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Original Research Article

Adductor Canal Block versus Femoral Nerve Block after Total Knee Replacement

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Abstract

Introduction: Postoperative pain after total knee replacement (TKR) may delay rehabilitation. Femoral nerve block (FNB) provides effective analgesia but can cause quadriceps weakness. Adductor canal block (ACB) offers analgesia with potential motor preservation. This study compared ACB and FNB for postoperative analgesia and functional recovery after TKR.

Materials and Methods: This prospective randomized comparative study included 120 patients undergoing elective unilateral TKR. Patients were allocated into two groups: ACB group (n=60) and FNB group (n=60). Postoperative pain scores, duration of analgesia, rescue analgesic requirement, quadriceps strength, time to ambulation, and complications were assessed.

Results: Baseline characteristics were comparable between groups. Postoperative VAS scores and duration of analgesia were similar between ACB and FNB groups (15.2 ± 3.8 vs 15.6 ± 4.1 hours; p=0.58). Rescue analgesic requirement was comparable (30.0% vs 33.3%; p=0.70). However, ACB provided better quadriceps preservation, with higher straight leg raise ability at 6 hours (58.3% vs 35.0%; p=0.01) and earlier ambulation (24.6 ± 5.2 vs 29.8 ± 6.4 hours; p<0.001). Complication rates were similar between groups.

Conclusion: ACB provides analgesia comparable to FNB while preserving quadriceps strength and promoting earlier mobilization after TKR. It may be preferred as a motor-sparing analgesic technique in enhanced recovery protocols.

Keywords: Adductor canal block; femoral nerve block; total knee replacement; Postoperative analgesia; Quadriceps strength; Mobilization.

Introduction

Total knee arthroplasty (TKA) is one of the most commonly performed and successful orthopaedic procedures for the management of advanced knee osteoarthritis and other end-stage degenerative knee disorders [1]. The increasing prevalence of osteoarthritis, ageing population, and improved surgical outcomes have contributed to a substantial rise in the number of TKA procedures performed worldwide. Although TKA provides significant improvement in pain, mobility, and quality of life, postoperative pain remains a major concern and continues to be an important factor affecting early recovery and patient satisfaction.[2] Pain following TKA is often moderate to severe in intensity and may negatively influence rehabilitation, delay functional recovery, and restrict early mobilization. Inadequate postoperative pain control can result in prolonged hospital stay, increased opioid consumption, delayed physiotherapy participation, and complications related to immobility, including venous thromboembolism and joint stiffness. Therefore, effective analgesia following TKA is essential to facilitate early ambulation, enhance functional recovery, and improve overall surgical outcomes.[3] Multimodal analgesia strategies incorporating systemic analgesics, periarticular infiltration, neuraxial techniques, and peripheral nerve blocks (PNBs) are commonly used to optimize pain management after TKA[4]. Among regional anaesthetic techniques, femoral nerve block (FNB) has traditionally been considered an effective and widely accepted method for postoperative analgesia following TKA. Continuous femoral nerve blockade has demonstrated significant benefits in reducing postoperative pain and opioid requirements, thereby improving recovery after surgery.[4] However, despite its analgesic effectiveness, FNB has certain limitations, particularly due to blockade of motor fibres supplying the quadriceps muscle. The resulting reduction in quadriceps strength may impair early ambulation, delay rehabilitation, and increase the risk of postoperative falls. These concerns have encouraged the search for alternative regional techniques that provide comparable analgesia while preserving motor function.[5]The adductor canal block (ACB) has emerged as a promising motor-sparing alternative to FNB for analgesia after TKA. The adductor canal primarily contains sensory branches, particularly the saphenous nerve, while relatively sparing the motor branches of the femoral nerve. Therefore, ACB may provide effective postoperative analgesia with better preservation of quadriceps muscle strength, allowing earlier mobilization and improved functional recovery.[6,7]

