Anatomical Aspects of the Gastrocnemius Aponeurosis and Its Insertion: A Cadaveric Study

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Anatomical variation in the attachment of the gastrocnemius muscle to the soleus muscle has not been studied previously. The gastrocnemius muscle may insert directly onto the tendinous superficial surface of the soleus; however, in most cases, the distal end of the gastrocnemius aponeurosis extends for a variable distance as a thin, tendinous sheet void of muscular attachments. Surgeons performing a gastrocnemius recession may target the exposed inferior portion of the aponeurosis that is not directly covered by muscle. This is the subject of this anatomical study. Fifty-three embalmed cadaveric specimens were dissected to measure the length of the gastrocnemius aponeurosis medially and laterally. Three aponeurosis length categories were subjectively developed according to the ease with which a surgeon might release the gastrocnemius from the soleus: long aponeurosis (minimum aponeurosis length greater than 10 mm; 53% of specimens); short aponeurosis (9%), and direct attachment of the gastrocnemius muscle to the soleus on the medial side, lateral side, or both (38%). The typical gastrocnemius aponeurosis in the sample was distinctly shorter medially and longer laterally. For aponeuroses in the long aponeurosis category, the median length medially was 22.5 mm and median length laterally was 51 mm. In the short aponeurosis category, median medial length was 5 mm and lateral length was 22 mm. The lateral length was 1.8 times greater than the medial length for the long aponeurosis and 5 times greater for the short aponeuroses. Understanding the variation of the gastrocnemius aponeurosis will aid the surgeon in choosing a recession technique, performing the procedure, and preventing iatrogenic complications. (The Journal of Foot & Ankle Surgery 46(2):101–108, 2007)

Key words: gastrocnemius recession, equinus, Achilles' lengthening

The gastrocnemius recession is a surgical procedure that involves transecting or lengthening the gastrocnemius aponeurosis at its insertion into the soleus aponeurosis. It is often performed as an ancillary procedure to treat a variety of foot and ankle disorders including symptomatic adult pesplanovalgus, plantar fasciitis, and diabetic forefoot ulcerations (1–4). A contracted or tight gastrocnemius muscle is thought to impart a deforming force on the foot throughout gait (5). Several recession techniques and surgical approaches have been described. Some surgeons advocate isolated gastrocnemius release through a medial or posterior approach, whereas others selectively lengthen the gastrocnemius aponeurosis with or without also lengthening the soleus

aponeurosis through a direct posterior approach (5–7). More recently, endoscopic gastrocnemius release has been used (8, 9).

Being aware of the range of anatomical variation in the size and attachments of the gastrocnemius aponeurosis may aid the surgeon when performing the gastrocnemius recession. The aponeurosis must be understood in the context of the anatomy of the entire triceps surae muscle complex. The triceps surae is formed of the relatively superficial gastrocnemius muscle, the deeper soleus muscle, and the Achilles' tendon, which forms from the fusion of the aponeuroses of the gastrocnemius and soleus. The soleus originates from the posterior aspects of the tibia and fibula. Its muscle fibers are anterior to its tendinous posterior or superficial surface, which forms a relatively broad, flat field for attachment of the gastrocnemius aponeurosis (Fig 1). The medial and lateral bellies of the gastrocnemius are very distinct proximally where they originate from the posterior aspects of the medial and lateral femoral condyles, respectively. The medial and lateral bellies abut and merge below the knee and then become more distinct distally. Unlike the soleus musculature, the gastrocnemius musculature is posterior (superficial) to its aponeurosis; both gastrocnemius muscle bellies anchor to a single thin aponeurosis on the muscle's deep

