e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(6); 378-383

Original Research Article

Comparison of Clonidine and Fentanyl as Adjuvants to Ropivacaine in Femoral Nerve Block for Postoperative Analgesia Following Arthroscopic Anterior Cruciate Ligament Reconstruction: A Prospective Observational Study

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Received: 01-03-2026 / Revised: 15-04-2026 / Accepted: 21-05-2026

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Conflict of interest: Nil

Abstract

Background: Femoral nerve block (FNB) is an effective analgesic technique for knee surgery, and adjuvants are commonly added to local anesthetics to enhance block quality and duration. This study compared clonidine and fentanyl as adjuvants to ropivacaine in FNB for postoperative analgesia following arthroscopic anterior cruciate ligament (ACL) reconstruction.

Methods: This prospective observational study included 40 ASA I-II patients (18-60 years) undergoing arthroscopic ACL reconstruction under spinal anesthesia. Patients received postoperative FNB with 20 mL of 0.2% ropivacaine containing either clonidine 1 µg/kg (Group C, n=20) or fentanyl 1 µg/kg (Group F, n=20). The primary outcome was duration of postoperative analgesia. Secondary outcomes included pain scores (Numerical Rating Scale, NRS), rescue analgesic consumption, block characteristics, hemodynamic parameters, and side effects over 24 hours.

Results: Duration of analgesia was comparable between groups (Group F: 10.50 ± 5.67 hours vs Group C: 9.82 ± 4.53 hours; p=0.676). NRS scores were similar at all time points, and no patient experienced severe pain. Total 24-hour diclofenac consumption was identical (90 mg) in both groups. Sensory block at 6 hours persisted in more patients in Group F (20% vs 0%; p=0.035). Hemodynamic parameters remained stable with no significant differences. No respiratory depression or serious adverse events occurred.

Conclusion: Both clonidine and fentanyl (1 µg/kg) as adjuvants to 0.2% ropivacaine in FNB provide comparable postoperative analgesia of approximately 10 hours following arthroscopic ACL reconstruction, with similar efficacy and favorable safety profiles.

Keywords: Analgesia, Anterior cruciate ligament reconstruction, Clonidine, Femoral nerve block, Fentanyl, Ropivacaine.

DOI: 10.25258/ijcpr.18.6.65

Introduction

Anterior cruciate ligament (ACL) injuries are common among recreationally active individuals, particularly those involved in sports. Arthroscopic ACL reconstruction is the mainstay of surgical management. Although minimally invasive, the procedure causes significant postoperative pain, especially during the first 24 hours, contributing to morbidity and delayed discharge. [1]

Several modalities have been used for postoperative pain control, including systemic opioids, non-steroidal anti-inflammatory drugs, neuraxial techniques, and peripheral nerve blocks. [1,2] Femoral nerve block (FNB) is attractive for knee surgery because the femoral nerve provides the primary sensory supply to the anterior knee. FNB is technically simple, cost-effective, and may be combined with general or spinal anesthesia. [3]

Ropivacaine is widely used for peripheral nerve blocks because it produces fewer central nervous system and cardiovascular adverse effects than

bupivacaine. [4,5] To prolong analgesia and improve block quality, adjuvants such as clonidine and fentanyl are frequently added to local anesthetics. [6,7]

Clonidine, an α_2-adrenergic agonist, enhances peripheral nerve blockade through direct action on peripheral α_2-receptors, potentiation of local anesthetic action, and local vasoconstriction reducing systemic absorption. [8,9] Fentanyl, a synthetic opioid, acts through peripheral opioid receptors on sensory neurons and may possess local anesthetic-like properties. [10]

Despite their widespread use, limited published data directly compare clonidine and fentanyl as adjuvants to local anesthetics in FNB, particularly for ACL reconstruction. This study compared the analgesic efficacy and safety of clonidine versus fentanyl added to ropivacaine for postoperative FNB in patients undergoing arthroscopic ACL reconstruction under spinal anesthesia.

