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Original Article

Analysis of Variations in Peroneus Longus Muscle: An Institutional Based Study

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ABSTRACT

Background: The peroneus longus muscle is an important muscle of the lateral compartment of the leg and plays a significant role in eversion, plantar flexion, and maintenance of the arches of the foot. Variations in its muscle belly, tendon formation, course, and insertion may have clinical importance during radiological evaluation and surgical procedures involving the lateral ankle and foot. Awareness of these variations is essential to avoid misdiagnosis and operative complications.

Aim: The aim of the present study was to analyze and document anatomical variations of the peroneus longus muscle in lower limb specimens.

Materials and Methods: The present observational descriptive study was conducted in the Department of Anatomy, Smt. Kashibai Navale Medical College and General Hospital, Narhe, Pune, Maharashtra, India. A total of 55 lower limb specimens were included. Well-preserved adult lower limb specimens with clearly identifiable structures of the lateral compartment were dissected. The peroneus longus muscle was studied for its origin, muscle belly, tendon formation, course, insertion, accessory slips, split tendon, additional insertion slips, and relationship with surrounding structures. Morphometric parameters including length of muscle belly, length of tendon, tendon width, and distance of tendon formation from the head of fibula were recorded. Data were analyzed using descriptive statistics, and side-wise comparison was performed wherever applicable.

Results: Out of 55 lower limb specimens, 28 were right-sided and 27 were left-sided. Normal anatomy was observed in 44 specimens, while anatomical variations were present in 11 specimens, giving an overall incidence of 20.00%. Variations were found in 6 right-sided specimens and 5 left-sided specimens, with no statistically significant side-wise difference. Accessory muscular slip was the most common variation, observed in 5 specimens (9.09%), followed by split tendon in 3 specimens (5.45%) and additional insertion slip in 3 specimens (5.45%). Morphometric measurements showed comparable values on both sides, and no significant side-wise difference was observed in muscle belly length, tendon length, tendon width, or level of tendon formation.

Conclusion: Anatomical variations of the peroneus longus muscle were observed in a considerable proportion of specimens. Accessory muscular slip was the most frequent variation. Knowledge of such variations is clinically important for anatomical understanding, imaging interpretation, and surgical procedures involving the lateral compartment of the leg and ankle region.

KEYWORDS: Peroneus Longus, Fibularis Longus, Anatomical Variation, Accessory Muscular Slip, Split Tendon.

INTRODUCTION

The peroneus longus muscle, also known as the fibularis longus, is an important muscle of the lateral compartment of the leg. It lies superficial to the peroneus brevis and extends from the upper lateral aspect of the fibula to the plantar aspect of the foot. Its tendon passes posterior to the lateral malleolus, runs along the lateral side of the calcaneum, grooves the cuboid, and finally

reaches the medial cuneiform and base of the first metatarsal. Because of this long and curved course, the peroneus longus acts across both the ankle and foot and has a close anatomical relationship with the lateral malleolus, peroneal retinacula, cuboid groove, os peroneum, and plantar arch. Knowledge of this anatomy is important during routine dissection, radiological evaluation, and surgical procedures involving the lateral ankle and sole of the foot.[1]

Functionally, the peroneus longus contributes to eversion and plantar flexion of the foot. Along with the peroneus brevis, it provides dynamic support to the lateral side of the ankle. It also plays an important role in stabilizing the first ray and supporting the transverse and longitudinal arches of the foot. Any abnormality in its origin, muscle belly, tendon formation, course, or insertion may alter the biomechanics of the ankle and foot. Variations may also influence the distribution of force during walking, running, and weight bearing. For this reason, anatomical study of the peroneus longus is not only of academic interest but also has practical relevance for orthopaedic surgeons, anatomists, physiotherapists, radiologists, and sports medicine specialists.[2]

Anatomical variations of the peroneus longus may occur in different forms. These include accessory muscular slips, abnormal origin, unusual tendon formation, split tendon, additional insertion slips, abnormal insertion, or association with accessory peroneal muscles. Some variations may remain asymptomatic throughout life, while others may contribute to lateral ankle discomfort, tendon crowding, stenosing tenosynovitis, snapping around the lateral malleolus, or difficulty in interpreting imaging findings. Accessory peroneal muscles, including variants related to the peroneal compartment, can sometimes be confused with soft tissue masses or pathological lesions if their anatomy is not clearly understood. Therefore, awareness of such variations helps to avoid diagnostic errors and unnecessary intervention.[3]

