

## Technical Guide

# Revisiting the Genicular Nerve Block: An Up-to-Date Guide Utilizing Ultrasound Guidance and Peripheral Nerve Stimulation – Anatomy Description and Technique Standardization

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**Background:** Over the last decade, several authors have reported that percutaneous peripheral nerve stimulation (PNS) can be used to assist in verifying the position of the procedure needle tip in relation to nerve structures, and that the combined technique using both ultrasound (US) guidance and PNS may serve as a reliable method for confirmation of the correct position of the procedure needle tip. It has also been reported that, when combined with US guidance, PNS may increase the success rate of pain management interventions.

**Objectives:** The aim of this technical report was to standardize an effective and easy to learn illustrated step-by-step technical approach to nerve identification during US-guided genicular nerve blocks, using percutaneous PNS as a verification instrument for procedure needle tip location.

**Study Design:** This technical protocol was developed based on the results of the authors' most recent cadaveric study on the innervation of the knee joint capsule. The technique was developed and tested by 4 different interventionists with different levels of expertise in US-guided procedures.

**Setting:** The cadaveric study of the knee joint capsule innervation was performed at the laboratory of the Division of Anatomy of one institution. The technical protocol using US and PNS was later developed at the medical simulation center of a different institution.

**Methods:** A team of anatomists from a division of anatomy of one institution performed the cadaveric study on the innervation of the knee joint capsule. A team of physicians then developed the step-by-step approach to this technical protocol at the medical simulation center of a different institution. Finally, the illustrated step-by-step approach was tested by 4 different interventionists with different levels of expertise in US-guided procedures (1 beginner-level user; 1 intermediate-level user; 2 expert-level users), using a portable percutaneous PNS and 2 different US transducers at 2 different institutions.

**Results:** This technical protocol was successfully developed based on the results of the cadaveric study on the innervation of the knee joint capsule. Additionally, it was later successfully tested by interventionists with various levels of expertise utilizing different US equipment at separate institutions.

**Limitations:** By combining US and nerve stimulation, this protocol requires the availability of both US equipment and necessary equipment for nerve stimulation that must all be made available in the sterile field. Another potential disadvantage is that nerve stimulation controls and the US image screen are generally located on 2 separate display panels, which could cause difficulty with visualization and simultaneous calibration for 2 individual devices.

**Conclusions:** Our illustrated step-by-step technical protocol can be effectively and safely utilized as a reliable method of training, by which physicians with little to moderate US experience can improve their skills in accurately identifying the genicular nerves while performing US-guided examinations with the intent of executing a peripheral nerve block.

**Key words:** Ultrasound, nerve stimulation, peripheral nerve block, genicular nerve, technical report

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**U**ltrasonography (US) has become an increasingly popular modality in facilitating the performance of peripheral nerve blocks and was one of the major driving forces behind the transformation that occurred in the fields of interventional pain medicine and regional anesthesia during the last 2 decades, by allowing the operator to visualize the nerve, the needle, and, more importantly, the spread of local anesthetic (LA) agents in real time (1).

Depending on the target nerves and the various US-guided techniques utilized worldwide for the localization of peripheral nerves, success rates ranging from 79% to 100% have been reported (2). However, it can sometimes be difficult for beginner-level interventionists to determine the proximity of the needle tip in relation to a targeted nerve structure on the US screen, and this visualization may become more difficult when the targeted structure is a small peripheral nerve (a genicular nerve, for example). Additionally, it should be considered that the high success rates reported for previously described US-guided peripheral nerve block techniques were achieved primarily because of the expertise of the authors/interventionists performing the procedures (2). Given the long learning-curve associated with US-guided procedures, a physician in training may require up to several years of tutored practice to obtain such high success rates. Thus any technical adjunct or technique standardization protocol may prove to be of great value, especially for a beginning to intermediate-level interventionist.

