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Master of Science

Morphological Classification of the Plantaris Muscle Origin: A Cadaveric Study in Korean

한국인의 장딴지빗근 이는곳 유형에 따른 형태학적 분류

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Morphological Classification of the Plantaris Muscle Origin: A Cadaveric Study in Korean

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ABSTRACT

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The plantaris muscle (PM) has a small spindle-shaped muscle belly and a long slender tendon traveling inferomedially between the gastrocnemius muscle and the soleus muscle, working as a weak flexor. The PM is a vestigial muscle, and its tendon is widely known as a suitable source for tendon graft in surgical practice. The absence of the PM varies from 7-20% of the general population. It has diverse variations, and many studies have focused on classifying the origin or insertion types and reporting unique variations. Recent studies also emphasize the potential clinical role of the PM, regarding the tennis leg syndrome, patellofemoral syndrome, iliotibial band syndrome, and mid-portion tendinopathy of the Achilles tendon.

The study aims to obtain the morphological features of the PM and retain the anatomical and physical anthropologic baseline data of the PM in the Korean populations applicable in clinical and surgical practice. Dissection was performed on 57 cadavers (114 lower limbs). The PM origin was classified into three types and the length and width of the muscle belly, tibia length, and myotendinous junction width were measured morphometrically according to sexes and body sides. Based on the measurements, a relative location of the MTJ by the tibia length was presented, which may be helpful for surgeons harvesting tendon donors or clinically diagnosing patients with posterior knee pain.

Keywords: Plantaris muscle, Origin type, Muscle belly, Myotendinous junction, Plantaris tendon, Tennis leg

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LIST OF ABBREVIATIONS

AT	Achilles tendon
BL	Belly length
BW	Belly width
DVT	Deep vein thrombosis
GM	Gastrocnemius muscle
iPM	inferior plantaris muscle
iPT	inferior plantaris tendon
lGM	lateral head of gastrocnemius muscle
mGM	medial head of gastrocnemius muscle
MTJ	Myotendinous junction
PFPS	Patellofemoral pain syndrome
PM	Plantaris muscle
SM	Soleus muscle
sPM	superior plantaris muscle
sPT	superior plantaris tendon
TL	Tibia length

INTRODUCTION

The plantaris muscle (PM) has a short spindle-shaped muscle belly originating from the lateral supracondylar ridge of the femur above the lateral head of the gastrocnemius muscle (lGM) and the knee joint capsule [1, 2]. Its small fusiform muscle belly ranges between 7 and 13 cm in length [3]. The PM has a long slender tendon typically traveling inferomedially and ends at the calcaneal tuberosity along with the calcaneal tendon [4]. The plantaris tendon is well known as a suitable source for tendon graft in surgical practice [5, 6, 7]. It is also often referred to as "freshman's nerve" or "fool's nerve" due to its morphological features, which make students mistake it for a nerve [2]. The PM is innervated by the tibial nerve and is sandwiched between the gastrocnemius muscle (GM) and soleus muscle (SM), comprising the triceps surae muscle group working as a flexor of the knee and ankle along with the PM [3, 8].

The PM is absent in 7-20% of the general population, and many studies have reported it to be highly variable in its course and both the origin and insertion [5, 6, 9, 10]. Some of the variations reported have two or more muscle bellies or tendons [11-15]. There may be a situation where a PM with an unusual course and its tendon may become entrapped between the tibial nerve and its branches to the GM or SM, resulting in compression neuropathy with similar symptoms to sciatica [16, 17]. A similar situation can occur in patients with a double or unilateral PM [16]. Considering the relatively high percentage of absence and variations of the PM, it has been considered a vestigial muscle [18 19]. However, recent studies consider PM a proprioceptive organ due to its high density of muscle spindles [9].

The PM is a biarticular muscle which makes it subject to rupture [4, 10]. Most of the tears occur at the level of the myotendinous junction (MTJ) and the muscle belly [16, 20]. Injuries can occur solely or simultaneously with the GM and SM, referred to as "Tennis leg" [4, 8, 10]. It is a clinical condition first described by Powell in 1883 as a sprain of the medial head of GM (mGM) [21]. However, in this day and age, clinicians also include PM sprains [22]. Tennis leg syndrome is a common sports-associated injury, usually injured with abrupt contraction movements or when the knee is excessively extended and the ankle is in dorsiflexion [9, 10, 22]. It commonly occurs when receiving service balls in a lunge position, which accompanies flexion of the knee. Patients with PM ruptures feel as if they have been kicked in the posterior knee and hear a 'pop' sound, accompanying severe pain [22]. There is a great deal of clinical importance not only among tennis players but also among basketball players and sprinters [18].

Previous studies lay stress on the morphological features of the PM in its proximal part affecting the occurrence of tennis leg syndrome or patellofemoral pain syndrome (PFPS) [9, 23]. Freeman et al. suggested that the variability of the PM may have a more critical role than previously thought and thus a more significant role in knee injuries [23]. Moreover, recent studies emphasize the potential intervention of the PM in the mid-portion tendinopathy of the Achilles tendon [24]. When the Achilles tendon ruptures, the adjacent PM can still cause plantar flexion at the ankle, setting off a confusing picture [2].

It is also essential to distinguish between deep vein thrombosis (DVT) when diagnosing patients with PM ruptures. The DVT can easily imitate the PM ruptures but requires different treatments [22]. Hypertrophy of the PM can cause pressure on the main trunk of the tibial nerve or on one of its branches, which may lead to popliteal entrapment syndrome. It is commonly compared with adventitial cystic disease due to the similarity of the symptoms [16]. For these reasons, the necessity of the morphological and anatomical study of the PM is coming into the spotlight.