The tendon of peroneus longus follows a complex course after leaving the lateral compartment of the leg. It passes through a fibro-osseous tunnel behind the lateral malleolus along with the peroneus brevis tendon and is retained by the superior peroneal retinaculum. It then courses inferior to the peroneal tubercle and enters the cuboid groove before crossing the sole. Because the tendon changes direction at the cuboid, this region is exposed to mechanical stress. Anatomical variations in tendon thickness, width, splitting, or insertion may modify frictional forces and may influence the development of tendon-related symptoms. Imaging studies also highlight the need to understand the normal and variant appearances of peroneal tendons during evaluation of lateral ankle pain.[4] Variations in the peroneal compartment have embryological and evolutionary importance. During limb development, muscle masses differentiate into individual muscles, and incomplete separation, persistence of accessory slips, or altered tendon migration may produce variations in adult anatomy. The peroneus longus has particular evolutionary importance because of its role in bipedal gait and maintenance of the arches of the foot. Its tendon has migrated functionally across the plantar aspect of the foot, giving it a major role in medial support despite its lateral compartment origin. Accessory slips or additional tendinous bands may therefore represent persistence or modification of developmental patterns.[5]

Clinically, peroneus longus variations are important because they may be encountered during procedures around the ankle, lateral malleolus, calcaneum, cuboid, and plantar foot. During operative exploration, a variant tendon or accessory slip may be mistaken for a torn tendon, fibrous band, or abnormal mass. In reconstructive surgery, the peroneus longus tendon may also be considered as a graft option in selected cases, making precise knowledge of its anatomy necessary. When a surgeon is unaware of possible variations, there may be risk of incomplete release, accidental injury, or misinterpretation of operative findings. Thus, cadaveric studies remain valuable because they provide direct anatomical information that complements imaging and clinical examination.[6]

MATERIALS & METHODS

The present study was designed as an observational descriptive study conducted in the Department of Anatomy, Smt. Kashibai Navale Medical College and General Hospital, Narhe, Pune, Maharashtra, India. The study was carried out to analyze and document the anatomical variations of the peroneus longus muscle with special reference to its origin, insertion, muscle belly, tendon, course, and associated morphological variations. A total sample size of 55 lower limbs was included in the study. The specimens were selected based on availability and suitability for anatomical examination. All 55 specimens were carefully dissected and evaluated for variations in the peroneus longus muscle.

Inclusion Criteria

All well-preserved adult lower limb specimens with clearly identifiable structures of the lateral compartment of the leg were included in the study. Specimens in which the peroneus longus muscle, its tendon, and surrounding anatomical structures could be dissected and examined properly were considered suitable for the study.

Exclusion Criteria

Lower limb specimens with congenital deformities, traumatic injury, surgical scars, pathological lesions, or damaged lateral compartment musculature were excluded from the study. Specimens with poor

preservation or unclear anatomical landmarks were also not included.

Methodology

A standard dissection method was followed for all specimens. A longitudinal skin incision was made along the lateral aspect of the leg, and the skin, superficial fascia, and deep fascia were carefully reflected. The lateral compartment of the leg was exposed, and the peroneus longus muscle was identified. The muscle was traced from its origin on the upper lateral surface of the fibula and adjacent intermuscular septa to its tendon passing behind the lateral malleolus and towards its insertion. Surrounding structures, including the peroneus brevis muscle, superficial peroneal nerve, lateral malleolus, and retinacula, were also observed.

Parameters Studied

The peroneus longus muscle was studied for its site of origin, extent of origin from the fibula, morphology of the muscle belly, presence of accessory slips, variation in tendon formation, course of the tendon, relationship with the peroneus brevis muscle, presence of split tendon, additional insertion, abnormal attachment, and any unusual relation with nearby neurovascular structures. Side-wise distribution of variations was also noted wherever applicable.

