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## Morphological Aspects Of Triceps Surae – A Cadaveric Study

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### **Abstract:**

*Introduction : Gastrocnemius and soleus belong to the superficial group of muscles of the posterior compartment of the leg. Equinus is the pathological condition affecting the lower limbs which usually remains unrecognized and untreated. Technologically and surgically advanced technique being used for the treatment of equinus is Endoscopic gastrocnemius recession (EGR). However with any endoscopic technique proper placement of the surgical instrument is imperative to success. One of the areas of utmost confusion with this technique is at what level the gastrocnemius has to be transected. Unfortunately there is no particular measurement accepted universally that would work for each patient to carry out the transection.*

*Aim : To study the morphology and variations of Gastrocnemius and its attachment with the Soleus which could be valuable to the surgeons for appropriate placement of instruments for successful transection. The study was carried out in 60 embalmed specimens (60 lower limbs). The dissection method followed was according to the Cunningham's Manual Of Practical Anatomy.*

*Conclusion : A thorough understanding of the variations in the gastrocnemius aponeurosis will help the practicing surgeons in the appropriate placement of the endoscopic instruments and hence leading to an efficient procedure without any iatrogenic complications .*

**Key words:** Gastrocnemius aponeurosis, Endoscopic gastrocnemius recession, iatrogenic, equinus

### **1.Introduction**

Gastrocnemius and Soleus belong to the superficial group of muscles of the posterior compartment of leg. Gastrocnemius arises by two heads (medial and lateral) which are connected to the femoral condyles by strong flat tendons. The fleshy part of the muscle extends to about midcalf, the muscle fibres of the medial head extending lower than the lateral head and inserts into a broad aponeurosis that develops on its anterior surface. The aponeurosis gradually contracts and receives the tendon of soleus muscle on its deeper surface to form the tendocalcaneus or the tendon of Achilles<sup>[1]</sup>. Soleus is a broad flat, sole shaped multipennate muscle situated immediately deep to the gastrocnemius. Takes origin from posterior surface and proximal quarter of the shaft of fibula, soleal line and middle third of medial border of the tibia and thereby forms a fibrous band between tibia and fibula. The two heads of the Gastrocnemius and Soleus together are called Triceps surae<sup>[3]</sup>. Gastrocnemius muscle provides the force of propulsion in walking, running and leaping. Soleus acting from below helps in steadying the leg on the foot in standing. The pathological conditions of the forefoot are common as it is continuously subjected to biomechanical forces, equinus being one among them which remains unrecognized. Equinus can be classified into four types: i. Pseudo equinus ii. Osseous equinus iii. Gastrocnemius equinus iv. Gastrocnemius – Soleal equinus. Gastrocnemius equinus can be treated using Endoscopic gastrocnemius Recession (EGR) which is a minimally invasive technique which requires less intraoperative time and has reduced post operative morbidity. The success of this technique depends on the proper placement of the instruments<sup>[2]</sup>.

### **2.Aims and objectives**

The aim of the present study was to note the contribution of medial and lateral head of the gastrocnemius in the formation of gastrocnemius aponeurosis and also to note the musculotendinous junction of the gastrocnemius and soleus muscle which could be valuable to the surgeons for appropriate placement of instruments for successful transection.

### **3.Materials and methods**

60 embalmed lower limb specimens were used to carry out the study. Scalpel, blunt and pointed forceps, cotton, black paper. The dissection method was according to the Cunningham's Manual Of Practical Anatomy. The study was carried out to look for the contributions by the medial and the lateral heads to the gastrocnemius aponeurosis, length of the aponeurosis and the point of attachment of soleus to gastrocnemius. Vernier calliper was used to measure the contributions of medial and lateral heads. The point of attachment of the gastrocnemius and soleus was measured using a measuring tape keeping in mind three positions; at the midpoint of the leg, above and below the midpoint of the leg. (Midpoint of the leg = centre of the line joining the lateral condyle of the tibia and posterior surface of the calcaneum).

