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Original Article

Comparison of Adductor Canal Block versus Femoral Nerve Block for Postoperative Analgesia Following Total Knee Arthroplasty

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ABSTRACT

Background: Effective postoperative analgesia following total knee arthroplasty (TKA) is essential for early mobilization, functional recovery, and patient satisfaction. Adductor canal block (ACB) has emerged as a motor-sparing alternative to femoral nerve block (FNB), potentially providing comparable analgesia while preserving quadriceps muscle strength.

Materials and Methods: This prospective randomized comparative study included 70 patients undergoing elective unilateral TKA under spinal anesthesia. Patients were randomly allocated into two groups: Group A (ACB, n = 35) and Group F (FNB, n = 35). Postoperative pain was assessed using the Visual Analogue Scale (VAS) at 2, 4, 6, 12, and 24 hours. Time to first rescue analgesia, 24-hour tramadol consumption, quadriceps muscle strength, time to ambulation, patient satisfaction, and postoperative complications were compared.

Results: Baseline demographic and clinical characteristics were comparable between the groups. VAS pain scores were similar throughout the postoperative period. The ACB group demonstrated a significantly longer time to first rescue analgesia (11.8 ± 2.9 vs. 9.4 ± 2.5 hours; $p = 0.001$), lower tramadol consumption (108.6 ± 42.4 vs. 152.9 ± 51.6 mg; $p < 0.001$), better quadriceps strength at 6 and 12 hours ($p < 0.001$), earlier ambulation (19.4 ± 3.1 vs. 25.8 ± 4.6 hours; $p < 0.001$), and higher patient satisfaction (9.1 ± 0.8 vs. 8.3 ± 1.0; $p = 0.001$). Excessive quadriceps weakness occurred less frequently in the ACB group (5.7% vs. 28.6%; $p = 0.011$).

Conclusion: Adductor canal block provided postoperative analgesia comparable to femoral nerve block while preserving quadriceps muscle strength, reducing opioid requirements, facilitating earlier ambulation, and improving patient satisfaction. ACB appears to be the preferred regional analgesic technique for enhancing early recovery following total knee arthroplasty.

Keywords: *Adductor canal block; Femoral nerve block; Total knee arthroplasty; Postoperative analgesia; Quadriceps muscle strength; Early ambulation.*

INTRODUCTION

Total knee arthroplasty (TKA) is one of the most frequently performed orthopedic procedures for the management of end-stage knee osteoarthritis and other advanced degenerative knee disorders that are refractory to conservative treatment. With increasing life expectancy, an aging population, rising prevalence of obesity, and greater expectations for maintaining mobility and quality of life, the number of primary and revision TKA procedures has increased substantially worldwide, making TKA one of the most commonly performed orthopedic operations.[1] TKA is highly effective in relieving pain, correcting deformity, restoring joint function, and improving overall quality of life. Despite these excellent long-term outcomes, the procedure is associated with significant postoperative pain, particularly during the first 24–72 hours after surgery[2]. Inadequately controlled pain may delay mobilization, impair participation in physiotherapy, prolong hospital stay, increase opioid consumption, reduce patient satisfaction, and predispose patients to postoperative complications such as deep vein thrombosis, pulmonary complications, joint stiffness, and chronic postoperative pain.[3,4]Optimal postoperative analgesia is therefore an essential component of enhanced recovery after surgery (ERAS) pathways for

