

## Cadaveric Study

## Accuracy of Ultrasound-Guided Genicular Nerve Block: A Cadaveric Study

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**Background:** Genicular nerve block has recently emerged as a novel alternative treatment in chronic knee pain. The needle placement for genicular nerve injection is made under fluoroscopic guidance with reference to bony landmarks.

**Objective:** To investigate the anatomic landmarks for medial genicular nerve branches and to determine the accuracy of ultrasound-guided genicular nerve block in a cadaveric model.

**Study Design:** Cadaveric accuracy study.

**Setting:** University hospital anatomy laboratory.

**Methods:** Ten cadaveric knee specimens without surgery or major procedures were used in the study. The anatomic location of the superior medial genicular nerve (SMGN) and the inferior medial genicular nerve (IMGN) was examined using 4 knee dissections. The determined anatomical sites of the genicular nerves in the remaining 6 knee specimens were injected with 0.5 mL red ink under ultrasound guidance. The knee specimens were subsequently dissected to assess for accuracy. If the nerve was dyed with red ink, it was considered accurate placement. All other locations were considered inaccurate.

**Results:** The course of the SMGN is that it curves around the femur shaft and passes between the adductor magnus tendon and the femoral medial epicondyle, then descends approximately one cm anterior to the adductor tubercle. The IMGN is situated horizontally around the tibial medial epicondyle and passes beneath the medial collateral ligament at the midpoint between the tibial medial epicondyle and the tibial insertion of the medial collateral ligament. The adductor tubercle for the SMGN and the medial collateral ligament for the IMGN were determined as anatomic landmarks for ultrasound. The bony cortex one cm anterior to the peak of the adductor tubercle and the bony cortex at the midpoint between the peak of the tibial medial epicondyle and the initial fibers inserting on the tibia of the medial collateral ligament were the target points for the injections of SMGN and IMGN, respectively. In the cadaver dissections both genicular nerves were seen to be dyed with red ink in all the injections of the 6 knees.

**Limitations:** The small number of cadavers might have led to some anatomic variations of genicular nerves being overlooked.

**Conclusions:** The result of this cadaveric study suggests that ultrasound-guided medial genicular nerve branch block can be performed accurately using the above-stated anatomic landmarks.

**Key words:** Knee pain, genicular nerve, nerve block, osteoarthritis, ultrasonography, cadaver study, injection, accuracy

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**T**he pain management of chronic knee osteoarthritis presents many challenges. Non-steroidal anti-inflammatory drugs (NSAIDs) have been suggested not to have long-term benefits

(1,2) and only limited use is recommended due to serious gastrointestinal, cardiovascular, and renal side effects (2). An intraarticular corticosteroid injection can only provide short-term symptomatic relief (3,4). There

are conflicting results for visco-supplementation (5,6). Acupuncture and prolotherapy have little evidence as complementary therapies (7,8). Although total knee joint arthroplasty is generally successful in advanced disease (9), it has an increased mortality and morbidity rate and in younger patients there is the likelihood of future revision surgery due to limited prosthesis lifetime (10).

Genicular nerve block and ablation with radiofrequency (RF) has recently emerged as a novel alternative treatment for chronic knee pain. Superomedial, inferomedial, and superolateral genicular nerve branches have been targeted for RF neurotomy in previous studies (11,12). These nerves have been selected for 2 reasons. First, the genicular nerves are the main innervating articular branches for the knee joint, and second, as these nerves are adjacent to the periosteum connecting the bone, they can be located using bony landmarks under fluoroscopic imaging. Needle placement has been successfully applied under fluoroscopic guidance with reference to bony landmarks (11,12). Ultrasound imaging has several advantages over fluoroscopy in pain interventions. It is inexpensive and easily repeatable. It does not expose the patient or the physician to ionizing radiation. There is a need for identification of anatomic landmarks to locate the genicular nerves under ultrasound imaging.