#### 4.Result

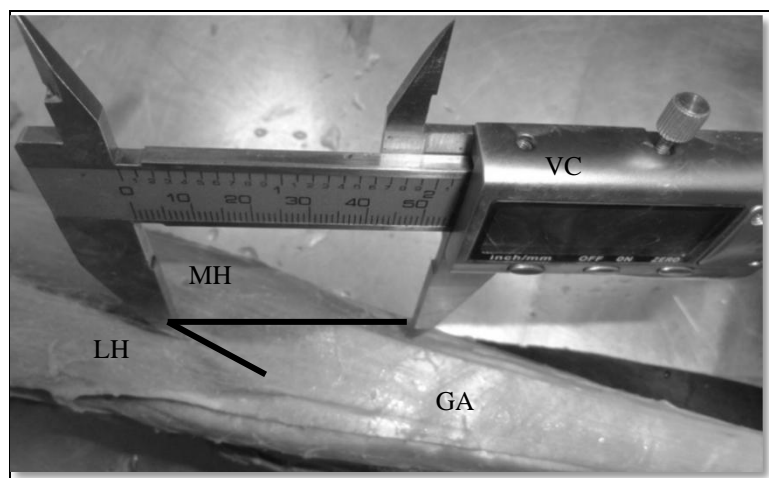
The present study was carried out to note the contributions by the medial and the lateral heads in the formation of gastrocnemius aponeurosis, point of attachment of gastrocnemius to the soleus muscle and the tendon length of the gastrocnemius aponeurosis. Contributions by the medial and the lateral heads of the muscle in the formation of gastrocnemius aponeurosis was noted and tabulated in Table 1.

Contribution by the 2 heads of gastrocnemius	No.of Specimens	Percentage(%)
Greater contribution by Medial Head	56	93.3
Greater contribution by Lateral Head	2	3.3
Equal Contribution by both the heads	2	3.3

*Table 1: The Variations In Contribution By Medial And Lateral Heads*

##### 4.1. Case 1

Contribution by the medial head to the gastrocnemius aponeurosis is larger than the lateral head. This is seen in most of the specimens. 93.3 % of the specimens show a larger contribution of medial head in the formation of the gastrocnemius aponeurosis (Fig.1).



*Figure 1: Greater Contribution By Medial Head*

MH- Medial head of Gastrocnemius; LH- Lateral head of gastrocnemius; GA- Gastrocnemius Aponeurosis; VC- Vernier Calliper. Black lines depict the measurement of medial and lateral heads in the formation of aponeurosis .

##### 4.2. Case 2

Contribution of the lateral head is usually less as compared to the contribution by the medial head. In the present study, however it was found that the contribution by the lateral head to the gastrocnemius aponeurosis was more in 3.3% of the cases (Fig2).



*Figure 2: Greater Contribution By Lateral Head*

MH- Medial head of gastrocnemius; LH- Lateral head of gastrocnemius; GA- Gastrocnemius aponeurosis.

##### 4.3. Case 3

In the present study, in 3.3% of the cases it was found that both the heads contributed equally in the formation of gastrocnemius aponeurosis (Fig 3).

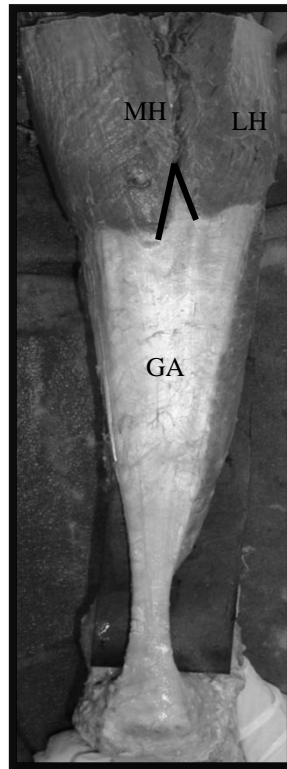


Figure 3: Equal Contribution By Both The Heads

MH- Medial head of gastrocnemius;LH- lateral head of gastrocnemius;GA- Gastrocnemius Aponeurosis.

