Technical Note

Surgeon-Directed Arthroscopic Infiltration Between the Popliteal Artery and Capsule of the Knee (IPACK) Block: Technical Description

Jeffrey B. Shroff, M.D., Philip Hanna, M.B.B.S., and Cory M. Edgar, M.D., Ph.D.

Abstract: Advances in regional anesthesia techniques for knee surgery have led to drastic improvements in postoperative pain control and have reduced reliance on perioperative opioid analgesics. The infiltration between the popliteal artery and capsule of the knee (IPACK) block has been a useful tool for providing posterior knee analgesia as an adjuvant to traditional femoral or adductor canal blocks in knee surgery. We present a simple and reproducible technique for the arthroscopic administration of this block.

Knee arthroscopy is one of the most common surgical procedures performed by orthopaedic surgeons.[1] There is growing interest in improving postoperative pain control for patients undergoing knee arthroscopy. Recently, there have been significant advancements in the use of perioperative nerve blocks, local anesthesia, and multimodal pain regimens to improve patient comfort and reduce reliance on opiate pain medications.[2-6] The infiltration between popliteal artery and capsule of the knee, or IPACK, block has been described as a motor-sparing nerve block that can provide posterior analgesia following knee surgery and serve as an adjunct to commonly used adductor canal or femoral nerve blocks.[7,8] We have devised a simple and reproducible technique for intraoperative, arthroscopic administration of local anesthetic in the space directly posterior to the knee capsule. In our practice, this seems to improve patient comfort postoperatively. In this Technical Note, we detail our technique for administration of this block as well as review the gross and arthroscopic anatomy. We also present cadaveric dissections showing the distribution of methylene blue staining to compare our block with a traditionally performed ultrasound-guided IPACK block.

Surgical Technique (With Video Illustration)

Indications

The block can be used for any patient undergoing knee arthroscopy, but in our practice, it is reserved for patients in whom arthroscopy is performed in conjunction with more painful or complex procedures, such as extensive manipulation, synovectomy or debridement, intra- or extra-articular ligament reconstructions, or periarticular osteotomies. This block is an excellent adjuvant to traditional regional blocks performed by anesthesia providers, such as femoral or adductor canal blocks. In our practice, we typically pair our block with a low-concentration femoral nerve block.

Positioning

The block can be performed using any standard knee arthroscopy positioning. Our preferred method is described. The patient is placed supine on the operating table with heels resting off the edge of the bed. Cotton cast padding followed by a pneumatic tourniquet is applied high on the operative thigh. A sequential compression device is placed on the nonoperative leg, which is then secured in an Allen Arthroscopic Well Leg

From the Department of Orthopaedic Surgery (C.M.E.), University of Connecticut Health Center (J.B.S., P.H.), Farmington, Connecticut, U.S.A.

The authors report that they have no conflicts of interest in the authorship and publication of this article. Full ICMJE author disclosure forms are available for this article online, as supplementary material.

Received August 26, 2022; revised manuscript received November 21, 2022; accepted December 8, 2022.

Address correspondence to Cory M. Edgar, M.D., Ph.D., Department of Orthopedic Surgery, University of Connecticut Health Center, 263 Farmington Ave., Farmington, CT 06030. E-mail: Coedgar@uchc.edu

