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Originalan rad **Original article**

COMPARATIVE EVALUATION OF ULTRASOUND-GUIDED ADDUCTOR CANAL BLOCK USING LEVOBUPIVACAINE WITH OR WITHOUT FENTANYL FOR POSTOPERATIVE ANALGESIA IN ARTHROSCOPIC KNEE SURGERY: A RANDOMIYED CONTROLLED TRIAL (Levobupivacaine with fentanyl in ACB)

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Abstract

Introduction**:** *Postoperative pain following knee surgery is often severe and may delay rehabilitation. This study evaluated the safety and efficacy of adding fentanyl to levobupivacaine in ultrasound guided adductor canal block (ACB).* ***Methods*****:** *One hundred patients scheduled for arthroscopic knee surgery were randomly assigned to two groups: Group L received 20 ml of 0.25% levobupivacane, while Group FL: who received Fentanyl (1μg/kg) with 0.25% levobupivacaine to a total volume of 20 ml. Postoperative analgesia, rescue analgesic requirement, patient satisfaction, hemodynamic stability, and complications were recorded.* ***Results*****:** *Group FL demonstrated significantly lower VAS pain scores and reduced rescue analgesic use compared to Group L. Patients in Group FL reported higher satisfaction with pain management and showed greater hemodynamic stability. Mild adverse effects, including nausea, vomiting, hypotension, and tachycardia, reported in both the groups.* ***Conclusion*****:** *The addition of fentanyl to levobupivacaine in ultrasound guided adductor canal block enhances postoperative analgesia, improves hemodynamic stability, increases patient satisfaction, and reduces analgesic requirements without increasing adverse effects in knee surgery patients.*

Key-words: *Adductor canal block; Levobupivacaine; Fentanyl; Post-operative analgesia; Knee surgery*

Introduction

Anaesthesia for surgery should provide not only intraoperative comfort but also adequate postoperative pain relief. Knee surgeries are frequently associated with moderate to severe postoperative pain, which impedes early mobilization and delays rehabilitation. Effective postoperative analgesia has been shown to enhance patient satisfaction, facilitate faster recovery, and reduce the length of hospital stay.

Several modalities are available for postoperative analgesia following knee surgery, including pre-emptive analgesia, local infiltration[1], systemic agents such as opioids and non-opioids, patient-controlled analgesia (PCA), epidural analgesia[2], peripheral nerve blocks, and multimodal combinations.[3] These approaches aim to minimize systemic opioid requirements and reduce associated adverse effects such as sedation, nausea, respiratory depression, constipation, and urinary retention.

The introduction of ultrasound guidance has significantly improved the safety and efficacy of regional anaesthesia by allowing clear differentiation between vascular and nonvascular structures and visualization of local anaesthetic spread.

Among peripheral nerve blocks, the femoral nerve block (FNB) has been widely utilized for knee surgery analgesia.[4] However, FNB produces motor blockade of the quadriceps due to its mixed motor and sensory innervation, thereby increasing the risk of falls during early ambulation.[5] To address this limitation, the adductor canal block

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(ACB) has gained popularity. By selectively blocking the saphenous nerve, which is primarily sensory, ACB provides effective postoperative analgesia while preserving quadriceps muscle strength. [6] This preservation of muscle strength facilitates early mobilization and physiotherapy, thereby minimizing the risk of complications such as deep vein thrombosis, falls, and joint stiffness. Moreover, ACB has been shown to reduce opioid consumption, consequently decreasing the incidence of opioid-related adverse effects including nausea, vomiting and, sedation during the postoperative period.[7] These advantages of ACB align well with the principles of Enhanced Recovery After Surgery (ERAS) protocols, promoting faster and safer postoperative recovery.

