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Review

The superficial peroneal nerve: A review of its anatomy and surgical relevance

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Abstract

Introduction

The superficial peroneal nerve gives motor supply to the lateral lower leg muscle compartment and innervates the dorsolateral aspect of the ankle and foot. The current article reviews the anatomy and surgical relevance of the superficial peroneal nerve with regards to common orthopaedic lower limb procedures.

Conclusion

Evidence shows the anatomy of this nerve can be highly variable. Knowledge of the differing course of the superficial peroneal nerve is essential to reduce the risk of iatrogenic injury during orthopaedic foot and ankle surgery.

Introduction

The superficial peroneal nerve (SPN) is a terminal branch of the common peroneal nerve providing motor supply to the lateral lower leg compartment and innervating the dorsum of the foot and ankle. Evidence shows that this nerve has highly variable anatomy throughout its course, potentially exposing it to iatrogenic injury. The aim of the current article was to review the anatomy of the SPN and describe the surgical relevance of this nerve to common orthopaedic lower limb procedures.

Discussion

Anatomy of the SPN at the knee

The common peroneal nerve takes origin from the sciatic nerve and is classically found superficially, winding around the fibula neck from posterior to anterior (Figure 1). The nerve subsequently divides in to the deep and superficial peroneal nerves, the latter usually travelling within the lateral compartment of the lower leg. Variation of the SPN can however exist even at its origin. One cadaveric study has shown that in ten percent of legs the common peroneal nerve divides into deep and superficial branches proximal to the knee joint[1].

It was also shown that in 30% of specimens, a separate cutaneous branch emanated from the common peroneal trunk, a branch that had not previously been recognized in the literature[1]. The same authors went on to demonstrate that during arthroscopically assisted inside-out lateral meniscus repair in fresh frozen cadavers, the risk of injuring the peroneal nerve or one of its branches was as high as 20% from insertion of meniscal sutures when a posterior retractor wasn't used[1].

Given such anatomical variation, portal insertion posterolaterally should be done using a scalpel to make the skin incision only, following immediately by blunt dissection to enter the knee joint.

Anatomy of the SPN in the lower limb and ankle

Below the knee joint, the SPN gives sensory innervation to the anterolateral leg and motor innervation to the lateral compartment of the leg: peroneus longus and peroneus brevis[2] (Figure 2).

The anatomy of the SPN is often described relative to the fasciae of the lower leg. The crural fascia invests all the muscles of the lower leg. Laterally, the crural fascia gives attachment to the intermuscular septum separating the anterior and lateral muscle compartments.

The SPN tends to become subcutaneous approximately half way down the lower leg by piercing the crural fascia over the lateral compartment, running superficially over the extensor retinaculum of the ankle, to supply the foot.

The SPN demonstrates great anatomical variation, potentially exposing the nerve to iatrogenic injury. At the level of the tibial diaphysis, a cadaveric study of 111 legs demonstrated four distinct variations in the anatomy of the SPN[3].

Most commonly, the nerve travelled within the lateral compartment of the leg (69.4% of specimens); in 16.2%, the SPN divided into branches to both the lateral and anterior compartments; in 8.1% of cases, the SPN travelled solely within the anterior compartment; and in the fourth group (6.3%), the SPN was found within the intermuscular septum[3].

A similar cadaveric study of 85 specimens reported that in 14 % of specimens the SPN exited into the anterior compartment rather than the lateral compartment. In a further 12%, the nerve divided in to branches to both the lateral and anterior compartments[4].

In contrast to such studies, one study of 68 cadavers has reported that the SPN has a relatively consistent proximal course[5]. In all specimens, the superficial peroneal nerve exited the peroneal muscles in the proximal third of the leg to run to the distal half of the lower leg in contact with the posterior aspect of the anterolateral intermuscular septum, within the lateral compartment. The SPN divided into its terminal branches

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after piercing the crural fascia in 65% of cases and in the remaining 35%, the SPN divided deep to the crural fascia.

In some cases, an accessory SPN may also exist, which often continues to the foot as a deep branch in anterior compartment of the leg, terminating as the MDCN of the foot[5].