The attachment of Gastrocnemius with soleus at different levels was noted. The levels taken into consideration were : attachment at the midpoint of the leg , above and below the midpoint of the leg as tabulated in Table 2.

Level of attachment	Percentage (%)	No.of specimens
At the midpoint	83.3	50
Above the midpoint	10	6
Below the midpoint	6.67	4

Table 2: The Different Levels At Which The Gastrocnemius Muscle Is Attached To The Soleus Muscle

#### 4.4. Case 4

Attachment of gastrocnemius to the soleus was found to be at the level of midpoint of the leg in 83.3% of the cases(Fig 4).

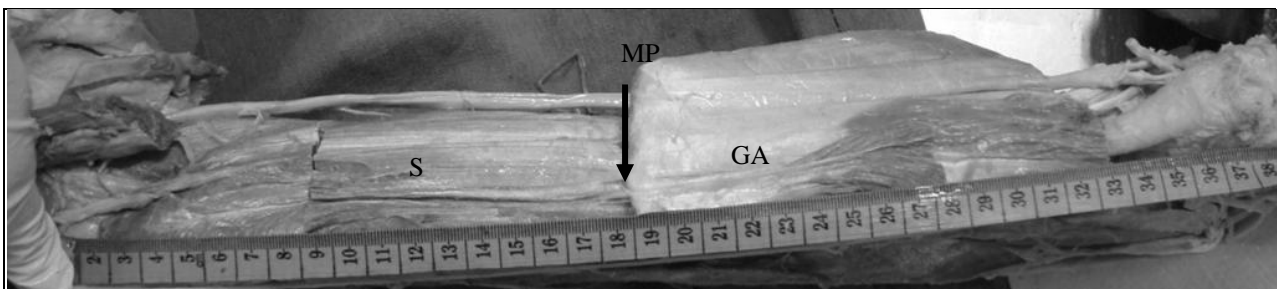


Figure 4

MP- Midpoint of the leg present at the centre of the line (depicted in the figure by using a measuring tape) joining the lateral condyle of the tibia and the posterior surface of the calcaneum ;S- Soleus muscle; Ga- Gastrocnemius Aponeurosis.

#### 4.5. Case 5

The present study showed the attachment of the gastrocnemius and soleus above the level of the midpoint in 10% of the cases (Fig 5).

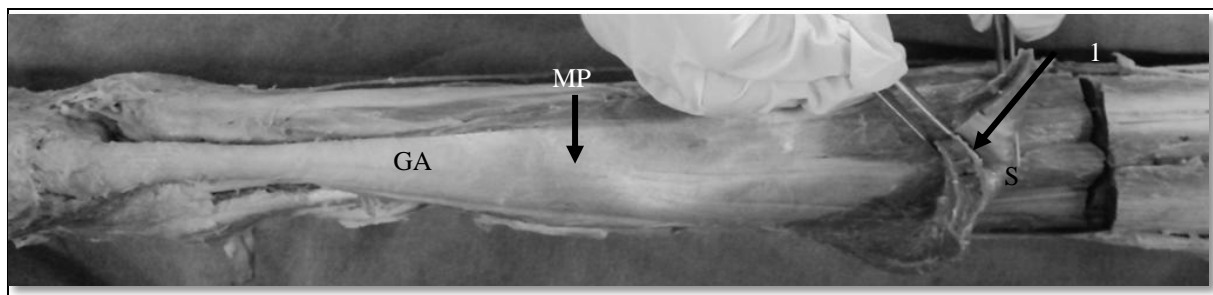


Figure 5

MP- Midpoint of the leg; S- Soleus muscle; GA – gastrocnemius Aponeurosis; 1- Fusion of the gastrocnemius with the soleus above the level of the midpoint.

#### 4.6. Case 6

In the present study, in 6.67% of the specimens the gastrocnemius was attached to the soleus below the level of midpoint (Fig 6).