Levobupivacaine, a long-acting amide local anaesthetic, offers a wider safety margin with reduced cardiotoxicity compared to bupivacaine.[8] Fentanyl citrate, a potent synthetic opioid agonist, by acting on μ-opioid receptors located on the peripheral sensory nerve fibers and in the dorsal root ganglia, achieves effective analgesia in the affected region. [9] In the presence of tissue inflammation, the expression and axonal transport of opioid receptors toward the nerve terminals is increased, thereby enhancing the analgesic potency of peripheral opioids.[9] Furthermore, when opioids are combined with local anaesthetics—which primarily inhibit voltage-gated sensory channels—there is a synergistic effect: the local anaesthetic blocks nociceptive conduction, while the opioid engages receptor-mediated inhibitory signalling, together targeting multiple pathways of pain transmission and neuronal excitability.[9]

The present study was undertaken to evaluate the safety and efficacy of ultrasound-guided ACB using levobupivacaine with fentanyl in patients undergoing arthroscopic knee surgery, with particular focus on postoperative pain control, opioid consumption, and preservation of quadriceps muscle strength.

Objectives

The present study was designed to assess whether addition of fentanyl to levobupivacaine in an adductor canal block improves analgesic efficacy and reduce the requirement for rescue analgesics.

Our primary objective was to evaluate the analgesic efficacy of fentanyl as an adjuvant to levobupivacaine in an ultrasound-guided adductor canal block. Secondary objectives were to monitor hemodynamic parameters during the preoperative period, to observe and document any adverse effects or complications associated with the intervention, and to determine the requirement for rescue analgesics.

Methods

After obtaining approval from the Institutional Ethics Committee (Ref. No. 16/2023, dated 26/08/2023), this prospective randomized controlled trial was conducted between September 2023 to August 2024 in the Orthopedic Operation Theatres of B.J. Medical College and Civil Hospital, Ahmedabad.

Patients aged 18–65 years of either sex, classified as ASA physical status I–III, and scheduled for elective knee surgery of approximately 2–3 hours duration were included. Exclusion criteria were age < 18 or > 65 years, ASA status IV–V, emergency surgeries, patient refusal, fever of any etiology, and known hypersensitivity to local anaesthetics.

Sample size calculation and randomization

Sample size calculation was done using Open epi software version 3. For sample size estimation, reference was taken from Kampitak W et al.[10] study in which postoperative mean VAS score was compared. By taking 90% confidence interval and 80% power, obtained sample size with mean difference method were 49 patients in each group (98 patients total). For rounding off, total of 100 patients was enrolled and randomized using the lottery method into two equal groups (n = 50 each):

Group L: 20 mL of 0.25% levobupivacaine.

Group FL: 20 mL of 0.25% levobupivacaine with fentanyl 1 μg/kg.

Preoperative preparation

All patients underwent routine pre-anaesthetic evaluation, including history, systemic and local examination, and relevant investigations. Patients were kept nil per oral for at least 6 hours. Written informed consent was obtained.

Anaesthetic technique

In the operating room, standard monitoring (pulse rate, non-invasive blood pressure, oxygen saturation, respiratory rate, and Electrocardiogram) was applied, intravenous access established, and crystalloids started. All patients received intravenous ondansetron 4 mg as a premedication. Spinal anaesthesia was administered under aseptic precautions at the L2–L3 or L3–L4 interspace using 0.5% hyperbaric bupivacaine after confirming free cerebrospinal fluid flow. Supplemental oxygen was provided via face mask at 4–5 L/min.

Block technique

At the conclusion of the surgery, a sealed opaque envelope was opened to determine the group allocation of the patient and the drug for the adductor canal block was prepared accordingly. Adductor canal block (ACB) was performed by a single experienced anaesthesiologist using a high-frequency linear ultrasound transducer. The probe was placed at the junction of the upper two-thirds and lower one-third of the thigh. The superficial femoral artery, sartorius, and adductor muscles were identified. The saphenous nerve and nerve to vastus medialis, located anterolateral to the artery, were targeted. A 22G, 100-mm needle was advanced in-plane from lateral to medial, and the study drug was injected after negative aspiration.