Several clinical trials and systematic reviews have compared ACB with FNB following TKA. Evidence suggests that ACB provides analgesic efficacy comparable to FNB while offering advantages in terms of quadriceps preservation, early ambulation, and functional outcomes. Jæger et al. demonstrated improved quadriceps strength with ACB compared with FNB, supporting its role as a motor-sparing technique.[6] Similarly, systematic reviews and comparative studies have reported that ACB may facilitate early rehabilitation without compromising postoperative pain control.[8,9] However, the superiority of ACB over FNB remains a subject of debate. Some randomized controlled studies have shown no significant differences between ACB and FNB regarding postoperative pain scores, opioid consumption, or functional recovery outcomes.[10,11] Differences in block technique, catheter placement, local anaesthetic volume, timing of administration, and assessment methods may contribute to variations in reported outcomes. Therefore, further comparative evaluation is required to determine the optimal regional analgesic technique following TKA. With increasing emphasis on enhanced recovery protocols after surgery, an ideal analgesic technique should provide effective pain relief while minimizing motor impairment and promoting early rehabilitation. Hence, the present study was designed to compare adductor canal block versus femoral nerve block after total knee replacement.

Materials and Methods

This prospective, randomized, comparative clinical study was conducted in the Department of Anaesthesiology at tertiary care hospital. The study was designed to compare the efficacy of ultrasound-guided adductor canal block (ACB) versus femoral nerve block (FNB) for postoperative analgesia in patients undergoing total knee replacement (TKR).

Study Population: A total of 120 patients scheduled for elective primary total knee replacement surgery under spinal anaesthesia were included in the study. Patients were randomly allocated into two equal groups of 60 patients each:

- Group A (n=60): Patients receiving ultrasound-guided adductor canal block (ACB)
- Group F (n=60): Patients receiving ultrasound-guided femoral nerve block (FNB)

Randomization was performed using a computer-generated random allocation sequence. Allocation concealment was maintained using sealed opaque envelopes, which were opened immediately before performing the block.

Inclusion Criteria

Patients fulfilling the following criteria were included:

- Patients aged 40–80 years
- Scheduled for elective primary unilateral total knee replacement
- American Society of Anesthesiologists (ASA) physical status I–III
- Patients willing to participate and provide written informed consent
- Patients undergoing surgery under spinal anaesthesia

Exclusion Criteria

Patients were excluded if they had:

- Allergy or contraindication to local anaesthetic drugs
- Pre-existing neurological deficit involving the lower limb
- Coagulopathy or ongoing anticoagulant therapy contraindicating regional block
- Local infection at the site of block placement
- Severe systemic illness (ASA IV or above)
- Revision knee arthroplasty
- Chronic opioid use or chronic pain disorder
- Patient refusal to participate

Preoperative Assessment: All patients underwent detailed preoperative evaluation, including history, physical examination, airway assessment, baseline investigations, and assessment of ASA physical status. Demographic characteristics including age, sex, body weight, height, and body mass index were recorded.

Baseline pain assessment was performed using the visual analogue scale (VAS), where 0 represented no pain and 10 represented the worst imaginable pain.

Anaesthetic Technique: All patients were kept fasting according to standard preoperative fasting guidelines. Routine monitoring including electrocardiography, non-invasive blood pressure, pulse oximetry, and respiratory rate was established before anaesthesia. Subarachnoid block was performed using standard aseptic precautions with appropriate dose of hyperbaric bupivacaine. Intraoperative anaesthetic management was standardized for all patients. Hemodynamic parameters were monitored throughout the surgical procedure.

Ultrasound-Guided Adductor Canal Block: Patients allocated to Group A received ultrasound-guided adductor canal block after completion of surgery. Under sterile precautions, a high-frequency linear ultrasound probe was placed at the mid-thigh level to identify the sartorius muscle, femoral artery, and adductor canal. After visualization of the target structures, a needle was advanced using an in-plane technique, and local anaesthetic solution was deposited around the femoral artery within the adductor canal.

