The Research of Medical Science Review
ISSN: 3007-1208 & 3007-1216 Volume 3, Issue 6, 2025

COMPARISON OF ADDUCTOR CANAL BLOCK VERSUS FEMORAL NERVE BLOCK FOR ANALGESIA EFFICACY AND QUADRICEPS STRENGTH IN PATIENTS UNDERGOING KNEE SURGERY

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DOI: http://doi.org/10.5281/zenodo.21394016

Keywords
Analgesics; Arthroplasty; Nausea; Nerve Block; Pain Management

Article History
Received: 27 April 2025
Accepted: 06 June 2025
Published: 23 June 2025

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Abstract

Objective: *To compare the efficacy of Adductor Canal Block (ACB) and Femoral Nerve Block (FNB) for analgesia and functional recovery in patients undergoing Total Knee Arthroplasty (TKA), focusing on opioid consumption, pain scores, nausea/vomiting, time to ambulation, and patient satisfaction.*

Study Design and Setting: *This was a double-blind randomized controlled trial conducted at Combined Military Hospital Kharian, a tertiary care facility.*

Methodology: *A total of 60 patients undergoing unilateral TKA were randomly assigned to receive either ACB (Group A) or FNB (Group B). Postoperative pain was assessed using the Visual Analog Scale (VAS) for rest and knee flexion. Total nalbuphine consumption was recorded, and incidence of nausea/vomiting and time to ambulation were evaluated. Patient satisfaction was assessed using a 5-point Likert scale.*

Results: *Both groups showed comparable opioid consumption, pain scores, and patient satisfaction ($p > 0.05$). ACB patients ambulated 39 minutes earlier than FNB patients (280.4 ± 58 minutes vs 319.0 ± 65 minutes, $p = 0.021$). There were no significant differences in nausea/vomiting incidence between the groups ($p > 0.05$).*

Conclusion: *Both ACB and FNB provide comparable analgesia after TKA, but ACB offers the advantage of faster ambulation, improving early recovery. ACB is a preferred technique for postoperative pain management and functional recovery after TKA, though further studies are needed to assess long-term outcomes.*

Introduction

Total Knee Arthroplasty (TKA) has become increasingly common worldwide, with studies reporting that incidence has more than doubled in many countries over the last 20 years.2 This is largely attributed to an aging population, increase in life expectancy and increased prevalence of obesity and osteoarthritis. Surgical techniques and implant design have also expanded indications for TKA, which is now being done on younger and more active patients. As the volume of procedures increases, optimization of perioperative care and postoperative rehabilitation has become important to improve outcome and reduce complication burden.

TKA is a major orthopedic procedure with extensive tissue trauma and bone manipulation. This leads to significant inflammatory responses causing significant pain and functional limitation. Prospective studies have reported measurable pain

scores in the postoperative phase following TKA, with early postoperative VAS scores ranging from 4/10 to 6/10 despite standard analgesic protocols.3, 4 Effective pain management is therefore essential component of perioperative care, as this can lead to delay in early mobilization and rehabilitation. There is also increased risk of complications and delay in recovery with poorly controlled pain.1 Multimodal analgesia is standard approach for pain management method after TKA , which includes oral and intravenous analgesics, periarticular injection, peripheral nerve blocks and epidural catheters.5 Peripheral nerve blocks (PNB) are aimed at providing effective analgesia as part of multimodal regime while minimizing opioid consumption and adverse effects.6 By targeting specific neural pathways, PNB provide site specific analgesia with minimal systemic side effects. This targeted analgesia not only improves pain control but also helps in early mobility and reduces opioid related side effects.

Femoral nerve block(FNB) is commonly employed as recommended PNB for postoperative analgesia after TKA because of its excellent analgesic and opioid sparing effect. However femoral nerve block is associated with weakness of quadriceps muscle fibers, which can lead to delayed mobility and increase risk of post-surgery falls.7, 8 This limitation has led to find an alternative technique with an aim to preserve quadriceps strength while providing same level of analgesia.

In recent years Adductor canal block (ACB) has shown promise as an alternative strategy to FNB that focuses on sensory blockade of saphenous nerve -largest sensory branch of femoral nerve- while preserving quadriceps motor function. Recently TKA is being performed as an outpatient procedure under Enhanced Recovery After Surgery (ERAS) protocol. Early mobilization is a key component of enhanced recovery protocols after TKA, which favors motor sparing blocks.

Preservation of quadriceps strength is important for early rehabilitation; therefore, ACB has gained popularity as it maintains muscle function and enhances postoperative mobility. ACB has been associated with a lower risk of postoperative falls compared to FNB, making it a reasonable option. It also provides analgesia to medial side of knee, improving patient satisfaction. When combined with multimodal analgesia, ACB can further reduce opioid consumption and related side effects. It aligns with ERAS goals of faster recovery, shorter hospital stays and improved functional outcome. Another advantage of this block is the relatively superficial anatomical location which makes the block easier to perform under ultrasound guidance. As a result, ACB is increasingly being incorporated into standardized analgesic protocols for TKA in many institutions.