Postoperative management and assessment

Patients were observed for 24 hours postoperatively. Postoperative pain was assessed using the Visual Analogue Scale (VAS) at 4, 8, 12, 16, 20, and 24 hours by blinded assessors. VAS score ranges from 0 (No pain) to 10 (Worst pain possible). Time to the 1st dose of rescue analgesia after ACB was measured. Rescue analgesia was provided with intravenous Tramadol 1–1.5 mg/kg, as required, within 24 hours. Beyond 24 hours, analgesia was managed by the orthopedic team. Patients were also observed for any adverse effects such as nausea, vomiting, dizziness, or any alteration in hemodynamic parameters. Injection Ondansetron 8 mg IV was administered for postoperative nausea and vomiting. Patient satisfaction was recorded after 24 hours of ACB block, using a 5-point Likert's scale (1 = strongly dissatisfied, 2 = Moderate dissatisfied, 3 = Neutral, 4 = Moderate satisfied, 5 = strongly satisfied).

Statistical Analysis*:*

All collected data were entered into Microsoft Excel and analyzed using Epi info software version 7.2.5. Continuous variables such as age, heart rate, mean arterial pressure, VAS scores, time to first rescue analgesia, and total tramadol consumption were expressed as mean ± standard deviation (SD). The comparison of continuous variables between the two groups was performed using the unpaired Student's t-test. A P-value of less than 0.05 was considered statistically significant. Categorical variables such as sex distribution and incidence of side effects were expressed as frequencies and percentages.

Results

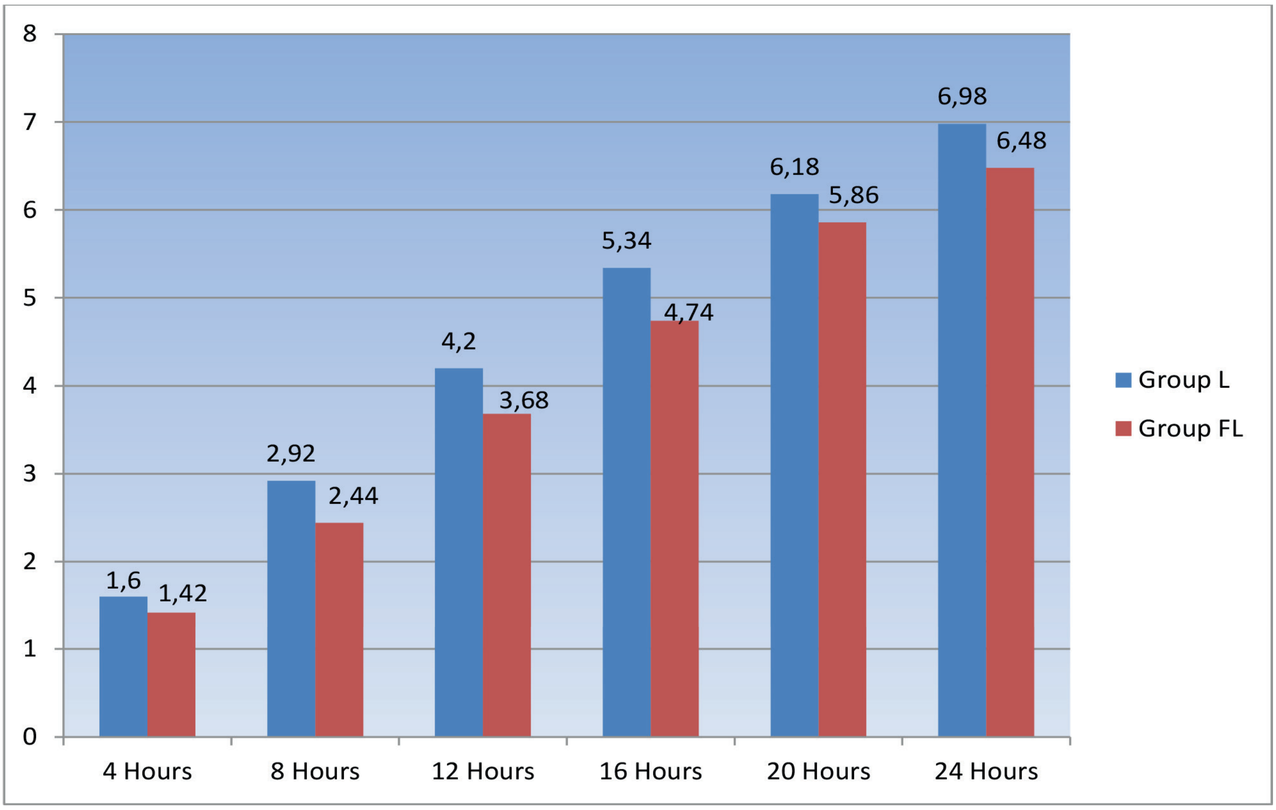
In our study, both groups were comparable in terms of demographic variables such as age and gender. The mean age was 45.56 ± 14.93 years in Group L and 47.06 ± 14.62 years in Group FL. Male and female patients were also distributed almost equally between the two groups. There was a statistically significant reduction in postoperative VAS scores in Group FL compared to Group L at all time intervals ($P < 0.05$), except at 4 hours postoperatively, where the difference was not statistically significant ($P = 0.073$), as shown in Figure 1.