Ultrasound-Guided Femoral Nerve Block: Patients in Group F received ultrasound-guided femoral nerve block. The femoral nerve was identified below the inguinal ligament using a high-frequency linear ultrasound probe.

After confirming needle placement adjacent to the femoral nerve, local anaesthetic solution was injected around the nerve under ultrasound guidance. The same concentration and volume of local anaesthetic were used in both groups to maintain uniformity.

Postoperative Analgesia Assessment: Postoperative pain intensity was assessed using the visual analogue scale (VAS) at predefined time intervals:

- Immediately after surgery (0 hour)
- 2 hours
- 6 hours
- 12 hours
- 24 hours

Duration of analgesia was defined as the time interval between completion of block administration and the first request for rescue analgesia. Patients with VAS score ≥ 4 received rescue analgesia according to institutional protocol. Total opioid consumption during the first 24 postoperative hours was recorded.

Assessment of Quadriceps Muscle Strength: Quadriceps strength was assessed postoperatively using standardized clinical assessment methods at predefined intervals. The ability to perform active straight leg raise and knee extension was evaluated to determine motor preservation following the nerve block.

Outcome Measures

The primary outcome was:

- Comparison of postoperative pain scores between ACB and FNB groups.

Secondary outcomes included:

- Duration of analgesia
- Total postoperative opioid consumption
- Quadriceps muscle strength
- Time to first ambulation
- Functional recovery parameters
- Incidence of block-related complications
- Patient satisfaction

Statistical Analysis: Data were entered into Microsoft Excel and analysed using SPSS, 26.Continuous variables were expressed as mean ± standard deviation or median with interquartile range depending on data distribution. Categorical variables were presented as frequency and percentage.

Comparison of continuous variables between the two groups was performed using Student's independent t-test or Mann–Whitney U test as appropriate. Categorical variables were analysed using Chi-square test or Fisher's exact test. Repeated measurements of postoperative pain scores were analysed using appropriate repeated-measures statistical tests. A p-value <0.05 was considered statistically significant.

Results

A total of 120 patients undergoing elective unilateral total knee replacement were enrolled and randomly allocated into two groups of 60 patients each. Group A received ultrasound-guided adductor canal block (ACB), whereas Group F received ultrasound-guided femoral nerve block (FNB). All patients completed the study protocol and were included in the final analysis. The baseline demographic and perioperative characteristics were comparable between both groups. The mean age was 64.8 ± 7.6 years in the ACB group and 65.3 ± 8.1 years in the FNB group (p=0.72). Gender distribution was similar between groups, with males comprising 22 (36.7%) and 24 (40.0%) patients, respectively (p=0.81). BMI (27.4 ± 3.2 vs 27.8 ± 3.5 kg/m²; p=0.53), ASA physical status distribution (p=0.91), and duration of surgery (118.6 ± 21.4 vs 120.2 ± 20.8 minutes; p=0.68) were comparable between groups.(Table 1) Postoperative pain scores assessed by VAS were comparable between ACB and FNB groups at all time intervals. The mean VAS score at 0 hour was 1.8 ± 0.7 in the ACB group and 1.9 ± 0.8 in the FNB group (p=0.46). At 2 hours, VAS scores were

2.4 ± 0.9 and 2.7 ± 1.0, respectively (p=0.08). Similarly, no significant difference was observed at 6 hours (3.1 ± 1.1 vs 3.2 ± 1.2; p=0.64), 12 hours (3.4 ± 1.2 vs 3.5 ± 1.3; p=0.68), and 24 hours (2.6 ± 1.0 vs 2.8 ± 1.1; p=0.31). The duration of analgesia was comparable between groups (15.2 ± 3.8 hours in ACB vs 15.6 ± 4.1 hours in FNB; p=0.58). Rescue analgesia was required in 18 (30.0%) patients in the ACB group and 20 (33.3%) patients in the FNB group (p=0.70).