While some studies have reported morphological features and variations of the PM regarding the origin and insertion type, its course, and size of the muscle belly, studies on Asians, especially Koreans, are scarce. The present study categorizes the PM origin into three types and analyzes the mean length and width of the PM belly, the width of MTJ, and tibia length in Koreans. It also introduces a rare variation having an additional PM. Moreover, it presents a relative location of the MTJ by the tibia length, which has not been studied in emphasis before. Understanding the location of MTJ as a reference might be helpful for surgeons harvesting tendon donors or clinically diagnosing patients with posterior knee pain.

This study aims to obtain morphological features of the PM and retain the anatomical and physical anthropologic baseline data of the PM in the Korean populations applicable in clinical and surgical practice.

MATERIALS AND METHODS

1. Materials

A total of 57 cadavers (30 Males, 27 Females) from three different medical schools at the anatomy department in Korea were used in this study. 25 cadavers were fixed by formalin and 32 were fresh cadavers. Samples with deformities, injuries, surgical history, symptoms, and signs on the posterior knee were excluded after verifying the presence of the PM. The mean age at death was 81.79 ± 8.98, and the age varied from 54 to 98 (**Table 1**). Out of 114 lower limbs, the PM was absent in ten limbs, and four limbs were excluded due to deformities. Therefore, morphometric measurements were made on 100 lower limbs.

Table 1. Categorization by age and gender in the Korean population

Age	Male	Female
59≤	1	0
60~69	2	2
70~79	10	7
80~89	15	9
≤90	2	9
Total	30	27
Mean Age	81.79 ± 8.98	

2. Methods

2.1 Dissection

The dissection was performed using traditional dissection techniques. The skin and muscle fascia of the distal 1/2 of the femur to the proximal 2/3 of the tibia was removed. Then, the mGM and lGM were distinguished with extreme caution not to harm the PM, which is in close contact with the lGM. After partially removing the mGM, the lGM was cut about 5cm distal from the origin. When the proximal part of PM and SM were exposed, structures not relevant to the present study were removed to get a clearer view of the PM. After sitting at the PM origin site, its presence was recorded initially, and then the measurements were made.

2.2 Measurements

The maximal length and width of the PM belly and the MTJ width were measured by an electronic digital caliper (CD-15APX, Mitutoyo Corp., Japan) up to 0.00cm. The maximal length of the muscle belly was measured from the exact point of origin to the distal muscle belly. The maximal width of the PM belly was measured at the widest point perpendicular to the maximal length. The maximal width of MTJ was measured at the distal belly, where the tendinous part starts.

A tape measure that measures up to 0.0cm was used to measure the tibia length. Palpation techniques were used to enhance the applicability for orthopedic surgeons and radiologists in surgical and clinical practices. After palpating and marking the apex of the medial condyle of the tibia and the apex of the medial malleolus, the distance between them was measured. All of the measurements were made by one independent practitioner.

2.3 Statistical analysis

The statistical analysis included morphometric measurements of 100 lower limbs out of 114 lower limbs: ten limbs were absent, and four limbs were excluded due to deformities. Samples were measured separately by gender and body sides. The statistical analysis was performed using R studio software ver. 4.0.2 for Windows (R studio PBC, Boston, MA, USA). The results are presented as mean and standard deviation unless otherwise stated. A p-value lower than 0.05 was considered significant.

The Fisher's exact test was used to analyze the frequency of occurrence and the correlation between the origin types by gender or body sides of the PM. The normality of the distribution of continuous data was checked with the Shapiro-Wilk test. When the data were not normally distributed, the Mann-Whitney U test was used to compare anthropometric measurements between sexes and body sides, respectively. When the data satisfied the normality and the assumption of homogeneity of variance, Independent samples t-test was used to compare anthropometric measurements between sexes and body sides, respectively.

The Kruskal-Wallis test with a dedicated post-hoc test (Dunn's test) was used to compare these measurements between PM origin types.

RESULTS

1. Frequency of occurrence of the plantaris muscle

Out of 114 lower limbs (60 limbs of males, 54 limbs of females) from 57 cadavers, the PM was present on 104 limbs (91.2 %) and absent on ten limbs (8.8 %). The PM occurred in 55 limbs (91.7%) of males and 49 limbs (90.7%) of females. A total of 51 cadavers (89.5%) had the PM on both sides of the leg (27 males, 24 females). The PM was absent on both sides of the limbs in two males and two females. The PM was present only on the left limb of one male, while one female had the PM only on the right limb. No significant differences in frequency of occurrence were observed between the sexes nor between the body sides.

2. Classification of the plantaris muscle origin

A total of 100 PM origins were classified into three key types by sex and body sides (**Table 2**). The origin of the PM was distinguished based on its exact location of origin, where the proximal muscle belly is attached and the course of muscle belly in the posterior knee compartment.

1) Type 1: the origin is characterized by a location at the lateral supracondylar ridge, capsule of the knee joint, lateral femoral condyle, and an attachment to the lGM (73%). – **Fig. 1A**, **Fig. 2A**

2) Type 2: the origin is characterized by a location at the knee joint capsule and to the lGM, with an attachment indirectly to the lateral femoral condyle (21%). – **Fig. 1B**, **Fig. 2B**

3) Type 3: the origin is characterized by a location only at the lateral femoral condyle and to the knee joint capsule, without an attachment to the lGM (6%). – **Fig. 1C**, **Fig. 2C**

Type 1 was the most frequent type (73%). Type 2 and 3 were 21% and 6%, respectively. The most frequent type of origin in men and women was type 1 (81.5% male, 63.0% female), and type 2 (16.7% male, 26.1% female) was second, followed by type 3 (1.9% male, 10.9%). The most frequent type of origin by body sides was type 1 (78.4% left, 67.3% right), and type 2 (15.7% left, 26.5% right) was second, followed by type 3 (5.9% left, 6.1% right). No significant difference in the types of origin was observed between the sexes nor between body sides.

Table 2. Classification of the plantaris muscle origin according to sex and body sides.