Despite a number of studies comparing ACB and FNB, the optimal regional anesthesia technique remains controversial.9-12 While several RCTs have reported comparable analgesic efficacy between two techniques, differences in quadriceps muscle strength, early mobilization and functional recovery have been inconsistently reported. Considering differences in patient demographics, perioperative protocols, and local anesthetic practices, evidence from Western populations may not directly apply to our clinical setting.

Therefore, present study aims to fill this gap by comparing analgesic efficacy and quadriceps muscle strength following these two types of PNB in our institution. We evaluated pain scores post-op, opioid consumed and time for early ambulation to find optimal regional anesthesia technique for postoperative analgesia following TKA.

Methodology

This double-blinded randomized controlled trial was conducted at Combined Military Hospital Kharian, a tertiary care hospital, from 1 July 2025 to 1 December 2025, after approval from the Institutional Ethical Review Committee (ERC No: A/25/62, dated 08 April 2025). The study was conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrollment. Patients were enrolled using non-probability consecutive sampling to include all eligible cases during the study period.

Patients of either gender aged ≥18 years with American Society of Anesthesiologists (ASA) physical status I or II who were booked for elective unilateral TKA under neuraxial spinal anesthesia.

Hemodynamically stable patients were included in the study. Patients with ASA III or IV, contraindication to neuraxial anesthesia, patients requiring conversion to GA intra-op, or with local anesthetic allergy were excluded. Infection at block site, pre-existing neurological deficit, chronic opioid use, or previous surgery at same knee were also excluded.

Sample size calculation was done using OpenEPI version 3.01. Based on previous studies comparing ACB and FNB for postoperative analgesia after TKR, mean VAS score was 3.2 ± 1.1 and 4.1 ± 1.3, respectively. With a 95% confidence interval and 80% study power the required sample size was 27 patients per group. To cater for the possible dropouts, 30 patients were included in each group, giving total sample size of 60. Patients were randomly allocated into two groups (Group A and Group B) using a computer-generated randomization sequence, and group allocation was concealed using sealed opaque envelopes.

After informed written consent patients were taken to OT and ASA standard monitoring including non-invasive blood pressure, ECG, and pulse oximetry was applied, patients were co-loaded with crystalloid and received spinal anesthesia in L3-L4 or L4-L5 interspace in sitting position. 25G Quincke needle was used for spinal under strict aseptic precautions, 1.8ml of 0.75% hyperbaric bupivacaine injected intrathecally. In addition, patients also received IV Paracetamol 1g every 8 hours, IV Ketorolac 30mg every 12 hours and IV dexamethasone 8mg stat perioperatively. IV Metoclopramide and IV Midazolam were given intraoperatively if required. PNB were performed by senior anesthesiologists and were not involved in postoperative assessment to maintain double blinding.

Patients of Group A were selected for ACB under Ultrasound (US) guidance. After skin was closed patient was helped in supine position, linear transducer was selected and placed on mid-thigh. Femur was identified on the US screen; probe was guided medially to identify femoral artery. The adductor canal was identified under ultrasound guidance with the femoral artery as the key landmark beneath the sartorius muscle. 22G SonoPlex II block needle was used with an in-plane technique, needle was advanced under direct visualization till it was under sartorius in adductor canal. After aspiration for blood 3-5ml normal saline bolus was used to identify correct position (anterior or lateral to femoral artery) and spread in adductor canal. 25ml of 0.5% bupivacaine was injected after confirmation with negative aspiration and spread in adductor canal was observed.

Patients of Group B received FNB at the end of surgery after surgical wound closure. Patients were in supine position; linear US probe was placed in middle of inguinal line to look for femoral artery and vein. Femoral nerve was then identified lateral to the femoral artery as triangular hyperechoic structure. After aseptic measures 22G Sonoplex II block needle was used with an in-plane approach till needle was in proximity to femoral nerve. Normal saline bolus was used to confirm needle position after which 25ml of 0.5% bupivacaine was injected after negative aspiration.

