

(RESEARCH ARTICLE)



Pain management In Total Knee Arthroplasty: Which helps in better post-operative outcomes?

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Abstract

Background: Individuals exhibit variations in pain perception and pain threshold, and these differences exist between the right and left limbs, resulting in biases related to inter-cerebral pain variability and inter-patient pain variability. Currently, there is limited available data comparing adductor canal block (ACB) with femoral nerve block (FNB) in individuals who have undergone bilateral total knee arthroplasty (TKA).

Methods: We conducted a prospective, non-randomized, controlled study involving patients scheduled for bilateral total knee arthroplasty (TKA) under central neuraxial anesthesia. Following surgery, patients received intermittent 12-hourly boluses of 15 mL ropivacaine 0.5% through two distinct peripheral nerve blocks (adductor canal block - ACB and femoral nerve block - FNB) in either of the lower limbs. The primary objective was to evaluate the postoperative Visual Analog Scale (VAS) score, while the secondary outcomes included the assessment of quadriceps muscle strength and the degree of flexion at the knee joint.

Results: Out of the 70 patients evaluated for eligibility, 63 were enrolled, and 60 were included in the final analysis. Visual Analog Scale (VAS) scores after both blocks during periods of rest at 30 minutes, 6 hours, 12 hours, and 48 hours post-operatively did not exhibit any significant differences. However, VAS scores during rest at 24 hours and during exercise at 24 hours and 48 hours demonstrated a notable disparity. Furthermore, there was a significant difference in favour of adductor canal block (ACB) over femoral nerve block (FNB) regarding quadriceps muscle strength and the degree of knee flexion at 24 hours and 48 hours post-operatively.

Conclusions: Adductor canal block (ACB) delivers comparable pain relief to femoral nerve block (FNB) both at rest and during passive exercise for up to 48 hours after surgery. ACB notably maintains the motor strength of quadriceps muscles when contrasted with FNB, and this preservation comes without introducing any additional complications.

Keywords: Regional nerve block; Paraesthesia; knee flexion; Range of movement; Patients

1. Introduction

Effective pain management is paramount for a successful recovery, preventing additional morbidity associated with pain, following total knee arthroplasty (TKA).[1] The integration of femoral nerve block (FNB) into the analgesic protocol has demonstrated superior pain control[2,3] and a reduction in hospital stays,[4] in comparison to relying solely on epidural or intravenous patient-controlled analgesia (PCA).[1,5,6] However, the extended motor blockade linked to FNB introduces a small (2%) but clinically significant risk of falls.[7,8] Balancing the objectives of achieving adequate pain relief and maintaining muscle strength poses an inherent challenge with FNB. Ideally, a nerve block should provide effective analgesia, minimize opioid use and associated side effects, and expedite mobilization by

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preserving motor strength. The increasing popularity of "fast-track" total joint replacements underscores the importance of preserving motor function while ensuring sufficient pain relief in orthopaedic surgeries. This approach facilitates the initiation of early physical therapy, accelerates recovery, and results in shorter hospital stays, reducing the likelihood of morbidity associated with immobility and hospital-acquired infections.

The introduction of ultrasonography has enabled the visualization of the adductor canal at the mid-thigh level, facilitating the successful implementation of adductor canal block (ACB) with a high success rate.[9,10] ACB has demonstrated effectiveness in postoperative pain control following knee surgery in recent years.[9,11] Anatomical studies of the adductor canal have further contributed to a better understanding of optimal techniques for achieving successful ACB. Examination of the adductor canal's anatomy has revealed its potential to serve as a conduit for various nerves, potentially including the vastus medialis nerve, medial femoral cutaneous nerve, articular branches from the obturator nerve, and the medial retinacular nerve.[10–12] Consequently, sensory alterations extend beyond the distribution of the saphenous nerve,[13] covering the medial and anterior aspects of the knee from the superior pole of the patella to the proximal tibia.

In this prospective, double-blinded, randomized, controlled study, we aimed to test the hypothesis that adductor canal block (ACB) would result in less quadriceps motor weakness than femoral nerve block (FNB) while providing non-inferior analgesia, as assessed by Numeric Rating Scale (NRS) pain scores and opioid use. Utilizing a joint hypothesis test with three primary outcomes, the hypothesis posited that ACB is superior in strength but not inferior in terms of pain scores and opioid use at 6 to 8 hours post-anaesthesia.

2. Material and Methods

In this prospective randomized controlled trial 60 patients were included after receiving approval from Ethics Board and written informed consent from the patients.