2212-6287/221118

https://doi.org/10.1016/j.eats.2022.12.005

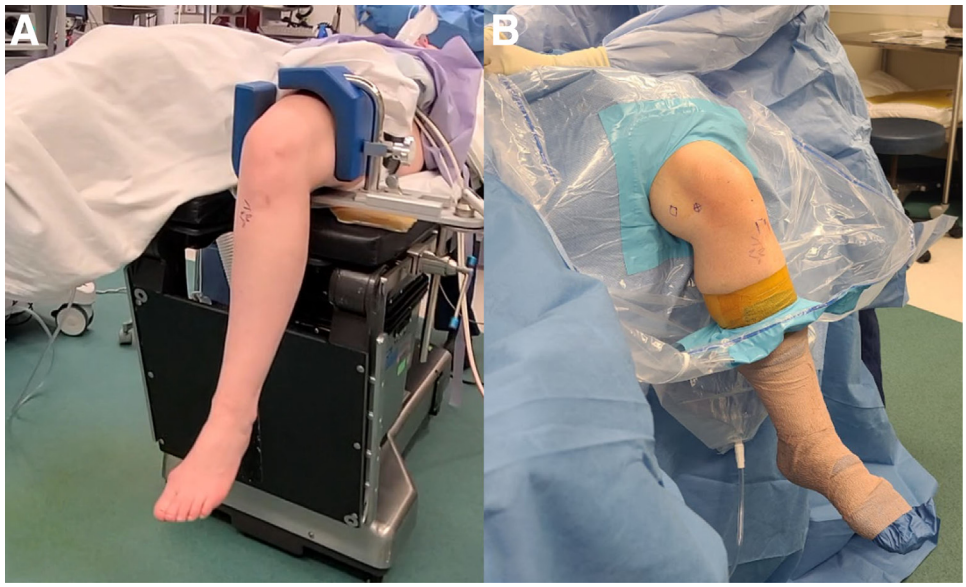

Fig 1. In (A), the left knee is viewed from an anterolateral view. The left knee is placed in a 360° leg holder before being prepped and draped. In (B), the left knee is viewed from an anteromedial view after being prepped and draped. In both (A) and (B), the patella, tibial tubercle, and medial epicondyle are identified with a marker. In addition, the anticipated position for the posteromedial portal creation is also identified with marker.

Holder (AliMed, Boston, MA) with the hip flexed and abducted slightly and the knee flexed. Care is taken to ensure that there is no pressure on the popliteal space. The operative leg is placed in an OSI Waterproof Arthroscopic Leg Holder (AliMed) that is positioned midway up the thigh and distal to the tourniquet (Fig 1). The end of the operative table is then fully flexed, and the pad is removed. This allows the operative knee to flex supported by the leg holder allowing 360° access to the knee. The knee is prepped and draped with chlorhexidine, followed by alcohol solution. The operative extremity is then draped in the standard fashion.

Surgical Technique

A standard anterolateral arthroscopic viewing portal is established with a no. 11 blade. The knee is extended, and the arthroscope is introduced into the suprapatellar pouch. Routine diagnostic arthroscopy is performed. Using the standard 30° arthroscope in the anterolateral portal, the knee is placed into flexion and the intercondylar notch is viewed. A modified Gillquist maneuver is used to access the posteromedial compartment of the knee. This is done by directing the arthroscope into the space between the medial aspect of the medial femoral condyle, the medial tibial intercondylar eminence, and the posterior cruciate ligament. Gentle pressure is used while sliding the scope along the medial aspect of the condyle. Valgus stress, slight knee extension, and anterior tibial translation can facilitate easier passage. This view allows evaluation of the posterior horn of the medial meniscus as well as the posterior meniscocapsular junction.

Referencing the posterior aspect of the medial femoral condyle and using the transillumination of the arthroscope an 18-gauge spinal needle is placed into the posteromedial compartment of the knee under direct vision (Fig 2). This is performed in the same manner as performing localization for the creation of a standard posteromedial portal. The bevel of the arthroscope is then directed laterally to follow the needle, as it is used to piece the posterior knee capsule toward the midline. A tactile reduction in the pressure needed to advance the needle should be noted and helps to identify when the needle has pierced the entire capsule. The stylette of the needle is then removed, and a syringe with the chosen anesthetic mixture is attached to the needle. We use a cocktail of 30 mL of 0.5% Marcaine, 20 mL of 0.9% normal saline, 1 mL of morphine 10 mg/1 mL, and 1 mL of Toradol 30 mg/1 mL. A volume of 10 to 15 mL of this solution is administered for the block. Aspiration is performed first to confirm that the needle is not within a blood vessel followed by gentle, steady administration of the medication. The medication should flow easily with minimal pressure required. If the medication does not flow easily, it could indicate that the needle is within the posterior capsule or the tendinous origin of the gastrocnemius. If this is the case, the needle should be advanced further or redirected. Once the medication has been administered, the needle is removed and the

