

Regional Distribution of the Saphenous Nerve below the Adductor Canal: An Anatomical Study

Paul Ragusa¹, Gina Sorrentino², Joseph Marino¹ and Giles R. Scuderi^{1*}

¹Northwell Health, New York, NY

²Zucker School of Medicine at Hofstra/Northwell, Hempstead, NY

*Corresponding author

Giles R. Scuderi, M.D. F.A.C.S., Vice President, Orthopedic Service Line, Northwell Health, Tel: (212) 434-4310 or (516) 801-8410, Fax: (212) 434-4309; Email: gscuderi@northwell.edu.

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Abstract

The adductor canal is an aponeurotic tunnel that courses between the anterior and medial compartments in the middle third of the thigh. The canal begins at the apex of the femoral triangle and extends to the adductor hiatus. Its major contents are the superficial femoral artery, the nerve to vastus medialis, and the saphenous nerve. The latter two nerves are branches of the posterior division of the femoral nerve. Along with the medial and intermediate cutaneous nerves of the thigh and the lateral femoral cutaneous nerve the saphenous nerve contributes to the sensory distribution around the anterior aspect of the knee. This anatomic cadaveric study defined the course of the saphenous nerve and its divisions along the medial aspect of the knee. Landmark-based distance measurements were recorded in reference to the proximal border of the patella, medial border of the patella, medial epicondyle, medial femoral condyle, and posterior femoral condyle. The clinical implications of our findings suggest there is opportunity to obtain medial sensory analgesia during total knee arthroplasty when periarticular injections of bupivacaine derived medications are injected in the region of saphenous nerve proximal and posterior to the medial femoral condyle.

Introduction

The adductor canal is an aponeurotic tunnel that courses between the anterior and medial compartments in the middle third of the thigh. The canal begins at the apex of the femoral triangle and extends to the adductor hiatus [1]. Its major contents are the superficial femoral artery, the nerve to vastus medialis, and the saphenous nerve. The latter two nerves are branches of the posterior division of the femoral nerve. Along with the medial and intermediate cutaneous nerves of the thigh (both branches of the anterior division of the femoral nerve) and the lateral femoral cutaneous nerve (from the lumbar plexus), the saphenous nerve contributes to the sensory distribution around the anterior aspect of the knee [2].

The nerve to vastus medialis (NVM) is a motor branch of the femoral nerve that descends through the proximal part of the adductor canal [1]. In the mid portion of its course the NVM enters a separate fascial sheath within the adductor canal and travels along the anteromedial aspect of vastus medialis lateral to the saphenous nerve and femoral vessels. It gives off three to four branches to the vastus medialis before piercing the distal third of the muscle [3].

The saphenous nerve is the largest sensory branch of the femoral nerve and provides sensation to the inferior aspect of the knee and medial part of the leg and foot [4]. The saphenous nerve travels along the lateral aspect of the superficial femoral artery (SFA) in the proximal thigh. It then crosses over the SFA anteriorly and runs medially along the SFA until emerging from the adductor canal with

the saphenous branch of the distal geniculate artery (SBDGA) deep to the vastoadductor membrane.

At the distal extent of the adductor canal lies the vastoadductor membrane (VAM), a sheath of fibers that travels from the tendinous portion of the adductor magnus to the vastus medialis [5]. After exiting the vastoadductor membrane with the SBDGA, the saphenous nerve bifurcates into the infrapatellar branch and sartorial branch [6]. The anatomy of these branches has been consistently reported on in the literature [1, 6-8].

The infrapatellar branch pierces the sartorius muscle and deep fascia to become subcutaneous and then courses laterally to form the infrapatellar plexus [1]. The sartorial branch of the saphenous nerve becomes subcutaneous between the sartorius and gracilis muscles; it then travels distally down the medial aspect of the knee and leg near the great saphenous vein [1].

More distally the sartorial branch continues along the medial tibia along with the long saphenous vein [9]. It supplies the skin to the medial foot [2].

Methods

One left fresh-frozen cadaveric knee of an 87 year Caucasian woman with no evidence of prior injury was utilized for this project. The knee was stored at -20 degrees Celsius and thawed overnight prior to dissection.

