Technical Note

Surgeon-Administered Anterolateral Geniculate Nerve Block as an Adjunct to Regional Anesthetic for Pain Management Following Anterior Cruciate Ligament Reconstruction

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Abstract: Regional anesthetic blockade of the adductor canal following anterior cruciate ligament reconstruction has gained popularity due to theoretical benefit of improved patient experience, decreased requirement for pain medication and maintained motor function. However, this block does not cover the anterior and lateral genicular innervation to the knee, which may lead to persistent pain postoperatively. The following Technical Note details the genicular nervous system and provides rationale and technique for performing a simple surgeon-administered regional anesthetic at the completion of anterior cruciate ligament reconstruction to address the anterior and lateral genicular nervous system.

Improvements in perioperative pain control techniques have allowed anterior cruciate ligament reconstruction (ACLR) to be predictably performed on an outpatient basis. Meanwhile, increased attention and public scrutiny ha ve been placed on the prescribing of opioid pain medication. As such, the development of safe and effective techniques to control patients' pain in the perioperative state is of paramount importance. Methods of regional anesthesia often used in ACLR include the femoral nerve block (FNB), adductor canal block (ACB), and/or sciatic nerve block.[1] These techniques target nerves proximal to the knee joint with the goal of decreasing sensation to the operative field and thus preventing postoperative pain.[1] However, these techniques can be associated with complications such as hematoma, systemic anesthetic toxicity, and vessel or nerve damage,[1] and blocks targeting the sciatic and femoral nerve indiscriminately decrease both sensation and motor function, which hinder patient mobility immediately postoperatively.

As such, an ideal block for ACLR would target sensation but not motor function, have minimal complication risk, and be easily reproducible. The knee has a complex circumferential innervation from branches of the femoral, obturator, and sciatic nerves that coalesces into the "genicular" nervous system. The anterior division of the genicular nervous system is the distal terminal branches of the femoral nerve. The femoral nerve divides into 5 branches. Four of these branches have a terminal branch (after muscle innervation) that innervates the capsule of the knee, synovium, and fat pad. The recurrent branch of the saphenous nerve and the nerve to the vastus medialis innervate the medial knee. The terminal branches to the vastus intermedius innervate the superior anterior knee, and the nerve to the vastus lateralis innervates the medial and lateral capsule, the fat pad, and synovium. The ACB has increased in popularity for ACLR recently, as it provides excellent sensory blockage without decreasing motor function.[1] However, this block specifically targets the saphenous nerve distribution, which may only address medial knee sensation, leaving the superior, anterior and lateral knee uncovered.

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To address this concern, we developed this simple, reproducible technique of surgeon-administered local anterolateral geniculate nerve blockage to supplement ACB for postoperative analgesia following ACLR (Fig 1, Video 1).

Surgical Technique (With Video Illustration)

Patient Positioning

The patient is positioned supine and a bump is placed under the ipsilateral hip to allow the knee to rest in neutral rotation. A post is placed laterally at the level of the tourniquet to allow application of adequate valgus force during arthroscopy.

Setup

After autograft harvest standard inferolateral and medial portals are created. All the necessary steps for an ACL reconstruction are performed. The authors prefer using an outside-in technique for the femoral tunnel using a FlipCutter device (Arthrex, Naples, FL), which requires a small incision made with an 11-blade overlying the superior aspect of the lateral femoral condyle. However, this technique is applicable to any ACLR method. Following fixation of the femoral and tibial tunnels, the knee is brought into slight flexion with a bump placed under the knee.

Anterolateral Local Anesthetic Injection

The 2-step injection is prepared with 20 cc of 0.25% bupivacaine loaded into a syringe with an 18-gauge needle. Anatomic landmarks are noted including the superior aspect of the patella as well as the lateral epicondyle (Fig 2). The first injection is targeted 2 fingerbreadths superior to the superolateral aspect of the patella (Fig 3). The needle is inserted down to the anterior femur, pulled back slightly, and the surrounding area is infiltrated with 10 cc of anesthetic. The second injection is targeted approximately 2 to 3 fingerbreadths laterally to the first injection and 2 to 3 fingerbreadths proximal to the lateral epicondyle in line with the lateral femur (Fig 4). Once again, the needle is inserted down until bone is encountered and then slightly retracted 1 to 2 mm before infiltration with the remaining 10 cc of anesthetic (Table 1).