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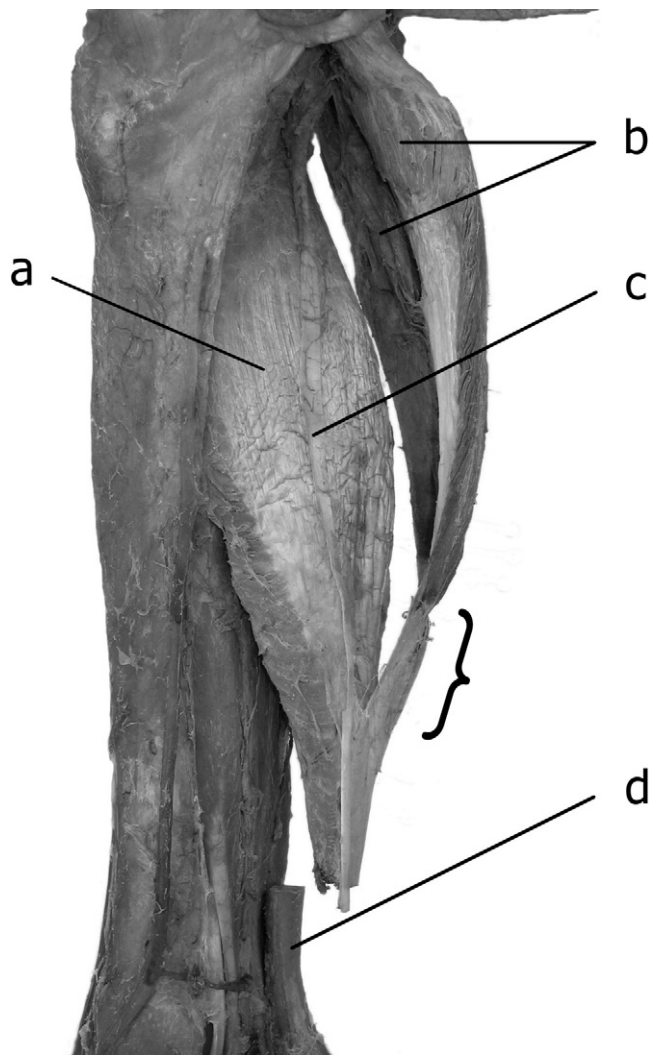
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FIGURE 1 Medial view of cadaveric specimen demonstrating the posterior compartment of the leg. Skin, subcutaneous tissue, and superficial fascia are removed. Soleus muscle (*a*). Gastrocnemius muscle (*b*). Plantaris (*c*). The gastrocnemius muscle fibers are posterior to its aponeurosis, whereas the soleus muscle fibers are anterior to its aponeurosis. The gastrocnemius aponeurosis continues for a variable distance inferior to the distal ends of the medial and lateral heads of gastrocnemius to reach its line of attachment to the soleus aponeurosis. In clinical practice, we term this portion of the gastrocnemius aponeurosis that is devoid of muscular attachment the "gastroc run-out" (*bracket*). Combined aponeuroses of soleus and gastrocnemius fuse to ultimately form the Achilles' tendon (*d*).

surface. Although the deep surface of the gastrocnemius aponeurosis and the superficial surface of the soleus aponeurosis are in direct contact with each other, there is little or no tendinous connection between them except at the inferior end of the gastrocnemius aponeurosis, where the two meet and abruptly fuse (Fig 1). The gastrocnemius aponeurosis continues for a variable distance inferior to the distal ends of the medial and lateral heads of gastrocnemius

to reach its line of attachment to the soleus aponeurosis. This inferior portion that has no muscle fibers attaching directly to it is covered by deep fascia and superficial fascia containing the small saphenous vein and the sural nerve. It is important to distinguish the exposed inferior portion because surgical division there eliminates the connection of the gastrocnemius to the Achilles' tendon, whereas targeting the superior portion in a lengthening procedure can leave much of the gastrocnemius muscle functionally intact.

When there is a lengthy gastrocnemius aponeurosis, it may easily be separated from the underlying soleus and selectively isolated for complete or partial transection. A short gastrocnemius aponeurosis and/or direct attachment of the muscle may make the transection more challenging. Although these relationships are easily recognized in the cadaver, the lengths of the gastrocnemius aponeuroses have not been previously quantified. Neither has any classification based on length as it relates to the ease of surgical release been established, nor have the relative incidences of the different types of attachment been established either. The purposes of this investigation were to quantify variation in the length of the gastrocnemius aponeurosis and to describe the morphology of the attachment of the gastrocnemius aponeurosis to the superficial surface of the soleus.

Materials and Methods

A total of 131 legs from 66 cadavers were obtained from full-body cadavers at the conclusion of 3 human gross anatomy laboratory courses. After overdissected and desiccated specimens were rejected, 53 specimens were available for inclusion in the study. Specimens chosen for the study showed no evidence of having had previous surgical intervention in the posterior compartment of the leg. Some of the specimens had been dissected by students; others were pristine at the time of selection. The students had been instructed to avoid vigorous dissection of the gastrocnemius aponeurosis, but some specimens were rejected because the natural extents of the gastrocnemius aponeurosis could not be determined with certainty. In general, this meant that specimens were not selected unless the deep fascia investing and connecting the muscles remained intact until the investigators dissected it.

There were 10 isolated left-side specimens, 13 isolated right-side specimens, and 30 right-side and left-side specimens from matched pairs. The mean age at death was 82.2 years (range, 53–97 years). The selected specimens were harvested from 19 men, 18 women, and 1 specimen of unknown sex. Racial and ethnic data were not obtained.

The skin, subcutaneous tissue, and most superficial investing deep fascia were removed from the specimens to expose the entire triceps surae. Proximally, the gastrocnemius and soleus were transected 2 to 3 cm superior to its

attachments of the gastrocnemius to the soleus. Distally, specimens were transected at the Achilles' tendon. These relevant sections of the specimens were removed as a unit and then pressed flat manually to eliminate the inherent curvature of the structures to be measured.