Dissection to identify the course of the saphenous nerve was performed. A midline skin incision was initiated in the proximal thigh and continued distally past the pes anserine. Skin flaps were developed down to deep fascia and reflected medially and laterally, respectively. The sartorius muscle was identified, cut at its distal quarter, and reflected to expose the adductor canal. The saphenous nerve was identified proximally and followed distally into the adductor canal. The vastoadductor membrane was identified and preserved.

The main trunk of the saphenous nerve was identified as it emerged from the vastoadductor membrane along with the SBDGA. The nerve was diligently dissected to its bifurcation into sartorial and infrapatellar branches. The branches were dissected distally to the area where they pierced the deep fascia to become subcutaneous. A subvastus approach was used to expose the knee joint and medial structures. The most prominent point of the medial epicondyle was identified, and overlying soft tissue was removed to allow for accurate localization. The anterior and medial portions of the medial meniscus were excised. During dissection, we were careful to identify the course of the saphenous nerve and its branches in relation to bony landmarks. Landmark-based distance measurements were recorded in reference to the proximal border of the patella, medial border of the patella, medial epicondyle, medial femoral condyle, and posterior femoral condyle.

Results

The saphenous nerve emerged from the vastoadductor membrane 10.7 cm proximal and 0.5 cm posterior to the medial epicondyle (Figure 1). In relation to the patella, this distance was 7.5 cm proximal to the superior border of the patella and 6.1 cm posterior to the medial border of the patella. In relation to the distal femoral joint line, this distance was 13.4 cm proximal to the distal medial femoral condyle. These distances did not change with the knee flexed to 90 degrees.

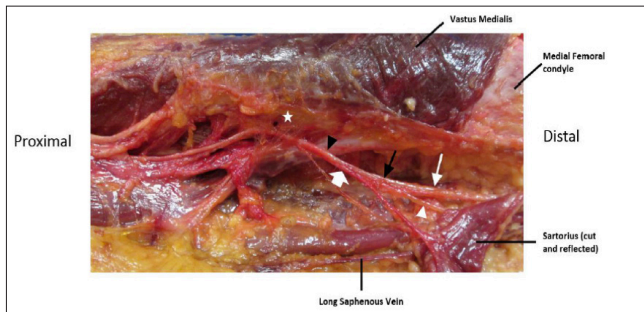


Figure 1: The main trunk of the saphenous nerve (black arrow head) emerges from the vastoadductor membrane (white star) along with the saphenous branch of the distal geniculate artery (thick white arrow). The saphenous nerve travels for 2 cm before bifurcating (thin black arrow) into infrapatellar (white arrow head) and sartorial branches (thin white arrow).

After emerging from the vastoadductor membrane, the saphenous continued for 2 cm before bifurcating into infrapatellar and sartorial branches. This branch point was 8.7 cm proximal and 0.5 cm posterior to the medial epicondyle. In relation to the patella, this distance was 5.5 cm proximal to the superior border of the patella and 6.1 cm posterior to the medial border of the patella. In relation to the distal femoral joint line, this distance was 11.4 cm proximal to the distal medial femoral condyle. These values did not change with the knee in 90 degrees of flexion.

The infrapatellar branch pierced the deep fascia posterior to the sartorius. With the knee extended 0 degrees, the course of the nerve was from superomedial to inferolateral (Figure 2). It bifurcated as it traveled across the anterior aspect of the knee. With the knee extended, the nerve was located 3.1 cm inferior to the medial epicondyle and 0.4 cm inferior to the distal femoral joint line. With knee flexion to 90 degrees the infrapatellar branch took on a more parallel course that was horizontal to the knee joint (Figures 3 & 4). In this position, it was located 5.2 cm inferior to the medial epicondyle and 2.5 cm inferior to the posterior medial femoral condyle.

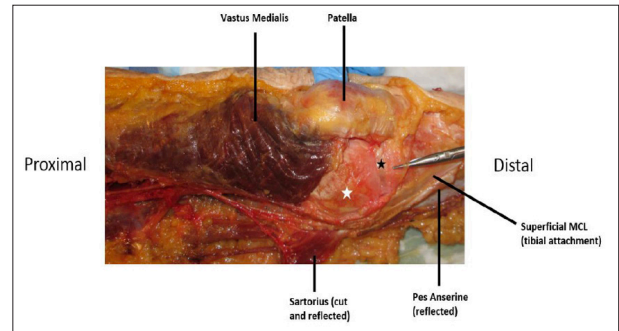


Figure 2: After piercing the deep fascia to become subcutaneous, the infrapatellar branch (under scissors) travels in a superomedial to inferolateral direction when the knee is in 0 degrees of extension. Note the bifurcation of the infrapatellar branch. Medial epicondyle (white star). Medial meniscus (black star).

