolar, at the middle third, it transforms to tendon and at the lower third, it consists of only tendon.

The tendon has no accessory bands.

Fig. 3. No accessory bands.

Relationship with surrounding landmarks:

The fibularis brevis: the fibularis longus muscle and tendon lays more superficial than the fibularis brevis

The retinaculum is posterior to the lateral malleolar.

The lateral sural cutaneous nerve: at the level of 1,5cm above the tip of the lateral malleolar, the fibularis longus tendon is 2 ± 0,2 cm from the lateral sural cutaneous nerve, at the level of 11,5cm, the distance is 4 ± 0,2 cm. Therefore, orientation of the lateral malleolar to the head of fibula, the lateral cutaneous sural nerveof thelower limb is far away from the tendon, the risk of nerve damage is almost low.

Superficial peroneal nerve: the common peroneal nerve goes around the head of the fibula then divides to the superficial and deep peroneal nerve. The superficial peroneal nerve then comes between the fibularis longus and brevis to provide branches for these muscles. At the lower part, it goes through the superficial fascia and stays more superficially, it does not cross the muscles at any point.

The deep peroneal nerve: after its division, the nerve then crosses under the fibularis longus almost perpendicularly, therefore, there is risk of nerve damage if the tendon stripper steers off too far from the muscle. In our research, mean distance from the muscle to the nerve was 71,1 ± 8,63 mm with min of 48mm and max of 86mm.

After the tendon was sutured with 4-strand technique, the mean graft diameter was 9,95 ± 1,27 with min of 8mm and max of 13mm, the length was 6-7mm which was suitable for both ACL and PCL reconstruction. It could be seen that graft from the whole tendon is relatively large, by taking only 2/3 of the tendon, the mean graft diameter was 7.83 ±0.77 with max of 9,5mm.

Tab 3: Force to rupture of the fibularis longus tendon

Description	Force to rupture (N)	Min- Max
Fibularis longus tendon	1170,4 ±203	1006.8-1720

Tab 4: Maximal length to rupture of the fibularis longus tendon

Description	Length to rupture (mm)	Min- Max
Fibularis longus tendon	14,29 ± 3,88	8.01-21.37

Discussion

All of twenty specimens were in good condition, no damage on the tendon was observed. After performing tendon harvest, the incision was made along the tendon stripper then further dissection was carried out to examine any damages to the lateral sural cutaneous nerve, superficial/deep peroneal nerve, vessels or other anatomical structures.

In our research, the mean tendons length was 29,25 ± 2,1 cm, with this length, if the tendon was folded once for 2-strand technique, the graft would have length of 14-15cm and for 4-strand technique, the length would be 6-7cm which is suitable for All-insides technique. Our result is similar to Phạm Quang Vinh1 (2017), mean length was 28,1 ± 2,35 cm with min of 22 cm, but significantly different from that of Do Phuoc Hung [2] (2008)s research on 15 formaldehyde preserved cadaver, the mean tendon length was 20,5cm. This could be due to the formaldehyde preservation caused the tendon to loose water affected the elasticity and length. In report of Jinzhong Zhao [3] (2012) mentioned that he has only harvested the anterior half of the tendon at the level above the lateral malleolar therefore, the mean tendon length was only 23,7 ± 1,4 cm.

The muscle attaches at the head of the fibula at 1/3 upper transformed to tendon. Orientated from posterior lateral ankle to the head of fibular, 1/3 of middle muscle transformed to tendon until completed the tendon only that point. For that reason, we started stripping at the tip of the malleolar.

The long fibularis tendon does not have secondary attachments on the entire tendon, the upper ankle segment, with this characteristic when taking the tendon, we can completely limit the fact that the attachments will affect the tendons path. This is an advantage over Hamstrings tendons when the semi-tendineux tendon are divided into many branches and located in high which affects the harvesting process as well as itquality. This result is similar to Nguyen Phuoc Hung [2] (2008) studied on 15 samples and Pham Quang Vinh [1] (2017) on 30 samples. Jinzhong Zhao [3] (2012) conducted biomechanical research and clinical application of the anterior half of the long fibula tendon as autologous graft source. The author also noted that the long fibula tendon did not have any secondary attachments.

The mean distance from tendon to nerve was 71.1±8.63mm, this was determined by the distance from the tip of the tendon stripper to the deep peroneal nerve. Min distance was 48mm and max was 86mm. Therefore, it is relatively safe to harvest the fibularis longus tendon. No damage to surrounding nerve were also mentioned in other reports.

The whole tendon would provide a relatively large 4-strand prepared graft with max diameter of 9,95±1,27 mm and mean length of 6-7cm. In some cases, this could be inappropriate since some femoral notch is small therefore large graft could cause impingement which could lead to reduced knee ROM or early graft failure. Therefore, we have harvested only the anterior 2/3 of the tendon because the posterior part consists mostly of muscle and by preserving the 1/3 parts of the tendon, the remaining tendon can still have its contribution in maintaining the metatarsal dome. The 4-strand graft made out of 2/3 of the tendon still had mean length of 6 – 7mm and mean diameter of 7.83 ± 0.77 mm with min of 6.5mm and max of 9.5mm which is suitable for cruciate reconstruction. The result is similar to Phạm Quang Vinhs research, his grafts diameter was 7,27 ± 0,34 but he used the whole tendon and 2-strand graft preparation technique.

The mechanical force measured on the long fibula tendon in our study showed that the maximum load-bearing force of the tendon was 1170,4 ± 203 N which is different from Phạm Quang Vinh research, the mechanical force measured was 1238,33 ± 217,53 N and for 4-strand semi-tendinosus and gracillis graft was 1125,33 ± 155,27 N.

The length changed when subjected to maximum tension of the long fibula tendon in our study was 14.29 ± 3.88 cm;This result compared with Pham Quang Vinh1's result was 14.43 ± 2.47 cm for the double convolution of the long fibula tendon and the four tapered-semi-tendon tendon bands was 14.77 ± 2.08 cm but this difference was not statistically significant with $p<0.05$.

Pearsall et al. (2003)4 studied 3 types of allografts used in knee surgery have not been reported. There were 2-strand tibialis anterior (TA), 2-strand tibialis posterior (TP) and 2-strand fibularis longus harvested from 16 fresh-frozen lower-limbs. The result showed that the TA and TP grafts had better tensile strength than conventional graft such as hamstrings.

The results from our study and other authors for maximal loading of long fibula tendons differed significantly. The load-bearing force of the long tendon in our study was 1238.33 ± 217.53 but it was 40kg in N, Do Phuoc Hung report [2], Jinzhong Zhao [3] with 1/2 long tendon 322.35 ± 63.18 N, Jin R was 1020.4 ± 175.4 N larger than the tibial tendon after 938.2 ± 216.7 N. This difference is related to tendon fixation method, race, age group, etc.

According to Tran Hoang Tung research [5] (2020) on 20 patellar tendon graft, the force to rupture was 846,5 ± 319,23 N which is less than our result however both are suitable for cruciate ligament reconstruction.

Conclussion

The fibularis longus tendon can be used as materials for knee cruciate ligament reconstruction instead of conventional Hamstrings tendon. In anatomy aspect, the fibularis longus does not have any accessory bands from the lateral ankle up to the head of fibula therefore the harvest of the tendon does not impact any surrounding superficial and deep peroneal nerves. The force to rupture and length of the long fibula tendon are both suitable as grafts for knee cruciate ligament reconstruction

Conflict of interest: The authors declare that they have no conflict of interest.

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