In 2005, Tsui et al (3) reported that nerve stimulation could be used to assist in verifying the position of the procedure needle tip in relation to nerve structures. This was later confirmed in 2007 by Chantzi et al (4), who reported that the combined technique using both US and percutaneous peripheral nerve stimulation (PNS) may serve as a reliable method for procedure needle tip location verification (3,4). Because procedure needles used during percutaneous PNS techniques are polymer coated, they are by definition echogenic, increasing their conspicuity during US-guided interventional pain medicine and regional anesthesia procedures. Both US-guidance and the ease of percutaneous PNS needle visualization has been shown to increase the success rate of pain management interventions (2).

In this original article, we begin by describing the results of our most recent cadaveric study on the innervation of the knee joint capsule. We then describe a standardized combined technique developed by our team, based on the insights obtained from our cadav-

eric study, for nerve identification during US-guided genicular nerve blocks. We used percutaneous PNS as a verification instrument as to the needle tip proximity relative to the selected nerve prior to the execution of the US-guided nerve block.

With this new technical approach to standardization, which combines our latest anatomic insights about the knee joint capsule innervation along with an illustrated step-by-step guide on how to best perform the technique, we hope to create an educational resource for beginner to intermediate-level US interventionists. We hope our guide will shorten their learning curve while striving for optimal success rates with US-guided genicular nerve blocks.

## **METHODS**

### **Technique Description**

This combined technique (using US and percutaneous PNS) for nerve identification during US-guided genicular nerve blocks was developed by an interdisciplinary team at 4 different international institutions: 2 anatomists from a department of surgery, 1 regional anesthesiologist at a department of anesthesiology and perioperative medicine, 2 pain medicine physicians at a department of pain medicine, and 1 physical medicine and rehabilitation (PM&R) physician at a department of PM&R. Approval of the ethical committee of all the institutions involved in this project was obtained prior to the anatomic dissection study and the development of our standardized combined technique.

This standardized combined technique was developed and tested by 4 different interventionists with different levels of expertise in US-guided procedures (1 beginner-level user; 1 intermediate-level user; 2 expert-level users), using 2 different US probes at 2 different institutions: (1) a 6-15 MHz linear array transducer (X-Porte, Fujifilm SonoSite, Inc., Bothell, WA); and (2) a 6-15 MHz linear array transducer (LOGIQ S8 XDclear, GE Healthcare Inc., Chicago, IL). Additional equipment included a portable percutaneous PNS (Stimplex HNS 12, B. Braun Medical Inc., Melsungen, Germany).

This combined technical approach targets 3 different genicular nerves (superior medial [SMGN], inferior medial [IMGN], and superior lateral [SLGN]) (Fig. 1 A, B, and C, respectively). Note: Cadaveric dissection, labeling, photography, and image postprocessing performed by the authors). These 3 articular branches were selected as targets for a combined block technique as they course at the periosteal level. SMGN and SLGN can be located