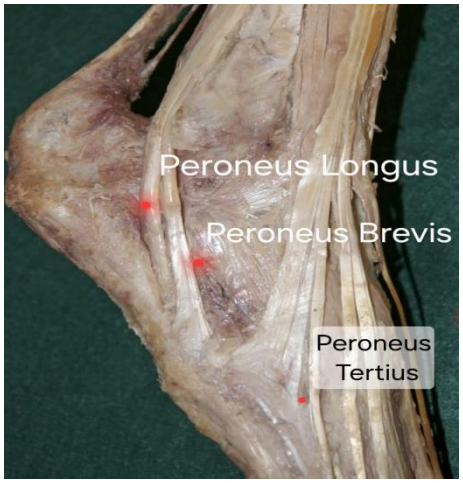

Fig 1: Peroneus muscles

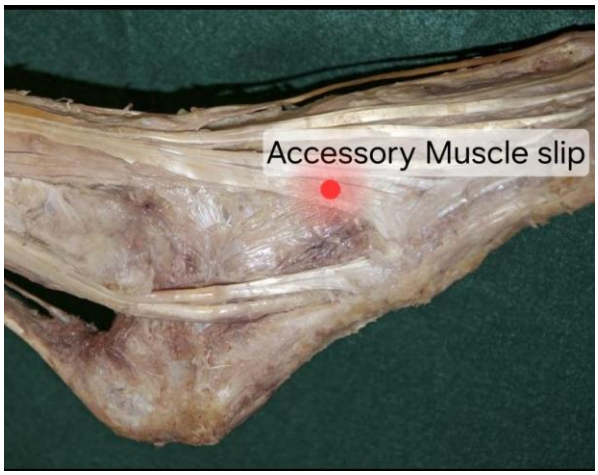

Fig 2: Accessory muscle tendon

Morphometric Measurements

Morphometric measurements were taken using a measuring tape and vernier caliper where required. The length of the muscle belly, length of the tendon, width of the tendon, level of tendon formation, and distance of tendon formation from fixed bony landmarks such as the head of fibula and lateral malleolus were recorded. All measurements were taken carefully to minimize observational error.

Observation of Anatomical Variations

Each specimen was examined for normal and variant anatomy of the peroneus longus muscle. Variations were classified according to changes in origin, muscle belly, tendon pattern, insertion, and accessory muscular or tendinous slips. Any unilateral or bilateral variation was recorded separately. Photographic documentation was done wherever significant variation was observed.

Statistical Analysis

The collected data were compiled and analyzed using descriptive statistics. Frequencies and percentages were calculated for categorical variables such as presence of variation, side involved, type of variation, accessory slips, and abnormal insertion. Mean and standard deviation were calculated for continuous variables such as muscle length, tendon length, tendon width, and level of tendon formation.

RESULTS

A total of 55 lower limb specimens were examined in the present study to observe anatomical variations of the peroneus longus muscle and its morphometric characteristics. Table 1 shows the distribution of specimens according to side. Out of the 55 lower limb specimens studied, 28 specimens belonged to the right side, accounting for 50.91% of the total sample, while 27 specimens belonged to the left side, constituting 49.09%.

Table 2 demonstrates the overall incidence of anatomical variations in the peroneus longus muscle. Normal anatomical pattern was observed in 44 specimens, representing 80.00% of the total sample. Anatomical variations were identified in 11 specimens, accounting for 20.00% of the total specimens studied. Thus, one-fifth of the examined lower limbs showed some form of variation in the morphology or tendon pattern of the peroneus longus muscle.

Table 3 illustrates the side-wise distribution of peroneus longus muscle variations. Among the right-sided specimens, variations were observed in 6 out of 28 specimens, representing 21.43%, whereas 22 specimens (78.57%) showed normal anatomy. On the left side, variations were present in 5 out of 27 specimens, accounting for 18.52%, while 22 specimens (81.48%) exhibited normal morphology. Overall, 11 specimens (20.00%) demonstrated anatomical variation, while 44 specimens (80.00%) did not show any variation. Statistical analysis revealed no significant difference

between the right and left sides with regard to the occurrence of variations, as indicated by a p value of 1.000.

Table 4 presents the different types of anatomical variations observed in the study. Accessory muscular slip was the most common variation encountered, observed in 5 specimens, accounting for 9.09% of the total sample. Split tendon variation was identified in 3 specimens (5.45%), while additional insertion slip was also noted in 3 specimens (5.45%). Altogether, these variations constituted 20.00% of the examined specimens.