Methods

Study Design and Setting: This prospective observational study was conducted in the Department of Anaesthesiology from November 2016 to March 2018 after approval by the Institutional Ethics Committee. Written informed consent was obtained from all participants. The study was reported in accordance with the STROBE guidelines for observational studies. [11]

Participants: Forty patients aged 18-60 years with American Society of Anesthesiologists (ASA) physical status I or II scheduled for elective arthroscopic ACL reconstruction under spinal anesthesia were enrolled. Exclusion criteria were: refusal of spinal anesthesia; ASA III-IV status; severe cerebrovascular, cardiac, renal, or hepatic impairment; contraindications to regional anesthesia (coagulopathy, spine deformities, local infection); pre-existing neurological deficit; inability to understand the Numerical Rating Scale (NRS); and surgical duration exceeding the effect of spinal anesthesia.

Anesthetic Technique: During the preoperative visit, patients were familiarized with the NRS (0 = no pain; 10 = worst imaginable pain). Standard monitoring (non-invasive blood pressure, electrocardiography, pulse oximetry, heart rate) was established and baseline vitals recorded. Spinal anesthesia was administered at L2-L3 or L3-L4 using 2.5 mL of 0.5% hyperbaric bupivacaine with 25 µg fentanyl. At the conclusion of surgery, nerve stimulator-guided FNB was performed; the femoral nerve was localized by quadriceps contraction at 0.5 mA, and 20 mL of 0.2% ropivacaine containing either clonidine 1 µg/kg (Group C) or fentanyl 1 µg/kg (Group F) was injected after negative aspiration.

Outcome Measures: The primary outcome was duration of postoperative analgesia, defined as time from FNB to first analgesic request. Secondary outcomes were: NRS pain scores at 0, 2, 4, 6, 8, 12, and 24 hours; total 24-hour analgesic consumption; sensory block (assessed by alcohol swab at the L4 dermatome); motor block (Modified Bromage Scale); hemodynamic parameters (heart rate, mean arterial pressure, respiratory rate); sedation score; and side effects including nausea, vomiting, respiratory depression, and local complications. Rescue analgesia with intravenous diclofenac 75 mg was given when the patient requested analgesia or the NRS score was ≥4.

Statistical Analysis: Quantitative variables were expressed as mean ± standard deviation and compared using the unpaired t-test. Qualitative variables were expressed as frequencies and percentages and compared using the Chi-square test or Fisher's exact test as appropriate. A p-value <0.05 was considered statistically significant. Analyses were performed using SPSS version 15.0.

Results

Patient Characteristics: Forty patients were enrolled, 20 per group. Demographic and surgical characteristics were comparable between groups (Table 1). The mean age was 28.15 ± 7.27 years, with a male predominance (92.5%). Mean body weight and duration of surgery were similar between groups.

Primary Outcome: The mean duration of postoperative analgesia was 10.50 ± 5.67 hours in Group F and 9.82 ± 4.53 hours in Group C, with no statistically significant difference (p=0.676), indicating comparable analgesic efficacy (Table 2).

Pain Scores: All patients were pain-free at 0 and 2 hours (NRS = 0). Mean NRS scores remained comparable at all subsequent time points (Table 2, Figure 1). No patient in either group experienced severe pain (NRS >7) during the 24-hour observation. The highest mean NRS occurred at 8 hours (Group F: 1.20 ± 1.79; Group C: 2.15 ± 1.73; p=0.096).

Rescue Analgesic Consumption: Total 24-hour diclofenac consumption was identical (90 ± 46.17 mg) in both groups. The first analgesic dose was required by 90% of Group F and 95% of Group C (p=0.548); a second dose by 30% and 20% respectively (p=0.465). Only one patient (Group C) required a third dose.

Block Characteristics: At 4 hours, sensory block at the L4 dermatome was present in 70% of Group F and 55% of Group C (p=0.327). At 6 hours, sensory block persisted in significantly more Group F patients (20% vs 0%; p=0.035), suggesting more prolonged sensory blockade with fentanyl.

Motor block (Modified Bromage score <4) was present in 80% and 70% at 2 hours (p=0.465) and 10% and 5% at 4 hours (p=0.548) in Groups F and C respectively. No sensory or motor block persisted beyond 8 hours (Table 3).

Hemodynamic Parameters: Heart rate, mean arterial pressure, and respiratory rate remained stable throughout the postoperative period, with no significant between-group differences at any time point (p>0.05). No patient had hemodynamic changes exceeding 20% from baseline (Figure 2).