Termination of the SPN

The SPN becomes superficial, crossing the distal fibula from posterior to anterior on average 11cm proximal to the tip of the fibula and usually within 6 – 12 cm of the lateral malleolus tip[6,7] (Figure 3, Figure 4 and Figure 5).

The SPN or its terminal branches cross the ankle joint to innervate the dorsum of the foot. The termination of the SPN in the lower leg has been classified into 3 distinct patterns according to a cadaveric study of 25 legs by Blair and Botte[6].

The most common was Type A (72%) whereby the nerve penetrated the crural fascia to become subcutaneous at an average distance of 12cm proximal to the ankle joint, dividing at an average distance of 4 cm proximal to the ankle joint into two terminal branches: a large medial dorsal cutaneous nerve (MDCN) and a smaller intermediate dorsal cutaneous nerve (IDCN).

For the type B pattern (16%) the MDCN and IDCN arose independently from the SPN in the mid-calf. The IDCN penetrated the crural fascia posterior to the fibula, crossing anteriorly approximately 5 cm above the ankle joint.

Type B patterns are considered to be at particularly high risk of injury during lateral malleolus fracture fixation.

For Type C patterns (12%), the IDCN penetrated the crural fascia anterior to the fibular an average of 5 cm above the ankle joint and continued distally in close proximity to the anterior fibular border[6].

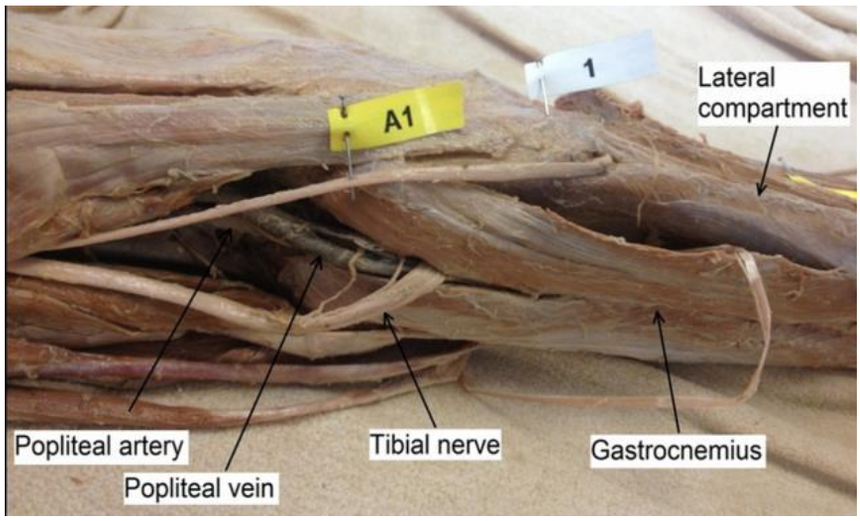

Figure 1: The common peroneal nerve lies laterally within the popliteal fossa, marked by flag A1. The nerve runs superficially over the fibula neck from posterior to anterior (flag 1 marks the fibula head), subsequently dividing into the deep and superficial peroneal nerves. In 10% of people the common peroneal nerve divides proximal to the knee joint.