The purpose of this cadaveric study was to investigate the location of the superomedial and inferomedial genicular nerve branches and to identify the anatomic landmarks to enable the application of ultrasound-guided genicular nerve block. It was also aimed to determine the accuracy of genicular nerve injection using these anatomic landmarks and ultrasound guidance in a cadaveric model.

## **METHODS**

### **General Design**

The study was conducted at Gülhane Military Medical Academy Anatomy Laboratory. Approval for the study was granted by the Local Ethics Committee. Ten knees from embalmed whole cadavers were used for this study. The study consisted of 2 stages. In the first stage of the study, 4 cadaveric knees were dissected to identify the anatomic relationship of the genicular nerves with the surrounding structures and to determine landmarks for ultrasound imaging. The accuracy of ultrasound-guided genicular nerve injection was tested in the other 6 knees at the second stage.

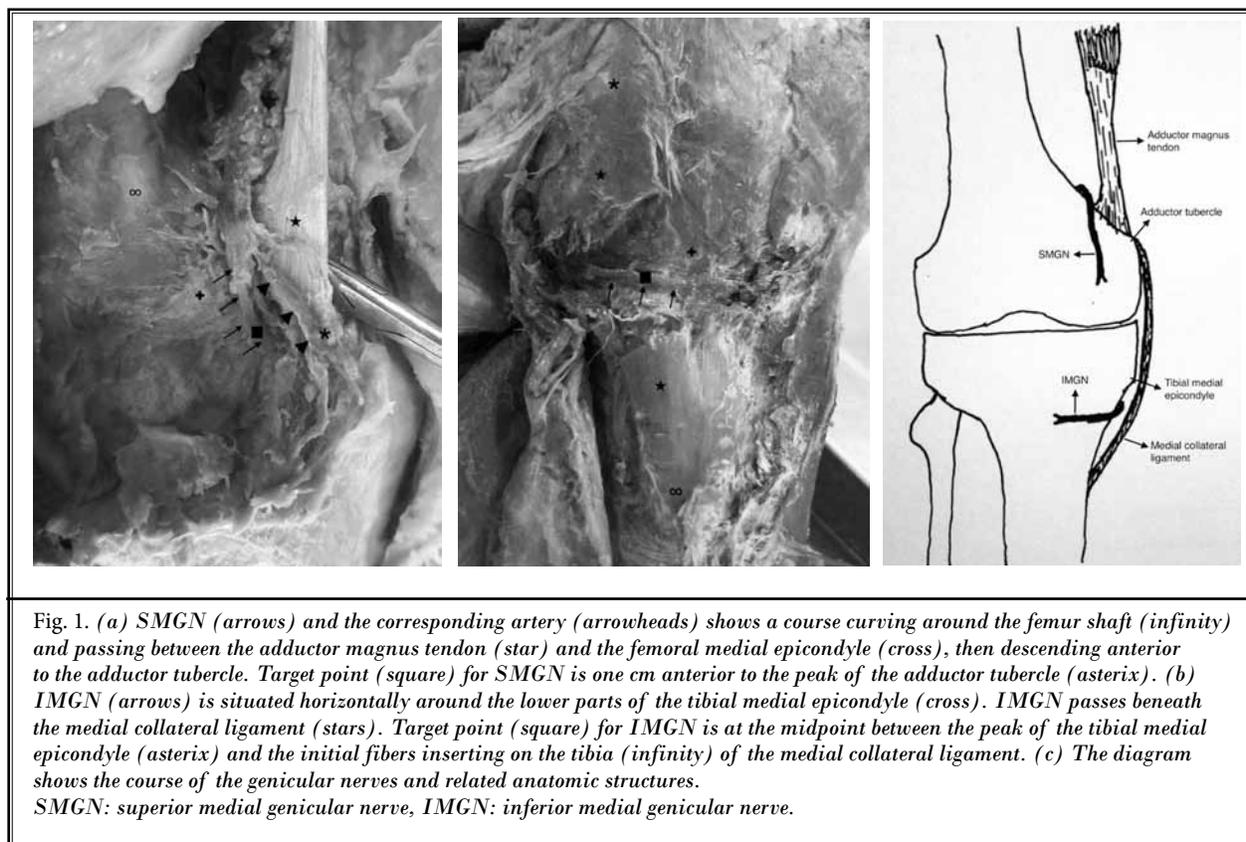
### **Cadaver Study**

None of the cadavers had a history of surgery or major procedures in the knees. The anatomic location of the superior medial genicular nerve (SMGN) and the inferior medial genicular nerve (IMGN), which are the branches of the tibial nerve, was examined in 4 cadaveric knees. All the cadavers were positioned lying on the lateral side with full knee extension for dissection by the investigator who was an experienced anatomist. The skin and subcutaneous tissues in the medial aspect of the knee were removed between the levels of the femoral medial epicondyle and the tibial medial epicondyle. The courses of both genicular nerves were followed from where they branched from the tibial nerve until they went deeper into the interior of the knee joint and disappeared.

The vastus medialis muscle in the superior part of the medial knee was reflected anteriorly to reveal the relationship of the SMGN to the adductor magnus tendon, the adductor tubercle, and the femoral medial epicondyle. The upper end of the medial collateral ligament is attached to the femoral medial epicondyle immediately below the adductor tubercle, which receives the attachment of the adductor magnus tendon. The SMGN branches from the tibial nerve in the superior popliteal region. It has a course of curving around the femur shaft and passes between the adductor magnus tendon and the femoral medial epicondyle, then descends approximately one cm anterior to the adductor tubercle.