Type of Origin	Sex		*p-value*	Body sides		*p-value*	Total
	M	F		Left	Right		
1	44	29	0.072	40	33	0.404	73
2	9	12		8	13		21
3	1	5		3	3		6
Total	54	46		51	49		100

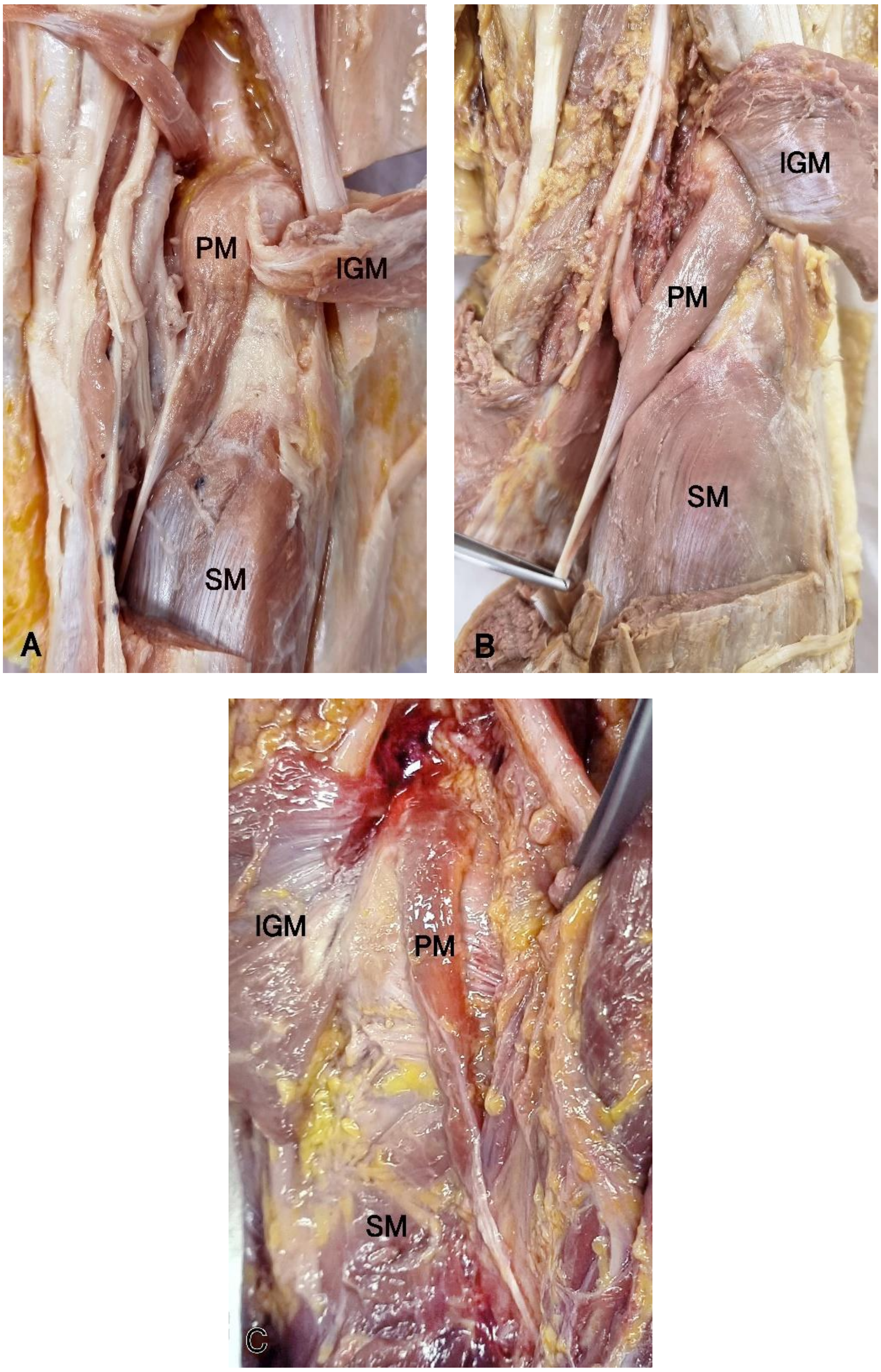

Fig 1. Three origin types of the plantaris muscle. Posterior view of the knee. (A) Type 1 origin of the plantaris muscle on the right knee. (B) Type 2 origin of the plantaris muscle on the right knee. (C) Type 3 origin of the plantaris muscle on the left knee. *PM, Plantaris muscle; lGM, lateral head of gastrocnemius muscle (cut); SM, soleus muscle.*