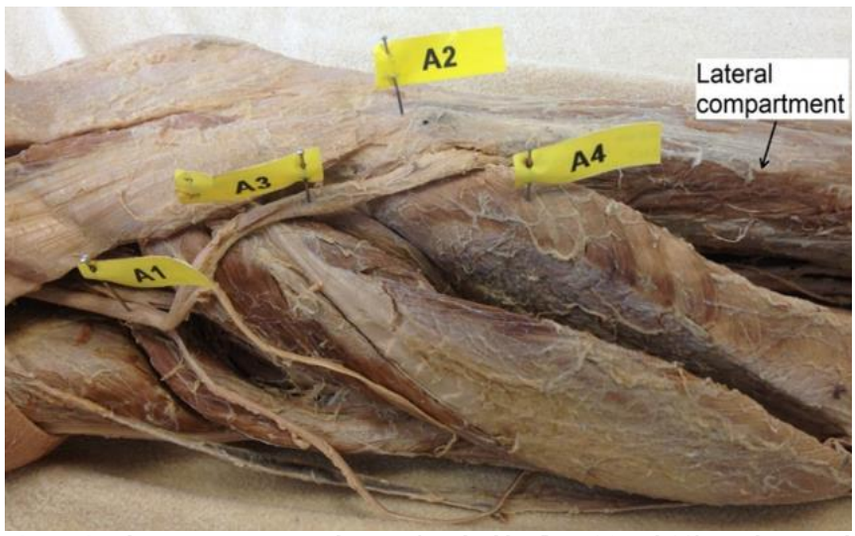

Figure 2: The common peroneal nerve (marked by flags A1 and A3) winds around the fibula neck. Flag A4 marks the muscle belly of the lateral head of gastrocnemius; just anterior to this lies the lateral compartment containing peroneal longus and brevis muscles. Flag A2 marks the fibula head.

The MDCN in the latter case penetrated the crural fascia 7 cm above the ankle joint[6].

In some cases (8.6%), the IDCN is absent, so that the dorsolateral part of the foot is supplied by the sural nerve rather than SPN[6]. Absence of the medial cutaneous branch occurs in less than one percent of cases in which case the medial part of the foot is supplied by the saphenous nerve or the deep peroneal nerve[6].

Relevance to surgical incisions over the lateral malleolus

Longitudinal incisions over the distal fibula lateral malleolus are commonly employed for ankle fracture fixation, open ankle arthrodesis or Brostrom-Gould repair for lateral ligament reconstruction. Some surgeons use a single incision down to bone over the lateral malleolus, but such an approach could potentially damage the SPN in cases where it pierces the deep fascia at a very distal position[8,9].

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One study of 85 cadaveric legs demonstrated that the SPN can cross only 3cm proximal to the distal tip of the lateral malleolus[4]. The risk of nerve injury is increased for the Blair and Botte type B patterns for the IDCN branch, which can cross the fibula within 7cm of the distal tip of the lateral malleolus[6]. It is therefore recommended to routinely to look for the SPN or IDCN following the skin incision over the lateral malleolus, so that if identified the nerve it can be transposed anteriorly and protected prior to deep dissection[9].

Other techniques to reduce the risk of injury are to centre the surgical incision over the posterior aspect of the malleolus, as the SPN or a terminal branch can lie along the anterior border of the fibula[5]. A more proximal incision over the lateral lower leg may be required to perform fixation of Weber C type fibula fractures or lateral fasciotomy for compartment syndrome. For the latter, we recommend using a tourniquet so that the SPN can be visualized and protected to prevent additional co-morbidity.

The superficial position of the SPN around the ankle makes it prone to injury even from non-operative interventions.

One study of patients with ankle fractures, demonstrated an incidence of painful symptoms from an SPN injury in 9% of patients treated with a cast compared with 21% of patients in the surgical group where an incision was made directly over the lateral malleolus[10]. For those patients in whom a posterolateral approach to the fibula was undertaken, the rate of SPN injury was zero[10]. Unrecognized SPN injury should be considered as a cause of chronic ankle pain following both non-operatively and operatively treated ankle fracture[10].

Ankle arthroscopy

Neurological injury is the most common complication associated with ankle arthroscopy[11]. In a study of 612 ankle arthroscopies, the superficial peroneal nerve was injured in 15 (2.5%) cases[11].

All nerve injuries occurred through direct injury from either portal placement or insertion of a pin distractor[11].

Blair and Botte reported that at the level of the malleoli, the MDCN was located approximately one half of the way from the lateral malleolus to medial malleolus, whilst the IDCN was one third of the distance[6]. The safest placement of the anterolateral portal during ankle arthroscopy to avoid injury to the SPN branches has been reported to be 2mm lateral to the peroneus tertius tendon[12]. Peroneus tertius however is not easily defined clinically. We therefore recommend marking the course of the SPN at the ankle preoperatively by performing the fourth toe flexion sign, with the foot plantarflexed and inverted[13] (Figure 6).

