

The Popliteal Nerve Block in Foot and Ankle Surgery: an Efficient and Anatomical Technique

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Abstract

The popliteal sciatic nerve block is a form of regional anesthesia most commonly used as a form of postoperative analgesia. It has shown to be effective for 15-20 hours postoperatively. It can also be used for various foot and ankle pathologies including fracture and dislocation reduction, exploration of foreign bodies, and bedside incision and drainage. The popliteal sciatic nerve block has an additional benefit in that it decreases amount of postoperative opioid consumption limiting the complications of these medications.

There are several techniques in administering this form of anesthesia including a posterior approach for prone patients, or a lateral approach for a supine patient which requires less time. It is physician preference whether the use of single or double injection technique is employed; however, ultrasound guidance and neurostimulation are typically utilized during this procedure. When using neurostimulation, a plantarflexion response is more predictive of complete sensory blockade than a dorsiflexion response. Using ultrasound with neurostimulation has greater efficacy at 60 minutes than using neurostimulation alone.

While this article's primary purpose is to review the current literature regarding the popliteal sciatic nerve block, the technique employed at our institution is described. Our technique utilizes a lateral approach in the operating room following induction of general anesthesia. Both ultrasound guidance and neurostimulation are used. An assistant holds the leg with the hip slightly flexed and the knee extended to allow for a taut neurovascular bundle. The approach is approximately 5-7 cm cranial to the lateral femoral condyle at a groove between the anterior border of the biceps femoris tendon and the vastus lateralis muscle. The neurostimulation device is set a 1.0 mA and is advanced until a plantarflexion response is noted. A total of 20-30 cc of 0.5% bupivacaine with epinephrine 1:200,000 is injected. The saphenous nerve can be anesthetized between the sartorius and vastus medialis muscles just anterior to the femoral artery. A combination of the popliteal sciatic nerve block and saphenous nerve block has shown to be efficacious in patient satisfaction and pain relief for 24 hours.

Keywords Popliteal nerve block; Peripheral nerve block; Post-operative pain relief

Introduction

The popliteal nerve block is a form of regional anesthesia utilized for a variety of foot and ankle conditions. This form of anesthesia has become a popular technique to decrease postoperative pain, decrease narcotic use, and increase patient satisfaction. This is evident by an increase in published techniques within foot and ankle literature in the 21st century [1]. Furthermore, a publication by Hegewald et al. has demonstrated that not only is the popliteal block highly efficacious, but can also be executed by the novice foot and ankle surgeon [2]. While principally used as a form of postoperative analgesia, it can be employed for fracture and dislocation reduction, exploration of foreign bodies, bedside incision and drainage procedures, and wound

debridements. Popliteal blocks can potentially be utilized as the sole source of anesthesia for foot and ankle surgery. This can be beneficial in medically compromised patients. Profound analgesia during both the operative and post-operative time periods and the avoidance of systemic complications such as nausea and vomiting are also potential benefits of the popliteal nerve block. Other advantages include earlier discharge from the post-anesthesia care unit and decreased opioid consumption perioperatively [3].

There are several approaches to administering a popliteal sciatic nerve block, all with unique advantages and disadvantages. Commonly, a posterior approach is employed with the patient positioned prone. Alternatively, the lateral approach can be used with patient in the supine position. The medial approach has been described in the literature, although it is less frequently utilized [4]. There are various techniques when administering anesthetic to the

therapeutic plexus of nerves of the popliteal fossa. Single and double injection, continuous infusion and bolus dosing through a perineural catheter, and the use of electrical stimulation with or without ultrasound guidance have all been described. In all cases, it is paramount to note the presence of the distal medial region of the foot and ankle innervated solely by the saphenous nerve [2]. This is a cutaneous branch of the femoral nerve. This region may need to be anesthetized separately when working in the dorsomedial aspect of the foot and ankle [2]. Recently, the use of liposomal bupivacaine has been utilized in popliteal nerve blocks seen in a small case series of three patients. The purpose was to provide long acting regional anesthesia without the risks of using a perineural catheter as liposomal bupivacaine can last up to 72 hours [5,6].