Adductor Canal Block

The patient is placed supine and sedated in the preoperative holding area. The insertion site is defined by the ultrasound image as the location in which the

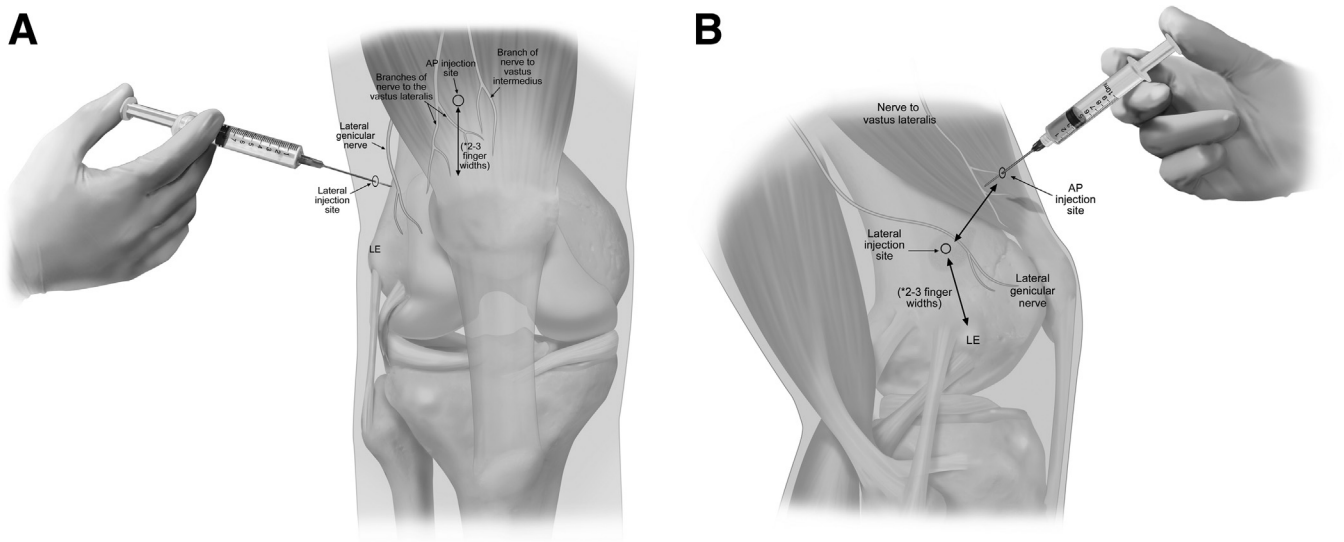

Fig 1. Drawing of the relevant neural anatomy as well as anatomic landmarks as viewed from anterior (A) and lateral (B). The anterior injection of the lateral geniculate nerve block is placed 2 to 3 fingerbreadths above the superior pole of the patella in-line with the lateral one-third of the patella. This injection targets branches of the nerve to vastus lateralis as well as the nerve to vastus intermedius. The nerve to the vastus lateralis is a terminal branch of the femoral nerve that runs obliquely along the periosteum of the metaphysis at the anterolateral aspect of the knee. It gives off a transverse superficial retinacular branch as well as a longitudinal deep capsular branch. This branch is not anesthetized by the typical adductor canal block. The articular branch of the nerve to the vastus intermedius runs along the anterior aspect of the distal femur towards the supra-patellar pouch of the knee capsule and is variably anesthetized by a typical adductor canal block. Meanwhile, the lateral injection of the lateral geniculate nerve block is placed 5 cm proximal to joint line, 2 to 3 fingerbreadths above the lateral epicondyle and 2 fingerbreadths lateral to the "anteroposterior injection site." This injection targets branches of the lateral genicular nerve as well as some variant branches of the nerve to vastus lateralis. The lateral retinacular nerve is a branch of the superolateral genicular nerve and contributes to lateral knee sensation. The branch point has been found to be located approximately 2 to 2.5 cm proximal to the tip of the lateral femoral epicondyle and 4 to 5.5 cm proximal to the lateral joint line. Neither of these branches is anesthetized by the typical adductor canal block.