Side Effects: The maximum sedation score was 2 (asleep but arousable) in both groups, with comparable sedation throughout. No respiratory depression (respiratory rate <8/min or SpO_2 <90%) occurred. Nausea was reported in 4 episodes among Group F patients and none in Group C, without retching or vomiting. No local complications (hematoma, redness, or infection) were observed at the injection site (Table 4).

Table 1: Demographic and surgical characteristics

Variable	Group F (n=20)	Group C (n=20)	p-value
Age (years)	29.40 ± 8.03	26.90 ± 6.39	0.283
Sex (Male/Female)	18/2	19/1	1.000
Weight (kg)	66.25 ± 11.97	65.20 ± 8.70	0.753
ASA status (I/II)	20/0	20/0	—
Duration of surgery (min)	97.50 ± 18.88	98.50 ± 26.21	0.891

Values are mean ± SD or n. Group F: Fentanyl; Group C: Clonidine; ASA: American Society of Anesthesiologists.

Table 2: Duration of analgesia and pain scores

Parameter	Group F (n=20)	Group C (n=20)	p-value
Duration of analgesia (hours)	10.50 ± 5.67	9.82 ± 4.53	0.676
NRS at 0 hour	0.00 ± 0.00	0.00 ± 0.00	—
NRS at 2 hours	0.00 ± 0.00	0.00 ± 0.00	—
NRS at 4 hours	0.10 ± 0.45	0.25 ± 0.79	0.463
NRS at 6 hours	1.15 ± 1.69	0.95 ± 1.32	0.679
NRS at 8 hours	1.20 ± 1.79	2.15 ± 1.73	0.096
NRS at 12 hours	0.85 ± 1.23	0.85 ± 1.31	1.000
NRS at 24 hours	0.10 ± 0.45	0.05 ± 0.22	0.657
Total diclofenac (mg/24h)	90.00 ± 46.17	90.00 ± 46.17	1.000

Values are mean ± SD. NRS: Numerical Rating Scale (0-10).

Table 3: Sensory and motor block characteristics

Time	Sensory F	Sensory C	p	Motor F	Motor C	p
0 h	20 (100%)	20 (100%)	—	20 (100%)	20 (100%)	—
2 h	20 (100%)	20 (100%)	—	16 (80%)	14 (70%)	0.465
4 h	14 (70%)	11 (55%)	0.327	2 (10%)	1 (5%)	0.548
6 h	4 (20%)	0 (0%)	0.035*	0 (0%)	0 (0%)	—
8 h	0 (0%)	0 (0%)	—	0 (0%)	0 (0%)	—

Values are n (%). *p<0.05. Sensory block: presence at L4 dermatome. Motor block: Modified Bromage score <4.

Table 4: Side effects profile

Side effect	Group F (n=20)	Group C (n=20)	p-value
Nausea	2 (10%)	1 (5%)	0.548
Vomiting	0 (0%)	0 (0%)	—
Sedation score >2	0 (0%)	0 (0%)	—
Respiratory depression	0 (0%)	0 (0%)	—
Hematoma	0 (0%)	0 (0%)	—
Local redness/swelling	0 (0%)	0 (0%)	—

Values are n (%). Nausea recorded as the number of patients experiencing nausea over 24 hours. Respiratory depression: respiratory rate <8/min or SpO_2 <90%.