Sixty individuals scheduled for elective total knee arthroplasty (TKA) were recruited. Allocation to either adductor canal block (ACB) or femoral nerve block (FNB) was determined through a randomization list.

Inclusion criteria comprised

- Elective unilateral TKA,
- Planned combined spinal epidural anesthetic,
- Age between 18 and 70 years,
- Ability to adhere to the study protocol, and
- American Society of Anesthesiologists class 1 to 3.

Exclusion criteria encompassed

- Contraindications for neuraxial anesthetic,
- Chronic analgesic use (defined as daily or nearly daily use for over three months),
- Hypersensitivity or allergies to local anesthetics,
- Intraoperative use of volatile anesthetics,
- Preexisting neuropathy in the operative limb,
- Contraindications to femoral or acb,
- Allergy to any study medications,
- Age below 18 or above 70 years, and
- American society of anesthesiologists class 4 or 5.

In the preoperative consultation, the study protocol and Visual Analogue Scale (VAS) scoring were thoroughly explained to all enrolled patients. VAS is a 10-point objective scale, ranging from "0" indicating "no pain at all" to "10" denoting "maximal possible pain"[14]. Bilateral total knee arthroplasty was conducted under combined spinal-epidural anaesthesia (0.5% bupivacaine heavy, 2.5 mL intrathecally). Intraoperative patient discomfort was addressed with an epidural top-up of bupivacaine 0.25% (5 mL) at the discretion of the supervising anaesthetist. The surgical procedure was consistently performed by the same surgeon.

Following the surgery, patients were transferred to the post-anaesthesia care unit. Peripheral nerve blocks, including Adductor Canal Block (ACB) and Femoral Nerve Block (FNB), were administered under aseptic precautions to the same patient on separate lower limbs once a VAS score of 6/10 was reached. The choice of the left or right lower limb for ACB and FNB alternated with each consecutive patient.

For FNB with perineural catheter insertion, the ultrasound-guided (USG) in-plane technique (6–13 MHz linear probe, GE Healthcare Systems, Phoenix, US) was employed. The USG probe was inclined perpendicular to the femoral artery and in-line with the inguinal ligament. An 18G Tuohy needle (10 cm) was inserted along the lateral border of the USG probe. Saline was injected to aid the procedure, and an epidural catheter (20G, triple orifice, Contiplex® Tuohy, B. Braun, Germany) was threaded under real-time ultrasound guidance.

For the Adductor Canal Block (ACB) with perineural catheter insertion, the ultrasonography (USG) probe was positioned at the junction of the middle and lower one-third thigh level. The femur was identified, and the probe was directed medially until the boat-shaped sartorius muscle came into view. Beneath the sartorius muscle, the femoral artery and vein were identified, and the adductor canal was discerned by observing the characteristic double contour of the vaso adductor membrane. Subsequently, an 18G Tuohy needle (10 cm in length) was inserted along the lateral border of the USG probe in a postero-lateral direction.

With the needle tip positioned medially to the femoral artery within the adductor canal, 5 mL of saline was injected to facilitate the ongoing procedure. An epidural catheter (20G, triple orifice, Contiplex® Tuohy, B. Braun, Germany) was then advanced 5 cm beyond the needle tip. Under continuous real-time ultrasound monitoring of saline spread, the catheter was slightly retracted to ensure its proximity to the saphenous nerve. Following this, the needle was withdrawn, and the catheter was securely anchored in place using a transparent dressing[15].

Post-procedure, 0.5% ropivacaine (15 mL) was injected every 12 hours through the FNB and ACB catheters for the subsequent 48 hours. All peripheral nerve block procedures were performed by the same anesthesiologist, and an independent nursing officer monitored patients and collected outcome data. Standard systemic analgesics, including paracetamol and diclofenac, were administered, with tramadol as a rescue analgesic for a VAS score >6. The epidural catheter was removed when the VAS score improved from 6/10 to 3/10 in both limbs under the effect of peripheral nerve blocks. In cases of block failure, epidural top-ups were administered, and these patients were excluded from the primary analysis. Postoperatively, patients were monitored for any adverse events.

The primary endpoint encompassed the evaluation of post-operative Visual Analogue Scale (VAS) scores measured at rest at 30 minutes, 6 hours, 12 hours, 24 hours, and 48 hours, along with assessments during exercise at 24 hours and 48 hours following the administration of Peripheral Nerve Blocks (PNBs). Secondary outcomes included the measurement of quadriceps muscle strength and the degree of knee flexion at 24 hours and 48 hours after PNB administration.