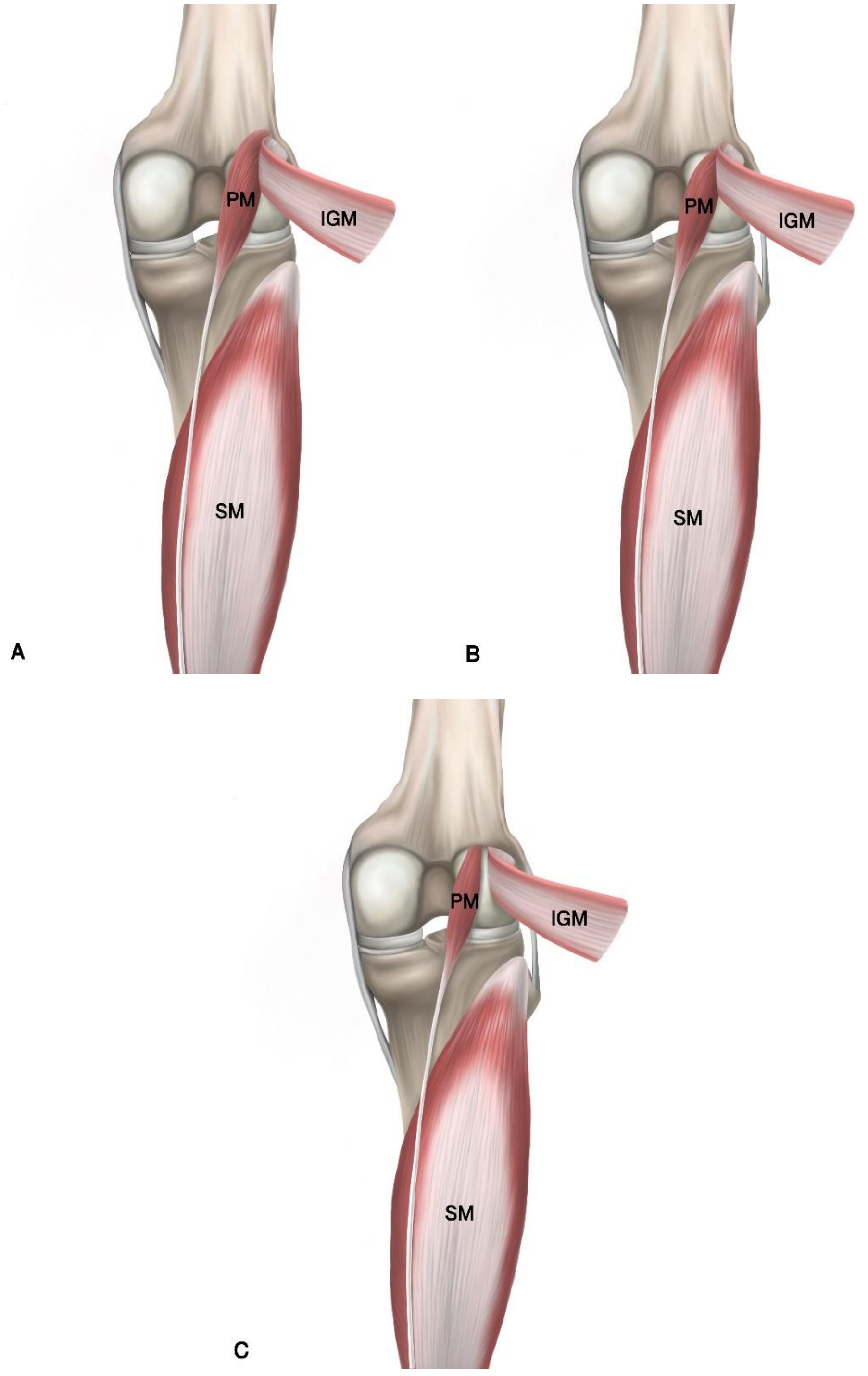

Fig 2. Schematic drawing of three origin types of the plantaris muscle. Posterior view of the right knee. (A) Type 1 of origin of the plantaris muscle. (B) Type 2 of origin of the plantaris muscle. (C) Type 3 of origin of the plantaris muscle. *PM, Plantaris muscle; lGM, lateral head of gastrocnemius muscle (cut); SM, soleus muscle.*

3. Variation of the plantaris muscle: Bicipital origin and its course of the plantaris muscle

During routine dissection in the popliteal region for research, a rare and unique variation of the PM having an additional PM was discovered in a 75-year-old Korean female cadaver on the right knee (**Fig. 3**). There was no homologic variation on the opposite side, and no signs of previous surgery or injury in the popliteal region were identified on both sides.

Two distinct PMs were present, the superior (sPM) and inferior PM (iPM), splitting into two parts at the distal belly. sPM originates from the lower lateral supracondylar ridge and the knee capsule. iPM is attached to the lGM and originates from the femoral condyle and sPM tendon. The iPM tendon travels between GM and SM and eventually ends at the calcaneal tuberosity along with the calcaneal tendon without spreading out in a wide fan shape. sPM tendon runs along with the iPM tendon until 1/3 of the GM and inserts at the fascia at the inner surface of proximal 1/3 of the mGM.