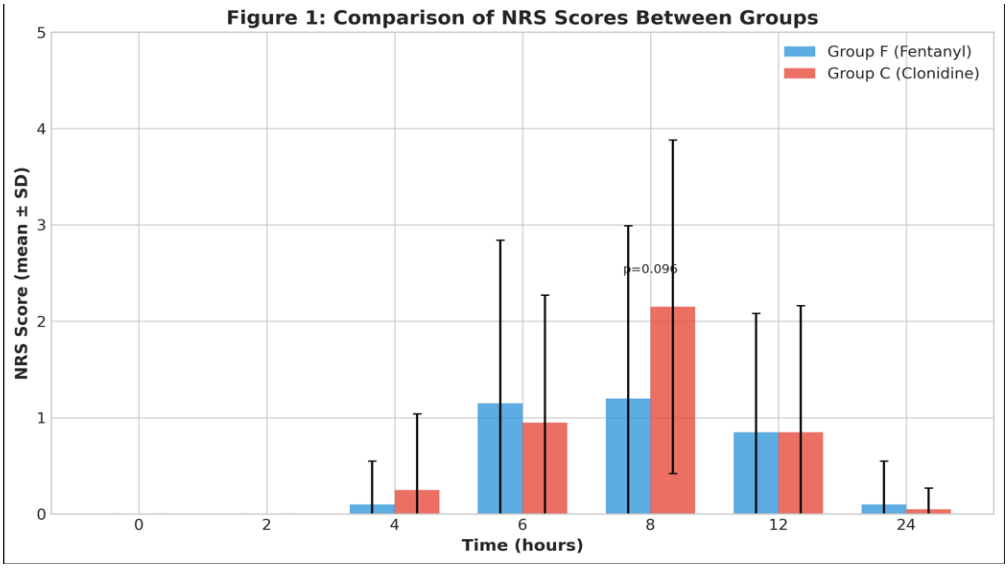

Figure 1: Mean NRS scores in the two groups at different postoperative time points. Error bars represent standard deviation. NRS: Numerical Rating Scale.

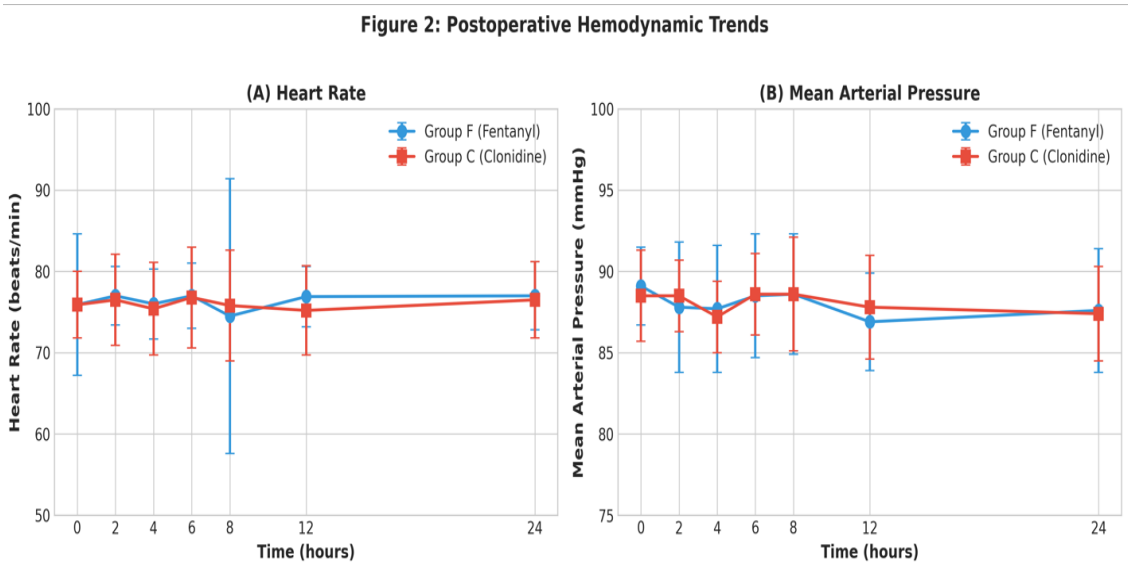

Figure 2: Postoperative hemodynamic trends: (A) heart rate (beats/min) and (B) mean arterial pressure (mmHg). Values are mean ± SD; no significant between-group differences at any time point.

Discussion

This study demonstrated that both clonidine and fentanyl, as adjuvants to 0.2% ropivacaine in FNB, provide comparable postoperative analgesia of approximately 10 hours following arthroscopic ACL reconstruction, with similar efficacy in pain control, rescue analgesic requirements, and safety profiles. The duration of analgesia observed is consistent with prior reports. Casati et al. [12] found that adding 1 µg/kg clonidine to 0.75% ropivacaine in sciatic-femoral block prolonged analgesia by approximately 3 hours, while a companion study by the same group reported that adding 1 µg/kg fentanyl to 0.75% ropivacaine produced no clinically relevant prolongation. [13]

Rajkhowa et al. [8] reported that adding 50 µg fentanyl to 0.5% ropivacaine in brachial plexus block extended sensory analgesia from 4.5 to 7.75 hours. Sahni et al. [14] studied clonidine via different routes following ACL reconstruction and reported analgesia of 9-10 hours when 1 µg/kg clonidine was used in femorosciatic block, closely matching our findings despite a different local anesthetic and the addition of a sciatic block. This concordance supports the robustness of our results.

