A Comparison of Intertendinous and Classical Approaches to Popliteal Nerve Block Using Magnetic Resonance Imaging Simulation

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The classical approach to sciatic nerve block in the popliteal fossa (popliteal block) often requires multiple attempts to localize the sciatic nerve. Recently, it has been suggested that an intertendinous approach to popliteal block may result in a more consistent localization of the sciatic nerve. In the current study, we compared anatomical landmarks for the intertendinous and classical approaches to popliteal block with respect to the accuracy in localizing the sciatic nerve using magnetic resonance imaging simulation. Two anesthesiologists experienced in popliteal block drew landmarks for the intertendinous and classical approaches on 10 volunteers; a 1.5 Tesla superconducting magnet was used to obtain simultaneous, 10-mm thick, fast-spin echo proton density transverse axial sequences of the lower extremities. Using these acquired images, the two approaches were simulated offline using previously identified landmarks. The spatial relationships of the simulated needle paths to the nerves and vessels in the popliteal fossa, as well as other relevant structures, were measured and compared. Simulation of the intertendinous approach to popliteal block resulted in needle-to-sciatic nerve contact in 14 legs (70%) versus 5 legs (25%) when the classical approach was used ($P < 0.05$). We conclude that the intertendinous approach might result in a more consistent localization of the sciatic nerve and may decrease the risk of sciatic vessel puncture.

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Sciatic nerve block in the popliteal fossa (popliteal block) has several advantages over other anesthetic techniques for lower extremity surgery (1). As opposed to the more proximal approaches to the sciatic nerve block, the popliteal block spares the hamstring muscles and promotes postoperative ambulation. Compared with spinal anesthesia, it results in a unilateral block, carries no risk of postdural puncture headache, results in prolonged postoperative analgesia, and can be performed in patients being treated with anticoagulant therapy. Despite these potential advantages, popliteal block is not often used for lower extremity surgery in the United States (2). The reasons for the infrequent use of this block may be related to inadequate training of residents (2), concerns over operating room efficiency, and a highly variable success rate of the block (2–4).

The most frequently used technique for popliteal block is the classical, posterior approach where the needle insertion site is 7 cm above the popliteal fossa crease and 1 cm lateral to the midline of the popliteal fossa triangle (formed by the popliteal fossa crease, the semimembranosus and semitendinosus muscles, and the biceps femoris muscles) (4). The needle is then advanced from posterior to anterior until the sciatic nerve is identified (3). However, these landmarks are rather unclear in many patients, and multiple attempts are often required to localize the sciatic nerve using this approach. Consequently, in our clinical practice and training of residents, we have developed a new intertendinous approach to popliteal block (5).[1] Using this approach, the needle is inserted at the midpoint between the tendons of the biceps femoris and semitendinosus muscles rather than 1 cm lateral to the midline of the popliteal fossa triangle as in the classical approach. In the current study, a magnetic resonance imaging (MRI) simulation of the popliteal block was undertaken to compare the accuracy of needle placement in relationship to the sciatic nerve using the intertendinous and classical approaches.

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[1] Regional techniques: www.NYSORA.com.

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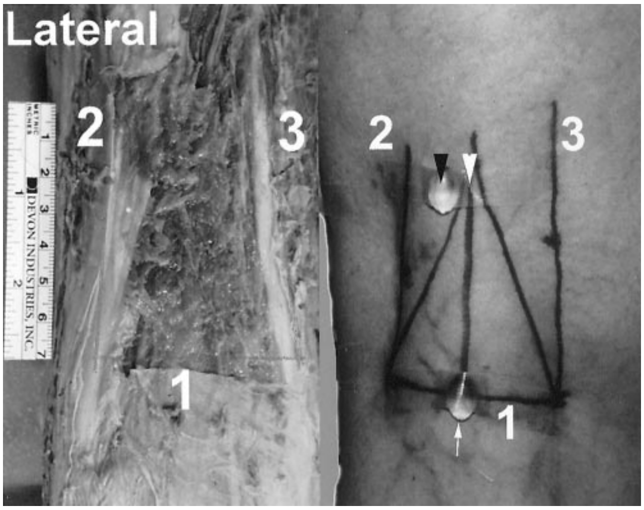

Figure 1. The surface anatomical landmarks for the intertendinous and classical approaches to popliteal block. The anatomical dissection at the level of the tendons of the hamstring muscles and corresponding surface anatomy in a patient are shown. The numbered structures are: 1) popliteal fossa crease, 2) tendon of biceps femoris muscle laterally, and 3) tendon of semitendinosus muscle medially. The white arrow is the center of the popliteal fossa crease. The white arrowhead is the needle insertion point for the intertendinous approach at the midpoint between the tendons of biceps femoris and semitendinosus muscles. The black arrowhead is the needle insertion point for the classical approach 1 cm lateral to the popliteal fossa triangle (shown in black). Both insertion points are at 7 cm above the popliteal fossa crease. The taped oval structures are vitamin E capsules, which were used as magnetic resonance imaging (MRI) markers.