Mean tramadol consumption was also comparable (76.5 ± 38.2 mg vs 82.4 ± 40.1 mg; p=0.41).(Table 2; Figure 1) Patients receiving ACB demonstrated significantly better preservation of quadriceps function compared with FNB. Straight leg raise at 6 hours was achieved in 35 (58.3%) patients in the ACB group compared with 21 (35.0%) patients in the FNB group (p=0.01). At 24 hours, straight leg raise was achieved in 54 (90.0%) patients in the ACB group and 43 (71.7%) patients in the FNB group (p=0.01). The mean quadriceps strength score at 24 hours was significantly higher with ACB compared with FNB (4.3 ± 0.7 vs 3.8 ± 0.8; p<0.001). Patients receiving ACB achieved earlier ambulation (24.6 ± 5.2 vs 29.8 ± 6.4 hours; p<0.001), better knee flexion at discharge (92.5 ± 10.4° vs 87.8 ± 11.2°; p=0.02), and shorter hospital stay (4.8 ± 1.2 vs 5.3 ± 1.4 days; p=0.04). (Table 3; Figure 2)

The incidence of postoperative complications was comparable between groups. Nausea/vomiting occurred in 6 (10.0%) patients in the ACB group and 8 (13.3%) patients in the FNB group (p=0.57). Sedation was observed in 3 (5.0%) and 4 (6.7%) patients, respectively (p=0.70). Urinary retention occurred in 2 (3.3%) patients receiving ACB and 3 (5.0%) patients receiving FNB (p=0.65). Knee buckling/fall episodes were lower in the ACB group compared with FNB (1.7% vs 8.3%), although the difference was not statistically significant (p=0.09). No block-related complications were observed in either group. Patient satisfaction scores were comparable between groups (8.6 ± 1.1 vs 8.2 ± 1.3; p=0.07). (Table 4; Figure 3)

Table 1: Demographic and Perioperative Characteristics of Study Participants (n=120)

Parameter	Group ACB (n=60)	Group FNB (n=60)	p-value
Age (years), Mean ± SD	64.8 ± 7.6	65.3 ± 8.1	0.72
Male, n (%)	22 (36.7)	24 (40.0)	0.81
Female, n (%)	38 (63.3)	36 (60.0)	
BMI (kg/m²), Mean ± SD	27.4 ± 3.2	27.8 ± 3.5	0.53
ASA physical status, n (%)			0.91
ASA I	12 (20.0)	10 (16.7)	
ASA II	40 (66.7)	42 (70.0)	
ASA III	8 (13.3)	8 (13.3)	
Duration of surgery (minutes), Mean ± SD	118.6 ± 21.4	120.2 ± 20.8	0.68

Table 2: Comparison of Postoperative Analgesic Outcomes between ACB and FNB Groups

Parameter	Group ACB (n=60)	Group FNB (n=60)	p-value
VAS pain score at 0 hour, Mean ± SD	1.8 ± 0.7	1.9 ± 0.8	0.46
VAS pain score at 2 hours, Mean ± SD	2.4 ± 0.9	2.7 ± 1.0	0.08
VAS pain score at 6 hours, Mean ± SD	3.1 ± 1.1	3.2 ± 1.2	0.64
VAS pain score at 12 hours, Mean ± SD	3.4 ± 1.2	3.5 ± 1.3	0.68
VAS pain score at 24 hours, Mean ± SD	2.6 ± 1.0	2.8 ± 1.1	0.31
Duration of analgesia (hours), Mean ± SD	15.2 ± 3.8	15.6 ± 4.1	0.58
Rescue analgesia required, n (%)	18 (30.0)	20 (33.3)	0.70
Tramadol consumption (mg/24 h), Mean ± SD	76.5 ± 38.2	82.4 ± 40.1	0.41