patients undergoing TKA. Effective pain management facilitates early ambulation, improves knee range of motion, accelerates functional recovery, reduces perioperative morbidity, and shortens hospitalization. Current ERAS protocols advocate a multimodal analgesic strategy that combines systemic analgesics with regional anesthesia techniques to maximize pain relief while minimizing opioid-related adverse effects, including nausea, vomiting, respiratory depression, sedation, constipation, and delayed rehabilitation.[5Among the available regional analgesic techniques, peripheral nerve blocks (PNBs) have become a cornerstone of multimodal analgesia following TKA because of their ability to provide targeted pain relief, decrease opioid requirements, and enhance postoperative recovery. The femoral nerve block (FNB) has long been considered the standard regional anesthetic technique for postoperative analgesia after TKA owing to its reliable analgesic efficacy and consistent reduction in postoperative pain and opioid consumption.[6,7] However, because the femoral nerve innervates the quadriceps muscle, FNB frequently produces varying degrees of motor weakness, which may impair early mobilization, reduce walking ability, delay rehabilitation, and increase the risk of postoperative falls.[8,9]To overcome these limitations, the adductor canal block (ACB) has emerged as a promising motor-sparing alternative. The adductor canal primarily contains sensory nerves, including the saphenous nerve and articular branches supplying the medial aspect of the knee, while largely preserving quadriceps motor function. Consequently, ACB has the potential to provide effective postoperative analgesia without significant impairment of muscle strength. Preservation of quadriceps function may facilitate earlier ambulation, improve participation in physiotherapy, enhance functional recovery, and reduce fall risk, making ACB an attractive option within ERAS protocols. The increasing use of ultrasound guidance has further improved the precision, safety, and success of ACB, contributing to its growing popularity in contemporary orthopedic anesthesia practice.[9,10]Although numerous randomized controlled trials, systematic reviews, and meta-analyses have compared ACB with FNB, the relative superiority of these techniques remains a subject of ongoing debate. Several studies have demonstrated that ACB provides analgesia comparable to FNB while preserving quadriceps strength and improving early mobilization and functional recovery.[10–13] Conversely, other investigations have reported no significant differences between the two techniques with respect to postoperative pain scores, opioid consumption, quadriceps strength, or rehabilitation outcomes.[14] These inconsistent findings indicate that further evidence is required to determine the optimal regional analgesic technique for patients undergoing TKA.

In view of these considerations, the present study was designed to compare adductor canal block and femoral nerve block for postoperative analgesia following total knee arthroplasty.

MATERIALS AND METHODS

This prospective, randomized, comparative study was conducted in the Department of Anaesthesiology at a tertiary care teaching hospital over a period of 18 months .The study included adult patients scheduled to undergo elective unilateral primary total knee arthroplasty (TKA) under spinal anesthesia.A total of 70 patients were enrolled in the study and were randomly allocated into two equal groups comprising 35 patients each:

- **Group A (Adductor Canal Block group):** Patients received ultrasound-guided adductor canal block (ACB) for postoperative analgesia.
- **Group F (Femoral Nerve Block group):** Patients received ultrasound-guided femoral nerve block (FNB) for postoperative analgesia.

Inclusion Criteria

Patients fulfilling all of the following criteria were included:

- Age between 45 and 80 years.
- Either sex.
- American Society of Anesthesiologists (ASA) physical status I–III.
- Scheduled for elective unilateral primary total knee arthroplasty.
- Patients willing to participate and providing written informed consent.

Exclusion Criteria

Patients with any of the following conditions were excluded:

- Refusal to participate.
- Known allergy or hypersensitivity to local anesthetic agents.
- Coagulopathy or patients receiving anticoagulant therapy.
- Infection at the site of needle insertion.
- Pre-existing peripheral neuropathy involving the operative limb.
- Chronic opioid use or opioid dependence.
- Severe hepatic or renal dysfunction.
- Revision or bilateral total knee arthroplasty.
- Body mass index (BMI) >40 kg/m².
- Cognitive impairment or inability to comprehend pain assessment scales.

Group Allocation
Eligible patients were randomly assigned to one of the two study groups using a computer-generated randomization sequence. Allocation concealment was achieved using sequentially numbered, opaque, sealed envelopes, which were opened immediately before administration of the nerve block.

Preoperative Assessment
All patients underwent detailed pre-anesthetic evaluation one day before surgery, including medical history, physical examination, airway assessment, and routine laboratory investigations. Patients were educated regarding the use of the Visual Analogue Scale (VAS) for pain assessment, where 0 represented no pain and 10 represented the worst imaginable pain.