Complications from popliteal nerve blocks are uncommon as the reported rate is 0-10% [6,7]. The most common complications include incomplete anesthesia, infection, and neuropraxia. Hajek performed a retrospective study of 157 procedures where a continuous popliteal nerve block was used for hallux valgus surgery. He reported a complication rate of 1.26% in the form of postoperative peripheral neuropathy, complete block failure in 4%, and partial failure in 10% [7]. In a study of 400 continuous popliteal nerve blocks for post-operative analgesia, Compère recorded one infection and two neuropathies. There were also three unsuccessful and twelve difficult popliteal blocks [8]. Reflex sympathetic dystrophy was also seen in one patient following popliteal nerve block after the nerve was punctured.

Published Techniques

While the sciatic nerve can be anesthetized in the gluteal region, the popliteal fossa is a more accessible region prior to performing foot and ankle surgery. Typically, the popliteal block is approached posteriorly which has a more direct anatomic access to the sciatic nerve for the prone patient.

Medial

In 2004, Guntz introduced a medial approach to the popliteal block. Following an anatomical study on six cadavers, a medial popliteal block was performed on twenty patients. The patient was placed in a supine position with the thigh flexed, abducted and externally rotated 30 degrees, while the leg was flexed 130 degrees. The location for needle entry was located superior to the adductor tubercle in an area known as Jobert's Fossa, a depression located anterior to sartorius and gracilis muscles and posterior to vastus medialis. At this location, the mean distance between skin and sciatic nerve was 6.62 cm. The mean time to perform the block was 5.6 minutes, in contrast to 4.10 minutes by the lateral approach. In the case series, the sensory block was complete in eighteen of twenty patients. With this approach, there is a greater risk for puncture of the popliteal vessels due to their medial position in relationship to the sciatic nerve [4].

Posterior

The more classic posterior approach allows easier access to the sciatic nerve in the popliteal fossa, but it typically requires prone positioning of the patient. Figure 1 demonstrates the anatomic landmarks of the popliteal fossa. This technique involves outlining the popliteal crease and the tendons of the medially located semitendinosus muscle and the laterally positioned biceps femoris muscle. The midline between semitendinosus and biceps femoris on the popliteal crease is noted, and the needle entry point is 7.0 cm

proximal and 1.0 cm lateral to the crease [9]. It is important to note the sciatic nerve divides into its tibial and common peroneal components at a mean distance of 60.5 millimeters superior to the popliteal fossa [10]. In a study by Rangel, the authors noted the tibial nerve component was located 10.7 millimeters deep to the posterior surface of the popliteal fossa. In this study, there was a successful block in all twenty-eight cases through a posterior approach in the supine position [11]. Lee performed an extensive anatomic study of the sciatic nerve and its components at the popliteal crease. The authors found the bifurcation point of the sciatic nerve was a mean 7.9 cm superior to the popliteal crease. Measuring from the most lateral aspect of the popliteal fossa, the tibial and common peroneal nerves crossed the popliteal crease at 5.5 cm and 2.9 cm, respectively. As the tibial and common peroneal nerves intersected the popliteal crease, the depths were 1.4 cm and 0.7 cm respectively [12].



Figure 1: Shown are the anatomical landmarks of the popliteal fossa.

Lateral

The lateral approach allows for a more practical and similarly efficacious application of the popliteal nerve block. For this reason, the lateral approach is the authors' preferred technique. With the patient in a supine position, a point is marked 7.0 cm cephalad to the lateral femoral condyle in the groove between biceps femoris and vastus lateralis muscles. The needle is advanced until the shaft of the femur is contacted. It is then withdrawn and redirected posterior at a 30 degree angle to the horizontal plane. In this technique described by Zetlaoui, the average time to perform the block was 4.10 minutes, and the motor blockade was complete in all patients within thirty minutes. All patients had good to excellent postoperative analgesia for 15-20 hours [9,13]. The lateral technique is an indirect approach; however it does not require the patient to be positioned prone.

Because the sciatic nerve bifurcation can be variable between patients, many advocate a double injection to ensure anesthesia of both the tibial and common peroneal components. There has been evidence demonstrating a double injection decreases onset time and improves success of the blockade. However, this additional maneuver

can offset the faster onset, potentially increasing patient discomfort, and increasing incidence of neurologic complications [14].