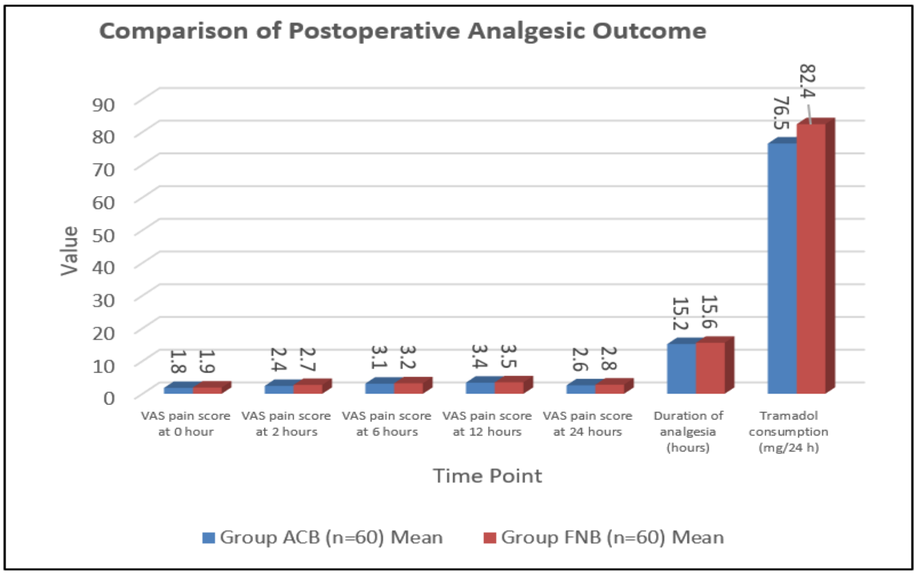

Figure 1: Comparison of Postoperative Analgesic Outcomes between ACB and FNB Groups

Table 3: Comparison of Motor Recovery and Functional Outcomes between ACB and FNB Groups

Parameter	Group ACB (n=60)	Group FNB (n=60)	p-value
Straight leg raise at 6 hours, n (%)	35 (58.3)	21 (35.0)	0.01
Straight leg raise at 24 hours, n (%)	54 (90.0)	43 (71.7)	0.01
Quadriceps strength score at 24 hours (0–5), Mean ± SD	4.3 ± 0.7	3.8 ± 0.8	<0.001
Time to first ambulation (hours), Mean ± SD	24.6 ± 5.2	29.8 ± 6.4	<0.001
Knee flexion at discharge (degrees), Mean ± SD	92.5 ± 10.4	87.8 ± 11.2	0.02
Duration of hospital stay (days), Mean ± SD	4.8 ± 1.2	5.3 ± 1.4	0.04

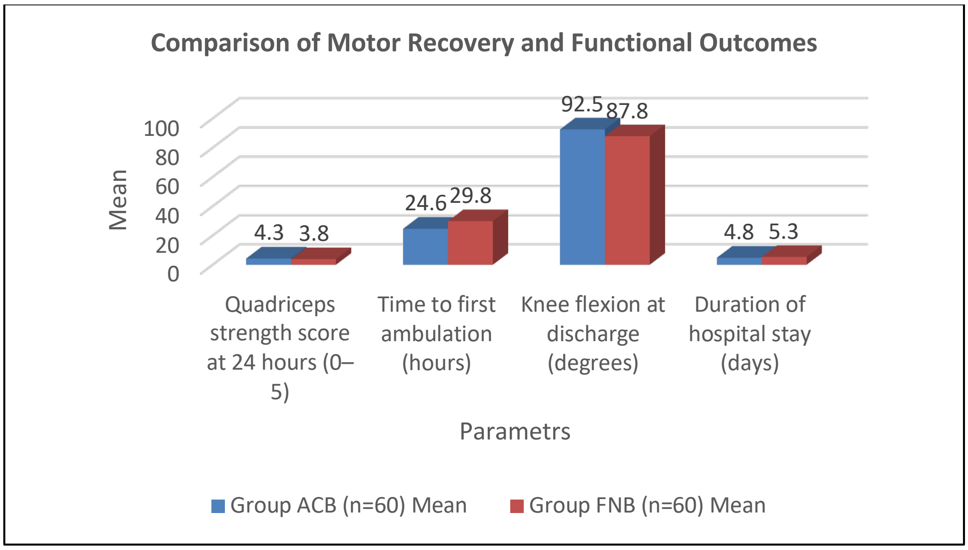

Figure 2: Comparison of Motor Recovery and Functional Outcomes between ACB and FNB Groups