Anaesthetic Technique
Standard fasting guidelines were followed. Upon arrival in the operating room, standard monitoring, including electrocardiography, non-invasive blood pressure, and pulse oximetry, was instituted. Intravenous access was secured, and patients received appropriate preloading with crystalloid solution.Subarachnoid block was performed under strict aseptic precautions at the L3–L4 or L4–L5 intervertebral space using a 25-G Quincke spinal needle. Following confirmation of free flow of cerebrospinal fluid, 3 mL of 0.5% hyperbaric bupivacaine (15 mg) was administered intrathecally. Surgery commenced after achieving an adequate sensory block to the T10 dermatome.

Intervention
Group A: Adductor Canal Block
At the completion of surgery, an ultrasound-guided adductor canal block was performed under aseptic precautions using a high-frequency linear ultrasound transducer. The femoral artery was identified within the adductor canal beneath the sartorius muscle at the mid-thigh level. A 22-G insulated block needle was advanced in-plane, and after negative aspiration, 20 mL of 0.25% **bupivacaine** was injected around the saphenous nerve within the adductor canal.

Group F: Femoral Nerve Block
Patients allocated to Group F received an ultrasound-guided femoral nerve block under aseptic precautions. The femoral nerve was identified lateral to the femoral artery below the inguinal ligament using a high-frequency linear ultrasound probe. Following negative aspiration, 20 mL of 0.25% bupivacaine was deposited around the femoral nerve under real-time ultrasound guidance.

Postoperative Analgesia
All patients received standardized multimodal postoperative analgesia consisting of intravenous paracetamol 1 g every 8 hours. Rescue analgesia with intravenous tramadol 100 mg was administered whenever the VAS score was ≥4 or upon patient request. The total rescue analgesic requirement during the first 24 postoperative hours was recorded.

Outcome Measures
Primary Outcome
- Postoperative pain intensity assessed using the Visual Analogue Scale (VAS) at rest and during knee movement at 2, 4, 6, 12, and 24 hours after surgery.

Secondary Outcomes
- Time to first request for rescue analgesia.
- Total rescue analgesic consumption during the first 24 postoperative hours.
- Quadriceps muscle strength assessed using the Medical Research Council (MRC) grading system at 6, 12, and 24 hours.
- Time to first ambulation.
- Patient satisfaction score at 24 hours.
- Incidence of postoperative nausea and vomiting.
- Incidence of block-related complications (hematoma, local anesthetic toxicity, nerve injury, infection, vascular puncture, or falls).

Data Collection
Demographic variables including age, sex, body mass index, ASA physical status, duration of surgery, and duration of anesthesia were recorded. Postoperative pain scores, motor strength, time to rescue analgesia, analgesic consumption, ambulation time, patient satisfaction, and adverse events were documented by an investigator blinded to group allocation.

Statistical Analysis
The collected data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) software version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation

(SD) or median (interquartile range) depending on data distribution, while categorical variables were presented as frequencies and percentages. Normality of continuous variables was assessed using the Shapiro–Wilk test. Continuous variables were compared using the independent Student's t-test for normally distributed data and the Mann–Whitney U test for non-normally distributed data. Categorical variables were analyzed using the Chi-square test or Fisher's exact test, as appropriate. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 70 patients undergoing elective total knee arthroplasty were included in the study, with 35 patients allocated to the Adductor Canal Block (ACB) group (Group A) and 35 patients to the Femoral Nerve Block (FNB) group (Group F).The baseline demographic and clinical characteristics were comparable between the two groups. The mean age was 64.2 ± 7.8 years in Group A and 63.6 ± 8.1 years in Group F (p = 0.741). The gender distribution, body mass index (BMI), ASA physical status, and duration of surgery did not differ significantly between the groups (all p > 0.05), indicating successful randomization and comparable baseline characteristics (Table 1).Postoperative pain intensity assessed using the Visual Analogue Scale (VAS) was similar between the two groups at 2, 4, 6, 12, and 24 hours following surgery. Although Group A demonstrated marginally lower VAS scores at 6, 12, and 24 hours, the differences were not statistically significant (all p > 0.05). The trend of postoperative pain scores over time in both groups is illustrated in Table 2 and Figure 1.The postoperative analgesic profile differed significantly between the study groups. Patients receiving adductor canal block experienced a significantly longer time to first rescue analgesia (11.8 ± 2.9 vs. 9.4 ± 2.5 hours; p = 0.001) and required significantly lower total tramadol consumption during the first 24 postoperative hours (108.6 ± 42.4 vs. 152.9 ± 51.6 mg; p < 0.001). Furthermore, a significantly lower proportion of patients in Group A required rescue analgesia compared with Group F (57.1% vs. 85.7%; p = 0.008) (Table 3).Quadriceps muscle strength, assessed using the Medical Research Council (MRC) grading system, was significantly better preserved in the ACB group. Mean MRC grades at 6 hours (4.3 ± 0.5 vs. 3.4 ± 0.7; p < 0.001) and 12 hours (4.6 ± 0.5 vs. 4.0 ± 0.6; p < 0.001) were significantly higher in Group A than in Group F. By 24 hours, quadriceps strength was comparable between the groups (p = 0.061) (Table 4, Figure 2).Functional recovery was significantly improved in patients receiving adductor canal block. The mean time to first ambulation was significantly shorter in Group A than in Group F (19.4 ± 3.1 vs. 25.8 ± 4.6 hours; p < 0.001). Although the length of hospital stay was slightly shorter in the ACB group, the difference was not statistically significant (4.6 ± 0.8 vs. 5.0 ± 0.9 days; p = 0.067). Patient satisfaction scores were significantly higher among patients receiving adductor canal block (9.1 ± 0.8 vs. 8.3 ± 1.0; p = 0.001) (Table 5, Figure 3).The incidence of postoperative complications was generally low in both groups. Postoperative nausea and vomiting, fall or near-fall episodes, and local hematoma occurred with comparable frequency (all p > 0.05). However, excessive quadriceps weakness was significantly less common in the ACB group than in the FNB group (5.7% vs. 28.6%; p = 0.011). No cases of local anesthetic systemic toxicity or nerve injury were observed in either group (Table 6).

Table 1. Baseline Demographic and Clinical Characteristics of the Study Population

Variable	Group A (ACB) (n=35)	Group F (FNB) (n=35)	p-value
Age (years), Mean ± SD	64.2 ± 7.8	63.6 ± 8.1	0.741
Male/Female, n	16/19	17/18	0.811
BMI (kg/m²), Mean ± SD	28.6 ± 3.2	29.1 ± 3.6	0.542
ASA Grade I, n (%)	8 (22.9)	7 (20.0)	0.918
ASA Grade II, n (%)	20 (57.1)	21 (60.0)	
ASA Grade III, n (%)	7 (20.0)	7 (20.0)	
Duration of Surgery (minutes), Mean ± SD	98.6 ± 12.4	101.3 ± 13.6	0.387

Table 2. Comparison of Postoperative VAS Pain Scores

Time after Surgery	Group A (ACB) Mean ± SD	Group F (FNB) Mean ± SD	p-value
2 hours	2.1 ± 0.8	2.0 ± 0.7	0.584
4 hours	2.5 ± 0.9	2.4 ± 0.8	0.673
6 hours	3.1 ± 0.9	3.4 ± 0.8	0.142
12 hours	3.5 ± 1.0	3.8 ± 0.9	0.187
24 hours	2.8 ± 0.8	3.0 ± 0.9	0.326