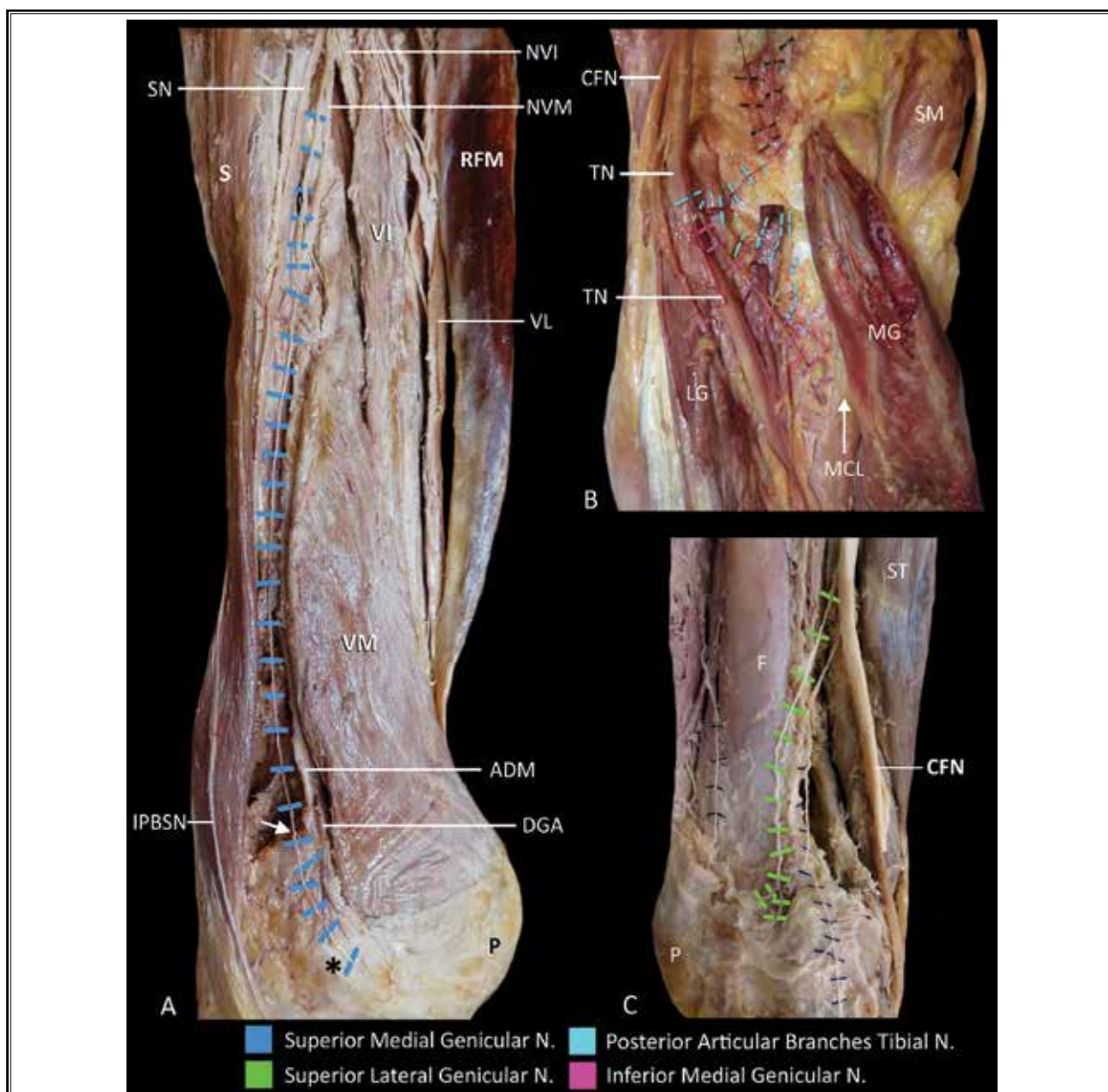


Fig. 1. Cadaveric dissection of the SMGN, IMGN, and SLGN. (A) SMGN, medial view. White arrow indicates origin of most proximal articular branch of the SMGN. (B) Articular branches originating from the tibial nerve, including the IMGN, posterior view. Note the IMGN coursing anterior deep to the MCL of the knee. (C) SLGN branching from the CFN, lateral view. Biceps femoris has been removed.

Abbreviations: ADM, adductor magnus tendon; CFN, common fibular (peroneal) nerve; F, femur; IPBSN, infrapatellar branch of the SN; LG, lateral head of gastrocnemius; MG, medial head of gastrocnemius (reflected); NVI, nerve to vastus intermedius; P, patella; RFM, rectus femoris muscle (reflected); S, sartorius; SM, semimembranosus; SN, saphenous nerve; ST, semitendinosus; TN, tibial nerve; VI, vastus intermedius; VL, vastus lateralis; VM, vastus medialis; \*, medial epicondyle.

at the junction of the shaft of the femur and the medial and lateral femoral condyles (MFC and LFC), respectively, whereas the IMGN can be located at the junction of the shaft of the tibia and the medial tibial condyle (MTC) (5,6).