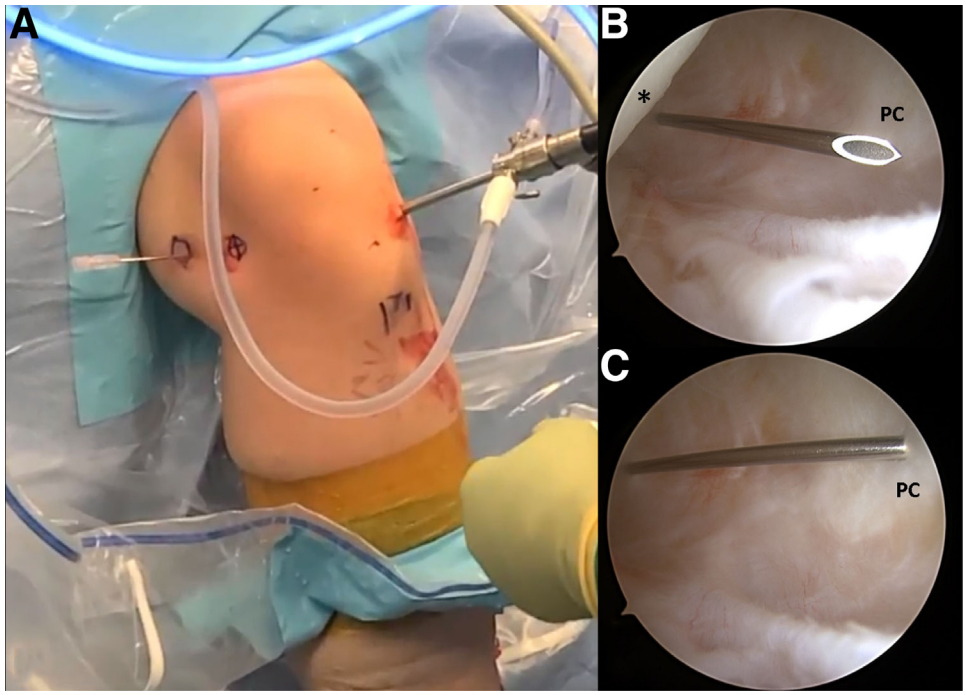

Fig 2. In (A), from an anteromedial view, the left knee is visualized with the arthroscope viewing the posteromedial compartment through the intercondylar notch from a standard anterolateral portal. In (B), an arthroscopic view with 30° arthroscope visualizes an 18-gauge spinal needle introduced into the posteromedial compartment. The medial femoral condyle is identified in (B) on the left-hand side of the image and the posterior capsule (PC) can be seen on the far-right side of the image. In (C), in the arthroscopic view, the needle is directed toward the midline and used to pierce the posterior capsule for administration of the IPACK block. (IPACK, infiltration between the popliteal artery and capsule of the knee.)

arthroscope can be returned to the anterior knee for continuation of the procedure. This is a motor-sparing nerve block, so no change in postoperative activity protocol is needed. A narrated video demonstration of this procedure can be viewed in Video 1.