Efficacy

The popliteal block is a powerful adjunct to the postoperative pain control regimen, and it can be utilized as the sole anesthetic technique for outpatient foot and ankle surgery. Hansen supported this when he performed various foot and ankle surgeries including a bunionectomy, open reduction and internal fixation of ankle fractures, ligament repair, Achilles tendon repair, hardware removal, and ankle arthroscopy, while using the popliteal block as the sole means of anesthesia. Out of the forty-eight patients, all were satisfied and seven stated this form of anesthesia was superior to previous anesthetic experiences [3]. In a large review by Provenzano, popliteal blocks were performed on 467 patients. This was successful as the sole anesthetic technique in 79% of cases, while 18% were converted to general anesthesia. The success of the popliteal block was a powerful predictor of same day discharge and decrease use of analgesics in the PACU [15].

The combination of a popliteal block and ankle block compared to popliteal block alone can significantly increase patient satisfaction throughout the postoperative period [16]. If using a peripheral nerve block as a sole source of anesthesia for surgical intervention proximal to the ankle, a popliteal block would most definitely suffice. However, when working distal to the ankle, some may choose to utilize a ring-type ankle block. Migues performed fifty-one unilateral forefoot procedures using solely a ring-type ankle block or popliteal block for anesthesia. There was 92% success in the ring-type ankle block group and 96% success in popliteal block group. The ring-type ankle block and popliteal block took 14.3 minutes and 19.2 minutes respectively, while the ring-type ankle block allowed 10.96 hours of postoperative analgesia and popliteal block allowed 14.32 hours [17].

Popliteal blocks have shown to decrease the amount of perioperative opioid consumption. This can aid in limiting opioid related complications including nausea and vomiting, respiratory depression, constipation, and dependency. Richman performed a meta-analysis to investigate the ability of popliteal blocks to reduce patient opioid consumption. He reviewed nineteen articles with 603 patients, and found a significant decrease in opioid use with the addition of a perineural block. Additionally, perineural analgesia provided better postoperative analgesia compared to opioids at 24, 48, and 72 hours. As expected, nausea, vomiting, sedation, and pruritis occurred more often with opioid use [18]. In a study of thirty total ankle implant arthroplasties performed by Gallardo, he found that a continuous infusion popliteal block provided significantly better pain control at 6, 12, 18, and 24 hours postoperatively compared to those without. The block group exhibited significantly lower consumption of morphine [19]. McLeod, however, performed a study showing 43% of patients with a popliteal block alone required opioids in the PACU compared to only 16% of those receiving simply an ankle block [20].

Ultrasound and neurostimulation

Because of the increasing popularity of ultrasound, it has become a popular area of research. Philips performed a retrospective review on treatment of sixteen patients in the emergency department using nerve-stimulator assisted popliteal blocks [21]. Cases included procedures of leg, ankle, and foot such as fracture reduction, splinting, irrigation, and debridement. In addition to high efficiency, there was a

high degree of patient satisfaction. Post procedural anesthesia lasted 90 to 120 minutes in all cases. It was concluded that this technique offers the advantage of relative cardiopulmonary safety, dense and prolonged analgesia, and maintenance of normal airway reflexes in patients with increased aspiration risk [21]. When comparing two stimulating groups with one non-stimulating group, higher visual analog scores were recorded in the non-stimulating group at 6-8 hours and 19-23 hours [22].

When using neurostimulation, plantarflexion response is more predictive of complete sensory blockade than using a dorsiflexion response [23]. The technique of using neurostimulation varies, but commonly a motor response is stimulated at approximately 0.5 mA to 1.0 mA until the foot plantarflexes and inverts in a pulsated fashion. The stimulation device is then decreased to 0.3 mA to dampen the electric pulse in order to get closer to the nerve without penetrating it [24]. Certainly, neurostimulation is a reliable technique that allows for increased efficiency and efficacy when dealing foot and ankle pathology.