Table 4: Postoperative Complications and Patient Safety Outcomes

Complication	Group ACB (n=60)	Group FNB (n=60)	p-value
Nausea/vomiting, n (%)	6 (10.0)	8 (13.3)	0.57
Sedation, n (%)	3 (5.0)	4 (6.7)	0.70
Urinary retention, n (%)	2 (3.3)	3 (5.0)	0.65
Knee buckling/fall episodes, n (%)	1 (1.7)	5 (8.3)	0.09
Block-related complications, n (%)	0	0	—
Patient satisfaction score (0–10), Mean ± SD	8.6 ± 1.1	8.2 ± 1.3	0.07

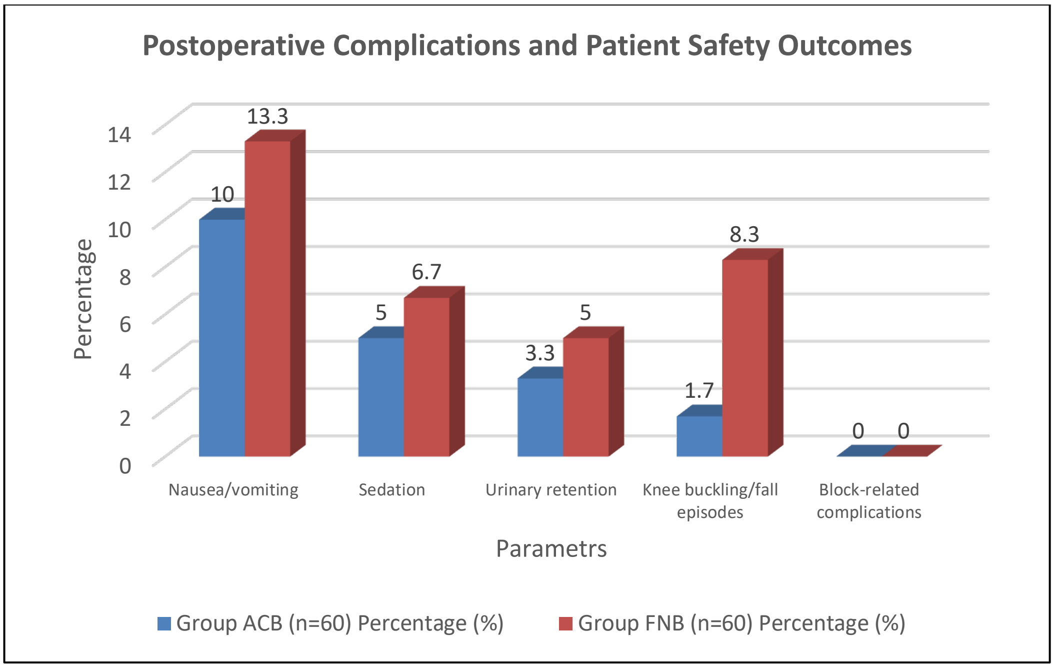

Figure 3: Postoperative Complications and Patient Safety Outcomes

Discussion

The present prospective comparative study evaluated the efficacy of ultrasound-guided adductor canal block (ACB) versus femoral nerve block (FNB) for postoperative analgesia and functional recovery after total knee replacement in 120 patients. Both techniques provided comparable analgesia; however, ACB demonstrated significant advantages in preserving quadriceps strength, facilitating early ambulation, and improving functional recovery. In our study, postoperative pain scores were comparable between both groups. The mean VAS score at 2 hours was 2.4 ± 0.9 in the ACB group and 2.7 ± 1.0 in the FNB group (p=0.08). Similarly, VAS scores at 6 hours (3.1 ± 1.1 vs 3.2 ± 1.2), 12 hours (3.4 ± 1.2 vs 3.5 ± 1.3), and 24 hours (2.6 ± 1.0 vs 2.8 ± 1.1) showed no significant difference. Duration of analgesia was also comparable between ACB and FNB groups (15.2 ± 3.8 vs 15.6 ± 4.1 hours; p=0.58).

These findings indicate that ACB provides analgesic efficacy comparable to FNB after total knee replacement. Gao et al. [2] reported similar postoperative pain control and opioid-sparing effects between ACB and FNB, while highlighting the functional advantages of ACB. Kapoor et al. [4] also concluded that ACB is non-inferior to FNB for analgesia with better preservation of motor function. Lund et al. [12] demonstrated effective analgesia with continuous ACB after major knee surgery, supporting its role as an alternative regional technique. A major finding of our study was superior preservation of quadriceps strength with ACB. Straight leg raise at 6 hours was achieved in 58.3% of patients in the ACB group compared with 35.0% in the FNB group (p=0.01). At 24 hours, quadriceps recovery remained higher with ACB (90.0% vs 71.7%, p=0.01). The mean quadriceps strength score at 24 hours was significantly better with ACB (4.3 ± 0.7 vs 3.8 ± 0.8; p<0.001). Our findings are consistent with Jæger et al. [6], who demonstrated significantly greater quadriceps preservation with ACB compared with FNB while maintaining similar analgesic efficacy. Kwofie et