For consistency, the landmarks for all measurements were identified and marked by one investigator (N. M. B.) and then verified and agreed upon by the other investigator (D. J. E.), who made all measurements (see below). Five red pins (points A, B, C, D, E) characterized the distal extent of the gastrocnemius muscle tissue (Fig 2). The most distal point on the medial border of the gastrocnemius was defined as point A. The most distal muscular attachment of the medial head of the gastrocnemius was defined as point B. The confluence of the medial and lateral heads of gastrocnemius was defined as point C. The most distal muscular attachment of the lateral head of the gastrocnemius was defined as point D. Finally, the most distal point on the lateral border of the gastrocnemius was defined as point E. These gastrocnemius pins always created a "W" configuration, with point B usually inferior to point D.

Five yellow pins (points P, Q, R, S, T) marked the points of attachment of the gastrocnemius aponeurosis onto the soleus (Fig 2). Above these points (superior), the gastrocnemius and soleus aponeuroses are not united and easily separated. Points P and T were defined as the sites where the medial edge and lateral edge of the gastrocnemius aponeurosis fused to the soleus. The most proximal points of attachment in the medial and lateral parts of the aponeurosis were marked as points Q and S, respectively. The most distal point of attachment between points Q and S was indicated by a yellow pin at point R. These 5 pins usually took the form of the letter "M."

A Cartesian coordinate system was created with its origin located at point A and its y-axis along the line segment anteroposterior (AP) to establish the locations of each of these landmark points (Fig 2). (Line segment AP was chosen as the y-axis because the superior-to-inferior axis of the lower limb could not be precisely determined from the bloc specimens, and because the medial edge of the gastrocnemius aponeurosis is a key surgical landmark when the gastrocnemius recession is performed through a medial approach.) In specimens with a very short AP length, the y-axis was established as a line segment connecting point A to an arbitrary point located distally along the medial edge of the gastrocnemius aponeurosis or Achilles' tendon. Using a ruled straightedge and calipers, orthogonal distances to the nearest millimeter from point A to each of the other points were measured parallel to this axis and perpendicular to it (x-axis). The Pythagorean theorem was used to calculate distances between points B and Q (medial aponeurosis) and also D and S (lateral aponeurosis) (Fig 2). Although intra-rater reliability was not assessed rigorously, occasional re-pinning and re-measuring suggested a 2-mm mar-
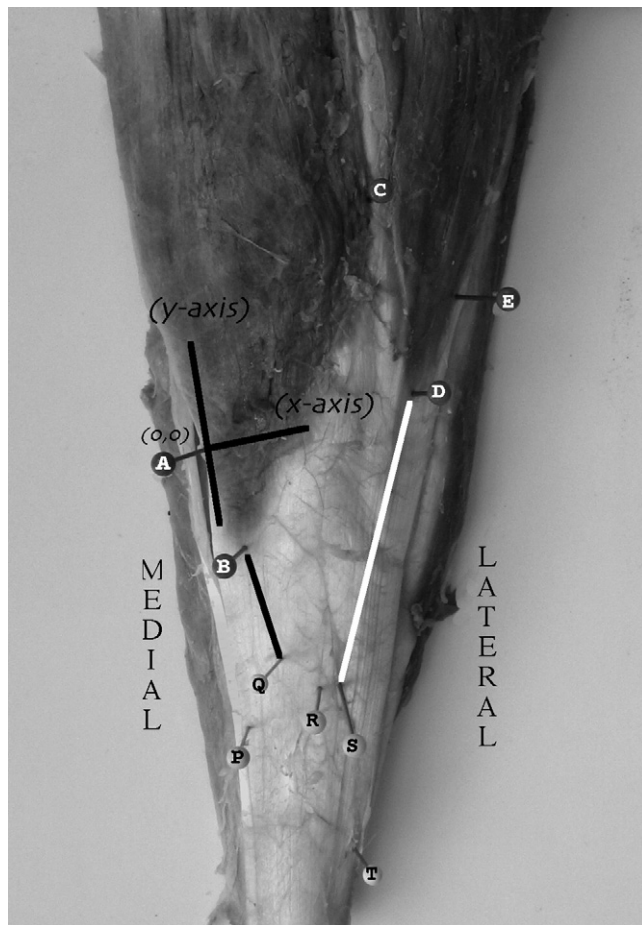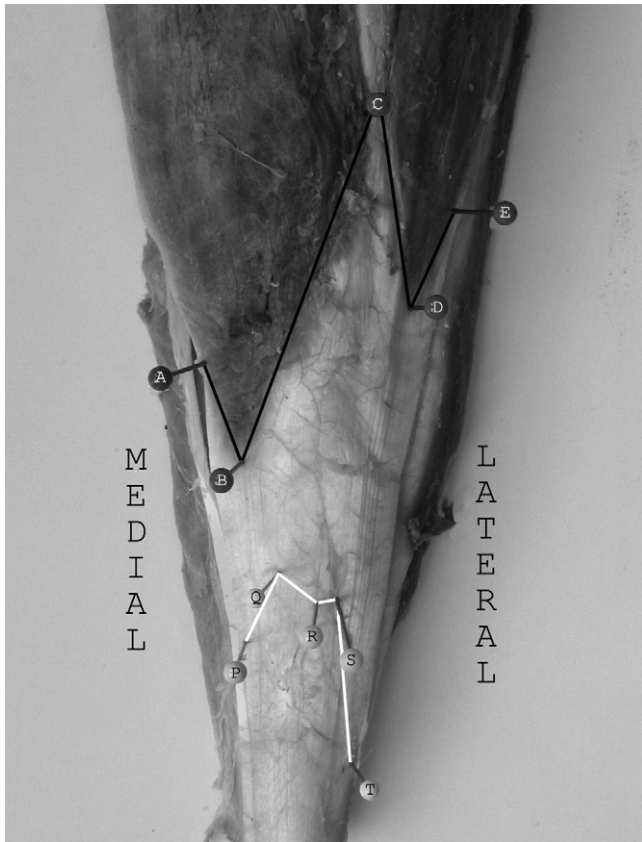