Quadriceps muscle strength, measured in kilogram force, was assessed with the patient in a supine position, knees flexed on a rolled pillow at 40°, and the bed angle set between 25°. This evaluation involved knee extension against the Lafayette dynamometer positioned over the base of the tibia, utilizing the Lafayette Manual Muscle Test System (Lafayette Instrument Company, Lafayette, Indiana, USA)[16]. The degree of knee flexion was measured in both legs with the patient in a supine position. The limb support was attached to the table end (80°–90° bend) and placed in the popliteal fossa to provide support to the knee while maintaining an angle for measuring knee flexion using a goniometer. The position of the ankle was not fixed to minimize patient discomfort.

The sample size determination utilized G power software Version 3.1 (Germany), with a two-sided hypothesis test, alpha error of 0.05, power of 80%, effect size of 0.53, allocation ratio of 1, and accounting for a 10% dropout rate. This resulted in a requirement of 60 samples. The effect size was based on a prior study's results (mean ACB 4 ± 2.2 ; mean FNB 3 ± 1.48) concerning pain scores during activity at 48 hours[17]. Statistical analysis was conducted using the Statistical Package for Social Sciences statistical software, Version 21 (IBM, Armonk, NY, US), and the data were presented through descriptive analysis. Comparison of primary and secondary outcomes was performed using the Wilcoxon signed-rank test, with a significance level set at $P < 0.05$.

3. Results

63 patients were successfully enrolled and ultimately 60 were included in the analysis. Three participants were excluded, with one experiencing failure in Femoral Nerve Block (FNB) and the remaining two encountering catheter dislodgement from the FNB site, as illustrated in Figure 1. The average age of the participants was 60 ± 4.8 years, the

mean weight was 67 ± 5.7 kg, and the mean height measured 159.7 ± 5.8 cm. The cohort comprised 33 male and 27 female patients, with 43 (71%) falling under ASA Class II.