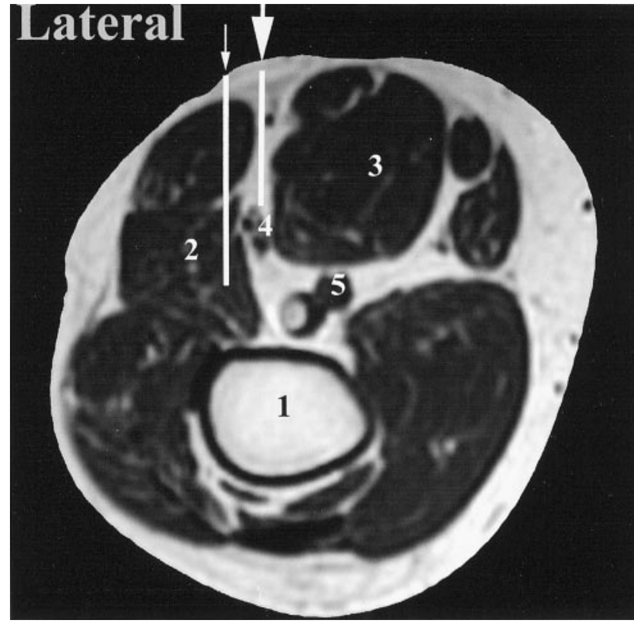

Figure 2. Simulation of intertendinous and classical approaches to popliteal block. Magnetic resonance imaging (MRI) is taken at 7 cm above the popliteal fossa crease. The large arrow indicates the simulated trajectories of needle insertion for the intertendinous approach (between the tendons of biceps femoris and semitendinosus muscles). The small arrow indicates the simulated trajectories of needle insertion for the classical approach. The numbered structures are: 1) femur, 2) biceps femoris muscle, 3) semitendinosus muscle, 4) popliteal nerve, and 5) popliteal artery and vein.

Materials and Methods

After approval by the IRB, 10 healthy, adult volunteers were enrolled in the study after written consent was obtained. The anatomical surface landmarks for needle insertion using the intertendinous and classical approaches to popliteal block were identified by two attending anesthesiologists familiar with popliteal block (authors of the study) and then labeled using MRI contrast markers (vitamin E capsules). The anesthesiologists jointly examined the extremities and agreed upon the landmarks and the insertion points for both approaches in all patients. For the classical technique, the needle insertion site (for offline simulation) was labeled with vitamin E capsules 7 cm above the popliteal fossa crease and 1 cm lateral to the midline of the popliteal fossa triangle (identified by drawing a line along the converging course of the bodies of the semimembranosus and biceps femoris muscles) (4). For the intertendinous approach, the needle insertion site was also labeled 7 cm above the popliteal fossa crease at the midpoint between the tendons of the semimembranosus and biceps femoris muscles, which is in contrast to the classical technique (Fig. 1). The described landmarks and needle insertion sites were performed on both legs for all subjects.

The volunteers were then placed on an MRI scanning table in the prone position with their legs fully extended so that the long axes of the feet formed a 90° angle with the horizontal plane of the table. MRI studies were conducted using a 1.5 Tesla superconducting magnet to scan both lower extremities simultaneously using a body coil. Fast-spin echo proton density transverse axial sequences of 10-mm thick slices were obtained from the level of the midthigh to the knee joint. The needle trajectories to sciatic nerve in the popliteal fossa (virtual needle insertions) were simulated offline using GE Signa Advantage, version 5.42 (IGC-Medical Advances, Milwaukee, WI) software by an independent, blinded interpreter. For both approaches, the simulations were performed at 7 cm above the popliteal fossa crease and at an angle perpendicular to the horizontal plane. A line simulating the needle insertion path (simulated or virtual needle) was placed through the labeled insertion sites on the image and extended anteriorly in a sagittal plane (perpendicular to the horizontal plane), as it would be done in a popliteal block (Fig. 2) (4,5). The order of simulations was random; approximately half of the simulations were first performed with the intertendinous approach and half with the classical approach. The spatial proximity of the needle trajectory to the sciatic nerve and its distance (relationship) to the structures

Table 1. Anatomical Measurements Relevant to Popliteal Nerve Block (n = 10)

Distances	Mean ± SE (mm)	Range (mm)
Skin–PN[a]	36 ± 4	25–41
PN–femur[a]	19 ± 3	13–24
PN-PV[b]	9.0 ± 4	2–18

PN = popliteal nerve; PV = popliteal vessels.
[a] Measured in the saggital plane (posteroanterior).
[b] Measured as the closest distance between the popliteal nerve and popliteal vein or artery.

important to popliteal block were measured for each simulation.

Data are expressed as means ± SE for continuous measures. Because both approaches were studied in the same volunteers, McNemar χ^2 tests were used to evaluate differences between the two approaches for the proportions presented in Table 2. Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS for Windows, version 5.0.2, SPSS, Chicago, IL); $P < 0.05$ was considered significant.