FIGURE 2 Cadaveric specimen demonstrating the landmarks used to identify the distal extent of gastrocnemius muscle (points A, B, C, D, E) and its insertion (points P, Q, R, S, T). The Cartesinan coordinate system was centered at point A (0, 0). The lengths of the medial and lateral aspects of the gastrocnemius aponeurosis, lines BQ (*black line* connecting points B and Q), and DS (*white line* connecting point D and S), respectively, were calculated with the Pythagorean theorem.

gin of error. No measurement of error analysis was conducted.

Each specimen was grouped into 1 of 3 predetermined categories of gastrocnemius insertion: direct attachment, short aponeurosis, and long aponeurosis. In the direct attachment category, the deep surface of either or both heads of the gastrocnemius muscle attached to the soleus aponeurosis at a point proximal to the inferior tip of the relevant gastrocnemius belly. Thus, if either point B was distal to or equal to point Q or point D was distal to or equal to point S, the specimen was classified as direct attachment. Specimens were categorized as short aponeurosis if there was no direct attachment and either the medial or lateral aponeurosis was 10 mm or less. Specimens in the long aponeurosis category had medial and lateral aponeuroses greater than 10 mm. The distinction between short and long aponeurosis categories

FIGURE 3 Cadaveric specimen demonstrating a long gastrocnemius aponeurosis of the medial and lateral aspects of the gastrocnemius aponeurosis. *Black line* delineates distal extent of muscular tissue (points A, B, C, D, E). *White line* delineates gastrocnemius insertion (points P, Q, R, S, T) onto the underlying soleus aponeurosis. A gastrocnemius recession may be easily performed with a long gastrocnemius aponeurosis.

TABLE 1 Numbers of specimens with long aponeuroses, short aponeuroses, and direct attachments (n = 53)

	Long Lateral	Short Lateral	Direct Lateral
Long medial	28	0	0
Short medial	5	0	2
Direct medial	9	3	6
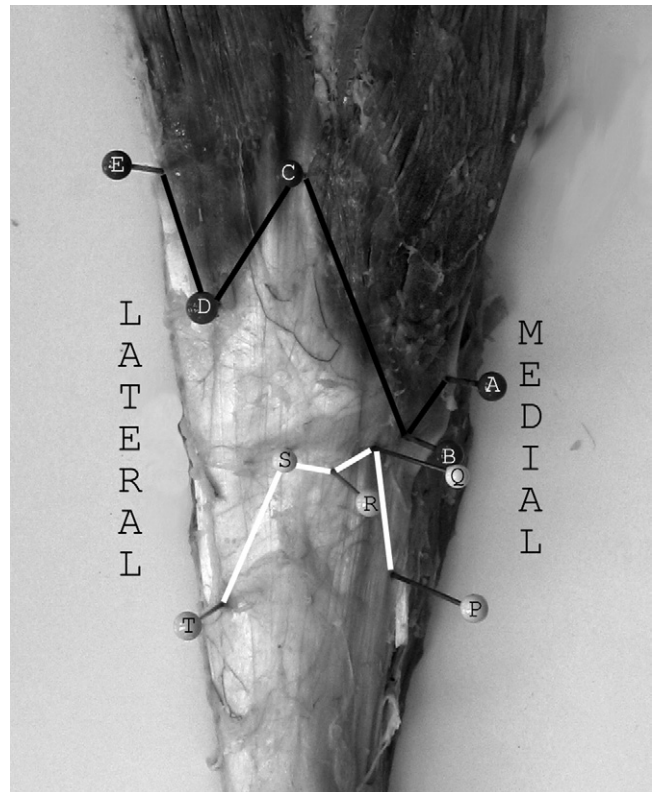
FIGURE 4 Cadaveric specimen demonstrating a short medial aponeurosis. *Black line* delineates distal extent of muscular tissue (points A, B, C, D, E). *White line* delineates gastrocnemius insertion (points P, Q, R, S, T) onto the underlying soleus aponeurosis. In this specimen, a short aponeurosis (BQ ≤ 10 mm) is identified medially.

