# Anatomy of Arterial Supply of the Soleus Muscle

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**Abstract-** Soft tissue defects of the lower limb are a challenge to the plastic surgeon but a soleus muscle flap often provides the solution. Various types of soleus muscle flap have been described, based mainly on the vascular supply. This study has been conducted as a descriptive study. The arterial blood supply of the soleus muscle was studied in 45 cadaveric lower limbs. The blood vessels and their branches to the muscle were dissected. The mean length of the soleus muscle was 37 ± 2.2 Cm. In 66.7% of the limbs at least two branches arose from the popliteal artery trunk. The average distance of the first branch was 2.61 ± 1.75 Cm distal to the fibular head. And the second branch was 3.88 ± 0.7 Cm distal to the fibular head. The average number of branches to the soleus muscle from the posterior tibial trunk was 4.3 ± 0.7. The average distance of the first branch was 9.4 ± 2.3 Cm from medial malleolus and second branch was 15 ± 3.4 Cm. The average number of branches to soleus arising from the proneal artery was 3.8 ± 0.8. The proneal artery gave 2-5 branches to the soleus muscle in the limbs that in 95.6% of the limbs were found three branches from proneal artery trunk to soleus muscle. In this study have been shown, the distribution of the arteries entering the soleus muscle and how the information may be used in the design of soleus muscle flaps. However, clinical application of distal pedicle soleus muscle flaps in Iranian population is not beneficial and we do not recommend it to the surgeons.



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## Introduction

The soleus muscle flap is a versatile flap that can be used to cover soft tissue defects in the lower limb. It is grouped as a type II muscle flap. The muscle is supplied by large and small vascular pedicles (1). Previous study reported that soleus as a bipennate muscle with independent neurovascular supplies to its medial and lateral halves (2). Intramuscular septum as a distinct watershed in the blood supply of the proximal half of the muscle and fine vascular communications between intramuscular vascular territories (2). Other study demonstrated a significant vascular communications between the medial and lateral systems (3). Several studies demonstrated the vascular supply of the muscle by injection studies. Some studies described the concept of angiosomes of the body and their injection studies showed that the soleus muscle has three angiosome territories and that they form important anastomotic links between the popliteal, proneal, and posterior tibial artery (4). The vascular pedicles to the lateral part of the muscle were described at three levels. The upper pedicles originated from the popliteal artery while the proneal artery gave a segmental blood supply to the upper part of the muscle and an axial type of supply to the lower part. Previous studies showed that all the pedicles were accompanied by venae comitantes, and both halves of the muscle were innervated independently (1-4) The soleus muscle flap is used to cover both middle and distal third defects of lower extremity. The muscle flaps can be either proximally or distally based. Distally based flaps have been described by other studies (2-6). Also these studies described hemisoleus flaps, in which the muscle is split and rotated to cover medial or lateral defects of the lower limb (2-3). In the composite flap the fibula, the lateral half of the soleus muscle, and the overlying skin are used to resurface soft tissue defects associated with bony defects (7-10). All these flaps that are useful in clinical practice are based on the vascular supply of the muscle. The aim of this study was to define in more detail the vascular supply of the soleus muscle and the distribution of the branches in relation to the design of flaps used in clinical practice.

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## Materials and Methods

The vascular supply of the soleus muscle was studied in 45 cadaver lower limbs from the Forensic Medicine Organization. The isolated lower limbs were selected from adults of the same ethnic origin. All limbs were from male cadavers. A longitudinal incision was made from the medial malleolus to the medial condyle of the tibia. The incision was deepened down to the muscles and the skin was reflected on both sides. The soleus muscle was identified anterior to the medial head of gastrocnemius.

The muscle was separated at the intermuscular plane. Both heads of gastrocnemius and plantaris were detached from the tendocalcaneus and reflected. The deep surface of soleus was separated from flexor digitorum longus at the middle third of the leg. The branches of the posterior tibial artery were identified at the proximal part of the soleus muscle and traced along the medial half of the muscle. The points of the origin of the branches were measured from the tip of the medial malleous. Similarly the branches of the proneal artery were traced along the lateral border.

During the process, the origin of the soleus muscle was dissected from the tibia and fibula, a process that facilitated the dissection in the upper part. The popliteal artery and its branches to the soleus muscle were identified at the popliteal fossa. Finally, the point of division of the popliteal artery and the origin of the proneal artery and the origin of the proneal artery from the posterior tibial artery were identified. These distances were measured from the tip of the head of fibula. The length of the soleus muscle was measured from the origin on the fibular head to its insertion into the calcaneus.

Statistical analysis of muscle measurements are listed as mean values with standard deviations.

## Results

The mean length of the soleus muscle was 37 ± 2.2 cm. In all the limbs the arterial blood supply of the soleus muscle was from the popliteal artery and its branches. The muscle received branches from the main trunk of the popliteal artery, the posterior tibial artery, and the proneal artery.

**Popliteal artery**

In 66.7% of the limbs at least two branches arose from the popliteal artery trunk. The average distance of the first branch was 2.61 ± 1.75 Cm distal to the fibular head. And the second branch was 3.88 ± 0.7 cm distal to the fibular head. In 93.4% of the limbs the first branch of the popliteal artery from the popliteal trunk to the muscle were found to arise 1 cm below and 4 cm above the fibular head and the second branch were found to arise 3 cm below and 4 cm above the fibular head.

**Posterior tibial artery**

The average number of branches to the soleus muscle from the posterior tibial trunk was 4.3 ± 0.7. The average distance of the first branch was 9.4 ± 2.3 cm from medial malleolus distal to the fibular head and second branch was 15 ± 3.4 cm. Also the average distance between first and second branch was 5.6 ± 2.3 cm. The minimum number of branches observed was three with a maximum of six. In 68.9% of the limbs the first branch of the posterior tibial artery was separated from medial malleolus in distance less than 10 cm.

