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MORPHOLOGICAL VARIATIONS AND SURGICAL IMPORTANCE OF THE PLANTARIS MUSCLE IN HUMANS

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ABSTRACT

The plantaris is coined from a Latin word 'planta' which means "The sole of the foot". The pain is a modality of sensation given to the mankind as blessing, because unless pain is felt the person will not consult the doctor and the pathology may go un-noticed. The small fusiform plantaris muscle, with its long slender tendon, is of great importance both from the anatomical and phylogenetic point of views and also from the surgical aspect.

The present study aims 1) To know the pattern of origin and insertion of the muscle which enables in diagnosing the posterior leg compartment syndrome and other pain associated symptoms of leg.2) To estimate the percentage of absence of the Plantaris muscle and its significance.3) To estimate the mean length, breadth and the thickness of the tendon which will help the plastic surgeons and the orthopedic surgeons for different types of reconstructive surgeries. The plantaris muscle and its tendon are subject to considerable variation in both the points of origin and insertion. In the present study of 50 lower extremities, six types of origin and five types of insertions of the tendon were observed and compared with the previous studies. The agenesis of the plantaris muscle was seen bilaterally of a male cadaver, an incidence of 4 percentage. After going through the review of literatures by various authors, the agenesis of the plantaris muscle is not well understood. Hence further study is required for the same.

Key Words: Obesity, Plantaris Muscle, Origin, Insertion, Agenesis

INTRODUCTION

Pagenstert *et al.*, (2005) studies have described anatomical procedure of using a free plantaris tendon graft for reconstruction of the anterior talofibular and calcaneofibular ligaments.

Das and Vasudeva (2006) have encountered a case of the plantaris muscle which was entrapped between tibial nerve and its branch to the soleus muscle, and they concluded that any tear of the plantaris muscle may involve the nerve to the soleus.

Steenstra and Van Dijk (2006) have described that during Achilles tendoscopy for patients with symptomatic Achilles tendinopathy, the plantaris tendon was fixed to the Achilles tendon at the level of complaints. Where in a normal situation the plantaris tendon can glide in relation to the Achilles tendon, it was postulated that the plantaris tendon plays a role in these medially located symptoms.

Santos *et al.*, (2009) concluded in support to the Bertelli's hypothesis; Tendo-osseous graft in the third postoperative week shows twice the tensile strength in comparison with conventional grafts, decreasing scar tissue formation, inducing early safe limb mobility, and lesser adhesions rates. Several tendons are available as possible sources of tendon grafts in secondary flexor tendon injuries reconstruction, including extensor digitorum longus tendon, Palmaris longus, and for over 60 years, the plantaris tendon has been used successfully. Their findings suggest that the plantaris tendon with its bony insertion is a reliable source as tendon graft for the reconstruction of chronic injuries in the flexor tendon surgery.

In the text book of anatomy Datta (2009) has written that, the Plantaris is a vestigial muscle in man. In the lower mammals its distal part is continuous with the plantar aponeurosis

Aragao *et al.*, (2010) in their study inferred that the plantaris muscle was present in all the 20 adult male lower limbs. At the level of the muscle/tendon transition, it was observed that the tendon extended along the entire lower third of the belly of the muscle. The mean length of the plantaris muscle from its

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proximal insertion to its distal insertion was 43.25 cm. The mean lengths of the belly of the muscle and the tendon were 11.38 and 33.26 cm respectively. The muscle/tendon ratio was 1.3 cm, muscle/belly 3.8 cm and muscle belly/tendon 0.3 cm.

Nayak *et al.*, in 2010 after studying 52 limbs noticed three types of origins and equal number of insertions. The PM took origin from type I: Lateral Supracondylar ridge, Capsule of Knee joint and Lateral head of gastrocnemius in 73.07% cases; type II: Capsule of Knee joint and Lateral head of gastrocnemius in 5.76% cases; type III: Lateral Supracondylar ridge, Capsule of Knee joint, Lateral head of gastrocnemius and fibular collateral ligament in 13.46% cases. The plantaris tendon was inserted into type I: to the flexor retinaculum of foot in 28.84% cases; type II: independently to the calcaneum in 36.53% cases; type III: to the tendocalcaneus at various levels in 26.92% cases. In four lower limbs (7.69%) the plantaris muscle was completely absent. Additionally the length and width of the plantaris muscle and its tendon were measured to know any side difference. There were no statistically significant differences between the measurements of left and right side ($p > 0.05$).