was based on the surgical experience of the primary author (N. M. B.); a short aponeurosis could make isolated transection of the gastrocnemius aponeurosis challenging.

Aponeurosis length measurements are expressed as medians and ranges because there was no assurance that the data would match the assumptions for parametric statistical analyses (for example, normal distributions, equal variances of subsets to be compared). The statistical significance of the difference between medial and lateral aponeurosis length for all long and short aponeurosis specimens was assessed by a 1-tailed Wilcoxon signed-rank test, a nonparametric alternative to the pairwise *t* test. No other statistical inferences were made.

Results

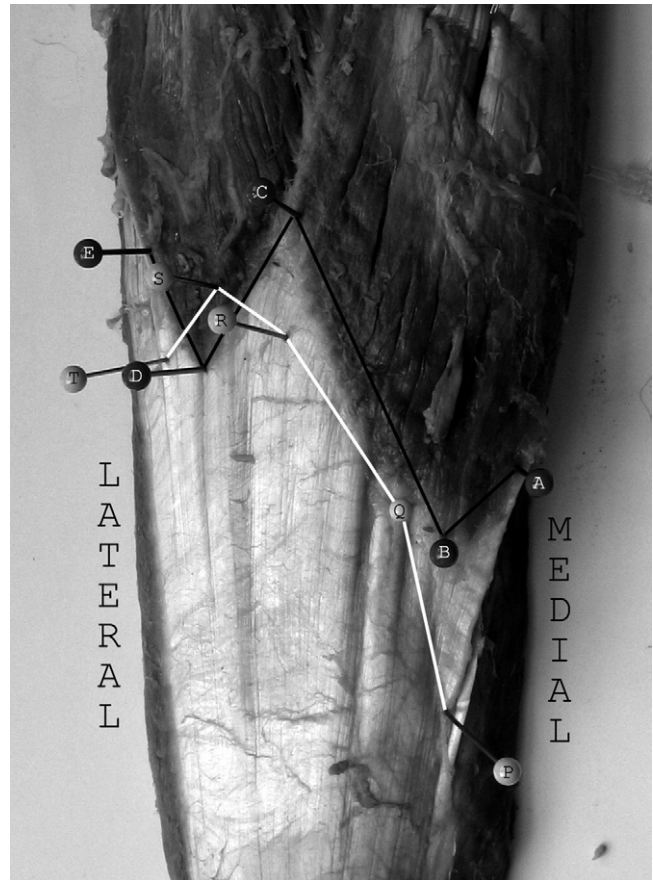There were 28 specimens with long aponeuroses both medially and laterally (53% of total specimens) (Fig 3 and Table 1). A long medial aponeurosis was never associated with a short lateral aponeurosis or a direct lateral attachment. Five specimens were categorized as short aponeurosis (9% of total specimens). All had a short aponeurosis medially (BQ ≤ 10 mm) and a long aponeurosis laterally (DS > 10 mm) (Fig 4). There were no instances of specimens with a short aponeurosis medially and laterally. Twenty specimens (38% of total specimens) were categorized as direct attachment because they had direct attachments of one or both heads of gastrocnemius. In this group, there were 12 direct attachments of the medial head only (Fig 5). Three of these were the only specimens with short lateral aponeuroses. Both heads of gastrocnemius attached directly to the
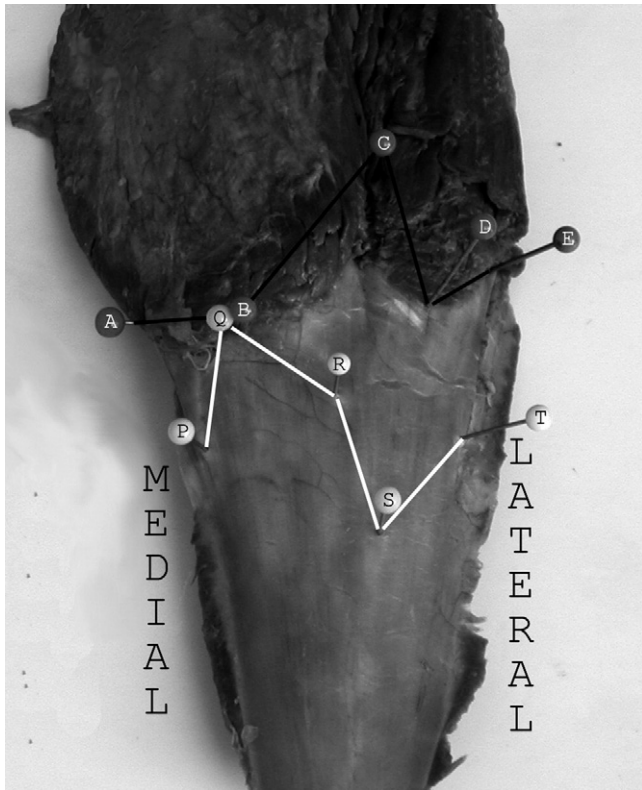
FIGURE 5 Cadaveric specimen demonstrating a direct attachment of the medial head of the gastrocnemius onto the soleus aponeurosis (points A, B, C, D, E). *Black line* delineates distal extent of muscular tissue. *White line* delineates gastrocnemius insertion (points P, Q, R, S, T) onto the underlying soleus aponeurosis.