In our dissections, the SMGN was found to be an articular nerve arising from the nerve to vastus medialis, a branch of the femoral nerve (Fig. 1A). This is consistent with previous findings in the literature (7).

The SMGN coursed along the posterior margin of the vastus medialis and then continued distally along the adductor magnus tendon (ADM) with the descending genicular artery (DGA). Superior to the adductor tubercle, the SMGN divided into articular branches that coursed distally to supply the superomedial knee joint.

The sciatic nerve divided at the apex of the popliteal fossa, into the tibial and common peroneal (fibular) nerves (CFN). Articular branches of the tibial nerve include the IMGN and posterior articular branches (Fig. 1B). The IMGN continued inferior to the MTC, deep to the medial collateral ligament (MCL), to terminate in the inferomedial knee joint capsule, consistent with previous cadaveric dissections (8).

The SLGN, an articular branch of the sciatic nerve or the common fibular (peroneal) nerve (CFN), coursed along the lateral margin of the popliteal fossa. The articular branch entered the anterior compartment of the thigh by passing between the tendon of biceps femoris and the femur. At the superior aspect of the LFC, the SLGN coursed with the deep branch of the superior lateral genicular artery (SLGA) to innervate the superolateral knee joint (Fig. 1C) (7,8).

Using the approach described by Yasar et al (10), combined with the initial landmark description by Choi et al (9), the MFC for the SMGN, the MTC for the IMGN, and the LFC for the SLGN are used as anatomic landmarks for transducer placement at the beginning of the US-guided examination in this technique (Fig. 2A, B, and C, respectively). Pictures with the transducer in the initial position for the US examination, in the sagittal orientation, overlying the MFC, the MTC, and the LFC, respectively (9,10). The genicular nerves are then identified by first localizing their correspondent arterial branches.

To identify the SMGN, the US transducer is first placed in the sagittal orientation over the MFC and then translated proximally to the level of the adductor tubercle and the insertion of the ADM, after which the bony cortex anterior to the peak of the adductor tubercle is targeted, near the SMGN corresponding artery (Fig. 3: Merged picture of the initial position of the transducer [left side], and US picture [right side] showcasing the insertion of the ADM, the superior medial genicular artery, and the SMGN itself).

To identify the IMGN, the US transducer is first placed in the sagittal orientation over the MTC and the MCL is visualized. The transducer is then translated distally to the level of the tibial insertion site of the MCL distal to the MTC, after which the bony cortex is targeted at the midpoint between the peak of the MTC

and the initial fibers inserting on the tibia of the MCL, near the inferior medial genicular artery (IMGA) (Fig. 4: Merged picture of the initial position of the transducer [left side], and US picture [right side] showcasing the level of the tibial insertion site of the MCL distal to the MTC, the IMGA, and the IMGN itself).

To identify the SLGN, the US transducer is first placed in the sagittal orientation over the LFC. The SLGA is then identified in the transition between the shaft of the femur and the superior aspect of the LFC, with the nerve adjacent to it. The bony cortex is then targeted near the SLGA (Fig. 5: Merged picture of the initial position of the probe [left side], and US picture [right side] showcasing the LFC, the SLGA, and the SLGN itself).