MATERIALS AND METHODS

The present study was carried out in the Department of Anatomy, Khaja Banda Nawaz Institute of Medical Sciences, Gulbarga. The plantaris muscle was dissected in 50 adult limbs (46 Male and 4 Female) available in the department, the average age of the cadavers is between 40 and 60 years, the limbs were preserved in 10% formalin for more than one year.

List of instruments used

1. Vernier's caliper
2. Scale
3. Cotton thread
4. Scalpel round blade
5. Scalpel pointed blade
6. Toothed forceps
7. Blunt forceps
8. Fine pointed forceps
9. Fine forceps
10. Hook
11. Small scissor
12. Large scissor

Adult cadavers were already preserved by the standard method of embalming for the purpose of dissection by the undergraduate medical students. After the dissection of popliteal fossa followed by dissection of the superficial compartment of the calf muscles by the undergraduates, careful dissection was done for the isolation of the plantaris muscle, the muscle was identified and traced from its origin to its insertion with blunt dissection and when required with the fine dissection keeping other related structures like muscles, vessels and nerves intact.

The morphology and the variations in origin and insertion were noted and documented. The length, breadth and the thickness of the muscle and tendon were measured using Vernier's caliper and with the help of thread and measuring scale. The point of measurement taken for the muscle is from its origin to the myotendinous junction and for the tendon is from the myotendinous junction to its distal attachment.

The following were the measurements kept in consideration for collecting the different parameters for this study.

1. The pattern of origin and shape of the muscle.
2. The length, breadth and thickness of the muscle belly.
3. The total length, breadth and thickness of the tendon.
4. The shape of distal insertion of the plantaris tendon in the Calcaneum.

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5. The position of the plantaris tendon in relation to the Achilles tendon.

The following types for the evaluation of the pattern of origin and insertion were made in this study.

Insertion pattern

Type-1 = on the calcaneum medial to Achilles tendon.

Type-2 = Fan shaped expansion superficial to Achilles tendon.

Type-3 = Fan shaped expansion deep to Achilles tendon.

Type-4 = Fan shaped expansion deep to Achilles tendon, and flexor retinaculum.

Type-5 = With the Achilles tendon to the calcaneum.

Origin pattern

Type-1 = Supracondylar ridge and oblique popliteal ligament.

Type-2 = Supracondylar ridge, lateral condyle and capsule of the knee joint.

Type-3 = Supracondylar ridge and lateral condyle of femur.

Type-4 = Supracondylar ridge, lateral condyle, capsule of the knee joint and lateral patellar ligament

Type-5 = Lateral condyle of femur only.

Type-6= Supracondylar ridge and interdigitations with lateral head of gastrocnemius.

RESULTS & DISCUSSION

The total 25 adult cadavers studied of which 23 were males and 2 were females, out of these there were 25 left and 25right limbs each belonging to the same gender. The statistical analysis was carried out by using the SPSS 19 Software and the results have been tabulated and represented in the form of charts and bars. After dissecting the specimens we could find different types of origin and insertion, accordingly it is observed that the insertion of the tendon is of five types and origin of the muscle belly is of six types.

Types of insertions

Type-1: The tendon is inserted into the calcaneum medial to the Achilles tendon in 33 out of 48 lower extremities examined, an incidence of **68.75%** the most common type of insertion we have encountered.

Type-2: The tendon near its insertion thinned out laterally to form a fan shaped expansion which is inserted into the calcaneum superficial to the Achilles tendon in 5 out of 48, an incidence of **10.41%**.

Type-3: The tendon near its insertion thinned to form a fan shaped expansion which is inserted into the calcaneum deep to Achilles tendon in 2 of 48 limbs, an incidence of **4.16%**.