Ultrasonography allows the physician to achieve visualization of the sciatic nerve in the popliteal fossa, and has been shown to increase patient benefit. With ultrasound, a distinction can be seen where the sciatic nerve bifurcates into its tibial and common peroneal nerve components. Patients with a popliteal block distal to the bifurcation exhibit a significantly faster time to complete block than a proximal block [25]. A distal block allows the physician to confidently block the separate nerve components. When compared to neurostimulation or other techniques, ultrasound has a higher success rate, faster onset, a less painful application, faster progression of sensorimotor block, all without an increase in block procedure time or complications. [26-29]. With ultrasonography, less anesthetic is required without any compromise in efficacy [30,31]. Dufour demonstrated the synergistic effect of ultrasound and neurostimulation. In his prospective, randomized study of 60 patients, there was 65% success of sensorimotor block at 30 minutes compared to 16% when using neurostimulation alone [31].

Authors' Technique



Figure 2: Shown are the basic materials needed for an effective and safe popliteal and sural nerve block. From left to right: nerve stimulator with 90 mm insulated needle, 30 cc syringe, ultrasound machine with musculoskeletal probe, local anesthetic, grounding patch for the nerve stimulator, sterile skin prep, and sterile gloves.

Figure 2 and Table 1 demonstrate the materials necessary to execute the procedure. The technique we most frequently utilize is the lateral approach. Many clinicians perform the popliteal block before the patient enters the operating room. This is typically performed in the preoperative holding area or a specialized procedure room. We feel that this method is inefficient and places undue anxiety and pain onto the patient. For this reason, we routinely perform the block once the patient has been induced with general anesthesia. We always perform the block with the aid of both ultrasonography and nerve stimulation. We feel this allows for a quick and safe approach to performing the block. Two knee positions are available while performing the procedure. The first is with the patient lying on the operating table in the supine position while the hip and knee are flexed to about 45 degrees. An assistant is utilized to hold this position (Figure 3).



Figure 3 : “Bent knee” technique. Anatomically, the neurovascular bundle becomes loose with this method. This may make for more difficult localization of the popliteal nerve.

In our opinion, a more efficacious method is with the hip slightly flexed and the knee extended (Figure 4). This provides a “taut” neurovascular bundle that is typically easier to manipulate under ultrasound control. The clinician performing the block will sit on the lateral aspect of the ipsilateral limb. The nerve stimulator is attached to the ipsilateral limb and a 90 mm insulated peripheral nerve needle. The portable ultrasound unit is placed adjacent to the contralateral limb to allow for screen visualization. The lateral aspect of the distal femoral region is prepped with a chlorohexidine or alcohol combination prep stick. The approach is about 5-7 cm cranial to the lateral femoral condyle at a groove between the anterior border of the biceps femoris tendon and the vastus lateralis muscle [Figure 4]. The ultrasound probe is placed with gel into the popliteal fossa. The tibial and common peroneal nerves are visualized distally. The probe is moved proximally until the branches converge into the popliteal nerve (Figures 5 and 6).

This is the location for nerve blockade. The nerve stimulator is set to 1.0 mA, and the insulated needle is advanced medially and slightly proximal and downward to avoid the femur. Once the needle is visualized on ultrasound, it is advanced towards the popliteal nerve. Upon approach of the epineurium, the nerve stimulator will invoke a plantarflexory response. At this point a print out of the image is taken for documentation purposes. Negative pressure is utilized on the syringe to ensure extravascular position and anesthetic is then

deposited in a circular fashion to bathe the nerve (Figure 7). Approximately 5-10 cc per quadrant are utilized for a total of 20-30 cc of anesthetic used. We prefer to use 0.5% bupivacaine with epinephrine in a 1:200,000 ratio. The known maximum dosage of this medication mixture is 45 ml [32]. Alternatively ropivacaine can be used, and is especially useful in the pediatric setting due to its low cardiogenic toxicity [32]. Not only does this provide prolonged anesthetic effect, but also provides a final failsafe against intravascular injection. Because our patients are under general or MAC anesthesia during the procedure, an intravascular injection will result in an instant rise in heart rate, which would alert the clinician of intravascular administration.



Figure 4: “Straight leg” technique. With this method, the neurovascular bundle becomes slightly taut. This allows for easier localization and manipulation of the nerve under ultrasound guidance, and hence a technically easier block to perform.



Figure 5: Here the two distal nerve components can be observed. The popliteal vessels can also be identified.