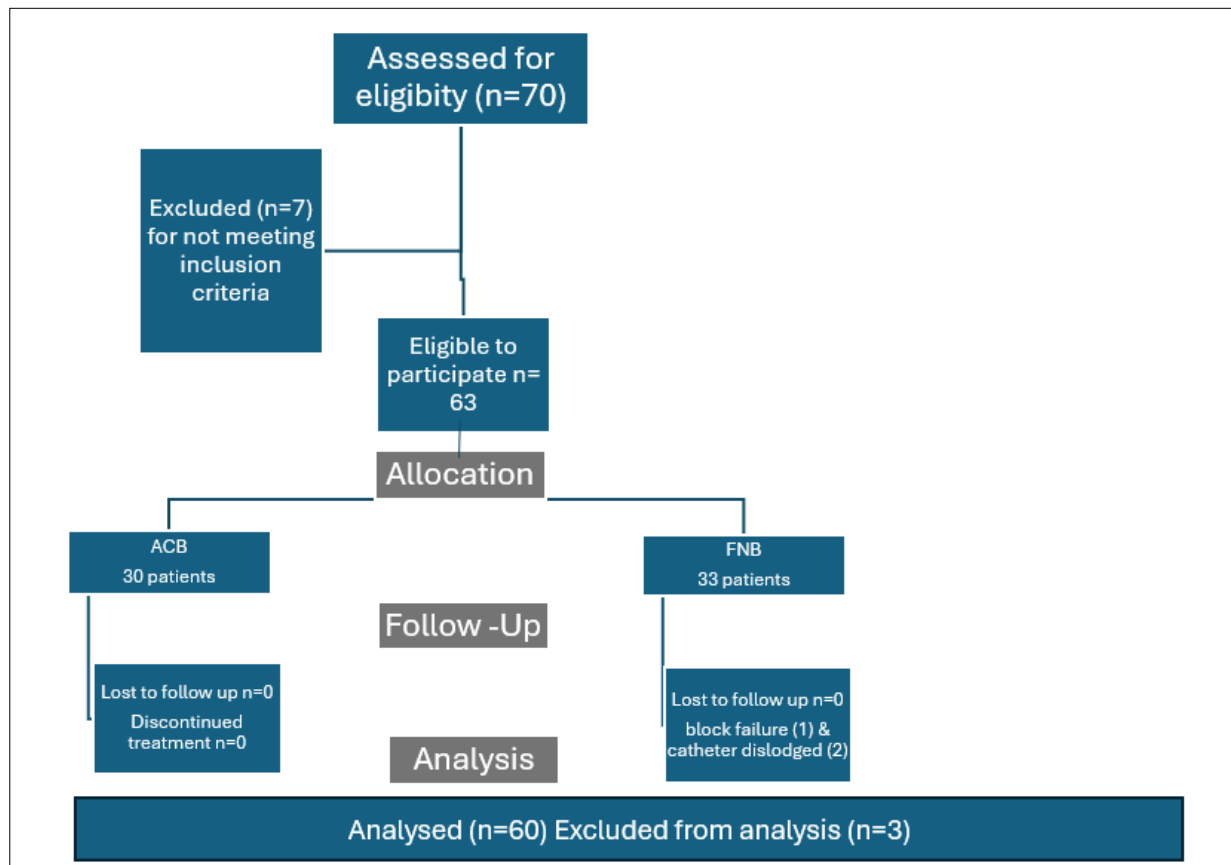


Figure 1 Patient flow in the study

Following the administration of the block, there was a notable reduction in VAS scores in both blocks. The average VAS scores in the ACB were consistently lower than those in the FNB at various time points, both during rest and exercise. Upon comparing the two groups, VAS scores at rest showed no significant differences between the blocks at most time points: at 0 minutes (ACB 7.4 ± 0.8 ; FNB 7.6 ± 0.8 ; $P = 0.07$), at 30 minutes (ACB 3.2 ± 0.7 ; FNB 3.3 ± 0.9 ; $P = 0.32$), at 6 hours (ACB 2.8 ± 0.6 ; FNB 3.05 ± 0.7 ; $P = 0.19$), at 12 hours (ACB 3.0 ± 0.6 ; FNB 3.1 ± 0.8 ; $P = 0.10$), and at 48 hours (ACB 3.2 ± 0.5 ; FNB 3.3 ± 0.6 ; $P = 0.12$). However, statistical significance was reached at 24 hours after initiating the block (ACB 3.1 ± 0.6 ; FNB 3.3 ± 0.6 ; $P = 0.02$). During exercise, the VAS score was significantly higher in the FNB compared to the ACB at 24 hours (ACB 3.7 ± 0.5 ; FNB 4.08 ± 0.5 ; $P = 0.01$) and at 48 hours (ACB 3.7 ± 0.5 ; FNB 4.2 ± 0.6 ; $P < 0.001$) after initiating the block.

Furthermore, the mean muscle strength values in the ACB were significantly greater than those in the FNB at 24 hours (ACB 2.1 ± 0.5 ; FNB 1.7 ± 0.4 ; $P < 0.001$) and at 48 hours (ACB 2.5 ± 0.5 ; FNB 2.2 ± 0.4 ; $P < 0.001$). The degree of knee flexion was also notably higher at 24 hours (ACB 84.4 ± 6.5 ; FNB 82.1 ± 6.6 ; $P = 0.04$) and 48 hours (ACB 104.5 ± 8.4 ; FNB 101.0 ± 8.0 ; $P = 0.04$) in the ACB compared to the FNB [Table 1].

There were no instances of patient falls within the initial 48 hours of recovery, and no notable complications related to the catheter, such as hematoma were observed in either block. There was catheter displacement in 2 patients in FNB block.

Table 1 Comparison of primary and secondary outcomes of study population by Wilcoxon signed-rank test

OUTCOME	TIMELINE	ACB	FNB	P value
VAS score at	0 min	7.4±0.8	7.6±0.8	0.07
rest	30 min	3.2±0.7	3.3±0.9	0.32
	6 h	2.8±0.6	3.05±0.7	0.19
	12 h	3.0±0.6	3.1±0.8	0.10
	24 h	3.1±0.6	3.3±0.6	0.02
	48 h	3.2±0.5	3.3±0.6	0.12
VAS score	24 h	3.7±0.5	4.08±0.5	0.01
during exercise	48 h	3.7±0.5	4.2±0.6	<0.001
Muscle strength	Baseline	2.79±0.5	2.80±0.5	0.96
(kgF)	24 h	2.1±0.5	1.7±0.4	<0.001
	48 h	2.5±0.5	2.2±0.4	<0.001
Degree of knee	24 h	84.4±6.5	82.1±6.6	0.04
flexion (degrees)	48 h	104.51±8.4	101.0±8.0	0.04

{Values are depicted as mean±SD; VAS=Visual Analogue Scale; time is taken from administration of block; kgF=kilogram force; P<0.05 is considered as statistically significant}

4. Discussion

This study's primary outcome was assessment of VAS scores) in the two blocks at rest, assessed at various time points up to 48 hours post-operation. The key finding at rest did not exhibit any significant differences. However, VAS scores during passive exercise at 24 and 48 hours revealed statistically significant difference. Secondary outcomes, specifically quadriceps muscle strength and the degree of knee flexion, were notably superior in ACB.