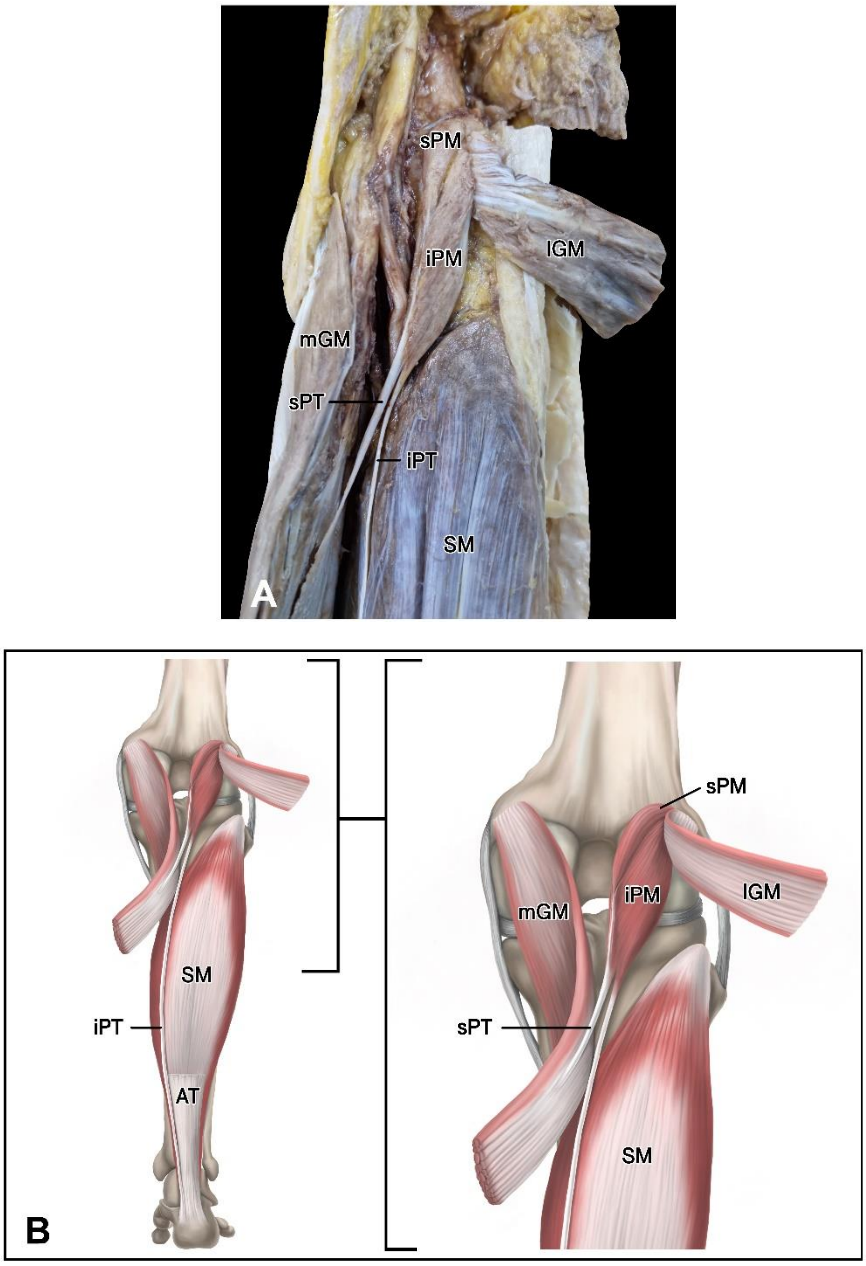

Fig 3. Variation of the plantaris muscle – Bicipital origin and its course of the plantaris muscle. Posterior view of the right knee. (A) Variation of the plantaris muscle. (B) Schematic drawing of a variation of the plantaris muscle. *sPM, superior plantaris muscle; iPM, inferior plantaris muscle; mGM, medial head of gastrocnemius muscle (cut); lGM, lateral head of gastrocnemius muscle (cut); SM, soleus muscle (cut); sPT, superior plantaris tendon; iPT, inferior plantaris tendon; AT, Achilles tendon (cut).*

4. Morphometric measurements of the plantaris muscle

Maximal belly length, belly width, MTJ width of the PM, and the tibia length of 100 limbs were measured and compared between sexes and body sides. The ratio of muscle belly length/tibia length and muscle belly width/tibia length were calculated to indicate the relative location of MTJ by the length of tibia.

Mean belly length, belly width, MTJ width, and the tibia length were 9.75 ± 1.61 cm, 1.88 ± 0.68 cm, 0.34 ± 0.12 cm, and 30.78 ± 1.92 cm, respectively. Mean belly length by the tibia length was 0.32 ± 0.05 cm, and mean belly width by the tibia length was 0.06 ± 0.02 cm, respectively.

No significant differences were found in all measurements between body sides. However, significant differences were found between sexes in all measurements, except the ratio of belly length to tibia length (**Table 3**).

Table 3. Morphometric measurements of the plantaris muscle belly and the tibia length according to sex and body sides. (BL, belly length; TL, tibia length)

Features	**Sex**		***p*-value**	**Body side**		***p*-value**	**Total** (n=100)
	Male (n=54)	Female (n=46)		Left (n=51)	Right (n=49)		
Belly length	10.17±1.49	9.27±1.62	0.005*	9.67±1.70	9.84±1.52	0.69	9.75±1.61
Belly width	2.11±0.74	1.60±0.48	<0.001*	1.84±0.59	1.92±0.77	0.96	1.88±0.68
MTJ width	0.37±0.13	0.31±0.10	0.036*	0.35±0.13	0.34±0.11	0.8	0.34±0.12
Tibia length	31.64±1.57	29.77±1.81	<0.001*	30.81±1.96	30.75±1.89	0.86	30.78±1.92
BL/TL	0.32±0.05	0.31±0.05	0.303	0.31±0.06	0.32±0.05	0.93	0.32±0.05
BW/TL	0.07±0.02	0.05±0.02	0.004*	0.06±0.02	0.06±0.02	0.98	0.06±0.02

5. Comparisons of the morphologic measurements of the plantaris muscle between origin types

A total of 100 PM origins were classified into three types (73 limbs in type 1, 21 limbs in type 2, and 6 limbs in type 3). The mean belly length, belly width, and MTJ width of the PM were compared by the types of origin.

The mean belly length of type 1 was 10.18 ± 1.39 cm, type 2 was 8.75 ± 1.39 cm, type 3 was 8.09 ± 2.31 cm. There were significant differences in the mean belly length between the three types ($p<0.001$). The mean difference between type 1 and type 2 were 1.43 cm ($p<0.001$), type 1 and type 3 were 2.09 cm ($p=0.03$), type 2 and type 3 were 0.66 cm ($p=0.832$). The boxplot of the mean belly length by the three types is shown in **Fig 4**.

The mean belly width of type 1 was 2.05±0.67 cm, type 2 was 1.46 ± 0.44 cm, type 3 was 1.22 ± 0.41 cm. There were significant differences in the mean belly width between the three types ($p<0.001$). The mean difference between type 1 and type 2 were 0.59 cm ($p<0.001$), type 1 and type 3 were 0.83 cm ($p<0.001$), type 2 and type 3 were 0.24 cm ($p=0.238$). The boxplot of the mean belly width by the three types is shown in **Fig 5**.

The mean width of the MTJ of type 1 was 0.37 ± 0.11 cm, type 2 was 0.28 ± 0.12 cm, type 3 was 0.26 ± 0.09 cm. There were significant differences in the mean width of the MTJ between the three types (p=0.003). The mean difference between type 1 and type 2 were 0.09 cm (p=0.014), type 1 and type 3 were 0.11 cm (p<0.05), type 2 and type 3 were 0.02 cm (p=0.586). The boxplot of the mean width of the MTJ by the three types is shown in **Fig 6**.

There were statistically noticeable differences between type 1 and the other types in belly length, belly width, and MTJ width. However, there were no significant differences between type 2 and type3 in all measurements.

