Narrative Review

Motor-Sparing Regional Anesthesia for Knee Surgery: The Adductor Canal Block, the Nerve to the Vastus Medialis, and the IPACK Block

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ABSTRACT

Effective analgesia after knee surgery has to be reconciled with the demands of enhanced recovery pathways, in which early ambulation and same-day or next-day discharge are explicit goals. The femoral nerve block, long the reference technique, achieves the first aim at the cost of the second: quadriceps weakness delays mobilization and raises concern about falls. Over the past decade the field has therefore reorganized itself around the idea of motor-sparing blockade — placing local anesthetic where the sensory supply of the knee can be interrupted while the motor supply to the quadriceps is left substantially intact. This review examines the three techniques that define current practice. The adductor canal block, and its more proximal variant the femoral triangle block, target the saphenous nerve and the articular branches travelling with the nerve to the vastus medialis; the accumulated randomized evidence shows analgesia broadly equivalent to the femoral nerve block with better preservation of quadriceps strength. The nerve to the vastus medialis has emerged as a structure of interest in its own right, since it carries both articular afferents to the anteromedial capsule and motor fibres, so that the balance between analgesia and strength depends on precisely where along the canal the injection is placed. The IPACK block addresses the posterior capsule, a territory none of the anteromedial techniques reaches. We summarize the anatomical basis of each block, the randomized and meta-analytic evidence supporting them, and the practical questions — injection site, volume, adjuvants, and the interaction with surgical local infiltration analgesia — that remain unsettled.

Keywords: adductor canal block; nerve to vastus medialis; IPACK block; motor-sparing analgesia; total knee arthroplasty; anterior cruciate ligament reconstruction

INTRODUCTION

Knee surgery, whether arthroplasty in an elderly comorbid patient or arthroscopic ligament reconstruction in a young athlete, produces pain that is severe, movement-evoked, and poorly controlled by systemic analgesia alone. For two decades the femoral nerve block was the standard regional answer, and it works: pain scores and opioid consumption fall consistently. The difficulty is that the femoral nerve is a mixed nerve, and blocking it proximally produces quadriceps weakness that can persist well beyond the analgesic window. In an era in which patients are expected to stand within hours of surgery, this is not a trivial trade-off, and the observation prompted a systematic search for techniques that separate the sensory from the motor supply of the knee [1].

The result is what is now generally called motor-sparing regional anesthesia. Rather than a single substitute for the femoral nerve block, it is a family of distal, largely fascial or perivascular injections chosen and combined according to which part of the joint is being operated on. Understanding them requires starting from the innervation of the knee capsule itself.

ANATOMICAL BASIS

Detailed cadaveric dissection has clarified the innervation of the anterior knee capsule. Tran and colleagues demonstrated that the anterior capsule receives articular branches from the nerve to the vastus medialis, the nerve to the vastus intermedius, the nerve to the vastus lateralis, and the medial and lateral retinacular nerves, with a reproducible distribution that lends itself to image-guided intervention [2]. Fonkoué and colleagues, mapping the sensory nerves of the whole capsule, confirmed this pattern and defined the corresponding targets for genicular blockade and radiofrequency ablation [3]. Two conclusions follow. First, the anteromedial capsule is disproportionately supplied by branches accompanying the nerve to the vastus medialis, which travel with the saphenous nerve in the distal thigh — this is what makes a distal, low-volume injection analgesically useful. Second, the posterior capsule is supplied largely by the popliteal plexus and by articular branches of the tibial and obturator nerves, which no anteromedial injection can be expected to reach.

The anatomy of the injection site itself has been a source of persistent confusion. What is commonly described in the literature as an "adductor canal block" is frequently, by anatomical criteria, a femoral triangle block: the canal proper begins where the sartorius crosses the medial border of the adductor longus, and many published injections are placed proximal to that point [4]. The distinction matters because the femoral triangle contains the nerve to the vastus medialis before it gives off most of its motor branches, whereas the canal proper contains predominantly sensory structures. Randomized comparisons of the two injection sites have found broadly similar analgesia, with the femoral triangle approach producing somewhat greater quadriceps involvement in some series [5], and a recent meta-analysis concluded that the two are analgesically comparable while noting the heterogeneity of how each was defined across trials [6].

FROM THE FEMORAL NERVE TO THE ADDUCTOR CANAL

The randomized evidence comparing the adductor canal block with the femoral nerve block after total knee arthroplasty is now extensive and internally consistent. Meta-analyses published from 2016 onward have repeatedly found equivalent pain scores and opioid consumption with significantly better preservation of quadriceps strength and earlier achievement of mobilization milestones [7–10]. Later syntheses, including a network meta-analysis and an updated analysis restricted to continuous catheter techniques, reached the same conclusion and additionally suggested a shorter length of stay [11,12]. A pragmatic cohort analysis found no additional early quadriceps weakness attributable to the adductor canal block itself when tourniquet use was accounted for, reinforcing the view that residual weakness after arthroplasty is largely surgical rather than anesthetic in origin [13].

The picture in anterior cruciate ligament reconstruction is similar but with a different emphasis, because in this population quadriceps function is not merely a discharge criterion but the central determinant of rehabilitation. Systematic reviews of level I trials have found the adductor canal block to provide analgesia comparable to the femoral nerve block with markedly less quadriceps inhibition [14–16]. Whether this translates into better long-term functional outcomes is less certain; one cohort of adolescents found no difference in quadriceps or hamstring strength at six months between femoral block, adductor canal block, and no block at all, which suggests that the advantage of motor sparing is expressed mainly in the early rehabilitation window [17].