Figure 2 shows that there was a significant difference in mean arterial blood pressure (MABP) between the two groups at all time intervals ($P < 0.05$), except at 4 hours postoperatively, where the mean arterial pressure was not significantly lower ($P = 0.445$). The mean heart rate was significantly reduced in Group FL compared to Group L at all time intervals, and this difference was statistically significant ($P < 0.05$), as shown in Figure 3.

Table 1 shows that there was a statistically significant difference in the time to the first dose of rescue analgesia (in hours) between Group L (15.24 ± 2.80) and Group FL (17.57 ± 2.58), with a P value of 0.000044 as per the unpaired t-test, indicating a highly significant result. It also shows that there was a statistically significant difference in the total dose of Inj. Tramadol administered in the first 24 hours (in milligrams) between Group FL (132.64 ± 16.82) and Group L (140.6 ± 18.20), with $P < 0.05$ as per the unpaired t-test.

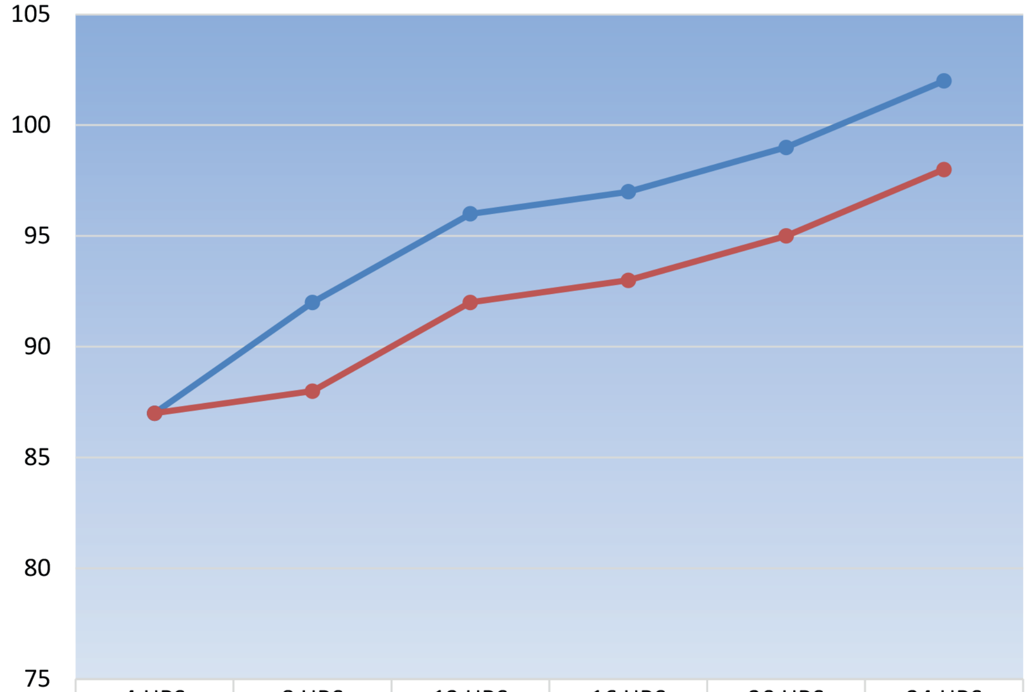
Group FL patients had higher satisfaction scores than those in Group L, as shown in Figure 4, while Table 2 presents the few adverse effects or complications encountered during the study across both groups.