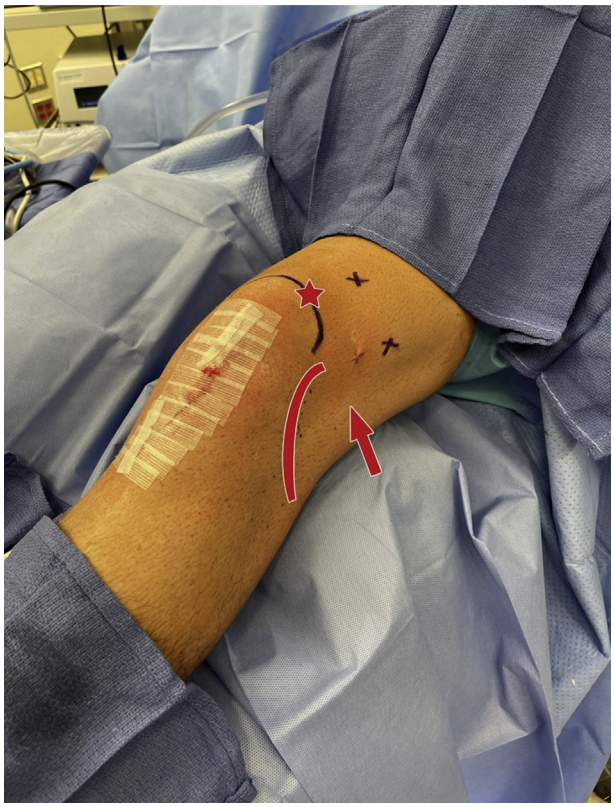

Fig 2. Clinical figure of the left knee with the patient positioned supine and the head at the top right. Identifying and marking relevant anatomic landmarks is crucial to performing the lateral geniculate nerve block accurately. At the completion of the surgical intervention and following closure of the wounds, the knee placed over a bump in slight flexion. The procedure is started by marking the patella (red star), lateral joint line (curved red line), and lateral epicondyle (red arrow) as reference points.

superficial femoral artery exists underneath the medial third of the sartorius muscle. The skin is prepped. Using an in-plane technique, an echogenic catheter-over-needle system (Pajunk, Alpharetta, GA) 75 mm with an 18-g catheter and 21-g needle is placed lateral to the superficial femoral artery and within the adductor canal. Then, 4 mL of normal saline is used to confirm proper tip placement within the adductor canal and 20 cc of ropivacaine 0.2% is placed through the catheter into the adductor canal. The perineural infusion of ropivacaine 0.2% at 6 mL/h with a bolus of 2 mL q30min is started immediately upon arrival in postanesthesia care unit.

Discussion

ACLR is commonly performed on an outpatient basis but can be associated with significant postoperative pain that may delay discharge and recovery, as well as hinder the postoperative rehabilitation process. As such, improvements in analgesic regimens in addition to local and regional anesthetic techniques are constantly being developed to facilitate faster, pain-free discharge and earlier rehabilitation. This is particularly relevant in the context that earlier mobilization after surgery acts to further decrease pain symptoms.[2,3]

Achieving pain relief postoperatively is challenging with only one single drug or technique. Multimodal anesthesia combines analgesics acting through different mechanisms to achieve the greatest level of pain control.[4,5] Combining nonsteroidal anti-inflammatory drugs, acetaminophen, and opioids have been shown to decrease postoperative pain, nausea and vomiting, recovery room length of stay, and total opioid use.[5,6] Adjuncts such as gabapentin and zolpidem can decrease postoperative opioid consumption.[5] However, these oral regimens may not provide adequate pain relief in the immediate perioperative period. Orthopaedic surgeons and anesthesiologists have worked together to develop and implement local and regional applications of anesthetics that can provide more comprehensive postoperative pain relief, while achieving the goals of early mobilization and rehabilitation. FNBs have been used as an effective method of pain control after ACLR but involve a combined blockage of motor and sensory nerves and are associated with decreased quadriceps strength postoperatively with an increased risk of falls.[5,7,8] Meanwhile, blocks targeting the saphenous nerve provide the opportunity for sensory blockage without the accompanying weakness and fall-risk associated with FNB. Conflicting results have been reported with ACB, with one study reporting equivalent pain relief and improved strength as compared with FNB following patellar tendon autograft ACLR,[9] and other studies reporting worse postoperative pain relief compared to FNB and no improvement compared to placebo block following hamstring autograft ACLR.[10,11] A 2019 Cochrane review was unable to show that ACB was superior to placebo treatment for improving postoperative pain and opioid consumption following knee surgery.[12] One explanation for this could be that the ACB block only targets the saphenous nerve distribution, meaning that the anterolateral aspect of the knee may not be anesthetized due to nerve contributions from other branches of the genicular nervous system.[13-15] Thus, the goal of our intervention was to supplement the ACB used by our acute pain service in a simple, anatomically based method that could be adopted readily by any surgeon with minimal increase surgical time (Table 2).