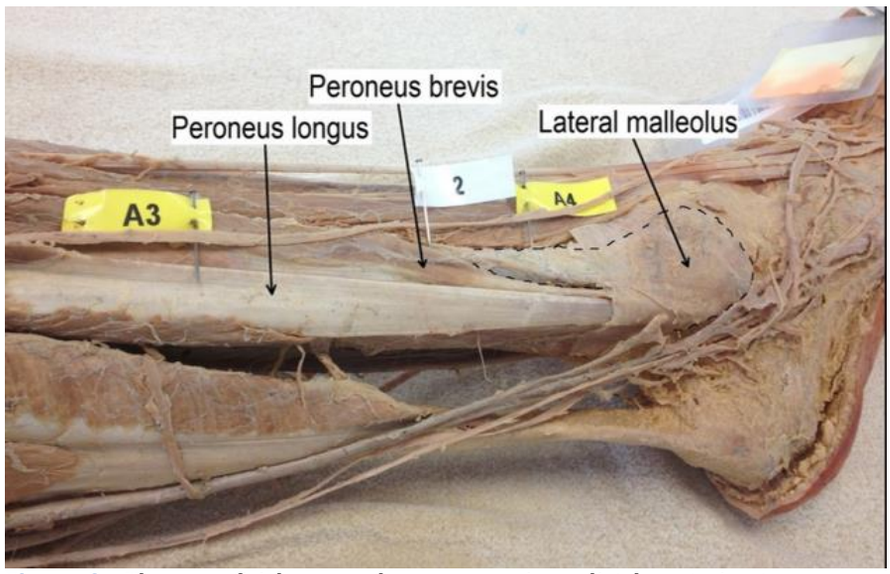

Figure 3: The superficial peroneal nerve runs immediately anterior to peroneus longus (flag A3) and superficial to peroneus brevis (flag 2). The nerve crosses over the fibula (flag A4) towards the ankle joint.

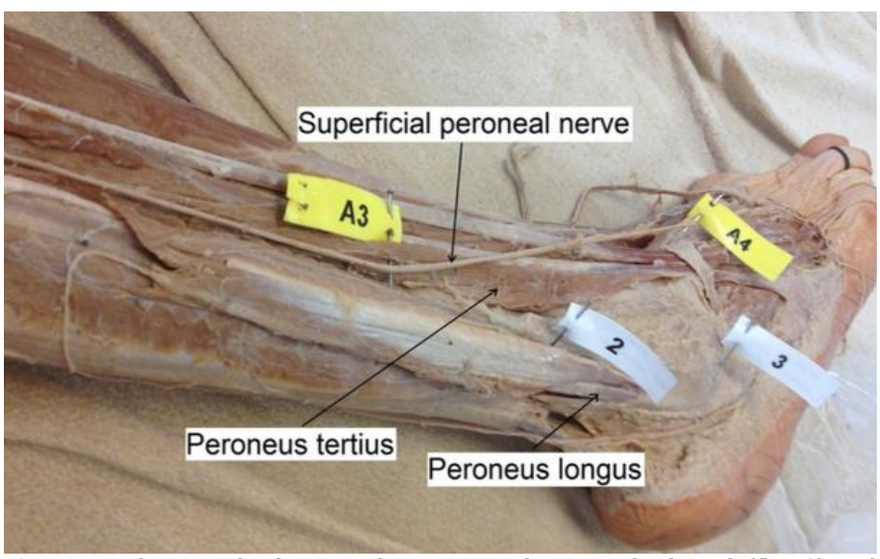

Figure 4: The superficial peroneal nerve runs between the lateral (flag 2) and anterior muscle compartments, crossing the ankle anterolaterally over peroneus tertius (flag A3) to innervate the dorsum of the foot (flag A4). Flag 3 marks the lateral malleolus.

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This manoeuvre accentuates the subcutaneous course of the branches of the SPN and has been shown to be positive in 87% of people[13].

We recommend safe portal entry using a scalpel to incise the skin only, followed immediately by blunt dissection to enter the ankle joint; this technique is especially important given the variable anatomy of the SPN and its terminal branches at the ankle joint. Anterior ankle arthroscopy can be undertaken using two methods: fixed continuous distraction with the foot mounted in a distraction holder or using a dorsiflexion technique, without traction. We prefer the latter technique because it facilitates an anterior working space.

The risk of neurological injury is low because dorsiflexion of the ankle ensures the nerves crossing the anterior ankle joint are not under tension during portal insertion. In a study of 1305 consecutive ankle arthroscopies, the dorsiflexion technique has been shown to have complication rate of only 3.5%, significantly lower compared with the continuous distraction technique which has an average complication rate of 10.3%[14].