FIGURE 6 Cadaveric specimen demonstrating a direct attachment of both heads of the gastrocnemius muscle onto the soleus aponeurosis. *Black line* delineates distal extent of muscular tissue (points A, B, C, D, E). *White line* delineates gastrocnemius insertion (points P, Q, R, S, T) onto the underlying soleus aponeurosis.

soleus aponeurosis in 6 specimens (Fig 6). Two specimens had direct attachment of the lateral head only.

Gastrocnemius aponeuroses were shorter medially and longer laterally. This was evidenced in 4 ways. First, Table 2 shows that for all categories of medial attachment, the median medial aponeurosis was shorter than the median lateral aponeurosis. Within the long aponeurosis group, the median BQ distance was 22.5 mm compared with a median DS distance of 51 mm, and within the short aponeurosis group, the median BQ distance was 5 mm compared with the median DS distance of 22 mm. Calculating the median ratio of lateral aponeurosis to medial aponeurosis shows that the lateral aponeurosis was 1.8 times greater than the medial aponeurosis for the long aponeurosis group versus 5 times greater for the short aponeurosis group (Table 2). Second, there were 42 specimens with a long lateral aponeurosis but only 28 long medial aponeurosis (BQ > 10 mm) (Table 1). Third, Table 1 also shows that there were 12 specimens with direct medial attachment and long or short lateral aponeuroses (DS median = 18 mm; range, 2–66 mm), but only 2 specimens had direct lateral attachment and short medial aponeurosis, and none had direct lateral attachment and long medial aponeurosis. Fourth, for 29 of the 33 specimens with

TABLE 2 Medians and ranges of lengths of medial aponeurosis, lateral aponeurosis, and DS/ BQ ratio

	Count	Medial Aponeurosis (BQ, mm)		Lateral Aponeurosis (DS, mm)		DS/BQ Ratio	
		Median	Range	Median	Range	Median	Range
Long	28	22.5	13–63	51	12–113	1.8	0.2–6.8
Short	5	5	4–8	22	15–91	5.0	2.8–18
Direct	20	0*	0*–10	7	0*–66	—	—

*Direct attachments were scored as 0 mm to calculate medians and ranges of lateral and medial aponeurosis.

no direct attachment, the medial aponeurosis was shorter than the lateral aponeurosis (BQ < DS). The median difference between medial aponeurosis and lateral aponeurosis (DS-BQ) for the 33 specimens was 20 mm (range, −38–87 mm). This difference is highly significant ($P \leq .001$, Wilcoxon signed-rank test, z = 3.74).

Discussion

Surgeons may release or lengthen the gastrocnemius aponeurosis (gastrocnemius recession) as an isolated procedure or concomitantly when treating equinus in neurologically normal individuals (5, 10). It is important to anatomically distinctly distinguish the portion of the gastrocnemius aponeurosis that is not attached to the muscle because surgical lengthenings of the aponeurosis may involve only the muscular-free portion, whereas other lengthenings specifically target the muscular-bound portion of the gastrocnemius aponeurosis. Several recession techniques have been described; however, variations in the gastrocnemius aponeurosis have not been studied previously.