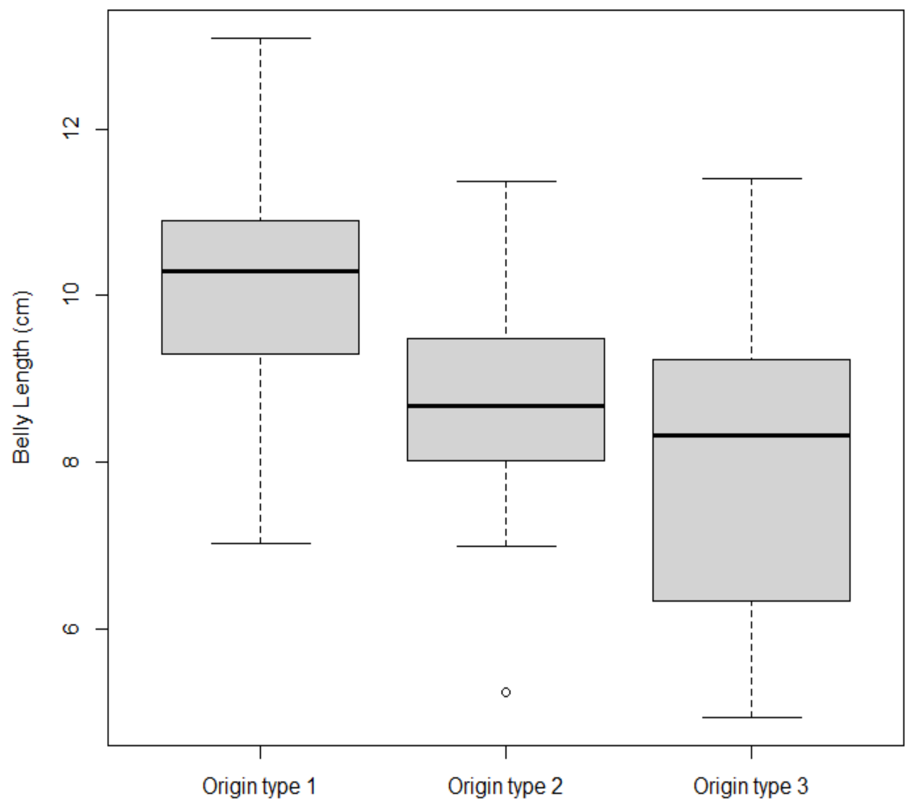

Fig 4. Boxplot of the mean belly length by three origin types of the plantaris muscle. A total of one hundred plantaris muscles are classified into three types (Type 1, 73 limbs; Type 2, 21 limbs; Type 3, 6 limbs)

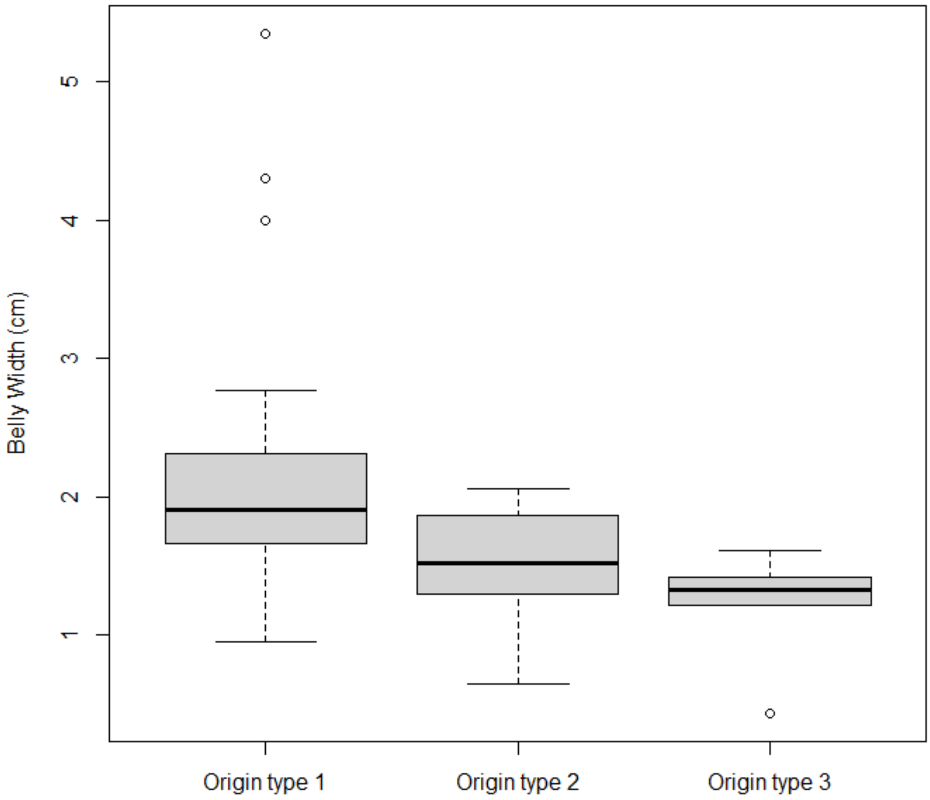

Fig 5. Boxplot of the mean belly width by three origin types of the plantaris muscle. A total of one hundred plantaris muscles are classified into three types (Type 1, 73 limbs; Type 2, 21 limbs; Type 3, 6 limbs).