Results

The mean age, weight, and height of the 10 volunteers was 39 ± 8 yr (range, 20–60 yr), 78 ± 12 kg (range, 53–90 kg), and 174 ± 9 cm (range, 162–186 cm), respectively.

The anatomical measurements of significance to popliteal block are presented in Table 1. The tibial and common peroneal components of the sciatic nerve appeared to be undivided or close on MRI images at 7 cm above the popliteal fossa crease in all studied extremities. The proportion of simulated needle-to-nerve contacts, as well as other simulated needle insertion characteristics, are presented in Table 2. Simulated needle-to-nerve contact occurred significantly more often with the intertendinous approach (70%) than with the classical approach (25%). In the remaining 30% of needle simulations that did not contact the sciatic nerve using the intertendinous approach, 10°–15° lateral redirection of the simulated needle placed the needle in line with the sciatic nerve, avoiding the risk of intersecting the popliteal artery or vein. In contrast, 75% of needle simulations using the classical approach missed the sciatic nerve and required medial redirection of the needle to reach the sciatic nerve. The required medial redirection of the needle (between 10° and 30°) to reach the sciatic nerve using the classical approach carries a risk of intersecting the popliteal artery and vein, which are situated medially to the sciatic nerve. Indeed, in three simulations using the classical approach, the simulated needle path encountered the popliteal vessels with medial redirections of the needle. Furthermore, passage of the simulated needle through the biceps femoris muscle occurred less often with the intertendinous approach (5%) than with the classical approach (85%) (Table 2).

Discussion

These data suggest that the intertendinous approach to popliteal block provides more accurate localization of the sciatic nerve in the popliteal fossa. Indeed, simulation of needle placement using the intertendinous approach resulted in needle-to-sciatic nerve contacts almost three times more often than with the classical technique. Furthermore, medial redirection of the needle (toward the popliteal vessels) was required to contact the sciatic nerve using the classical approach as opposed to the lateral redirection with the intertendinous technique.

We speculate that the main reason for difficulty in localizing the sciatic nerve using the classical approach is an inability to accurately identify the boundaries of the popliteal fossa triangle. The base of the triangle is formed by the popliteal fossa crease and the sides by the semitendinosus and semimembranosus muscles medially and the biceps femoris muscle laterally. Whereas the muscular boundaries of the triangle are easily identified in cadavers, they are much more obscure and can be difficult to discern in living patients (Fig. 1). Consequently, it is not often clear what part of the muscles, tendon, or body is palpated in many subjects. In contrast, the tendons of these muscles, which we proposed as landmarks for the intertendinous approach, are easily and accurately identified, even in an obese patient (5). Importantly, these tendons do not converge into a triangle (as the muscles do higher in the thigh), but rather they follow a near-parallel course in the popliteal fossa. These data and data from another of our clinical studies (5) indicate that the sciatic nerve is more accurately identified with the intertendinous approach using the tendons as landmarks rather than the popliteal fossa triangle that is used in the classical approach to popliteal block. Because the muscle boundaries of the popliteal triangle are often difficult to appreciate with accuracy, it is possible that the tendons are often mistaken as the boundaries of the muscles. In that case, placement of the needle would then be too lateral for needle contact with the sciatic nerve. This medial redirection of the needle, which would be required to reach the sciatic nerve, may carry an increased risk of puncturing the popliteal vessels, especially when longer needles (e.g., 40 mm or longer) are used. In addition, needles inserted using the classical approach more often transect the body of the biceps femoris muscle, which may result in discomfort during the procedure.

The use of MRI to compare needle trajectory does not provide information on clinical success of the block or

Table 2. Needle Trajectories Measurements in Relation to Popliteal Fossa Structures

	Classical (%)	Intertendinous PNB (%)	*P*
Needle-to-popliteal nerve contact	5 (25)	14 (70)	<0.05
Needle distance ≥2 mm from popliteal nerve	14 (70)	4 (20)	<0.05
Needle passed through biceps femoris muscle	17 (85)	1 (5)	<0.05
Needle-to-popliteal artery or vein contact	0	0	

All data expressed as number of occurrences (*n*).
PNB = popliteal nerve block.

the difference in the ease of nerve localization between the intertendinous versus classical approaches. Nevertheless, in another clinical study, we demonstrated that the intertendinous approach to popliteal block resulted in a 100% success rate (5). The results of the current study may also have been affected by bias because of the fact that unblinded investigators (two authors of the study) identified the landmarks for both approaches. However, the risk for this bias is small for two reasons. First, the landmarks for both the intertendinous and classical approaches were identified using predetermined criteria, and there was uniform agreement between the two investigators with respect to the needle insertion site. Second, our finding of increased frequency of needle to nerve contact with the intertendinous approach in the current study is in agreement with our earlier clinical study.

In summary, under the conditions of our study, the intertendinous approach to popliteal block results in more proximate needle placement to the sciatic nerve in the popliteal fossa. In contrast, relying on the popliteal fossa triangle in the classical approach may result in needle placement that is too lateral to the sciatic nerve. This may require more attempts at nerve localization and redirection of the needle medially, which places the popliteal vessels at risk of puncture.

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