Relevance to forefoot surgery

The anatomy of the SPN over the dorsum of the foot is variable according to cadaveric studies[6,7]. Surgical approach to the subtalar joint, employing an incision made from the tip of the fibula to the base of the fourth metatarsal can injure the IDCN or the sural nerve. Dorsal approaches to the midfoot for arthrodesis or fracture fixation can injure the deep and superficial peroneal nerves.

With regards to the MDCN, Canovas et al. reported that it divides into three branches at a level varying from 5 to 20cm in relation to the first interdigital space[7]. An important and consistent dorsomedial branch to the great toe arises from the MDCN, to innervate the skin over the hallux.

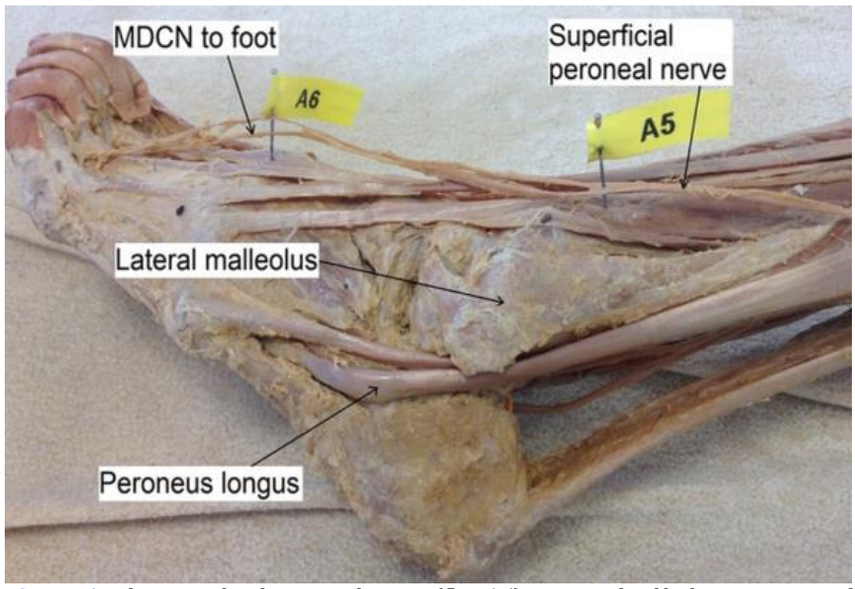

Figure 5: The superficial peroneal nerve (flag A5) crosses the fibula an average of 11cm proximal to the tip of the lateral malleolus, dividing into its terminal branches to the dorsum of the foot, including the medial dorsal cutaneous nerve (MDCN) to the great toe and intermediate dorsal cutaneous nerve (IDCN). Studies show that the SPN or the IDCN can cross the fibula within 3cm of the lateral malleolus tip.

Figure 6: The fourth toe flexion sign to define the course of the superficial peroneal nerve across the ankle joint and into the foot. This should be done prior to ankle arthroscopy to reduce the risk of iatrogenic nerve injury during portal insertion.

This branch can lie as close as 6mm to the extensor hallucis longus tendon[15].

A dorsomedial approach to the first metatarsophalangeal (MTP) joint was historically employed to perform arthrodesis or cheilectomy. Such an approach can injure the medial cutaneous branch, causing numbness or a painful neuroma.

It is therefore recommended that all surgery to the first MTPJ is carried out through a medial approach or true dorsal approach[15].

Conclusion

According to cadaveric studies the SPN has highly variable anatomy from its origin at the level of the knee to its terminal branches to the dorsum of the foot. Knowledge of these variations is

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therefore important for both foot and ankle surgeons and trauma surgeons. The key anatomical locations where the nerve is at risk are as follows: 1) in the lower leg where the SPN becomes superficial (ranging from 3-12 cm above the ankle joint); 2) over the distal fibula where the SPN or IDCN cross from posterior to anterior; 3) over the anterolateral ankle joint where the SPN or its terminal branches extend to the foot; 4) over the first MTP joint which is supplied consistently by a medial dorsal cutaneous branch.

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