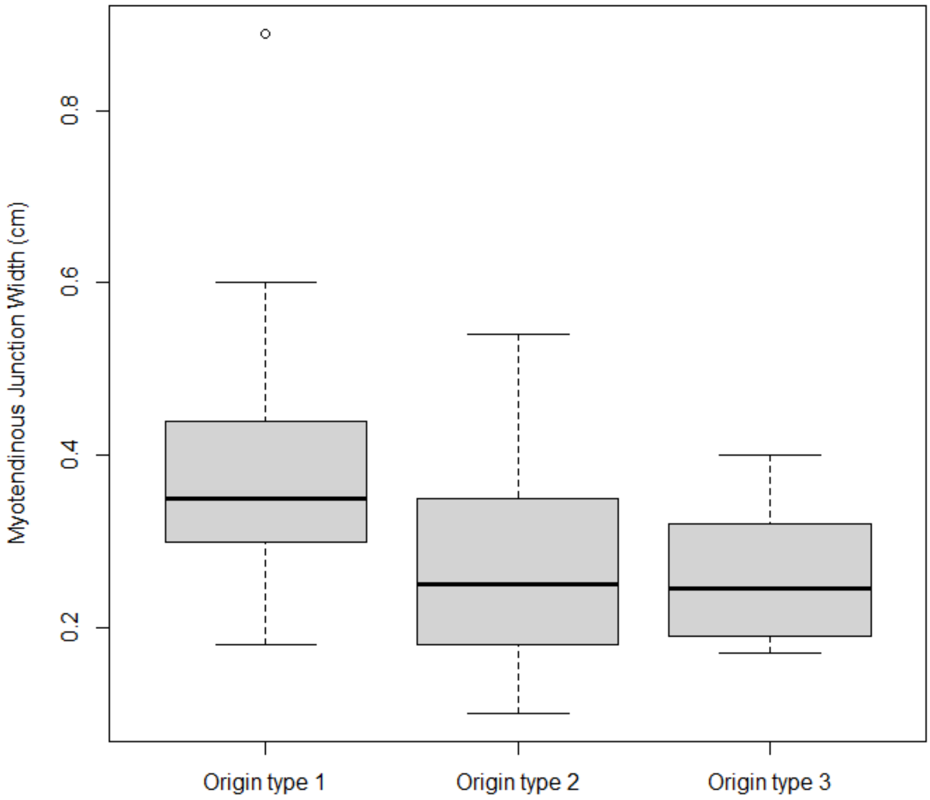

Fig 6. Boxplot of the mean width of the myotendinous junction by three types of the plantaris muscle origin. A total of one hundred plantaris muscles are classified into three types (Type 1, 73 limbs; Type 2, 21 limbs; Type 3, 6 limbs).

DISCUSSION

The PM has a small spindle-shaped muscle belly and a long slender tendon [16]. It typically originates from the lateral supracondylar ridge of the femur above the lGM and inserts at calcaneal tuberosity [1, 2, 4]. The plantaris tendon travels inferomedially between GM and SM, which comprises the triceps surae muscle group working as a flexor of the knee and ankle along with PM [3, 8]. The morphological features of the plantaris tendon make it a suitable source for tendon graft in surgical practice [5-7].

The PM is absent in 7-20% of the general population [18]. Detailed information on the occurrence of the PM by the population with the number of samples used in each study is presented in **Table 4** [1, 4, 7, 16, 18, 23-30]. However, recent studies suggest this figure ranges from 90 to 100% (Nayak et al., 2010; Aragão et al., 2010; Van Sterkenburg et al.,2011; Olewnik et al., 2017), with both Van Sterkenburg et al. and Aragão et al. reporting 100% of presence [4, 18, 24, 29]. In the present study, the PM was present in 104 lower limbs (91.2 %), showing similar results comparing with the recent literature findings.

The PM has been considered a vestigial muscle. However, recent studies consider the PM a proprioceptive organ due to its high density of muscle spindles [9]. Peck et al. reported that the PM has over nine times the spindle density of the GM, concluding that the smaller muscle may be far more sensitive to both magnitude and velocity of stretch imposed on the disparate type of pairing known as a 'parallel muscle combination' [31].

Many studies have reported that PM is highly variable in both the origin and insertion or even its course [5, 6, 9 10]. Some even reported it with two or more muscle bellies or tendons [11, 12, 15]. Herzog et al. determined the prevalence of a new accessory PM [13]. Out of 1000 patients, the accessory PM was detected in 63 patients (6.3%). Rana et al. reported double PM having two muscle bellies and tendons, the inner and outer belly [14]. The inner belly tendon had a typical course, while the outer belly fused with the lateral side of the common tendon of GM and SM a little below the middle of the leg, but the tendons belonged to each belly. The present study also introduces a variation of PM, having an additional PM with two distinct muscle bellies and tendons. While many studies have reported different kinds of unique variations of PM having accessory bellies or insertions as mentioned above, to author's knowledge, none of them has ever reported an identical variation introduced in this present study before (searched on PubMed, Embase, Cochrane Library, CINAHL, google scholar). Also, the MTJ and tendon width of sPM, which is the additional PM, is wider than the iPM, distinguishing our case from others.

Although many authors categorized the PM origin types in their own classification system, the present study proposes a simplified three-fold classification of the PM origin in the Korean population. Both type 1 and type 2 have localized attachments to the lGM, but type 3 had no attachment to the lGM.

In 2008, Freeman et al. revealed three main types based on 40 limbs: The muscle was attached without contact with neighboring muscles (n=26; 56.5%), or was present but varied from previous descriptions (n=14; 30.4%), or was absent (n=6; 13%) [23]. However, since the present study did not consider the absence of the PM as an origin type, the percentage of presence should be modified as follows. The most common type is 65%, the second common type is 22.5%, followed by the third type as 12.5%.

In 2010, Nayak et al. discovered three types of origins in 52 limbs of adult Indians [29]. The origin types were: type 1, Lateral supracondylar ridge, capsule of the knee joint and lGM in 73.07% cases; type 2, Capsule of the knee joint and the lGM in 5.76% cases, type 3, Lateral supracondylar ridge, capsule of knee joint, lGM and fibular collateral ligament in 13.46% cases. The location of type 1 origin seems to be very similar in both Indians and the present study. Also, the proportion percentage in type 1 is almost the same, and type 2 and 3 are similar to our case. However, they categorized type 3 origin as an attachment to the fibular collateral ligament, but such type was not observed in the present study.