al. [13] also reported improved quadriceps strength and reduced functional impairment with ACB compared with FNB. Charous et al. [14] attempted to minimize quadriceps weakness associated with continuous FNB by modifying local anaesthetic delivery methods; however, clinically relevant motor blockade remained a limitation of FNB. In the present study, ACB was associated with significantly earlier mobilization. The mean time to first ambulation was 24.6 ± 5.2 hours in the ACB group compared with 29.8 ± 6.4 hours in the FNB group (p<0.001). Knee flexion at discharge was also significantly greater with ACB (92.5 ± 10.4° vs 87.8 ± 11.2°, p=0.02). Tan et al. [10] reported improved early rehabilitation outcomes with ACB after total knee arthroplasty, with comparable analgesic effects to FNB. Hussain et al. [7] in their systematic review and meta-analysis also concluded that ACB provides similar pain relief while improving early functional recovery due to better motor preservation. In our study, knee buckling/fall episodes were lower in the ACB group compared with FNB (1.7% vs 8.3%), although the difference was not statistically significant (p=0.09). Elkassabany et al. (2016) reported an increased risk of falls following FNB compared with ACB after total knee arthroplasty, suggesting that preservation of quadriceps function with ACB may improve postoperative safety. The overall complication profile was comparable between groups. Nausea/vomiting occurred in 10.0% of ACB patients and 13.3% of FNB patients, while sedation occurred in 5.0% and 6.7%, respectively. No block-related complications were observed. Sakura [15] and Saranteas et al. [16] emphasized that ultrasound guidance improves the safety and accuracy of peripheral nerve blocks but requires careful attention to anatomical variations and technical limitations. Neal et al. [17] highlighted the importance of appropriate dosing and monitoring during continuous ACB due to potential concerns regarding local anaesthetic-induced myotoxicity.

Limitations

The study was limited by the single-centre design and relatively short postoperative follow-up period, which may restrict the generalizability of findings. Objective assessment of muscle strength using advanced functional testing methods and long-term rehabilitation outcomes were not evaluated.

Conclusion

Adductor canal block provides comparable postoperative analgesia to femoral nerve block after total knee replacement, with superior preservation of quadriceps strength and earlier functional recovery.

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