After identification of the targeted genicular nerve on the US examination, a 21-gauge, 10-cm insulated percutaneous PNS needle (Stimplex, B. Braun Medical Inc.) is inserted in a proximal to distal direction and advanced in parallel to the long axis of the US transducer (in-plane approach) until the tip of the PNS needle rests adjacent to the identified nerve structure on the US equipment screen. A sensory stimulation test is then performed (stimulation frequency set at 2 Hz, the impulse duration at 1.0 ms, and the intensity of the stimulating current starting at 1.5 mA), preferably by a second operator who controls the nerve stimulator. The sensory stimulation test is considered positive when the patient describes a pressure-like pulsatile sensation, which is concordant with his/her usual distribution of pain. During the test, the tip of the PNS needle is repositioned until the minimal stimulating current is less than 0.5 mA to confirm that the nerve structure identified on the US equipment screen is in fact the targeted genicular nerve. To help guide the repositioning of the PNS needle tip during the stimulation test, the patient is asked if he/she feels tingling, pain, or discomfort in the area of typical joint pain.

On identification of the targeted genicular nerve with the US linear transducer and confirmation of the correct position of the PNS needle tip with nerve stimulation, a standard mixture of LA (with or without corticosteroid) is injected in the area using the same polymer-coated, echogenic, percutaneous PNS needle.

The combined block of the genicular nerves (SMGN, IMGN, and SLGN) is considered successful when the patient experiences a decrease in numeric pain scores between 50% and 80%, or a 3-point reduction in the Numeric Rating Scale, for more than 24 hours.

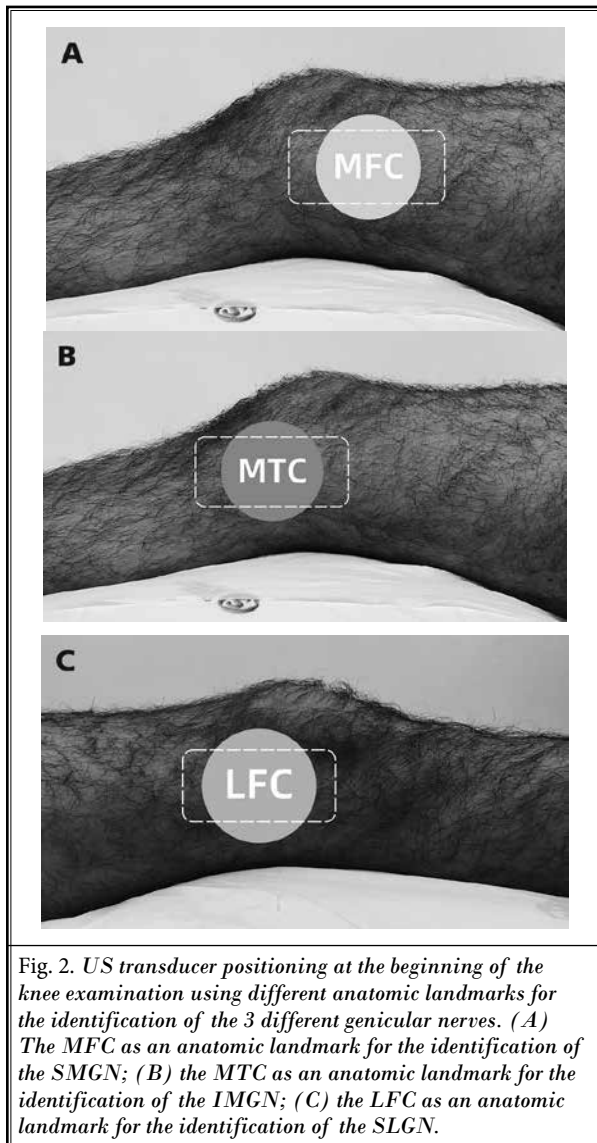


Fig. 2. US transducer positioning at the beginning of the knee examination using different anatomic landmarks for the identification of the 3 different genicular nerves. (A) The MFC as an anatomic landmark for the identification of the SMGN; (B) the MTC as an anatomic landmark for the identification of the IMGN; (C) the LFC as an anatomic landmark for the identification of the SLGN.