In 2013, Ahmed et al. distinguished six types during their examination of 48 limbs, reporting the origin types at the following sites: Type 1, supracondylar ridge and oblique popliteal ligament (25%); Type 2, supracondylar ridge, lateral condyle and capsule of the knee joint (29.16%); Type 3, supracondylar ridge and lateral condyle of femur (35.41%); Type 4, supracondylar ridge, lateral condyle, capsule of the knee joint and lateral patellar ligament

(4.16%); Type 5, lateral condyle of femur only (4.16%); Type 6, supracondylar ridge and interdigitations with the lGM (2.08%) [30].

In 2020 Olewnik et al. proposed a six-fold classification system of the PM origin during their examination of 128 lower limbs [16]. The most common origin type - type I (48.4 %) was divided into two subtypes (A, B): subtype A (39.8 %) attaching to the lGM, lateral femoral condyle and the capsule of the knee joint, and subtype B (8.6 %), attaching to the lGM, the lateral femoral condyle, knee joint capsule and the popliteal surface of the femur. The second most common type was type II (25 %), locating on the knee joint capsule and to the lGM, attaching indirectly to the lateral femoral condyle. The third most common type was type III (10.15%), attaching to the lateral femoral condyle and the knee joint capsule. Type IV (6.25 %), the rarest type, attaching to the lateral femoral condyle, knee joint capsule, and iliotibial band. Type V (8.6 %) originated only from the lateral condyle of the femur. Type VI (1.6 %) contains only rare cases. It was possible to identify type I – subtype a, type II, and type III in the present study.

Different morphological measurements of the PM belly and tendon were reported by ethnicity in European, American, Asian, and Korean. In 2010, Aragao et al. measured the belly length of the PM of 20 limbs of the Brazilians as 11.38 cm [18]. Ahmed et al. in 2013 measured the belly length, belly width, and tendon width of 50 limbs of Indians as 7.99 cm, 1.62 cm, 0.3 cm, respectively [30]. In 2016, Najma Mobin measured the mean belly length of 60 limbs of Indians as 7.65 cm [32]. A study of 128 limbs of Polish in 2020 by Olewnik et al. presented measurements of the PM [16]. The mean muscle belly length, belly width, and tendon width were 9.001 cm, 1.88 cm, and 0.34 cm. However, it is essential to note that Ahmed et al. and Olewnik et al. measured the tendon width. Since the present study measured the width of the MTJ, it seems to be challenging to compare the measurements.

When diagnosing patients with injuries at the calf and popliteal area, many practitioners mostly rely on MR and ultrasound imaging [33]. However, cognizing the exact location of the muscle belly and MTJ, where injuries occur frequently, would be helpful when examining a patient. The present study indicates a relative location of the MTJ by the tibia length. It has not been studied in emphasis before. Understanding the location of MTJ might be helpful for surgeons harvesting tendon donors or clinically diagnosing patients with posterior knee pain.

While many pieces of literature have reported morphological features of the PM regarding the origin and insertion type, its course, and thickness of the muscle belly, studies on Asians, especially Koreans, are scarce. The present study will retain the anatomical and physical anthropologic baseline data of the PM of the Koreans by obtaining a general idea of the morphological features of the PM by classifying and simplifying the three origin types of the PM and setting representative measurements of the PM. Moreover, indicating the relative location of MTJ by the length of the tibia in Korean would be helpful in both clinical and surgical practices.

Table 4. Reported presence of the plantaris muscle.

Study	Population	Number of samples (limbs)	Presence (%)
Wagenseil et al. (1936)	Chinese	149	92
Harvey et al. (1983)	Australian	1316	81.8
Simpson et al. (1991)	American	23	91.3
Li et al. (2000)	Chinese	20	85
Alagoz et al. (2008)	Turkish	34	94.1
Freeman et al. (2008)	Netherlands	46	86.96
Nayak et al. (2010)	Indian	52	92.31
Aragão et al. (2010)	Brazilian	20	100
van Sterkenburg et al. (2011)	Netherlands	107	100
Ahmed and Sarwari (2013)	Indian	50	96
Olewnik et al. (2017)	Polish	50	96
Olewnik et al. (2018)	Polish	130	89.2
Olewnik et al. (2020)	Polish	142	90.1
Present study (2021)	Korean	114	91.2
Mean		161	91.86

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국문요약

장딴지빗근은 작은 방추형의 힘살과 장딴지근과 가자미근 사이에 안쪽 아래로 주행하는 얇고 긴 힘줄로 구성되어 있으며, 약한 굽힘 작용을 한다. 장딴지빗근의 힘줄 부위는 힘줄 이식술의 재료로 사용되기도 한다. 장딴지빗근은 인구의 7-20%에서 발견되지 않으며, 흔적기관으로 널리 알려져 있다. 다양한 변이를 보이는 이 근육은 이는곳과 닿는곳의 유형을 분류하거나 특이한 변이를 보고하는 연구가 주로 이루어졌다. 최근의 연구에서는 장딴지빗근과 관련하여 테니스 레그, 슬개대퇴 증후군, 장경인대 증후군, 아킬레스 건염 등 임상적 의의에 초점을 둔다.

본 연구의 목적은 한국인의 장딴지빗근 이는곳의 형태학적인 특성을 파악하여 임상적으로 활용 가능한 해부학적, 체질인류학적 기초자료를 확보하는 것이다. 총 57구(114쪽)의 한국인 시신을 해부하여 장딴지빗근의 발생 빈도를 파악하고, 이는곳의 유형을 분류하며, 힘살의 길이와 너비를 성별과 좌우로 나눠 계측하였다. 또한, 정강뼈 길이에 따른 근힘줄이음부의 상대적인 위치를

제공하였으며 이는 오금 부위에 통증이 있는 환자를 진단하거나 힘줄 이식술 수행 시 임상적으로 유용하게 활용이 가능할 것으로 사료된다.

중요단어: 장딴지빗근, 이는곳 유형, 힘살, 근힘줄이음부, 장딴지빗근 힘줄, 테니스 레그