THE NERVE TO THE VASTUS MEDIALIS AS A TARGET

Interest has recently shifted from the canal as a compartment to the nerve to the vastus medialis as a specific structure. This nerve is identifiable sonographically at the entry to the adductor canal, where it lies adjacent to the saphenous nerve before diverging medially [18]. Because it carries both articular afferents to the anteromedial capsule and motor fibres to a muscle that contributes to terminal knee extension, it occupies an intermediate position on the analgesia–motor spectrum. Deliberately including it in the block, by a slightly more proximal or higher-volume injection, may improve coverage of the anteromedial capsule at the cost of

some vastus medialis weakness; excluding it preserves strength but may leave a portion of the capsule unblocked. This trade-off is the central unresolved question in anteromedial knee blockade, and it is being addressed prospectively in arthroscopic as well as arthroplasty populations. A related question is whether the volume of injection matters more than its precise level: a randomized comparison of a discrete saphenous nerve block with a high-volume proximal adductor canal injection in arthroscopic knee surgery found the two to give comparable analgesia, implying that proximal spread can substitute to some extent for proximal needle placement [19].

COVERING THE POSTERIOR CAPSULE: THE IPACK BLOCK

Posterior knee pain is the most common reason an otherwise well-executed adductor canal block fails. The IPACK block — infiltration between the popliteal artery and the capsule of the knee — was devised to reach the popliteal plexus and the articular branches supplying the posterior capsule without blocking the tibial or common peroneal nerves, and so without producing foot drop [20].

The evidence is genuinely mixed and needs to be read with attention to the comparator. A systematic review and meta-analysis by Hussain and colleagues found that adding the IPACK block to an adductor canal block produced a modest, short-lived analgesic benefit that was largely abolished when surgical periarticular local infiltration analgesia was also used [21]. A randomized non-inferiority trial reached a compatible conclusion, showing the adductor canal plus IPACK combination to be non-inferior to periarticular injection [22], and a randomized trial comparing IPACK plus periarticular block with adductor canal block alone likewise showed improvement chiefly in the early postoperative hours [23]. Several further meta-analyses have confirmed a small reduction in early rest and movement pain and in opioid consumption without a consistent effect on function or length of stay [24–27]. One randomized placebo-controlled trial has additionally reported a reduction in chronic post-arthroplasty pain when the IPACK block was added [28], a finding that requires replication before it changes practice. Narrative syntheses that place the block within the wider multimodal pathway reach a pragmatic conclusion: the IPACK block is worth adding when the surgeon does not perform thorough posterior capsular infiltration, and adds little when they do [29,30]. Cadaveric and clinical work comparing the IPACK approach with a dedicated popliteal plexus block suggests that a more targeted injection may achieve the same coverage with less local anesthetic [31].

EXTENDING THE BLOCK

Because these are largely single-shot techniques applied to a procedure whose pain lasts several days, duration is a practical constraint. Perineural or intravenous dexamethasone is the most widely used solution, and a randomized trial in anterior cruciate ligament reconstruction under multiple lower limb blocks confirmed a meaningful prolongation of analgesia [32]. Continuous adductor canal catheters remain an option where infrastructure permits, and comparative meta-analysis suggests they retain the motor-sparing advantage of the single injection [12]. The alternative strategy — accepting a single-shot block and planning explicitly for its resolution — has gained ground as awareness of rebound pain has increased, and argues for scheduled multimodal analgesia rather than rescue opioid alone [33].

PRACTICAL SYNTHESIS AND UNRESOLVED QUESTIONS

For total knee arthroplasty, current evidence supports an adductor canal or femoral triangle block as the anteromedial component, combined with either surgical periarticular infiltration or an IPACK block for the posterior capsule, within a multimodal pathway [1,29]. For anterior cruciate ligament reconstruction, an adductor canal block is preferable to a femoral nerve block, with the addition of a nerve to the vastus medialis component still under evaluation [14–16,18].

Three questions remain genuinely open. The first is nomenclature and technique: until trials report the injection level against an anatomical landmark rather than a conventional label, comparisons across studies will remain difficult to interpret [4]. The second is the interaction with surgical infiltration, which

determines whether the IPACK block adds value in any given institution [21]. The third is whether motor sparing measured in the first two days translates into any difference in functional recovery at three to six months, where the available data are so far neutral [17].

CONCLUSION

Motor-sparing blockade of the knee is best understood not as a single technique but as the deliberate matching of injection sites to the sensory territories that a given operation disturbs. The adductor canal block has displaced the femoral nerve block on the strength of consistent randomized evidence; the nerve to the vastus medialis defines the boundary at which additional analgesia begins to cost motor function; and the IPACK block completes posterior coverage in settings where the surgeon does not. Progress from here depends less on new blocks than on precise anatomical reporting and on outcome measures that extend beyond the first postoperative day.

AUTHOR CONTRIBUTIONS

The author confirms sole responsibility for the following: study conception, literature search and appraisal, interpretation of the evidence, and manuscript preparation and revision.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest.

ETHICS STATEMENT

This article is a narrative review of previously published literature. It does not report any study involving human participants or animals performed by the author, and therefore ethics committee approval and informed consent were not required.

ARTIFICIAL INTELLIGENCE DISCLOSURE

Artificial intelligence tools were used to assist with literature retrieval and language editing. All scientific content, interpretation, and conclusions are the responsibility of the author, who has reviewed and verified the final manuscript.

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