The relationship of the IMGN to the medial collateral ligament, the tibial medial epicondyle, and the pes anserinus were revealed in the inferior part of the medial knee. The lower end of the medial collateral ligament is inserted into the medial surface of the body of the tibia below the tibial medial epicondyle. The IMGN branches from the tibial nerve in the inferior popliteal region and is situated horizontally around the lower parts of the tibial medial epicondyle. The deep surface of the medial collateral ligament covers the IMGN, which then passes beneath the medial collateral ligament at the midpoint between the peak of the tibial medial epicondyle and the initial fibers inserting on the tibia of the medial collateral ligament.

Both nerves accompanied the corresponding arteries on their way to the interior of the knee joint. Both nerves lay on the bony surface and were connected to the periosteum. The course of the genicular nerves and related anatomic structures are shown in Fig. 1. The adductor tubercle for the SMGN and the medial collateral



ligament for the IMGN were determined as anatomic landmarks for ultrasound scanning.

### Ultrasound Scanning Technique and Injection Procedure

The ultrasound scanning was performed using a 12-5 MHz linear transducer (LOGIQ E Portable; GE Healthcare, China) by an investigator with more than 4 years of experience in musculoskeletal ultrasonography. The probe was sagittally placed in the medial aspect of the knee which was in full extension and lying on the lateral side. The anatomic landmarks defined in the cadaver study were imaged.

The transducer was placed in a sagittal orientation over the femoral medial epicondyle. The transducer was then translated proximally to the level of the adductor tubercle and the insertion of the adductor magnus tendon was imaged. The bony cortex one cm anterior to the peak of the adductor tubercle was targeted for the injection to the SMGN (Fig. 2a). Thereafter, the transducer was placed in a sagittal orientation over the tibial medial epicondyle. The medial collateral ligament was visualized. The transducer was then translated distally

to the level of the tibial insertion site of the medial collateral ligament below the tibial medial epicondyle. The point of the bony cortex at the midpoint between the peak of the tibial medial epicondyle and the initial fibers inserting on the tibia of the medial collateral ligament was targeted for the injection to the IMGN (Fig. 2b).