Review of Anatomy

The popliteal fossa is a diamond-shaped space immediately posterior to the knee joint. The space is defined by the semimembranosus, which forms the superomedial border, the biceps femoris, which is the superolateral border, and the medial and lateral heads of the gastrocnemius, which form the inferomedial and lateral borders, respectively. The floor of the popliteal fossa consists of the posterior femur superiorly, the popliteus muscle and overlying fascia laterally, and the posterior knee capsule centrally. The popliteal fascia forms the roof of the popliteal space. The femoral artery becomes the popliteal artery as it exits the adductor hiatus medially and enters the popliteal fossa. This is the most medial and deep structure within the fossa. Just lateral to the artery is the popliteal vein, which gives rise to the small saphenous vein near the distal aspect of the fossa. The tibial and common peroneal nerves are found lateral and more superficial to the vascular bundle. These nerves branch from the sciatic nerve near the most proximal apex of the fossa. The common peroneal nerve runs along the lateral aspect of the popliteal fossa just posterior to the biceps femoris muscle. The tibial nerve moves medially as it travels distally and exits the fossa to eventually join the posterior tibial artery in the deep posterior compartment of the leg. The tibial nerve provides branches to the medial and lateral heads of the gastrocnemius, a branch to the sural nerve, and relevant to our discussion a fine meshwork of nerves called the popliteal plexus that provides innervation to the posterior knee capsule. Figure 3 depicts a cadaveric dissection of the popliteal fossa. A spinal needle has been positioned for performance of the arthroscopic IPACK block via the aforementioned technique, demonstrating its central position within the popliteal fossa and relationship to the surrounding anatomy.

Comparison of Methylene Blue Staining With Our Technique Versus Traditional IPACK Block

To compare our block with a traditional ultrasound-guided IPACK block, we performed each injection on a cadaveric knee specimen with methylene blue dye and then performed a posterior knee dissection to evaluate the pattern of staining.

Fig 3. From a posterior view, a cadaveric dissection of the posterior aspect of a left knee can be visualized following needle placement for IPACK block under arthroscopic control. The medial gastrocnemius muscle (labeled MG on the image) is retracted medially, and the lateral gastrocnemius (labeled LG on the image) and neurovascular bundle is retracted laterally (labeled NB on the image) exposing the posterior capsule (labeled C on the image). The needle tip, which can be viewed in the central portion of Figure 3, is noted to be correctly positioned within the retrocapsular space. (IPACK, infiltration between the popliteal artery and capsule of the knee.)

Ultrasound-Guided IPACK Block

The ultrasound-guided block was performed by a trained anesthesiologist with experience performing the technique. The cadaveric knee was positioned on its side with the lateral side of the knee facing up. A curvilinear ultrasound probe was placed on the posterior aspect of the knee. The popliteal vascular bundle was visualized at the level of the medial and lateral femoral condyles. The probe was then directed proximally to the region of the femoral metaphysis just proximal to the femoral condyles. A 22-gauge calibrated block needle was inserted on the lateral aspect of the knee parallel to the posterior aspect of the femoral metaphysis. Under ultrasound guidance, the needle was advanced deep to the vascular bundle to the medial aspect of the popliteal space. The needle was slowly withdrawn while 0.5 mL of methylene blue mixed in 19.5 mL of normal saline was injected.

With a second cadaveric knee, we performed our technique for arthroscopically administered IPACK block as described. Again, 0.5 mL of methylene blue mixed in 19.5 mL of normal saline was injected.

Both specimens were then stored for 48 hours, after which posterior knee dissections were performed. Figure 4 depicts representative photographs of the 2 specimens and demonstrates that the techniques yielded similar patterns of methylene blue staining. There was significant staining of the entirety of the posterior knee joint capsule and undersurface of the vascular sheath. The main portions of the tibial and common peroneal nerves were relatively spared.

Discussion

With the ongoing trend of greater numbers and more complex surgical cases being performed on an outpatient basis, as well as new focus on improving postoperative pain control and limiting reliance on opioid pain medications, advanced regional anesthetic techniques are becoming more important. Traditionally motor-sparing peripheral nerve blocks, such as an ultrasound-guided IPACK blocks, can reduce postoperative pain and the need for additional opioid consumption.[9-11] These blocks have been shown as successful for reducing pain following various knee arthroscopy procedures, highlighting their applicability.[12,13] The technique presented here is directly controlled and directed by the surgeon and is a simple, fast, and safely reproducible way to perform an IPACK block under arthroscopic control. Additional considerations for the use of this technique can be found in Table 1 and Table 2.