Notably, not all patients experienced clinically significant disparities in post-operative analgesia, aligning with Elkassabany et al.'s findings, which reported similar pain scores, analgesic requirements, and recovery quality between the two blocks.[18] However, our results contradicted those of Memtsoudis et al., who reported better qualitative pain relief with FNB over ACB 24 hours after TKA.[16]

The observed differences in analgesic properties between ACB and FNB may stem from their distinct scopes of sensory block . FNB's sensory block includes the saphenous nerve, the nerve to vastus medialis, and the medial femoral cutaneous nerve, providing analgesia to the medial and anterior knee. In contrast, ACB involves multiple nerves, resulting in greater analgesic benefits attributed to the sensory block of the posterior branches of the obturator nerve.[19] Placing the perineural catheter tip distally in ACB contributes to improved analgesia as compared to FNB by spreading local anaesthetic into the popliteal fossa, affecting the posterior branch of the obturator nerve and the popliteal plexus.[20]

To mitigate bias, each participant underwent FNB on one lower limb and ACB on the other. This approach is consistent with Koh et al.'s study[21], comparing ACB and FNB in the same patient undergoing bilateral TKA, demonstrating consistent analgesic levels between knees receiving either ACB or FNB and better quadriceps muscle strength recovery in knees with ACB during the initial 48 hours.

Quadriceps muscle strength assessment post-operatively for knee extension revealed statistically significant differences favoring ACB, in line with previous studies. [18,19,21] This arises from the inhibition of the nerve to the vastus medialis and its sensory branches, both intramuscular and extra muscular, providing sensation to the knee joint in the distal region of the adductor canal. ACB leads to selective motor weakness specifically in the vastus medialis, preserving the motor function of the remaining three quadriceps components (rectus femoris, vastus lateralis, and vastus intermedius) since their motor nerves do not pass through the adductor canal. In contrast, FNB blocks the nerve supply to all four muscles of the femur.[20,22]

Some studies found no significant differences in muscle strength between ACB and FNB, suggesting that factors such as pain or peri-surgical conditions, including tourniquet use, may influence outcomes. Jaeger et al.'s study,[22] which did not find differences in quadriceps muscle strength between the two groups at 24 hours after TKA, highlighted potential bias from large bolus volumes applied during USG-guided ACB at the mid-thigh level. In our study, catheter placement at the junction of the middle and lower one-third of the thigh, guided by USG visualization of the vasoadductor membrane, aimed to eliminate this possible bias.

Knee flexion degree assessment using a goniometer at 24 and 48 hours post-operation revealed statistically significant differences between ACB and FNB, consistent with Grevstad et al.'s and Govil's study. [23,24] The leg receiving ACB exhibited better knee flexion, potentially attributed to the superior analgesic effects of ACB at 24 and 48 hours during physical exercise and sparing of the tibial nerve.

No instances of patient falls due to weakness were observed, especially in the FNB group.[25] Additionally, no complications related to catheter placement, such as infection, nerve injury, or hematoma formation, were reported during the administration of either ACB or FNB. Catheter displacement occurred in 2 patients.

Several potential limitations were acknowledged in our study. Administering two different blocks in two limbs of a single patient hindered accurate assessments of ambulation ability, gait traits, and fall incidence. Monitoring catheter tip or drug migration in the adductor canal post-initial placement or drug administration was not conducted. Logistic issues prevented the monitoring of hospital stay length, and due to the participants being admitted on the first outpatient department visit, pre-operative rehabilitation for quadriceps muscle strengthening was not implemented.[26]

5. Conclusion

Femoral nerve block (FNB) and adductor canal block (ACB) are comparable solely in delivering post-operative pain relief in knee arthroplasty. ACB outperforms FNB in preserving quadriceps muscle strength without introducing any additional complications.

Compliance with ethical standards

Statement of ethical approval

Ethical clearance sought

Statement of informed consent

Informed consent was obtained from all individual participants included in the study.

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