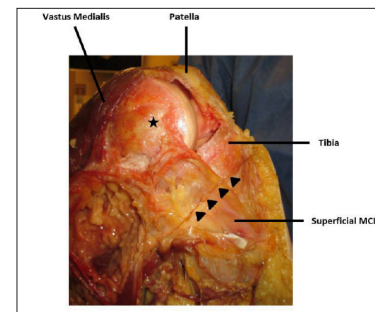


Figure 3: With the knee flexed to 90 degrees, the infrapatellar branch (black arrow heads) takes on a more horizontal course parallel to the joint line. The medial meniscus was excised to better visualize posterior femoral condyle. Medial epicondyle (black star).

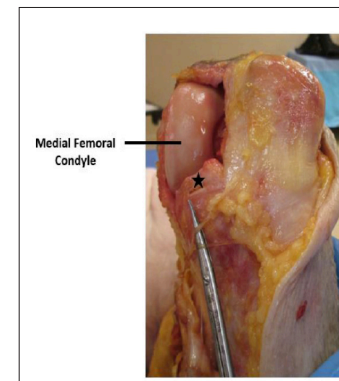


Figure 4: Anterior view with the knee flexed to 90 degrees. The infrapatellar branch (under scissors) bifurcates. Medial meniscus (black star).

The sartorial branch was found to pierce the sartorial fascia anteriorly (Figure 5). It was located 2.9 cm posterior to the medial epicondyle. In relation to the patella, it was located 7.9 cm posterior to the medial border of the patella.

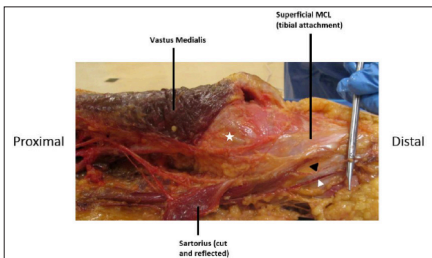


Figure 5: After piercing the deep fascia to become subcutaneous, the sartorial branch (under scissor/black arrow head) continues distally into the leg along with the long saphenous vein (white arrow head). Medial epicondyle (white star).



Figure 6: 3 1/2 inch (88.9 mm) spinal needle inserted parallel to the posterior condyle with the knee in 30 degrees of flexion. Hub of needle is at the medial epicondyle.



Figure 7: 3 1/2 inch (88.9 mm) spinal needle inserted parallel to the posterior condyle with the knee in 90 degrees of flexion. Hub of needle is at the medial epicondyle.

Discussion

In our specimen, the saphenous nerve emerged from the vastoadductor membrane 10.7 cm proximal and 0.5 cm posterior to the medial epicondyle. In relation to the patella, this distance was 7.5 cm proximal to the superior border of the patella and 6.1 cm posterior to the medial border of the patella. With respect to the knee in extension, this distance was 13.4 cm proximal to the joint line at the distal medial femoral condyle. These results are consistent with those of Horn et al. who studied the anatomy of the saphenous nerve and its two branches as they exited the adductor canal [10]. They found that the distance from the proximal patella to the distal end of the adductor canal was 10.25 cm (range 7-11.5 cm). In addition, they found that the saphenous nerve bifurcated into sartorial and infrapatellar branches 6.6 cm (range 5-9 cm) posterior to the medial border of the patella.

To our knowledge, the relationship of the vastoadductor membrane to the medial epicondyle has not been described. However, it has been described in relation to the adductor tubercle, a structure that is close in proximity to the medial epicondyle. Tubbs et al studied the vastoadductor membrane and the location of the VAM in relation to the adductor tubercle [5]. They found the length of the VAM to be 7.6 cm (range 5.5-15 cm) and the distance from the distal border of VAM to adductor tubercle to be 10 cm (range 7-15 cm). These measurements are consistent with ours. Although close in proximity, the adductor tubercle is not typically a palpable structure in most surgical exposures of the knee joint; therefore, we feel the medial epicondyle to be a more useful anatomical landmark.