The comparable efficacy of clonidine and fentanyl may reflect their distinct but convergent mechanisms. Clonidine enhances peripheral blockade through α_2-adrenoreceptor activation, modulation of hyperpolarization-activated currents, and local vasoconstriction, [8,15] whereas fentanyl

acts via peripheral opioid receptors, which are upregulated during inflammation. [10,16]

The significantly prolonged sensory block at 6 hours in the fentanyl group (20% vs 0%; p=0.035) may reflect preferential C-fiber effects through peripheral opioid receptors. However, this did not translate into clinically meaningful differences in pain scores or overall analgesic duration.

The absence of significant hemodynamic effects is reassuring. Clonidine 1 μg/kg did not produce clinically significant hypotension or bradycardia, consistent with reports that perineural clonidine doses up to 150 μg rarely cause significant hemodynamic change, [17,18] while perineural fentanyl 1 μg/kg also maintained hemodynamic stability.

The low incidence of nausea (10% overall, all in the fentanyl group) compares favorably with the 20-30% commonly reported following opioid-based systemic analgesia, [19] likely reflecting the opioid-sparing effect of effective regional analgesia and the use of a non-opioid rescue analgesic. Mild sedation did not interfere with patient assessment.

Our findings are closely paralleled by Chaudhary et al., [20] who compared clonidine and fentanyl (each 1 μg/kg) as adjuvants to bupivacaine in femoro-sciatic nerve block for ACL reconstruction. They reported a pain-free period of 10.06 hours with clonidine and 7.94 hours with fentanyl, with comparable postoperative pain scores between the two adjuvant groups - consistent with the equivalent analgesic efficacy observed in our study.

Several studies underscore the benefits of FNB for ACL reconstruction. Guirro et al. [21] showed that FNB combined with spinal anesthesia improved pain control within 12 hours compared with spinal anesthesia alone, and Mulroy et al. [22] reported prolonged analgesia with FNB using 0.25% bupivacaine. Our study extends this evidence by showing that lower-concentration ropivacaine (0.2%) with an adjuvant provides effective analgesia of comparable duration. The systematic review by Fowler et al. [4] further demonstrated that peripheral nerve block offers analgesia comparable to epidural techniques with fewer adverse effects, supporting FNB as a valuable component of multimodal analgesia. The single-injection ropivacaine FNB has also been shown to provide effective early analgesia after knee surgery. [23,24]

Limitations

This study has several limitations. The observational design without randomization may introduce selection bias. The absence of a plain-ropivacaine control group limits quantification of the adjuvant effect. Pain from the posterior knee and graft harvest site, innervated by the sciatic and obturator nerves, was not assessed.

Ambulation at 24 hours could not be evaluated owing to institutional protocols. Finally, the modest sample size may have limited the detection of small between-group differences.

Conclusion

Postoperative femoral nerve block with 20 mL of 0.2% ropivacaine combined with either clonidine 1 μg/kg or fentanyl 1 μg/kg provides effective analgesia of approximately 10 hours following arthroscopic ACL reconstruction under spinal anesthesia. Both adjuvants demonstrate comparable analgesic duration, pain reduction, and rescue analgesic requirements, with similar favorable safety profiles. Either adjuvant may be selected based on availability and clinician preference.

Author contributions

[Author 1&4]: Conceptualization, data collection, writing – original draft. [Author 2&5]: Supervision, methodology, writing – review & editing. [Author 3]: Statistical analysis, writing – review & editing. All authors approved the final manuscript.

Ethical approval: Institutional Ethics Committee, Lady Hardinge Medical College (Approval No: [LHMC/ECHR/2016/44R1])CTRI NO-CTRI/2018/04/013231 Dated-13/04/2018.

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