**Proneal artery**

The average number of branches to soleus arising from the proneal artery was 3.8 ± 0.8. The proneal artery gave 2-5 branches to the soleus muscle in the limbs that in 95.6% of the limbs were found three branches from proneal artery trunk to soleus muscle. In 91.1% of the limbs the first branch of the proneal artery from the proneal artery to the muscle were found to arise 4 Cm below and 10 Cm above the fibular head. The second branch found to arise 7 Cm below and 14 Cm above the fibular head.

Summery, the upper part of the soleus muscle received its blood supply from branches of the popliteal trunk, posterior tibial artery, and the proneal artery.

## Discussion

The soleus muscle is used to reconstruct soft tissue defects of the lower limb. The muscle can be used in various ways to create different types of flap, and the principle depends on its vascular supply. The soleus muscle blood supply according to the classification of Mathes and Nahai is Type II (1). It is supplied by large dominant vascular pedicles and minor pedicles. The main blood supply is through the major pedicles and they are found along the proximal part of the muscle. The minor pedicles provide additional blood supply to the muscle and are distributed in the distal part of the muscle. Our dissections of lower limbs showed the following pattern of blood supply to the soleus muscle. The vascular supply of this muscle is from the popliteal artery and its major divisions. In 66.7% of the limbs,

The popliteal artery is divided to two branches to the proximal part of the muscle.

The posterior tibial artery gave a series of branches to soleus throughout its course along the muscle. The branching pattern of the proneal artery was different from that of the posterior tibial artery.

The soleus- fibula free transfer flap was described in the previous study (7-9). The lateral half of the muscle and fibula with or without a skin island is transferred as a free flap for soft tissue and bony defects and the vascular supply to this flap is from the peroneal artery. Our dissection showed a consistent anatomical pattern of arterial supply to the upper lateral half of the soleus muscle in most of the specimens.

Our dissection showed that in most of the limbs the first branch of medial tibial is the largest branch is the vascular supply of soleus muscle (Figures 1 & 2).

**Figure 1.** Branch of posterior tibialis artery to medial hemisoleus muscle

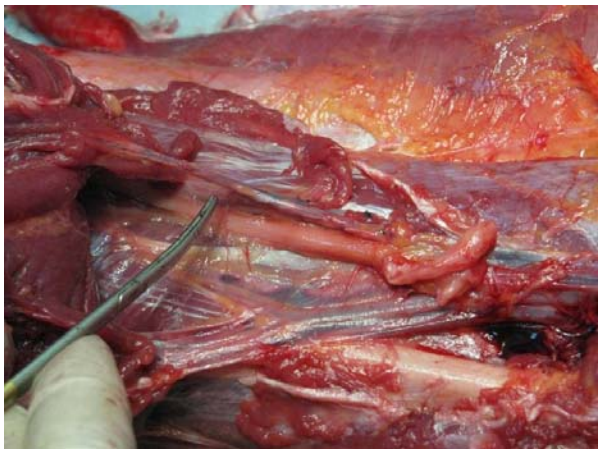

**Figure 2.** Vascular anatomy of soleus muscle showed popliteal artery branches

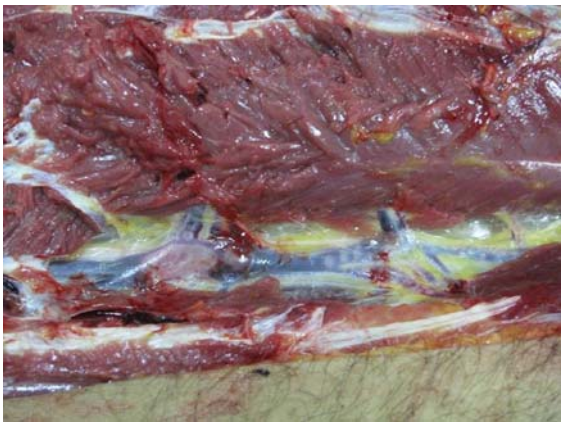

**Figure 3.** Branch of proneal artery to lateral hemisoleus

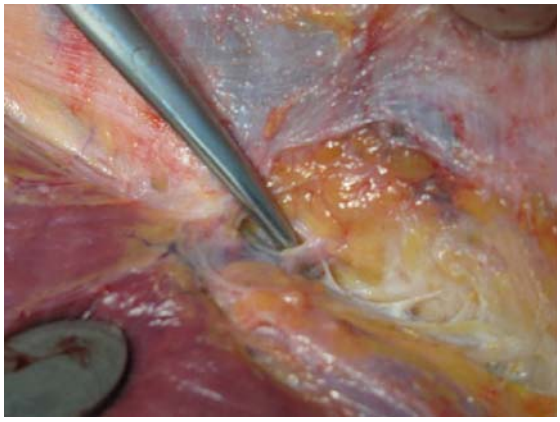

**Figure 4.** Skin perforator of lateral proneal artery branch

In our observation second branch of lateral proneal artery is the main branch in the muscle ( Figure 3). Also in most of the limbs, skin perforator was on average 1-2 Cm of the lateral proneal artery branch (Figure 4).

Our dissection showed that average distance of the first tibial was 9 Cm to soleus muscle, which is higher than previous anatomic reports.

We concluded that the distribution of the arteries entering the soleus muscle and how the information may be used in the design of soleus muscle flaps. However the clinical application of distal pedicle soleus muscle flaps in Iranian population is not beneficial and we do not recommend it to the surgeons.

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