Understanding the innervation to the knee joint and capsule allows for anatomic placement of the anesthetic. The lateral retinacular nerve is a branch of the superolateral genicular nerve and contributes to lateral knee sensation. The branch point has been found to be located approximately 2 to 2.5 cm proximal to the tip of the lateral femoral epicondyle and 4 to 5.5 cm proximal

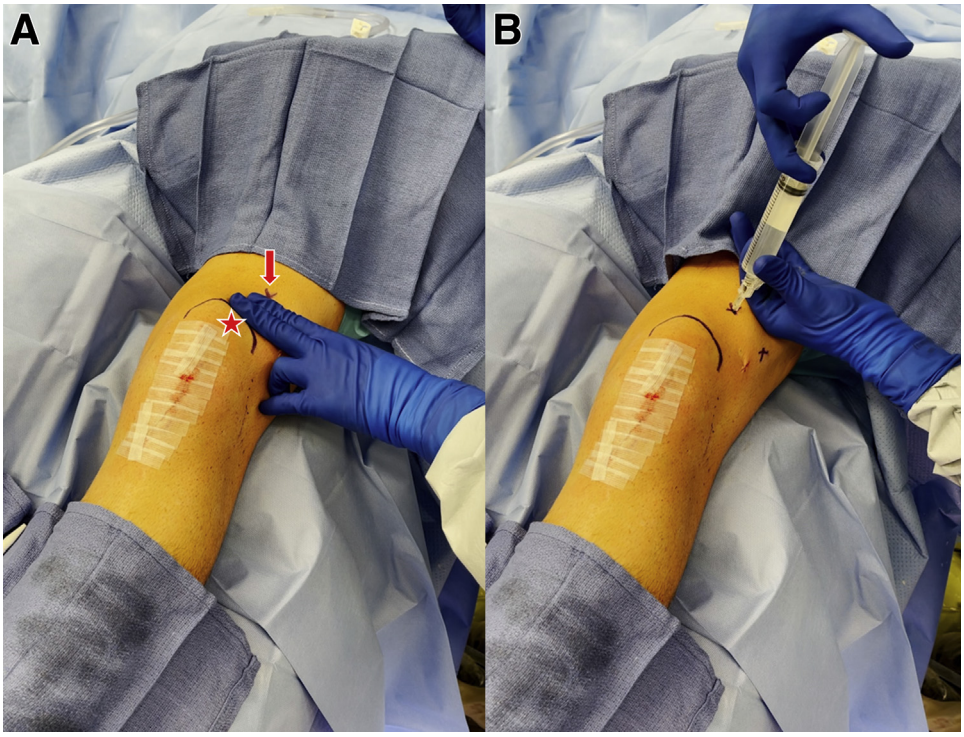

Fig 3. Clinical figure of the left knee demonstrating the anterior injection of the lateral geniculate nerve block, targeting branches of the nerve to the vastus lateralis and vastus intermedius. (A) The injection point (red arrow) is marked out 2 to 3 fingerbreadths above the superolateral pole of the patella (red star). (B) A 22-gauge needle is inserted down to periosteum, retracted 1 to 2 mm, and the area infiltrated with local anesthetic.

to the lateral joint line.[13,14] Meanwhile, the nerve to the vastus lateralis is a terminal branch of the femoral nerve that runs obliquely along the periosteum of the metaphysis at the anterolateral aspect of the knee. It gives off a transverse superficial retinacular branch as well as a longitudinal deep capsular branch.[13] Neither of these branches is anesthetized by the typical ACB. The articular branch of the nerve to the vastus intermedius runs along the anterior aspect of the distal femur toward the supra-patellar pouch of the knee