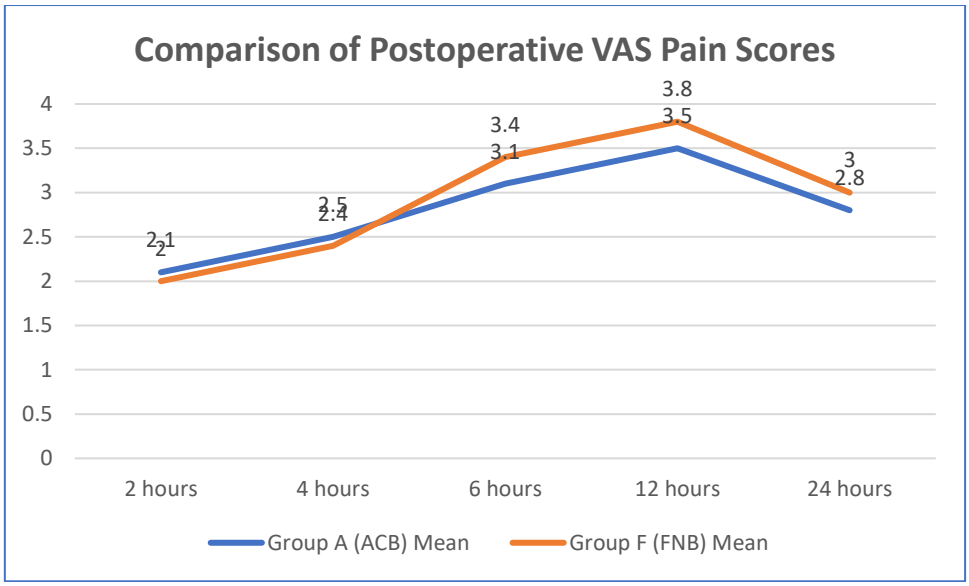

Figure 1 Comparison of Postoperative VAS Pain Scores

Table 3. Comparison of Rescue Analgesia Requirement

Variable	Group A (ACB) (n=35)	Group F (FNB) (n=35)	p-value
Time to First Rescue Analgesia (hours), Mean ± SD	11.8 ± 2.9	9.4 ± 2.5	**0.001**
Total Tramadol Consumption (mg/24 h), Mean ± SD	108.6 ± 42.4	152.9 ± 51.6	**<0.001**
Patients Requiring Rescue Analgesia, n (%)	20 (57.1)	30 (85.7)	**0.008**

Table 4. Comparison of Quadriceps Muscle Strength (MRC Grade)

Time	Group A (ACB) Mean ± SD	Group F (FNB) Mean ± SD	p-value
6 hours	4.3 ± 0.5	3.4 ± 0.7	**<0.001**
12 hours	4.6 ± 0.5	4.0 ± 0.6	**<0.001**
24 hours	4.9 ± 0.3	4.7 ± 0.4	0.061

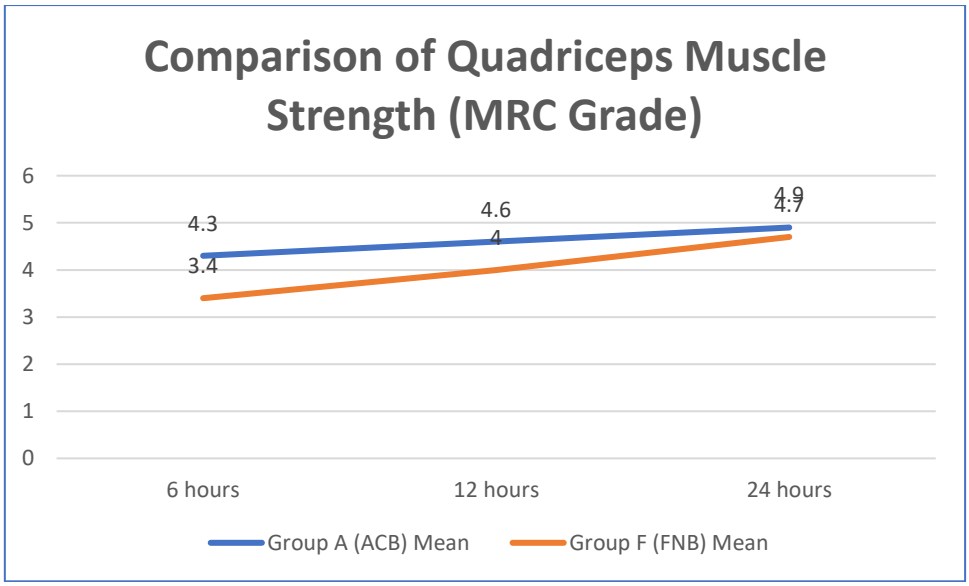

Figure 2 Comparison of Quadriceps Muscle Strength (MRC Grade)