Figure1. Graphical representation of Mean Postoperative VAS score at different time intervals between the two groups.



X- Axis represents different postoperative time intervals; Y- Axis represents VAS scores ranging from 0 to 10.

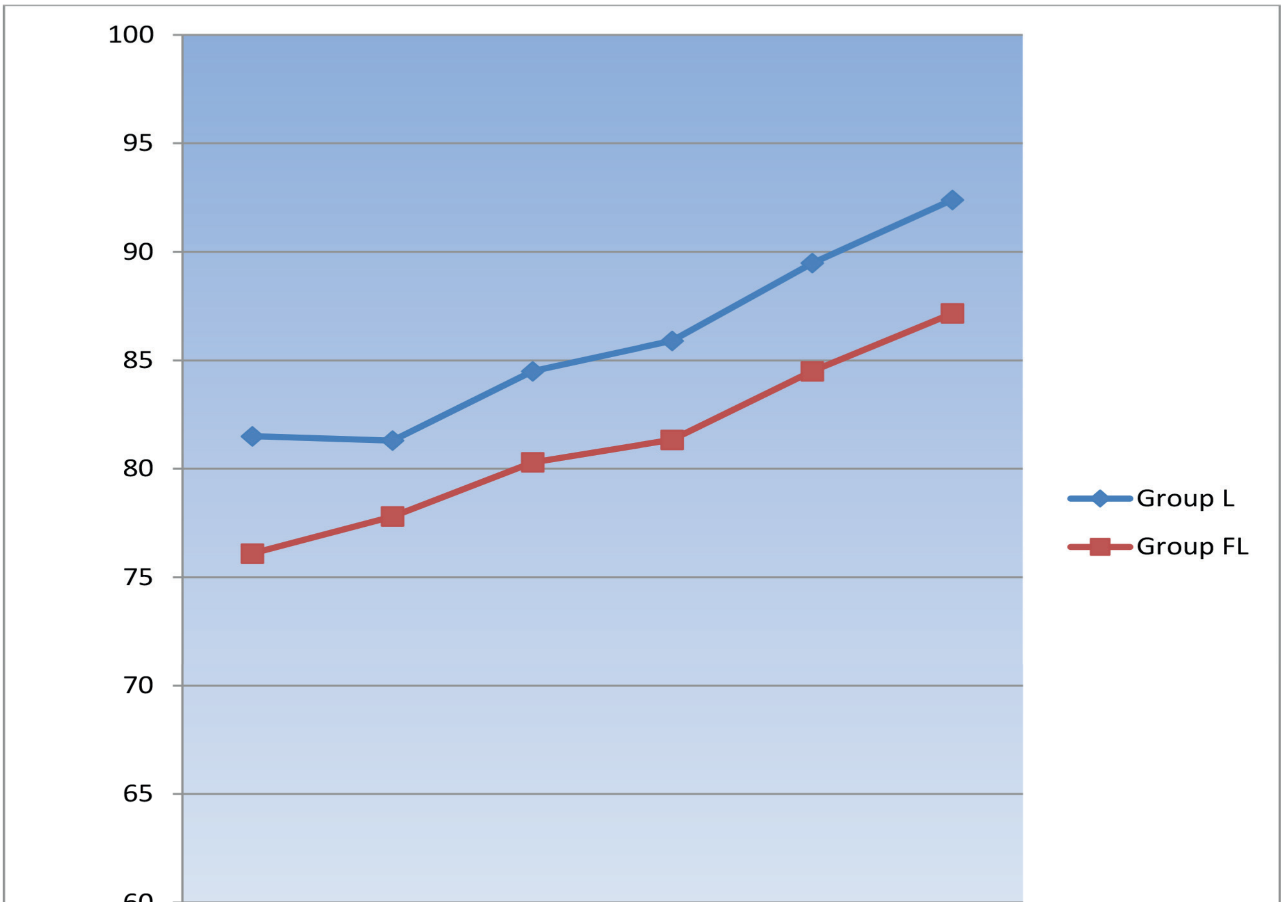
Figure 2. Graphical representation of the mean arterial blood pressure (MABP) between the two groups.