After the procedure, patients were observed in Post anesthesia care unit (PACU) for 45 mins before being shifted to surgical ward. Anesthesiologists and nursing staff who followed up on patients were blinded regarding the group patient belonged to. Postoperative analgesia was standardized in both groups. IV Nalbuphine 0.1mg/kg was administered to patients over 24 hours as part of multimodal analgesia, in addition patients also received bolus of 2 mg as required when they complained of pain. Additional doses were administered as required with breaks of 4-6 hours and total nalbuphine consumption during first 24 hours postoperatively was recorded. Patients were assessed on arrival in PACU and then subsequently in ward for 24 hours following operation. Postoperative pain was evaluated using VAS at rest and on knee flexion hourly for first 6 hours, and then every 6 hours until 24 hours. Nausea and vomiting were documented as opioid-related side effects. Time to ambulation (defined as the 'time from completion of surgery until the patient was able to stand and walk with assistance for the first time') and patient satisfaction (using '5-point Likert scale, 1=very dissatisfied, 5=very satisfied') were also recorded.13

Primary outcome measure was total amount of Nalbuphine consumed during first 24 hours after surgery. Secondary outcome measured were pain score during rest and during knee flexion (VAS), opioid side effects, time to initial ambulation and overall patient satisfaction.

Statistical Analysis: Data was analyzed using IBM SPSS Statistics version 27. Quantitative variables such as age, pain scores, and total Nalbuphine consumption were presented as mean ± standard deviation (SD) for normally distributed data or median with interquartile range (IQR) for non-normally distributed data. Qualitative variables including gender, nausea, vomiting, and patient satisfaction were summarized as frequencies and percentages.

Normality of data was assessed by Shapiro-Wilk test. For comparison of continuous variables between the two groups, the independent sample t-test was applied for normally distributed data, while the Mann–Whitney U test was used for non-normally distributed data. Associations between categorical variables were analyzed using the Chi-square test. A p-value ≤ 0.05 was considered statistically significant.

Results

Data analysis showed that baseline demographic characteristics were comparable between the two groups like age, weight, height, BMI and gender (Table-I). The mean age of patients in Group A was 64.17±6.1 years, and in Group B, it was 62.63±5.5 years (p = 0.314) Distribution of gender was similar between two groups with 56.7% males in each group. There were no significant differences in weight, height, or BMI (p > 0.05 for all). There were no significant differences in pain scores at rest or during knee flexion between the two groups at any time point (Table-II). Total nalbuphine consumed in first 24 hours was similar between the groups. Group A consumed 11.00±2.76 mg and Group B consumed 11.35 ±2.83 mg (p = 0.624), indicating that pain management was comparable in both groups. The incidence of nausea and vomiting was similar between the groups, with no significant differences observed at 6, 12, 18, or 24 hours (Table IV). The median time to initial ambulation was significantly shorter in Group A (280.4 ± 58 minutes) compared to Group B (319.0 ± 65 minutes) (p = 0.021). Patient satisfaction was similar between the groups, with both groups reporting a median satisfaction score of 5 (4–5) (p = 0.141). In conclusion, while Group A and Group B were similar in terms of nalbuphine consumption, nausea/vomiting incidence, and patient satisfaction, Group A demonstrated significantly faster ambulation (p = 0.021). This suggests that the adductor canal block may contribute to early mobility and faster recovery after total knee arthroplasty.

Table-I: Demographic characteristics of patients (n = 60)

Variable	Group A (n=30)	Group B (n=30)	P-value
Age (years)	64.17±6.137	62.63±5.530	0.314
Weight (kg)	81.86±14.681	81.82±13.783	0.991
Height (cm)	160.5±6.341	159.54±5.164	0.524
BMI (kg/m2)	32.0±6.50	32.1±5.593	0.927
Gender, n (%)			
Male	17 (56.7%)	17 (56.7%)	1.000

Female	13 (43.3%)	13 (43.3%)	
Values are presented as mean ± SD or n(%).			

Table-II: Post-surgery VAS pain scores both at rest and during knee flexion (n = 60)

Time after surgery	Group A (n=30)	Group B (n=30)	P-value
Pain at rest			
6 h	0 (0-2)	1 (0-2)	0.167
12 h	1 (0-2)	1 (0-2)	0.557
18 h	1 (0-2)	1 (0-3)	0.927
24 h	1 (0-2)	1 (0-2)	0.890
Pain during flexion			
6 h	1 (0-2)	1 (0-3)	0.645
12 h	1 (0-2)	2 (0-2)	0.730
18 h	2 (0-2)	1 (0-2)	0.890
24 h	1 (0-2)	1 (0-2)	0.640
Values are presented as median (IQR). P-values calculated by Mann–Whitney U test.			

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Table-III: Total Nalbuphine consumption in first 24 hours (n = 60)

Variable	Group A (n=30)	Group B (n=30)	P-value
Total nalbuphine in 24 hours (mg)	11.00±2.769	11.35 ±2.839	0.624
Values are presented as mean±SD. P-values calculated by independent sample t-test.			

Table IV: Incidence of Nausea/Vomiting and Patient Satisfaction Scores (n = 60)

Time/Patient Satisfaction	Group A (n=30)	Group B (n=30)	P-value

Nausea(yes) at 0 h	2	3	0.640
Nausea(yes) at 6 h	1	3	0.301
Nausea(yes) at 12 h	1	1	1.000
Nausea(yes) at 18 h	0	1	0.313
Nausea(yes) at 24 h	0	0	
Patient satisfaction score	5 (4-5)	5 (4-5)	0.141
Values are presented as number (%) for nausea (Yes) and as median (interquartile range) for patient satisfaction. P-values for nausea (Yes) were calculated using the Chi-square test, and for patient satisfaction calculated by Mann–Whitney U test.			