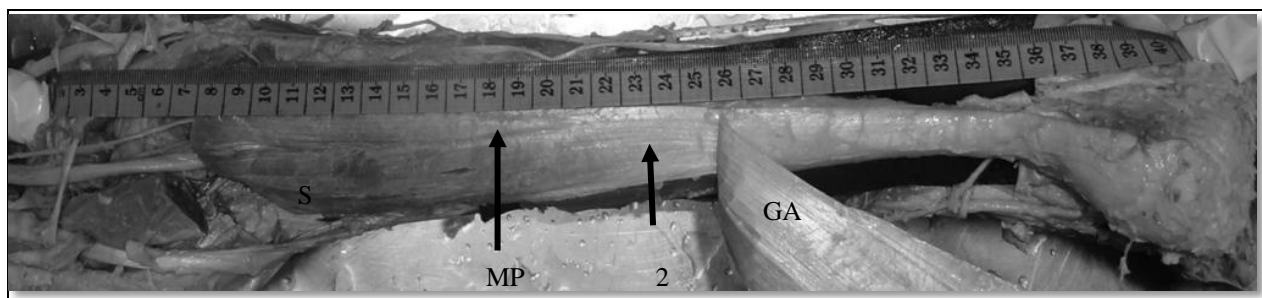


Figure 6

MP- Midpoint of the leg; S- Soleus muscle; GA- Gastrocnemius Aponeurosis; 2- Attachment of the gastrocnemius and soleus below the level of midpoint of leg.

Tendon length of the gastrocnemius aponeurosis was also measured from the calcaneal tubercle to the gastrocnemius indentation or the fanning of the aponeurosis into the muscle belly. The range was observed to be between 19-27 cm with the mean range of the gastrocnemius tendon being 21.1cm (Fig 7).

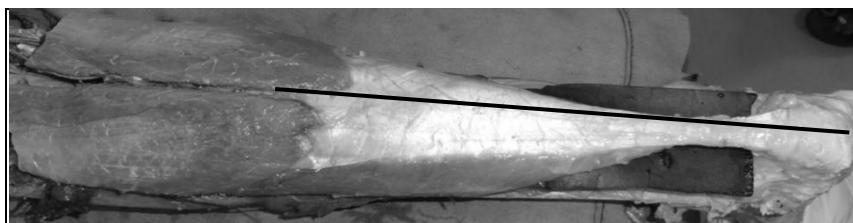


Figure 7: Tendon Length Of Gastrocnemius Aponeurosis

## 5. Discussion

Gastrocnemius muscle plays a key role in the pathology of foot and ankle specially gastrocnemius equinus which is treated by the Endoscopic gastrocnemius recession (EGR). Unfortunately, minimal studies have been carried out to note the variations in the formation of the musculotendinous junction which is necessary to determine the level of appropriate placement of the instruments for EGR.

Barett et al; studied 55 cadavers and recommended positioning of the cannula 16.4 to 17cm proximal to the calcaneal insertion of the Achilles tendon. He also suggested palpation of the Achilles tendon distal to proximal till it fans out into the gastrocnemius 3-4 cm above this fanning is considered a good level for placement of the instruments for an effective EGR with less iatrogenic complications<sup>[2]</sup>.

Interesting literature on Gastrocnemius has been reported by Blitz et al; who focussed mainly on finding an apt region for EGR. They developed three categories for the determination of gastrocnemius length depending on the ease with which a surgeon might release the gastrocnemius from soleus. The study was carried out in 53 embalmed cadavers and the length of the gastrocnemius aponeurosis was noted both medially and laterally. The three categories were long aponeurosis which was found in 53% of the specimens, short aponeurosis was found in 9% of the specimens and in 38% of the specimens direct attachment of the gastrocnemius to the soleus muscle either medially or laterally. The long aponeurosis category showed the lateral length to be 1.8 times greater than the medial length. However, in the short aponeurosis category it was found that the lateral length was 5 times greater than the medial length<sup>[3]</sup>.