Table 5 depicts the side-wise distribution of the various types of anatomical variations. Accessory muscular slips were identified in 3 right-sided specimens and 2 left-sided specimens, with an overall incidence of 9.09%. Split tendon variation was present in 2 right-sided and 1 left-sided specimen, contributing to 5.45% of the total sample. Additional insertion slips were observed in 1 right-sided specimen and 2 left-sided specimens, accounting for 5.45% overall. Statistical comparison of these variations between the two sides did not reveal any significant difference. The p values for accessory muscular slip and split tendon were 1.000, while the p value for additional insertion slip was 0.611.

Table 6 summarizes the morphometric parameters of the peroneus longus muscle on both sides. The mean length of the muscle belly on the right side was 24.60 ± 2.10 cm, while on the left side it was 24.30 ± 2.00 cm. The mean tendon length measured 12.80 ± 1.40 cm on the right side and 13.10 ± 1.50 cm on the left side. The mean tendon width was 4.30 ± 0.50 mm on the right side and 4.20 ± 0.60 mm on the left side. The mean distance of tendon formation from the head of fibula was 7.90 ± 0.80 cm on the right side and 7.80 ± 0.70 cm on the left side. Statistical analysis of all morphometric parameters showed no significant side-wise difference, as all p values were greater than 0.05.

Table 1: Distribution of Specimens According to Side

Side	Number of specimens	Percentage
Right	28	50.91%
Left	27	49.09%
Total	55	100.00%

Table 2: Overall Incidence of Variation in Peroneus Longus Muscle

Finding	Number of specimens	Percentage
Normal anatomy	44	80.00%
Anatomical variation present	11	20.00%
Total	55	100.00%

Table 3: Side-wise Distribution of Peroneus Longus Muscle Variation

Side	Variation present	Variation absent	Total	Percentage of variation	p value
Right	6	22	28	21.43%	1.000
Left	5	22	27	18.52%	
Total	11	44	55	20.00%	

Table 4: Types of Anatomical Variations Observed

Type of variation	Number of specimens	Percentage
Accessory muscular slip	5	9.09%
Split tendon	3	5.45%
Additional insertion slip	3	5.45%
Total variations	11	20.00%

Table 5: Side-wise Distribution of Different Types of Variations

Type of variation	Right	Left	Total	Percentage	p value
Accessory muscular slip	3	2	5	9.09%	1.000
Split tendon	2	1	3	5.45%	1.000
Additional insertion slip	1	2	3	5.45%	0.611

Table 6: Morphometric Parameters of Peroneus Longus Muscle

Parameter	Right side Mean ± SD	Left side Mean ± SD	p value
Length of muscle belly	24.60 ± 2.10 cm	24.30 ± 2.00 cm	0.590
Length of tendon	12.80 ± 1.40 cm	13.10 ± 1.50 cm	0.447
Width of tendon	4.30 ± 0.50 mm	4.20 ± 0.60 mm	0.506
Distance of tendon formation from head of fibula	7.90 ± 0.80 cm	7.80 ± 0.70 cm	0.623

DISCUSSION

In the present study, 55 lower limb specimens were examined, including 28 right-sided specimens (50.91%) and 27 left-sided specimens (49.09%). This nearly equal side distribution allowed a reasonable comparison of peroneus longus muscle variations between the two sides. In the study by Prakash et al. (2011), 70 lower limb specimens were dissected to study anatomical variations of peroneal muscles in an Indian population, which was a slightly larger sample than the present study. They observed peroneus quartus muscle in 3 out of 70 specimens, giving an incidence of 4.30%, whereas the present study observed overall peroneus longus-related anatomical variations in 11 out of 55 specimens, giving a higher incidence of 20.00%. The difference may be due to the fact that the present study included multiple variations such as accessory muscular slip, split tendon, and additional insertion slip, while Prakash et al. mainly documented accessory peroneal muscle variation.[7]

The overall incidence of anatomical variation in the present study was 20.00%, with normal anatomy observed in 44 specimens (80.00%). This finding is close to the observation of Sobel et al. (1990), who dissected 124 legs from 65 fresh cadavers and reported peroneus quartus muscle in 27 legs, giving an incidence of 21.70%. Although Sobel et al. studied the peroneus quartus as an accessory peroneal muscle rather than isolated variations of the peroneus longus, their incidence was comparable to the present finding of 20.00%. This similarity supports the view that variations in the lateral compartment of the leg are not rare and should be considered during anatomical dissection, imaging, and operative procedures around the lateral ankle.[8]