Table 5. Comparison of Functional Recovery and Patient Satisfaction

Variable	Group A (ACB) (n=35)	Group F (FNB) (n=35)	p-value
Time to First Ambulation (hours), Mean ± SD	19.4 ± 3.1	25.8 ± 4.6	**<0.001**
Length of Hospital Stay (days), Mean ± SD	4.6 ± 0.8	5.0 ± 0.9	0.067
Patient Satisfaction Score (0–10), Mean ± SD	9.1 ± 0.8	8.3 ± 1.0	**0.001**

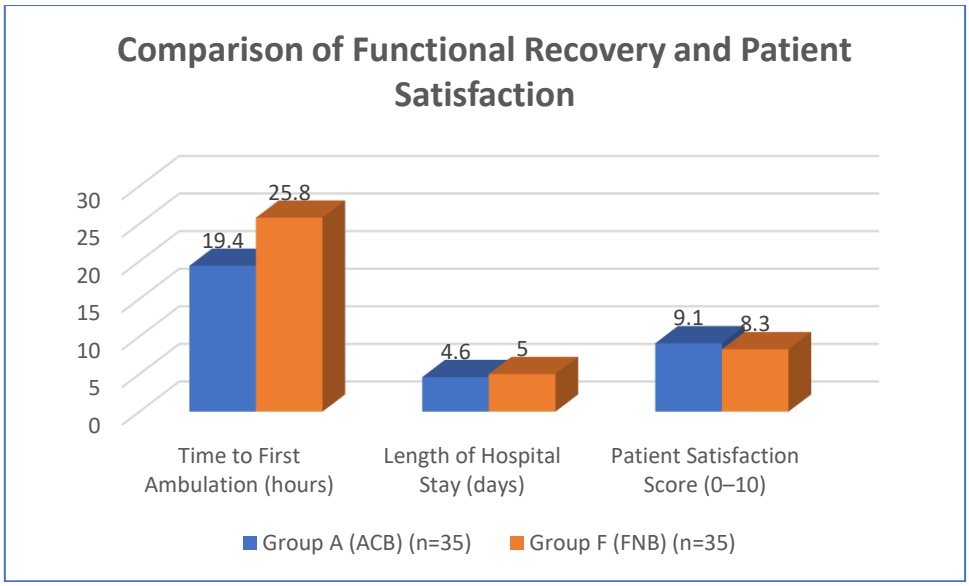

Figure 3 Comparison of Functional Recovery and Patient Satisfaction

Table 6. Comparison of Postoperative Complications

Complication	Group A (ACB) n (%)	Group F (FNB) n (%)	p-value
Postoperative Nausea and Vomiting	4 (11.4)	6 (17.1)	0.495
Excessive Quadriceps Weakness	2 (5.7)	10 (28.6)	**0.011**
Fall/Near Fall Episodes	0 (0.0)	3 (8.6)	0.076
Local Hematoma	1 (2.9)	2 (5.7)	0.554
Local Anesthetic Toxicity	0 (0.0)	0 (0.0)	—
Nerve Injury	0 (0.0)	0 (0.0)	—