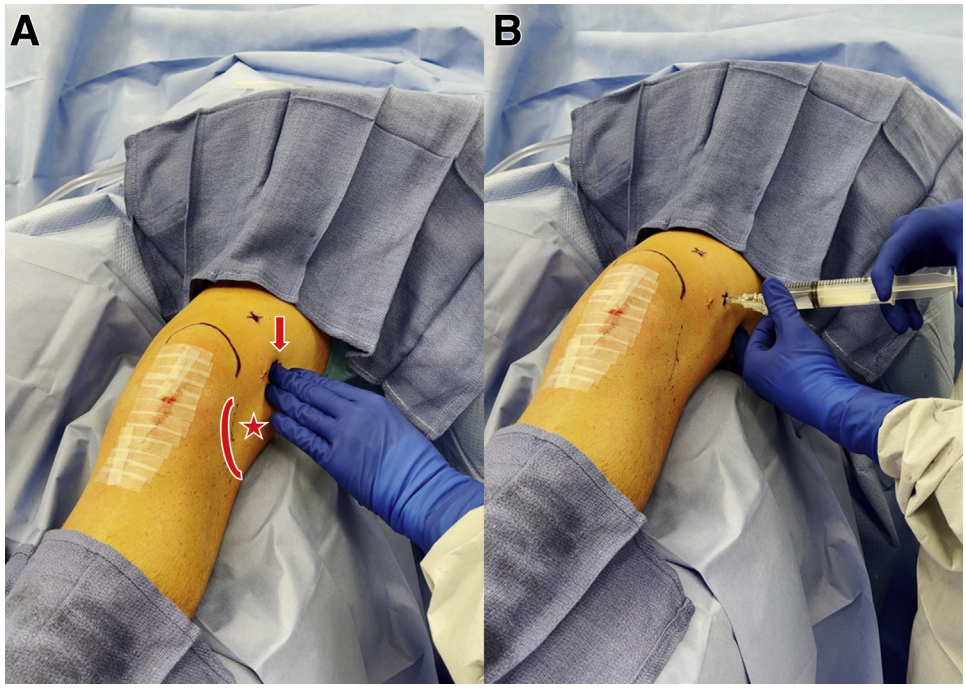

Fig 4. Clinical figure of the left knee demonstrating the lateral injection of the lateral geniculate nerve block, targeting branches to the nerve to the vastus lateralis and the lateral retinacular nerve. (A) The injection point (red arrow) is marked out 5 cm above the joint line (curved red line), 2-3 fingerbreadths above the lateral epicondyle (red star) and 2 fingerbreadths lateral to the AP injection site (black marker "x") along the lateral femur. The injection should be in line with the lateral femur, which can be palpated manually moving proximally from the lateral epicondyle. (B) A 22-gauge needle is inserted down to periosteum, retracted 1-2 mm, and the area infiltrated with local anesthetic.

Table 1. Pearls and Pitfalls

Pearls
The block can be performed at the end of the case by the surgeon while an assistant closes to save time.
Perform the block as close to final dressing application as possible to ensure long-lasting relief.
If performing an out-side in technique for drilling the femoral tunnel, a small amount of anesthetic should be applied to the laterally based incision and tunnel track.
Make sure to withdraw the needle just a few millimeters from the periosteum to ensure the infiltration occurs around the nerve branches.
After the reconstruction is finished, the saline is left inside the surgical field and observed for 10 to 20 seconds. Pneumothorax is excluded by absence of rising air bubbles.
Pitfalls
Be sure to confirm the appropriate amount of anesthetic for each individual patient with the anesthesiologist prior to injection to avoid anesthetic toxicity.

capsule and is variably anesthetized by the ACB.[13,16] As such, the block described in this article specifically targets these 3 nerve branches with the goal of decreasing postoperative pain to the lateral side of the knee following ACL reconstruction. In addition, this anesthetic administration technique may also have benefit for patients undergoing inside-out lateral meniscus repair, or lateral ligamentous reconstruction.

Caldwell and Selepec[17] recently published their technique for local-only, surgeon administered "circumferential anterior genicular nerve block," performed at the end of ACLR. Their technique eschews a regional block by the anesthesia team, and focuses on the 6 terminal, sensory-only, genicular nerve branches. 60 cc of 0.25% bupivacaine is injected in 10 separate locations in the medial, anterior, and lateral knee based on anatomic landmarks without ultrasound guidance, followed by 2 injections into the infrapatellar fat pad.[17] The technique is inexpensive ($6 per injection) and rapid, taking 1 to 2 minutes, and they reported overall low rates of opioid use following ACLR.

Conclusions

In this technique article, we describe a simple, surgeon administered local anesthetic technique to be performed at the conclusion of ACLR. Our hope is that this supplement to the ACB typically performed during ACLR will facilitate earlier rehabilitation, patient discharge, and decreased opioid usage postoperatively.

Table 2. Advantages and Disadvantages

Advantages
Very quick and cost effective.
Does not require use of ultrasound.
Covers painful region of the knee not typically covered by adductor canal blockade.
Purely sensory blockage without affecting motor function.
Disadvantages
Does not cover the nerve distributions of the inferior lateral aspect of the knee, although surgical pain in this region is uncommon after uncomplicated ACLR.
Effects of bupivacaine injection may last only 4-8 hours after surgery, providing only short-term postoperative pain relief

ACLR, anterior cruciate ligament reconstruction.

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