Figure 6: The two distal nerves converge into the popliteal nerve.



Figure 7: The needle can be visualized surrounding the popliteal nerve.

We then perform a saphenous nerve block with the aid of ultrasonography. Previous techniques describe a blind approach to the saphenous nerve with limited longevity of the block [1]. The ipsilateral limb is then extended and allowed to externally rotate at the hip. This allows direct access of the saphenous component of the femoral nerve. The saphenous nerve lies just anterior to the femoral artery as it courses through the adductor canal. It can be accessed in the mid-thigh as it passes beneath the sartorius muscle (Figure 8). At this point, ultrasonography is used to visualize the femoral artery, and the needle is inserted anterior to the artery (Figure 9). This is where the nerve will lie. Negative pressure is again utilized to ensure extravascular position, and 10 cc of anesthetic is administered in this area. The needle is removed, all ultrasound gel is cleansed from the patient, and the surgeon is ready to proceed with the procedure. This technique ultimately allows for decreased amount of anesthetic intra-

operatively, as well as decreased amount of opioid analgesics throughout the perioperative course [18].

Items Needed for a Popliteal Block
Musculoskeletal Ultrasound w/ Probe
Ultrasound Gel
Peripheral Nerve Stimulator and Grounding Pad
90 mm Insulated Needle
30 cc Syringe
Long-Acting Local Anesthetic
Sterile Skin Prep
Sterile Procedure Gloves
A Competent Assistant

Table 1: A simple checklist for the clinician to perform an effective popliteal nerve block. A Competent Assistant is not pictured.



Figure 8: The approach for the saphenous nerve block.

Conclusion

While the primary purpose of this research paper was to discuss evidence medicine for the popliteal sciatic nerve block as well as our technique, we also wanted to discuss its wide variety of clinical applications. However, it should be noted that the popliteal block has its greatest utility combined with general anesthesia in its use for extended postoperative analgesia due to its consistently high success and satisfaction rates.

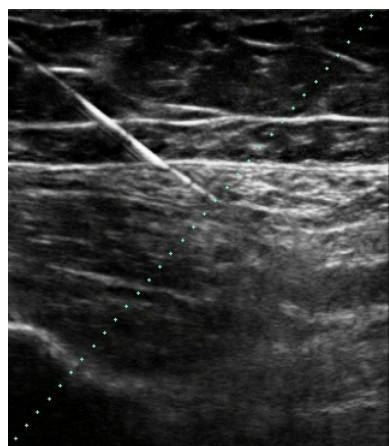


Figure 9: The femoral artery can be seen just deep to the tip of the needle. The femur is noted to the bottom left of the screen. The saphenous nerve runs parallel to the superficial femoral artery.

In a study of 1088 patients for all types of ambulatory surgery, the most important factor in determining discharge time from the PACU was the choice of anesthesia [33]. Symptoms from general, spinal, or epidural anesthesia include pain, postoperative nausea and vomiting, urinary retention, as well as respiratory and hemodynamic instability. Many of these issues can be circumvented with the popliteal sciatic nerve block [3,7]. General anesthesia itself does not relieve postoperative pain [29]. In a study by Rongstad, twenty-two out of twenty-three patients who had a previous foot or ankle operation stated that a popliteal block was better than their previous pain control regimen. This allowed for a more gradual return of pain sensation, which was more tolerant to oral pain medications [34]. With the advent of liposomal bupivacaine, the use of popliteal nerve block has the potential to be predictably efficacious in terms of pain relief in the future. While many studies have demonstrated success of the popliteal block as the sole source of patient anesthesia, most patients and surgeons prefer the comfort and general predictability of general or MAC anesthesia.

In the senior author's experience [MBC] there is grave concern for the development of compartment syndrome in the post-operative setting. Commonly, after foot and ankle surgery, patients are placed into rigid synthetic short leg casts. Patients experiencing therapeutic analgesia secondary to the popliteal block may be unable to sense an increase in pain or paresthesias secondary to postoperative edema within the cast. Patients may also underestimate post-operative pain while the popliteal block is in effect. This may lead to an increase in opioid consumption and anxiety when the block wears off. Careful monitoring of the patient in the initial post-operative phase is paramount to prevent these complications.

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