	4 HRS	8 HRS	12 HRS	16 HRS	20 HRS	24 HRS
GROUP L	87	92	96	97	99	102
GROUP FL	87	88	92	93	95	98

X- Axis represents different postoperative time intervals; Y- Axis represents mean arterial blood pressure MABP measured as mm Hg

Figure 3. Graphical representation of the mean heart rate between the two groups.



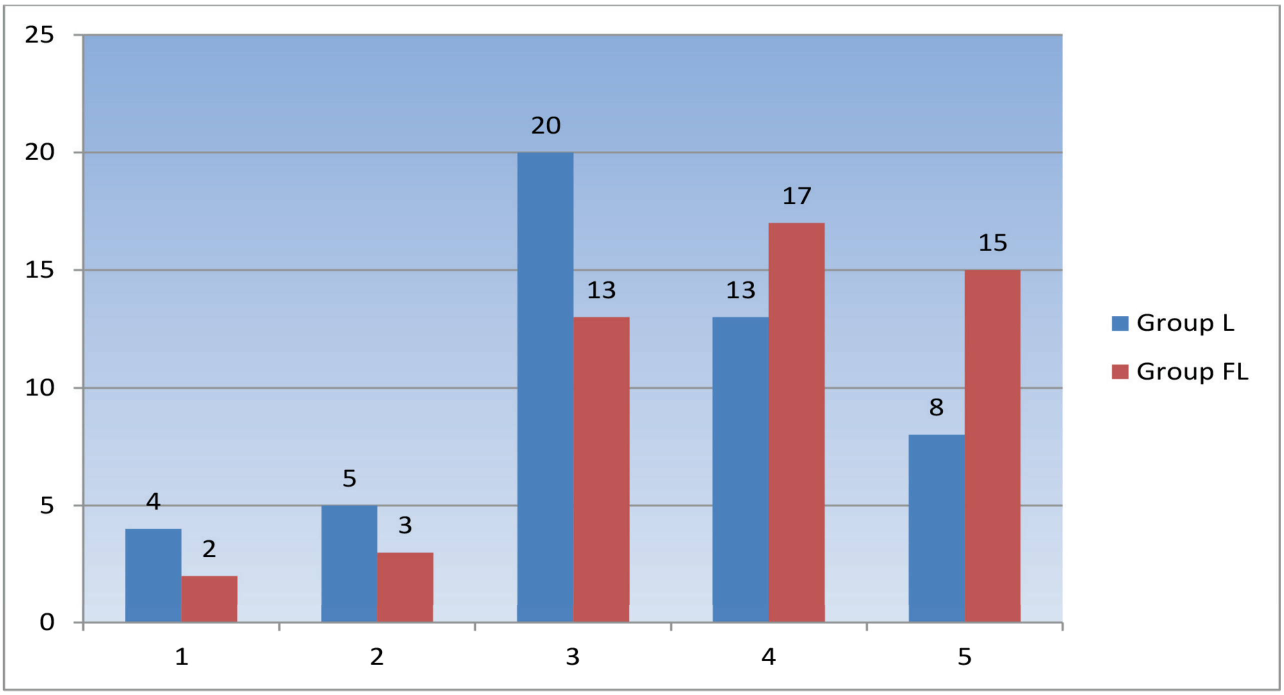
	4 Hours	8 Hours	12 Hours	16 Hours	20 Hours	24 Hours
Group L	81,5	81,3	84,5	85,9	89,48	92,4
Group FL	76,1	77,8	80,3	81,34	84,5	87,16