Type-4: In this type of insertion the tendon is deep to the Achilles tendon; in addition few slips from the tendon are attached to the flexor retinaculum in 2 of 48 limbs, an incidence of **4.16%**.

Type-5: The tendon inserted into the calcaneum along with the Achilles tendon in 6 out of 48 limbs in which the plantaris was present, an incidence of 12.5%. There was complete bilateral agenesis of plantaris muscle in 2 limbs of the same male cadaver, an incidence of **4.16%**. Table 1 shows the incidences of different types of plantaris tendon insertions.

Table 1: Showing the percentage and frequencies of the different types of insertion (Total number of specimens are 50-2(agenesis) =48 specimens)

TYPE OF INSERTION	FREQUENCY	PERCENTAGE
Type 1	33	68.75%
Type 2	5	10.41%
Type 3	2	4.16%
Type 4	2	4.16%
Type 5	6	12.5%
Total	48	100.0%

Types of Origin

There is not much literature available on the variations of plantaris muscle in relation with its origin, unless as a case report which brings the attention of specially the orthopedic surgeons for the diagnosis of the patellofemoral pain syndrome (PFPS). In the present study it is also encountered a case in which few

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fibers of the muscle are arising from the lateral patellar ligament bilaterally in a male cadaver. Depending upon the observations six types of origin of the muscle belly are described as follows;

Type-1: The muscle fibers originated from the popliteal surface of supracondylar ridge just proximal to the origin of lateral head of gastrocnemius and some fibers also from oblique popliteal ligament in 12 out of 48 limbs dissected, an incidence of **25%**.

Type-2: The muscle was originated from the following sites, popliteal surface of supracondylar ridge, oblique popliteal ligament and thin bundle of fibers from the posterior part of the capsule of the knee joint in 14 of 48 limbs, an incidence of **29.16%**.

Type-3: From popliteal surface of supracondylar ridge of the femur and from posterior surface of lateral condyle of femur in 17 of the 48 limbs, an incidence of **35.41%**, and the commonest of all types of origin.

Type-4: From Supracondylar ridge, posterior surface of lateral condyle, posterior part of the capsule of the knee joint and few slips of muscle fibers originated from the lateral patellar ligament in 2 of 48 lower limbs, an incidence of **4.16%**. In this case the muscle presented was bilateral, having four sites of origin.

Type-5: From posteromedial surface of the lateral condyle of the femur only, shape of the muscle belly is triangular in 2 of 48 limbs, an incidence of **4.16%**.

Type-6: Supracondylar ridge and interdigitations with lateral head of gastrocnemius in the right limb of a male cadaver in 1 of 48 limbs, an incidence of **2.08%**.

Table 2: Showing the percentage and frequency of the different types of origin (Total number of specimens are 50-2(agenesis) =48 specimens)

TYPE OF ORIGIN	FREQUENCY	PERCENTAGE
Type 1	12	25.00
Type 2	14	29.16
Type 3	17	35.41
Type 4	2	4.16
Type 5	2	4.16
Type 6	1	2.08
Total	48	100.0

Table 3: Showing the mean values of length, breadth and thickness of the plantaris muscle and tendon in the male and female in centimeters.

SEX	ML cm	MB cm	MT cm	TL cm	TB cm	TT cm
FEMALE	7.55	1.35	.33	30.72	.31	6.75
MALE	8.03	1.64	.42	33.37	.30	6.78
TOTAL	7.99	1.62	.41	33.16	.30	6.78
SD	2.11	.58	.28	7.16	.13	7.24

ML=Muscle length, MB=Muscle breadth, MT=Muscle thickness, TL=Tendon length, TB=Tendon breadth, TT=Tendon thickness, SD=Standard deviation.

In the present study the above said types of variations are not observed. All the specimens presented with plantaris muscle were having single muscle only with no double or accessory muscle. The myotendinous junction was found at the level of origin of the soleus muscle which coincides with the findings of Helms *et al.*, 1995.⁶

In all the limbs studied the nerve supply to the plantaris muscle was by tibial nerve only.

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