DISCUSSION

The present prospective randomized comparative study evaluated the effectiveness of ultrasound-guided Adductor Canal Block (ACB) versus Femoral Nerve Block (FNB) for postoperative analgesia following total knee arthroplasty (TKA). Our findings demonstrated that ACB provided analgesia comparable to FNB while offering significant advantages in prolonged analgesia, reduced opioid requirement, better preservation of quadriceps muscle strength, earlier ambulation, and higher patient satisfaction.Baseline demographic and perioperative characteristics were comparable between the two groups, with no significant differences in age, gender distribution, BMI, ASA grade, or duration of surgery, indicating successful randomization and minimizing confounding factors. Similar baseline characteristics have also been reported in the meta-analysis by Jauregui et al.[15], ensuring that postoperative outcomes reflected the analgesic intervention rather than patient-related variablesPostoperative pain scores assessed using the Visual Analog Scale (VAS) at 2, 4, 6, 12, and 24 hours were comparable between the two groups. Although the ACB group showed marginally lower pain scores at later postoperative intervals, these differences were not statistically significant. These findings are consistent with the meta-analysis by Jauregui et al.[15], which demonstrated no significant difference in postoperative pain between ACB and FNB, and with the updated meta-analysis by Gong et al.[16], which similarly reported equivalent analgesic efficacy for continuous ACB and continuous FNB during the first 48 postoperative hours.

Despite comparable pain scores, patients receiving ACB experienced a significantly longer time to first rescue analgesia (11.8 ± 2.9 vs. 9.4 ± 2.5 hours; $p = 0.001$), lower 24-hour tramadol consumption (108.6 ± 42.4 vs. 152.9 ± 51.6 mg; $p < 0.001$), and fewer patients required rescue analgesia (57.1% vs. 85.7%; $p = 0.008$). Although earlier meta-analyses reported similar opioid consumption between the two techniques,[15,16] the reduced opioid requirement observed in our study may reflect differences in multimodal analgesic protocols and perioperative rehabilitation practices.A major strength of ACB in our study was superior preservation of quadriceps muscle strength. Mean MRC grades were significantly higher in the ACB group at both 6 and 12 hours postoperatively ($p < 0.001$), while both groups achieved near-complete recovery by 24 hours. These findings closely agree with Jauregui et al.[15], Gong et al.[16], and the randomized trial by Jaeger et al.[17], all of whom demonstrated that ACB preserves quadriceps strength because it predominantly blocks sensory fibers while sparing the motor branches of the femoral nerve.Functional recovery was also superior with ACB. Patients ambulated significantly earlier (19.4 ± 3.1 vs. 25.8 ± 4.6 hours; $p < 0.001$) and reported higher satisfaction scores (9.1 ± 0.8 vs. 8.3 ± 1.0; $p = 0.001$), whereas hospital stay remained comparable between groups. Similar improvements in early mobilization and functional recovery have been reported by Jauregui et al.[15], Gong et al.[16], and a recent 2024 network meta-analysis, which identified ACB as the preferred motor-sparing regional analgesic technique following TKA.Postoperative complications were infrequent in both groups. Although postoperative nausea and vomiting occurred at similar rates, quadriceps weakness was significantly less common with ACB (5.7% vs. 28.6%; $p = 0.011$), and no cases of nerve injury

or local anesthetic systemic toxicity were observed. These findings further support the favorable safety profile of ACB reported in previous systematic reviews.[15–17]

CONCLUSION

The present study demonstrated that adductor canal block (ACB) provided postoperative analgesia comparable to femoral nerve block (FNB) following total knee arthroplasty while offering superior preservation of quadriceps muscle strength. Patients receiving ACB experienced a longer duration of analgesia, reduced opioid consumption, earlier ambulation, and higher patient satisfaction with fewer motor-related complications. These findings are consistent with recent randomized trials and systematic reviews supporting the motor-sparing advantages of ACB. Therefore, ACB may be considered the preferred regional analgesic technique for enhancing early functional recovery after total knee arthroplasty without compromising pain control.

Limitations

This study was conducted at a single tertiary care center with a relatively small sample size. Postoperative outcomes were assessed only during the first 24 hours; therefore, long-term functional recovery and chronic pain outcomes could not be evaluated. In addition, rehabilitation protocols and individual variations in pain perception may have influenced postoperative recovery despite standardized perioperative management.

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