X- Axis represents different postoperative time intervals
Y- Axis represents mean heart rate
Mean Heart Rate was measured as beats per minute (bpm)

Table 1. Comparison of Time to the 1st dose of rescue analgesia and total dose of Rescue analgesic (injection Tramadol) between the two groups.

VARIABLES	GROUPS		P Value
	Group L	Group FL	
TIME TO THE 1ST DOSE OF RESCUE ANALGESIA (in HOURS)	15.24 ± 2.8	17.57 ± 2.58	0.000044
TOTAL DOSE OF RESCUE ANALGESIA (in mg)	140.6 ± 18.201	132.64 ±16.822	0.0253

Figure 4. Comparison of Patient Satisfaction Score between the two groups.



X-Axis shows Likert's satisfaction scale grading
Y-Axis shows number of patients

Table 2. Comparison of Adverse effects/ Complications between the two groups.

COMPLICATION	GROUP L	GROUP FL
Nausea	2	1
Vomiting	1	0
Hypotension	0	1
Bradycardia	0	0
Tachycardia	1	0
Dizziness	0	0

Discussion

Peripheral nerve blocks for lower extremity surgery have historically been less common than those for the upper extremity, largely due to anatomical complexity and the predominant use of neuraxial anaesthesia.[11] Unlike the brachial plexus, the nerves of the lower limb are widely distributed, making blockade technically challenging. However, advances in ultrasound technology, nerve stimulators, and specialized needles have facilitated precise localization, improved block success rates, and reduced complications.[12]

Femoral nerve block (FNB) has been the most frequently employed technique for postoperative analgesia in knee surgery.[4] Despite its effectiveness, FNB is associated with significant drawbacks, most notably quadriceps muscle weakness, which increases fall risk and may lead to serious complications, including ligament injury or fracture.[13] Additional risks include vascular puncture, hematoma, femoral neuritis (0.59%), and rare permanent nerve injury (0.2%).[14] Although large retrospective analyses suggest no strong association between FNB and falls[15], concerns about mobility and safety persist.

Adductor canal block (ACB) provides an attractive alternative. By targeting the saphenous nerve and sensory branches of the femoral and obturator nerves within the adductor canal, ACB achieves effective sensory blockade while largely sparing motor fibres.[16] This motor-sparing quality of ACB block results into better preservation of quadriceps strength, facilitating early and safe early mobilization and rehabilitation, after knee arthroplasty.[1]]

Levobupivacaine, the S(−) enantiomer of bupivacaine, is preferred for its lower cardiotoxicity and prolonged duration of action.[8] Wall PDH et al.[18] demonstrated that ACB with levobupivacaine offers superior analgesia and lower pain scores compared with FNB, both at rest and during mobilization. Fentanyl, a potent μ-opioid receptor agonist, has been employed as an adjuvant in regional blocks to enhance quality of the block and prolong the duration of analgesia, while minimizing opioid-related systemic side effects.

Ultrasound guidance has further strengthened the utility of ACB, offering real-time visualization of neural and vascular structures.[19] This has improved block accuracy, reduced performance time, and minimized complications such as intravascular injection or local anaesthetic toxicity.[20]

According to the findings of the present study, a single-shot ultrasound-guided adductor canal block (ACB) with a combination of levobupivacaine and fentanyl (FL group) provided superior postoperative analgesia compared to levobupivacaine alone. This combination prolonged the time to the first rescue analgesic requirement, reduced pain scores, and decreased the overall need for supplemental analgesics within the first 24 hours.