A 22-gauge 38-mm spinal needle was advanced in parallel to the long axis of the transducer (in-plane approach) until the needle tip touched the bone. One or 2 needle repositioning attempts were allowed during the procedure. When the investigator thought he had correctly placed the needle to the genicular nerves, 0.5 mL of red ink was injected under real-time ultrasound guidance, and the needle was removed.

### Assessment

After completion of all 6 injections, the cadavers were dissected to show the locations of the red ink. If the nerve was dyed with red ink it was considered accurate placement. Dye observed on either only the nerve or both the nerve and surrounding tissue was regarded as accurate. All other locations were considered

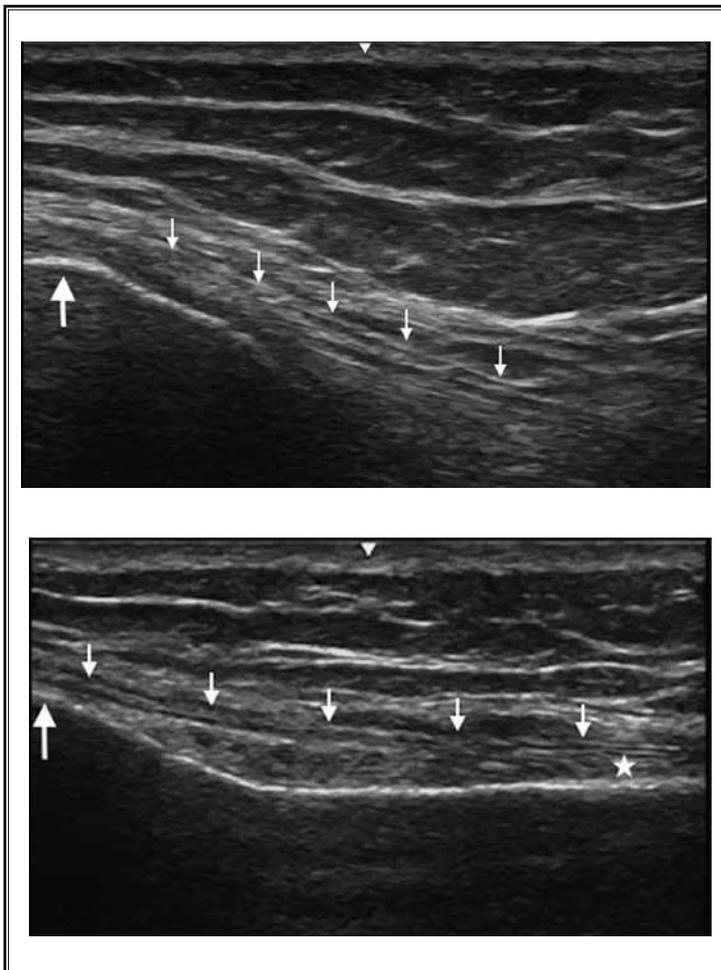


Fig. 2. The adductor tubercle for SMGN and the medial collateral ligament for IMGN were determined as anatomic landmarks in ultrasound scanning. (a) The transducer was placed in a sagittal orientation over the femoral medial epicondyle. The transducer was then translated proximally to the level of the adductor tubercle and the insertion of the adductor magnus tendon (thin arrows) was imaged. The bony cortex one cm anterior to the peak of the adductor tubercle (thick arrow) was targeted for the injection to the SMGN. (b) The transducer was placed in a sagittal orientation over the tibial medial epicondyle. The medial collateral ligament (thin arrows) was visualized. The transducer was then translated distally to the level of the tibial insertion site of the medial collateral ligament below the tibial medial epicondyle. The point of the bony cortex at the midpoint between the peak of the tibial medial epicondyle (thick arrow) and the initial fibers inserting on the tibia of the medial collateral ligament (star) was targeted for the injection to the IMGN.