Discussion:

Pain management after total knee arthroplasty (TKA) can be challenging due to the older age of patients and the need for early mobilization to reduce complications.14 Multimodal analgesia is the standard practice and includes a combination of intravenous opioids, NSAIDs, neuraxial blocks, peripheral nerve blocks, steroids, and sometimes antidepressants. Different routes of administration are employed to enhance mobility and reduce the risk of morbidity and mortality. Peripheral nerve blocks (PNB) have emerged as a reliable method to reduce opioid consumption and minimize opioid-related side effects.15

Several PNB, including FNB, ACB, electroacupuncture and other regional techniques, such as the infiltration between the popliteal artery and capsule (iPACK) and sciatic nerve blocks, have been used to manage postoperative pain after TKA.16, 17 Although the FNB remains one of the most commonly used techniques for postoperative analgesia following total knee arthroplasty, evidence suggests that its motor blockade effect on the quadriceps may hamper early mobilization and functional recovery.18 19

Local anesthetic infiltration techniques, such as periarticular local infiltration analgesia (LIA), have been used as an adjunct to PNB in total knee arthroplasty to decrease early postoperative opioid required and pain scores compared with placebo or no infiltration.20

ACB has been suggested in the literature as an alternative to FNB for postoperative analgesia in TKA, providing equivalent analgesic efficacy while reducing quadriceps motor weakness.9, 21, 22 In our study the primary outcome, nalbuphine consumption, was not shown to be statistically significant between the two groups, suggesting that both techniques provide similar levels of analgesia during the first 24 hours post-surgery. Similarly, we observed no significant differences in nausea/vomiting incidence or patient satisfaction between the groups, indicating that neither approach led to worse side effects or dissatisfaction.

Our findings supplement previous studies, which reported that FNB is associated with a higher risk of postoperative falls due to quadriceps weakness.19, 23, 24 This weakness , may be mitigated by using ACB, which preserves motor function and promotes early mobilization. Similar findings have been observed in studies comparing ACB with FNB, emphasizing that ACB is a motor-sparing alternative with similar analgesic efficacy, as suggested by Jaeger et al. and Yin et al.

Our study highlights benefit of ACB in fostering early mobility, a crucial element in the recovery following TKA. Specifically, the ACB group (Group A) exhibited earlier mobilization by 39

minutes compared to the FNB group (Group B), implying that ACB may speed up recovery. This observation aligns with the results of Jaeger et al., who also documented a decreased time to ambulation in patients who received ACB. A possible rationale for this outcome could be the preservation of quadriceps strength with ACB, which selectively targets the saphenous nerve while sparing the motor fibers responsible for quadriceps function. Conversely, FNB, which blocks a larger segment of the femoral nerve, weakens quadricep fibers, thereby contributing to delayed ambulation.

Limitations of the study: This includes the relatively small sample size (n=30 per group) which limits the generalizability of the findings. A larger cohort would help validate these results and improve the external validity of the study. We only focused on short-term outcomes; it would be worthwhile in future to look at long-term recovery including pain relief and patient satisfaction for 3 to 6 months. Comparing these PNB with multimodal analgesia and epidural blocks can help in identifying best approach for TKA.

Future research could look for different dosing regimens for ACB and FNB, effect of additive agents or modified approaches to improve their effectiveness. Studies evaluating postoperative function, knee joint recovery, and functional outcomes can also add value to the long-term benefits of these blocks.

Conclusion

Both ACB and FNB provide comparable analgesia after Total Knee Arthroplasty, with no significant difference between opioid consumption, nausea/vomiting or patient satisfaction. However, ACB may be the preferred technique after TKA as it provides similar analgesia to FNB with benefit of early ambulation, which can decrease hospital stay, prevents immobility related problems and improve functional outcome. Objective measurement of muscle strength can help confirm benefit of ACB in preserving quadriceps strength, supporting its role as recommended strategy in TKA patients. Future multi center trials can focus on long-term outcomes to further validate these findings. Moreover, exploring optimal dosing and technique modifications for ACB could further improve postoperative pain management and functional recovery.

Acknowledgment: Nil
Conflicts of Interest: Nil
Funding Source: Nil
Authors Contribution:
Dain bin Khalid: Abstract, literature review and results
Shais Talat: Introduction, abstract, literature review, data collection, result
Tahir Saleem: Abstract, literature review and results
Bismah Abaid Ur Rehman: Discussion, literature review, data collection
Moin Iqbal: Literature review data collection

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