The procedure was first described by Vulpius and Stoffel in 1913 in neurologically impaired individuals for the treatment of spastic equines (11). They performed a chevron transection of the gastrocnemius aponeurosis as well as incision of the deep fibers of the soleus at the middle of the leg. Subsequently, in 1924, Silfverskiöld distinguished between isolated gastrocnemius equinus and gastrocnemius soleus equinus by comparing ankle dorsiflexion with the knee flexed to dorsiflexion with the knee extended (12). Through a transverse incision in the popliteal crease, he released the gastrocnemius origins from the femoral condyles and positioned the muscle below the knee, thereby converting the gastrocnemius to a muscle that would act on the ankle and subtalar joints only. In 1950, Strayer sectioned the gastrocnemius aponeurosis transversely where it attached to the soleus aponeurosis (13, 14). Baker advocated a tongue-and-groove cut (15). Lamm et al recently published their technique of a gastrocnemius soleus recession through a posterior midline approach (7). Baumann and Koch performed multiple transections of the muscular bound portion of the gastrocnemius aponeurosis with or without aponeurotic lengthening of the soleus through an 8 cm–12 cm medial incision for spastic contractures in a pediatric population (16). Similarly, the primary author (NMB) and Rush prefer to perform isolated transection of the muscular bound portion of the gastrocnemius muscles—a procedure we better termed the Gastrocnemius Intramuscular Aponeurotic Recession (GIAR) (21). In this situation, the insertion of the gastrocnemius aponeurosis is undisturbed. Several authors have described modifications of the original Vulpius procedure, and other techniques and approaches have been described (13–21).

It is more difficult to predict the functional effects of performing a Vulpius transection (both gastrocnemius and soleus aponeurosis) or of incidentally incising part of the soleus aponeurosis at the point of a direct gastrocnemius attachment. When the soleus aponeurosis is transected, the muscle retains at least some continuity through the intact deeper muscle tissue, but the extent to which soleus muscle fibers that originally inserted on the soleus aponeurosis proximal to the transection can transmit force to the Achilles' tendon through the remaining connective tissue of the muscle is unknown. An isolated gastrocnemius recession with the Strayer method or GIAR will influence only the gastrocnemius muscle.

Thorough understanding of the anatomy of the confluence of the gastrocnemius and soleus will aid the surgeon in the performance of the gastrocnemius recession. A lengthy gastrocnemius aponeurosis is easily separated from the underlying soleus aponeurosis, and it may be selectively transected. A case with a short aponeurosis is more challenging: it may not be possible to perform the transection with a single transverse cut across the aponeurosis, and transection of the distal part of the gastrocnemius musculature may occur. A short aponeurosis can often be converted into a long aponeurosis by forcible blunt dissection. In some cases, the gastrocnemius aponeurosis may be extended, thus allowing sufficient aponeurosis for transection. When the deep surface of the distal part of the gastrocnemius muscle itself attaches directly to the soleus without an aponeurosis, the recession cannot be completed without either transecting the soleus aponeurosis or detaching the gastrocnemius muscle from its direct insertion. This may result in iatrogenic transection of sections of the soleus aponeurosis and shredding of the musculature, and a gastrocnemius soleus recession is unintentionally performed. With direct attachments, the anatomy may lend itself to a GIAR instead. A recent retrospective study by Rush demonstrated a low morbidity in 126 cases with a high gastrocnemius recession (22).

The large DS/BQ ratio in the short aponeurosis group (median, 5.0) demonstrates that if a short aponeurosis is encountered medially, the lateral aponeurosis is likely to be long enough to not present a challenging surgical release unless the lateral gastrocnemius muscle has a direct attachment. This finding is especially important when performing a gastrocnemius recession through the medial approach because the portion of the aponeurosis that is more likely to be narrower will be encountered first and will be visualized easily.

Specimens with direct attachment (no aponeurosis) of both gastrocnemius heads to the soleus accounted for 36% of the 20 direct attachment specimens. Among specimens with at least one direct attachment (either medial or lateral), the most common variation was the isolated medial head attachment (55% of all direct attachment specimens). Direct medial head attachment was associated with a median lateral aponeurosis of 18 mm. This finding suggests that after the direct attachment of the medial head is surgically released, then the lateral aponeurosis will usually not pose a surgical problem. However, 3 of these 12 specimens that had short lateral aponeurosis may have presented a surgical challenge. Isolated lateral head attachment was the least common variation (9%). One of these 2 specimens had a

long medial aponeurosis (11 mm), and the other had a short medial aponeurosis (6 mm).

The anatomical aspects of the gastrocnemius aponeurosis identified in this study demonstrate that the medial side is in every way likely to be more restricted than the lateral side: it is more likely to have a direct attachment, more likely to have a short aponeurosis, and if the aponeurosis is long both medially and laterally, the medial aponeurosis is likely to be the shorter of the 2. Even if there is a direct attachment or short aponeurosis medially, a long lateral aponeurosis is mostly likely to be identified laterally. Because of this widening of the gastrocnemius aponeurosis from medial to lateral, we believe than an open gastrocnemius recession would be technically easier to perform through a medial or posterior approach because the medial side with less aponeurosis wound be directly visualized and encountered first.