The main trunk of the saphenous nerve continued for 2 cm before bifurcating into infrapatellar and sartorial branches. This branch point was 8.7 cm proximal to the medial epicondyle, 5.5 cm proximal to the superior border of the patella, and 11.4 cm proximal to the distal femoral joint line. These results are differed with those of Horn et al. who found that the bifurcation occurred 2.7 cm (range 2.1-3.4 cm) proximal to the superior border of the patella. In our specimen it was more than 2 cm more proximal than the high end of their range.

Multiple studies show the variable course and branches of the infrapatellar branch of the saphenous nerve [11-13]. After branching from the saphenous nerve, the infrapatellar branch travels in a medial to lateral direction as it courses proximal to distal. Kerver et al studied the infrapatellar branch and found that it does this at about a 45 degree angle with respect to the horizontal axis of the knee when the knee is extended and almost parallel to the joint when the knee is flexed to 90 degrees [12]. These findings were consistent with what we observed in our specimen. They also found that at the level of the mid-patella the infrapatellar branch is 52.2-54.2 mm away from the medial border of the patella; at the level of the inferior pole of the patella, the nerve is 43.3-44.3 mm from the medial margin of the patella ligament [12].

Kalthur et al found a variable course of the infrapatellar branch with respect to the point where the nerve pierces the fascia lata, the location of its main nerve trunk in relation to the patella, and the number and location of its terminal branches with respect to the patella and tibial tubercle [10]. They found the most common location for the nerve to become subcutaneous was anterior to the sartorius. This differed from our specimen where the nerve was noted to pierce the fascia posterior to the sartorius. Our finding is more consistent with that of Arthornthurasook and Gaew-Im who found the piercing point to be posterior to the sartorius [14]. In addition, they found the main trunk to be 4-9 mm from the medial border of the mid-patella. The number of branches varied from one to three.

To our knowledge, the relationship between the infrapatellar branch and the distal femoral condyle or posterior femoral condyle has not been described. During its course anteriorly, it was located 3.1 cm inferior to the medial epicondyle and 0.4 cm inferior to the distal medial femoral condyle with the knee in 0 degrees of extension. With the knee flexed to 90 degrees the infrapatellar branch became more parallel to the horizontal knee axis. In this position, it was measured to be 2.5 cm inferior to the posterior femoral condyle and 5.2 cm inferior to the medial epicondyle.

In our specimen the sartorial branch was found to pierce the sartorial fascia distal to the joint line. Dunaway et al. studied the location of the sartorial nerve in relation to the joint line [7]. They found that the nerve travels 17 mm (range 0-25 mm) posterior to the anterior border of the sartorius muscle and becomes subcutaneous or extrafascial anywhere from 37 mm proximal to 30 mm distal to the joint line. Tothonglor et al. found that in the majority of cases the sartorial branch emerged from the deep fascia separately from the infrapatellar branch [15]. Alternatively, they found in a smaller percentage of people the saphenous nerve emerged as a single trunk and later bifurcated. The results of this study were consistent with that of Arthornthurasok and Gaew-Im who found that in the majority of patients the piercing point of the sartorial nerve was distal to the medial epicondyle [14]. In our specimen the sartorial branch was located 7.9 cm posterior to the medial border of the patella at its midpoint and 2.9 cm posterior to the medial epicondyle. This differed from the results of Wijdicks et al. who studied the sartorial branch of the saphenous nerve in relation to the medial knee structures [8]. They found the perpendicular distance of the saphenous nerve to be 5.0 ± 1.1 cm medial to adductor tubercle.

The clinical implications of our findings suggest there is opportunity to obtain medial sensory analgesia during total knee arthroplasty when periarticular injections of bupivacaine derived medications are injected in the region of saphenous nerve proximal and posterior to the medial femoral condyle. In a review of the neuroanatomy of the knee, Guild revealed that there are specific periarticular sites that are highly innervated and should be infiltrated with local anesthetic to provide post-operative pain relief [16]. Our current study demonstrated the path of the saphenous nerve as it exits the adductor canal and bifurcates into the sartorial nerve and infrapatellar branch of the saphenous nerve. As noted by Benzon, the saphenous nerve has a more posterior, not medial, position relative to the medial femoral condyle [17]. This may be a reason for some inconsistent results with injections in the region of the saphenous nerve. Periarticular injection of the posterior medial capsule proximal to the medial femoral epicondyle, as well as injection deep and superficial to the insertion of the pes tendons as the nerve penetrates the sartorius, should provide sensory analgesia on the medial aspect of the knee.

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