Another study conducted by Blitz et al; suggested that the gastrocnemius intramuscular aponeurotic recession be performed in the transection zone which is located inferior to the area where the medial head and the lateral head of the gastrocnemius forms the aponeurosis and also located superior to the lower or the inferior portions of the two heads of the gastrocnemius muscle. The mean

proximal to distal length of the transection zone was found to be 50mm and the mean width was found to be 88mm. The contribution of the medial aspect of the aponeurosis was 60% to the width of the transection zone and the contribution by the lateral aspect was found to be 40% to the width of the transection zone. Hence, a distal transection would have a larger biomechanical effect as compared to the proximal transection, it was observed that the distal transection would release more gastrocnemius fibres from their action of plantar flexion<sup>[4]</sup>.

According to Pinney et al ; the point of release of gastrocnemius was noted to be at 18mm distal to the surface landmark which was the gastrocnemius indentation created by the distal extent of the gastrocnemius muscle belly. To minimize the length of the incision required for EGR a posteromedial incision beginning 2cm distal to the surface landmark and extending proximally was suggested<sup>[5]</sup>.

The most evident complication with EGR is the injury to the sural nerve. The sural nerve can be damaged easily during this procedure due to its anatomical location in relation to the gastrocnemius muscle. A study conducted by Tashjian et al; the successful release of gastrocnemius depends on the knowledge of anatomy of gastrocnemius- soleus junction and its relationship to the sural nerve. The study done on 14 cadavers revealed the width of the tendon at the junction of the gastrocnemius muscle with the soleus muscle to be 58mm, the distance of the sural nerve from the lateral border of the tendon was 12mm . Ratio of the distance of the gastrocnemius – soleus junction from the distal tip of fibula and the length of the fibula was 0.5. An interesting conclusion derived was that the fibula can serve as an excellent landmark for the localization of the gastrocnemius soleus junction at the time of the recession technique<sup>[6]</sup>.

A study was conducted by Elson et al; in 40 embalmed cadavers in which they found five patterns of conjoint junction morphology. The morphology of the conjoint junction of the tendons of gastrocnemius and soleus and the location of the gastrocnemius tendon relative to bony landmarks would help in incision planning for open or endoscopic division of tendon. Gastrocnemius tendon can be located between 38 and 46% of the distance between the upper border of the calcaneum and the head of the fibula. the values for the midline was 45-58% and that of the lateral side of the calf was 48-51%. The location of the gastrocnemius tendon relative to bony landmarks may help to guide incision planning for open or endoscopic division of the tendon<sup>[7]</sup>.

The previous literature suggests that the cannula should be placed at 16.4 to 17cm proximal to the calcaneal insertion of Achilles tendon and the preferred site for incision to carry out EGR should be 2cm distal to the gastrocnemius indentation. In the present study the majority of the specimens ;93.3% showed the greater contribution of the medial head in the formation of gastrocnemius aponeurosis. Gastrocnemius fused with the soleus at the midpoint of the leg in 83.3% of the specimens . Since the range of the tendon length was found to be 19-27cm; hence the transection should be carried out 2cm distal to the above mentioned range( i.e 17-25cm) in consideration with the tendon length. The transection of gastrocnemius at this level would release more of medial head fibres as the contribution of the medial head is greater in the formation of gastrocnemius aponeurosis. The positioning of the instruments should be preferably done above the midpoint of the leg for proper transection. Though, the data available in literature on the cadaveric studies carried out on the gastrocnemius is limited, the authors have tried to focus their attention on some aspects of morphology of triceps surae hoping that it would be useful for the surgeons performing the endoscopic gastrocnemius recession technique.

## 6. Conclusion

A proper understanding of the variations in the gastrocnemius aponeurosis as well as the morphological aspects of triceps surae will help the operating surgeon to choose a relevant recession technique and also to perform an accurate procedure thereby preventing any complications which could be caused due to sural nerve injuries.

Gastrocnemius equinus if untreated may lead to various other complications such as metatarsalgia, plantar fasciitis etc. Though the surgeons are generally aware of this condition , the equinus still remains an unattended and untreated pathology . By the use of a proper effective recession technique , the foot surgery results are expected to show a tremendous improvement. Endoscopic recession technique is precise and can be easily carried out provided the surgeon is appropriately trained. The future scope of the EGR technique can be its use in the diabetic patients who suffer from ulceration and various other pathologies.

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