## DISCUSSION

Our combined technique for genicular nerve blocks (which targets the SMGN, IMGN, and the SLGN) was developed based on our cadaveric dissection study, the anatomy and histology studies of Hirasawa et al (6); Tran et al (7,8); Yasar et al (10); and Kennedy et al (11); the clinical reports of Protzman et al (12); and the controlled clinical trial of Choi et al (9), who demonstrated improvement in pain and function in chronic knee osteoarthritis following radiofrequency (RF) neurotomy of the SMGN, IMGN, and SLGN.

The innervation of the knee joint is provided by various articular branches. According to Tran et

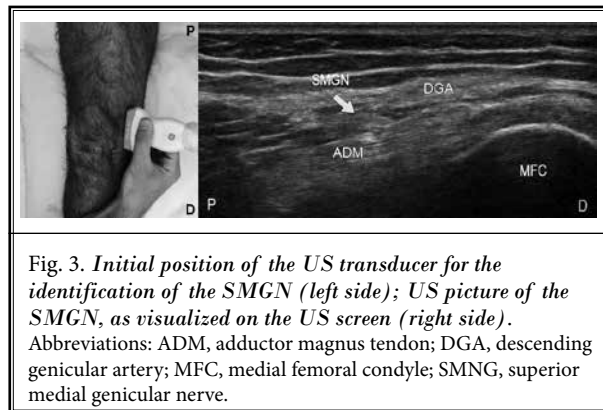


Fig. 3. Initial position of the US transducer for the identification of the SMGN (left side); US picture of the SMGN, as visualized on the US screen (right side). Abbreviations: ADM, adductor magnus tendon; DGA, descending genicular artery; MFC, medial femoral condyle; SMNG, superior medial genicular nerve.

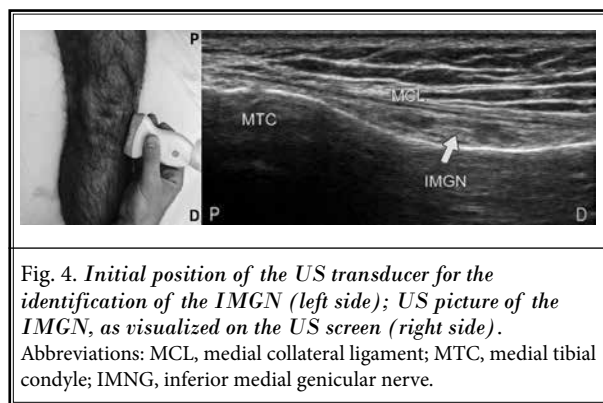


Fig. 4. Initial position of the US transducer for the identification of the IMGN (left side); US picture of the IMGN, as visualized on the US screen (right side). Abbreviations: MCL, medial collateral ligament; MTC, medial tibial condyle; IMGN, inferior medial genicular nerve.

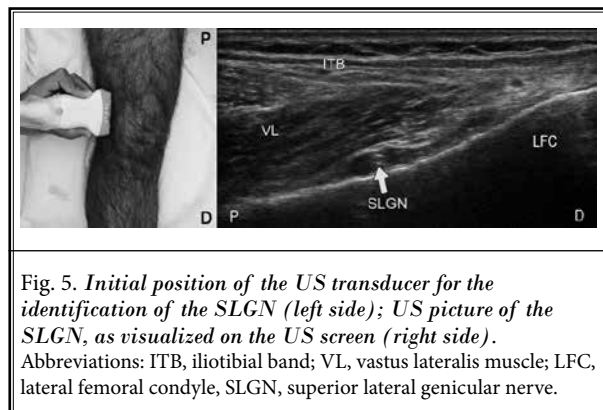


Fig. 5. Initial position of the US transducer for the identification of the SLGN (left side); US picture of the SLGN, as visualized on the US screen (right side). Abbreviations: ITB, iliotibial band; VL, vastus lateralis muscle; LFC, lateral femoral condyle; SLGN, superior lateral genicular nerve.