SMGN: superior medial genicular nerve, IMGN: inferior medial genicular nerve. Fig. 2a: Top = superficial; right = cranial. Fig. 2b: Top = superficial; left = cranial.

inaccurate. The information was compiled for analysis to determine the accuracy of the injection.

## RESULTS

The post-injection cadaveric dissections revealed that 12 of the 12 ultrasound-guided injections (100%) accurately placed the red ink. Both genicular nerves in all 6 knees were dyed with red ink.

## DISCUSSION

In this study, the anatomic landmarks were identified for ultrasound-guided genicular nerve block, which offers advantages over previously reported fluoroscopically guided techniques, including being inexpensive, easily repeatable, and the avoidance of radiation. In a cadaveric model, the accuracy of SMGN and IMGN block was confirmed utilizing the adductor tubercle and the medial collateral ligament as the landmarks for ultrasound guidance.

The nerve supply of the knee joint is provided by various articular branches. Kennedy et al (13) described 2 groups of articular branches in the knee: anterior and posterior groups. The nerves in the anterior group are the articular branches of the femoral, the common peroneal, and the saphenous nerve. The posterior group consists of articular branches of the tibial, the obturator, and the sciatic nerves (13,14). The tibial nerve projects articular branches at the popliteal fossa and is mainly responsible for innervation of the medial and posterior aspect of the knee joint (15). The articular branches of the common peroneal nerve innervate the inferolateral and anterolateral aspect of the articular capsule (14,15). The saphenous nerve gives sensation to the anteroinferior side of the capsule (15). Based on the study of Choi et al (11), who targeted superomedial, inferomedial, and superolateral articular branches for radiofrequency neurotomy and showed improvement in pain and function in chronic knee osteoarthritis, the current study investigated 2 of these 3 genicular nerves.

The most important advantage of ultrasound is excellent soft tissue imaging, which enables the use of soft tissue structure as landmarks other than bony landmarks. Protzman et al (12) in a single case study employed ultrasonography to identify the genicular arteries and nerves and subsequently placed the needle with bony landmarks using fluoroscopic imaging. Ultrasound allowed them to locate the nerves more accurately in this single case. However, it could be suggested that ultrasound imaging of that kind of small nerve may not be achieved every time due to possible technical issues regarding the low performance of the ultrasound system and thick subcutaneous fat tissue in obese patients which might decrease the quality of echoic images. In cadaveric specimens, the genicular nerves and arteries could not be identified with ultrasonography. In the current study, it was aimed to identify anatomic landmarks for genicular nerves for ultrasound guidance. These landmarks show where the genicular nerves should be and in cases where the nerves are visible, they can also be visualized in this technique. Otherwise, the landmarks would help to locate the genicular nerves. Future studies may investigate if ultrasonography is feasible to directly visualize the genicular nerves in a larger sample group and which genicular nerves can be better identified using ultrasound.

Some limitations are worthy of consideration in

the study. A small number of cadavers was used in the investigation, so some anatomic variations of genicular nerves may have been overlooked. The lack of a control group is another limitation of the present study. Future studies with control specimens injected under fluoroscopic guidance would allow comparison between ultrasound and fluoroscopic imaging methods. Only 2 of the 3 previously reported genicular nerves were investigated in this study as it has been suggested that only these 2 genicular nerves are involved in clinically evident knee pain. The medial articular branches were targeted as of the 3 knee components, the one most frequently affected in knee osteoarthritis is the medial compartment as a result of knee varus torque (16). Medial genicular nerve block can be considered to relieve knee pain, but confirmation of these results requires future clinical studies. Finally, that the nerves were not visualized directly under ultrasound guidance can be regarded as a limitation of the study.

## CONCLUSION

In conclusion, the results of the present study demonstrated that superior and inferior medial genicular nerve branches can be precisely located using the above-stated anatomic landmarks and ultrasound guidance. The accuracy of the ultrasound-guided genicular nerve block was also confirmed in the cadaveric model.

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