In the present study, side-wise analysis showed variations in 6 out of 28 right-sided specimens (21.43%) and 5 out of 27 left-sided specimens (18.52%), with no statistically significant difference between the two sides ($p = 1.000$). This finding is comparable with Shyamsundar et al. (2012), who studied the insertion of the peroneus longus tendon in 26 feet from 14 adult cadavers and noted that variations were present not only among different cadavers but also within paired feet. In their study, a sesamoid bone was present within the tendon under the cuboid in 16 out of 26 feet, and 12 of these feet showed additional lateral insertion bands. In comparison, the present study showed additional insertion slips in 3 out of 55 specimens (5.45%). The lower frequency in the present study may be related to differences in the definition of insertional variation and the broader specimen-based method used in this study.[9]

Accessory muscular slip was the most common variation in the present study, observed in 5 out of 55 specimens (9.09%). This was lower than the incidence reported by Hecker et al. (1923), who observed peroneus quartus muscle in approximately 13.00% of specimens. The present finding of accessory muscular slip was also lower than the 21.70% incidence reported by Sobel et al., but higher than the 4.30% incidence reported by Prakash et al. The variation in incidence across studies may be explained by population differences, sample size, embalming and dissection methods, and whether the investigators included only peroneus quartus or all accessory muscular slips related to the peroneal compartment.[10]

Split tendon variation was observed in 3 out of 55 specimens (5.45%) in the present study. Saupe et al. (2007), in an MRI-based study of 65 asymptomatic ankles, reported several anatomical variants associated with peroneal tendon disorders, including peroneus quartus muscle in 11 ankles (17.00%), peroneal tubercle in 36 ankles (55.00%), and variable morphology of the retromalleolar groove. Although their study was

radiological and not cadaveric, it showed that peroneal tendon-related anatomical variants can be found even in asymptomatic individuals. Compared with their 17.00% incidence of peroneus quartus, the present study showed a lower incidence of split tendon variation, but the finding remains clinically relevant because tendon splitting or crowding in the retromalleolar region may predispose to pain, tenosynovitis, or diagnostic confusion.[11]

Additional insertion slip was found in 3 out of 55 specimens (5.45%) in the present study, with 1 case on the right side and 2 cases on the left side, showing no significant side predominance ($p = 0.611$). Zammit et al. (2003) reported an incidence of peroneus quartus muscle of 6.60% in their cadaveric and MRI review, which is very close to the 5.45% incidence of additional insertion slips observed in the present study. Their study also emphasized that accessory peroneal structures commonly arise from the peroneus brevis region and may insert near the calcaneum, especially the retrotrochlear eminence. In comparison, the present study focused on peroneus longus-related additional insertion slips, but both studies highlight that accessory tendinous insertions around the lateral ankle and foot are important anatomical findings.[12] The morphometric analysis in the present study showed that the mean length of the muscle belly was 24.60 ± 2.10 cm on the right side and 24.30 ± 2.00 cm on the left side, while the mean tendon length was 12.80 ± 1.40 cm on the right side and 13.10 ± 1.50 cm on the left side. The mean tendon width was 4.30 ± 0.50 mm on the right side and 4.20 ± 0.60 mm on the left side, and the distance of tendon formation from the head of fibula was 7.90 ± 0.80 cm on the right side and 7.80 ± 0.70 cm on the left side. None of these parameters showed statistically significant side-wise difference. Park et al. (2012) described that variations of lower limb musculature may be explained on developmental grounds, as differences in muscle differentiation and tendon formation can persist into adult anatomy. The present symmetrical morphometric findings suggest that although anatomical variations were present in 20.00% of specimens, the basic dimensions of the peroneus longus muscle and tendon remained relatively comparable between right and left sides.[13]

CONCLUSION

The present study observed anatomical variations of the peroneus longus muscle in 20.00% of the examined lower limb specimens. Accessory muscular slip was the most common variation, followed by split tendon and additional insertion slip. No statistically significant difference was found between right and left sides regarding the occurrence of variations. Morphometric parameters of the peroneus longus muscle were also comparable on both sides. Knowledge of these variations is important for anatomists, radiologists, orthopaedic surgeons, and clinicians dealing with lateral ankle and foot disorders.

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