We most commonly perform this block during anterior cruciate ligament (ACL) reconstruction. There have been numerous studies documenting the relatively high incidence of concomitant lesions of the posterior horn of the medial meniscus, or meniscocapsular junction in patients with ACL injuries.[14,15] For this reason, we have incorporated routine evaluation of the posterior compartment of the knee into our standard diagnostic arthroscopy. Although the addition of this block adds a negligible amount of time to the total length of the procedure, this technique does require a blind stick intraoperatively, as opposed to the preoperative use of ultrasound guidance for placement. However, based on our cadaveric evaluation of methylene blue staining, our block deposits medication in the same anatomic space as a traditionally performed ultrasound-guided IPACK block.

The use of this technique is advantageous, as it reduces the need for additional rescue blocks and/or intraoperative narcotic use. To this point, a retrospective review of patients undergoing ACL reconstruction at our institution showed a reduction in the need for postoperative sciatic rescue nerve following the

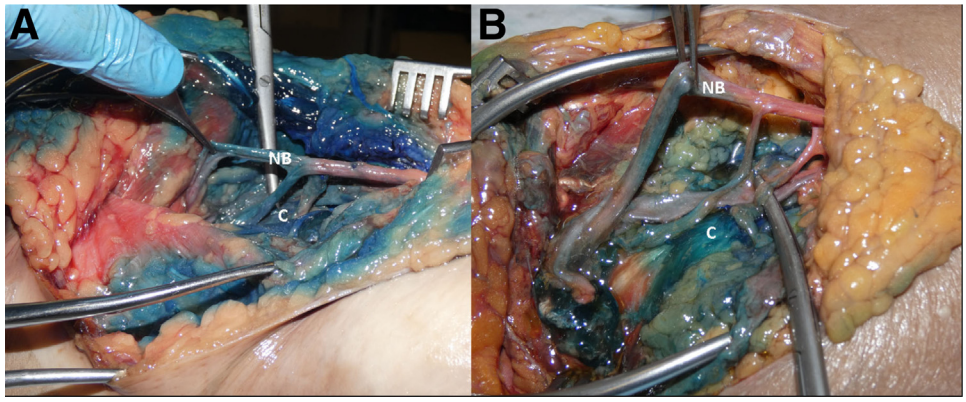

Fig 4. From a posterior view, in (A), the cadaveric posterior knee dissections performed following simulated IPACK block with methylene blue dye using ultrasound guidance can be visualized. In (B), the cadaveric posterior knee dissections performed following simulated IPACK block with methylene blue dye sing arthroscopic assistance can be visualized. Images in (A) and (B) demonstrate comparable staining patterns involving the posterior capsule and neurovascular bundle. (C, posterior capsule; IPACK, infiltration between the popliteal artery and capsule of the knee; NB, neurovascular bundle.)

implementation of this block. The findings were particularly noticeable in patients who had concomitant meniscal repair, highlighting the value of this technique in patients with concomitant injury. We are in the process of submitting these data for publication, and a prospective study evaluating the true clinical efficacy of this block is forthcoming.

Table 1. Pearls and Pitfalls

Pearls	Pitfalls
• Position the patient in knee flexion, ensuring there is ample space behind knee • Enter the capsule posterior medial at the level of the root of the medial meniscus • An 18-gauge spinal needle that is 3.5 inches length allows for proper access to the posterior medial compartment • During injection, pull back on the plunger to aspirate intermittently to ensure no blood or fluid in the back flow • Penetrate capsule to depth no more than 5 mm	• Overpenetration can result in neurovascular injury • Avoid knee extension during the procedure • Patients with obesity undergoing this technique present more of a challenge

Table 2. Advantages and Disadvantages

Advantages	Disadvantages
Surgeon direction/controlled	The technique is a blind stick, as opposed to preoperative use of ultrasound guidance for placement.
Billable service	
Reduction in "rescue blocks" and intraoperative narcotic usage	
This technique is as simple, fast, and safe as guided-ultrasound procedure	