There are several limitations in this study. The specimens were obtained as a convenience sample from cadavers that had been dissected in a medical school anatomy course. The anatomical variation of the sample may not match the variation in a population of patients with pathological conditions affecting the foot and ankle. Potential specimens were rejected if there was evidence that students had stripped away some of the fleshy gastrocnemius muscle fibers at the insertion onto the aponeurosis or if they had increased the length of the aponeurosis distally. However, no record of which specimens came from previously undissected lower limbs was kept. Several candidate specimens were rejected because desiccation made it hard to determine the exact location of the attachments of the gastrocnemius aponeurosis.

Establishing the Cartesian coordinate system according to the medial edge of the gastrocnemius aponeurosis (line segment between points A and P) allowed quick, reproducible measurements. This alignment is pertinent to surgery because the medial edge of the gastrocnemius is a key surgical landmark when the gastrocnemius recession is performed through a medial approach. However, in 11 cases with little or no medial aponeurosis, the standard axis could not be used, and in cases where the gastrocnemius aponeurosis tapered strongly from a wide muscle, the axis defined by points A and P was rotated far from the superior-to-inferior axis of the whole limb. Neither of these issues affects the results of the trigonometric calculations to obtain BQ and DS distances.

For the purposes of this study, we defined a short aponeurosis as ≤10 mm of gastrocnemius aponeurosis because it was felt that this length may present a challenge when surgically releasing the aponeurosis. As such, we created a classification scheme based on this assumption, and short aponeuroses were distinguished from long aponeuroses based on a predetermined categorization and not based on a post hoc categorization determined by our observations. It is possible that categorizing shorter aponeuroses is of no clinical or surgical significance, and the distinction between a direct attachment from those with any length aponeurosis at all may be the influential surgical decision-making factor.

Recognition of the existence of short aponeuroses and direct attachments of the gastrocnemius to the soleus aponeurosis raises several questions regarding anatomical, functional, and technical aspects of the gastrocnemius recession. Are the observed variations in the type of gastrocnemius insertion and the length of aponeurosis associated with pathological conditions such as equinus, or with specific foot types such as pes planovalgus? Are postoperative complications more common or more severe when gastrocnemius recession is performed across a direct attachment? Should lengthening of the muscular-bound portion of the gastrocnemius aponeurosis (i.e., GIAR) be performed with direct attachments? Are there differences between isolated gastrocnemius recession and combined gastrocnemius soleus recession with regard to the overall desired functional effect of the release procedure (that is, increasing dorsiflexion at the ankle with the leg extended at the knee)? The answers to the latter 2 questions will provide information pertaining to the appropriate amount of care to be taken in minimizing transection of the soleus when a direct attachment is present. One would also want to know how the anatomy of the attachment and the chosen surgical approach relate to functional outcomes and differences in the incidence and severity of complications in the short and long term. Would preoperative assessment with magnetic resonance imaging or ultrasound be worthwhile? Finally, how can knowledge of gastrocnemius aponeurosis anatomy best be applied in the context of endoscopic surgery?

Conclusion

Variations in the gastrocnemius aponeurosis length are encountered during surgery and have not been studied previously. The 3 anatomical categories of gastrocnemius length were subjectively created based on the ease with which a surgeon might selectively release the gastrocnemius aponeurosis from the soleus. They are as follows: 1) direct attachment with no aponeurosis on either the medial and/or lateral side; 2) short aponeurosis (≤10 mm); and 3) long aponeurosis. When there is a lengthy gastrocnemius aponeurosis, it may easily be separated from the underlying soleus and selectively isolated for complete or partial transection. A short gastrocnemius aponeurosis and/or direct attachment of the muscle may make the transection more challenging.

Understanding the range of anatomical variation in the insertion of gastrocnemius onto the tendinous superficial surface of the soleus muscle will aid the surgeon in choosing a recession technique and performing the procedure.

Based on this cadaveric study, the following anatomical observations were made:

1. Long aponeurosis group was the most common variation (53% of specimens). The direct attachment group occurred in 38% of specimens, and short aponeurosis group was the least common (9% of specimens).
2. There is an anatomical widening of the gastrocnemius aponeurosis demonstrated by an overall pattern of shorter aponeuroses medially with longer aponeuroses laterally. A short aponeurosis encountered medially is typically associated with a lengthier lateral aponeurosis, and a long aponeurosis encountered medially is typically associated with an even longer lateral aponeurosis.
3. In regards to direct attachments the following observations were made: 1) isolated direct attachment of the medial head of gastrocnemius was the most common finding, and it is typically associated with a lengthy lateral aponeurosis; and 2) isolated direct attachment of the lateral head of gastrocnemius is an uncommon finding.

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