al (7,8), and Kennedy et al (11), these nerves can be divided into the anterior and the posterior groups. The nerves in the anterior group originate from the femoral, common fibular, and saphenous nerves (SNs), whereas the posterior group consists of the articular branches from the tibial, obturator, and sciatic nerves (7,8,11). In a recent cadaveric study by Tran et al (7,8), the SMGN was shown to be a terminal articular branch of the femoral nerve (anterior group) and not the tibial nerve (posterior group). The tibial nerve (posterior

group) gives off articular branches at the popliteal fossa and is the main innervation of the posterior aspect of the knee joint (9,10). However, the tibial nerve also provides an articular branch (IMGN) that supplies the inferior medial aspect of the anterior knee joint capsule. The articular branches of the CFN (anterior group), which include the SLGN, can originate directly from the sciatic nerve and innervate the superior lateral aspect of anterior knee joint capsule (7,8). In addition, the CFN has been reported to innervate to the posterior knee joint capsule. The SN gives sensation to the anterior inferior aspect of the anterolateral knee joint capsule (7,8).

Although our combined technique is intended to provide a complete genicular nerve block, other authors, such as Kesikburun et al (13), have suggested that targeting the SMGN and IMGN alone might be enough for a successful block in the majority of the patients with chronic knee joint pain, as these might be the only 2 genicular nerves involved in clinically evident knee pain related with medial compartment knee osteoarthritis. Given that the most frequently affected component in knee osteoarthritis is the medial compartment, this means that blocking the SMGN and IMGN alone might be sufficient to achieve a successful block in a large number of patients, while minimizing the risks associated with interventional procedures that target a greater number of nerves around the knee joint (13).

It should also be mentioned that despite the advantages that our combined technique offers, there are also potential drawbacks associated with the use of percutaneous PNS as an adjunct to US-guided small peripheral nerve blocks. One of drawbacks of this technique is that by combining US and nerve stimulation, it requires the availability of both US equipment and the necessary equipment for nerve stimulation that must all be made available in the sterile field. Another potential disadvantage of our combined technique is that nerve stimulation controls and the US image screen are located on 2 separate display panels (US and portable PNS), which could cause difficulty with visualization and simultaneous calibration for 2 individual devices, in cases in which a second assistant is not available for the procedure. In the same scenario, the processes required in setting and changing of device adjustment controls could also possibly lead to unintentional procedure needle tip or US transducer movement. However, these issues could be solved in the future with the development of US equipment that also has the ability of incorporating the mechanics of a nerve stimulator

(14). Finally, it should be considered that utilization of percutaneous PNS might add an extra expense to the patient's charges.

Another aspect that should be considered when preparing to perform this technique is that some patients might have difficulty in describing either the intensity or location of the stimulation, and this can become more challenging in cases in which the patient has been previously sedated.

Some authors, such as Beach et al (15), have also reported that when both the needle and target nerve structure are adequately imaged with the US equipment, nerve stimulation when combined with US has a moderate to high false-negative rate. However, it should be considered that potential problems with adequate nerve stimulation, when used in conjunction with US, could be related to the US gel. Tsui et al (3) reported that when 5% dextrose is used, as a nonconducting medium, it does not affect electrical conduction during nerve stimulation. Thus it is important to avoid using saline solution or gel as a sound medium because it may hinder any subsequent attempts to stimulate the nerve (3).

## CONCLUSIONS

According to our experience, we can propose our combined US-guided technique with the use of percutaneous PNS as an adjunctive reliable approach for performing a complete genicular nerve block in patients with chronic knee joint pain. This block may serve as a diagnostic test to ascertain whether the patient might be a candidate for a subsequent RF neurotomy of the SMGN, IMGN, and SLGN.

By having our technical approach developed and later successfully tested by 4 different physicians at different levels of expertise in US-guided procedures, we hope that our protocol can now be effectively and safely utilized as a reliable method of training, by which physicians with little to moderate US experience can improve their skills in accurately identifying the genicular nerves, while performing US-guided examinations with the intent of executing a peripheral nerve block.

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