References

1. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, and National Center for Health Statistics. Vital and Health Statistics from the Centers for Disease Control & Prevention/National Center for Health Statistics. National hospital discharge survey: annual summary. www.cdc.gov/nchs/data/series/sr_13/sr13_140.pdf. Accessed April 1, 2021.
2. Barber FA, Gladu DE. Comparison of oral ketorolac and hydrocodone for pain relief after anterior cruciate ligament reconstruction. *Arthroscopy* 1998;14:605-612.
3. Barber FA, McGuire DA, Click S. Continuous-flow cold therapy for outpatient anterior cruciate ligament reconstruction. *Arthroscopy* 1998;14:130-135.
4. Beck PR, Nho SJ, Balin J, et al. Postoperative pain management after anterior cruciate ligament reconstruction. *J Knee Surg* 2004;17:18-23.
5. Farid IS, Heiner EJ, Fleissner PR. Comparison of femoral nerve block and fascia iliaca block for analgesia following reconstructive knee surgery in adolescents. *J Clin Anesth* 2010;22:256-259.
6. Harris NJ, Bickerstaff DR, Farquharson D. Post-operative analgesia following anterior cruciate ligament reconstruction: A controlled study using femoral nerve regional anaesthesia. *Knee* 1997;4:197-201.
7. Kim DH, Beathe JC, Lin Y, et al. Addition of infiltration between the popliteal artery and the capsule of the posterior knee and adductor canal block to periarticular injection enhances postoperative pain control in total knee arthroplasty: A randomized controlled trial. *Anesth Analg* 2019;129:526-535.
8. Sankineani SR, Reddy ARC, Eachempati KK, Jangale A, Gurava Reddy AV. Comparison of adductor canal block and IPACK block (interspace between the popliteal artery

and the capsule of the posterior knee) with adductor canal block alone after total knee arthroplasty: A prospective control trial on pain and knee function in immediate postoperative period. *Eur J Orthop Surg Traumatol* 2018;28:1391-1395.
9. Chan E, Howle R, Onwochei D, Desai N. Infiltration between the popliteal artery and the capsule of the knee (IPACK) block in knee surgery: A narrative review. *Reg Anesth Pain Med* 2021;46(9).
10. D' Souza RS, Langford BJ, Olsen DA, Johnson RL. Ultrasound-guided local anesthetic infiltration between the popliteal artery and the capsule of the posterior knee (IPACK) block for primary total knee arthroplasty: A systematic review of randomized controlled trials. *Local Reg Anesth* 2021;14:85-89.
11. Guo J, Hou M, Shi G, Bai N, Huo M. iPACK block (local anesthetic infiltration of the interspace between the popliteal artery and the posterior knee capsule) added to the adductor canal blocks versus the adductor canal blocks in the pain management after total knee arthroplasty: A systematic review and meta-analysis. *J Orthop Surg Res* 2022:17.
12. Huang A, Singh PA, Woon KL. Interspace between the popliteal artery and the capsule of the knee (IPACK) block for anterior cruciate ligament reconstruction surgery: A Two case series. *Open J Anesthesiol* 2020;10(4).
13. Singleton J, Ramesh V, Odeleye A, Sebastian M. B133 Modified IPACK block and blockade of the vastus lateralis and anterior femoral cutaneous nerve branches in total knee arthroplasty. *Reg Anesth Pain Med* 2022;47(1).
14. Liu X, Feng H, Zhang H, et al. Arthroscopic prevalence of ramp lesion in 868 patients with anterior cruciate ligament injury. *Am J Sports Med* 2011;39:832-837.
15. Stephen JM, Halewood C, Kittl C, et al. Posteromedial meniscocapsular lesions increase tibiofemoral joint laxity with anterior cruciate ligament deficiency, and their repair reduces laxity. *Am J Sports Med* 2016;44:400-408.