Beyond statistical significance, these findings hold an important clinical relevance. Prolonged and effective analgesia enables patients to engage in earlier mobilization, thereby reducing the risk of postoperative complications such as venous thromboembolism and joint stiffness. Furthermore, by reducing opioid requirements, this approach minimizes the incidence of opioid-related side effects—including nausea, sedation, and respiratory depression—thereby enhancing overall patient comfort and satisfaction. Collectively, these factors contribute to shorter hospital stays, faster rehabilitation, and improved functional recovery, outcomes that are particularly valuable in the context of modern enhanced recovery after surgery (ERAS) protocols.

These results are consistent with previous studies. Kampitak et al.[10] demonstrated that the addition of local infiltrative analgesia (LIA) to a single-shot ACB with 0.5% levobupivacaine (20 mL) significantly prolonged the time to the first rescue dose. Similarly, Hanson et al.[21] reported that ACB used as part of a multimodal analgesic regimen for patients undergoing medial meniscopathy surgery under general anaesthesia resulted in significantly lower pain scores and opioid consumption compared with controls. Egeler[22] concluded that ACB was associated with significantly reduced analgesic consumption following total knee arthroplasty (TKA) compared with placebo, findings that are in agreement with our results.

Most comparative studies evaluating ACB and femoral nerve block (FNB) have reported comparable analgesic efficacy after knee surgery. However, ACB offers a distinct functional advantage over FNB- the preservation of quadriceps strength. This allows for safer early ambulation and initiation of physiotherapy, ultimately facilitating early discharge and better patient outcomes. Whereas FNB is associated with postoperative quadriceps paresis, delayed mobilization, and prolonged hospital stay. Thus, current evidence supports the role of ultrasound-guided ACB, particularly when combined with adjuvants such as fentanyl, as an effective, safe and clinically valuable modality for postoperative pain management in knee surgeries.

In summary, the findings of this study highlight the clear clinical advantages of using a combination of levobupivacaine and fentanyl for ultrasound-guided adductor canal block in patients undergoing knee surgery. This technique not only ensures superior analgesia but also promotes early mobilization, reduces opioid consumption, and potentially shortens hospital stays—key objectives of enhanced recovery protocols.

Limitations and Future Scope

The present study was limited by its relatively small sample size and short follow-up duration of 24 hours, which may not capture late-onset complications or long-term functional outcomes. In addition, only a single dose of fentanyl was evaluated, and dose–response relationships could not be explored. Future large-scale, multicentre trials with longer follow-up are warranted to validate these findings, assess optimal dosing strategies, and evaluate the impact of adductor canal block with adjuvants on long-term recovery, rehabilitation, and patient-reported quality of life.

Despite the limitations, study's strengths- including its prospective randomized design, use of ultrasound guidance, and standardized anaesthetic protocols- enhance their clinical relevance of the results and help balance the limitations.

Conclusion

Ultrasound-guided adductor canal block with levobupivacaine offers effective postoperative analgesia in patients undergoing knee surgery. The addition of fentanyl as an adjuvant significantly enhances block efficacy by prolonging the duration of analgesia, reducing pain scores, delaying the need for rescue analgesics, and lowering overall opioid consumption, while preserving quadriceps muscle strength. Thus, this technique represents a safe and reliable component of multimodal analgesia for knee surgeries, facilitating early mobilization and improved postoperative recovery.

Conflict of interest and Funding Statement
The authors declare no conflict of interest and no external funding for this study.

References

1.Andersen KV, Bak M, Christensen BV, Harazuk J, Pedersen NA, Soballe K. A randomized, controlled trial comparing local infiltration analgesia with epidural infusion for total knee arthroplasty. Acta Orthop. 2010;81(5):606-10.

2.Thorsell M, Holst P, Hyldahl HC, Weidenhielm L. Pain control after total knee arthroplasty: a prospective study comparing local infiltration anesthesia and epidural anesthesia. Orthopedics. 2010;33(2):75-80.

3.Paul JE, Arya A, Hurlburt L, Cheng J, Thabane L, Tidy A. Femoral nerve block improves analgesia outcomes after total knee arthroplasty: a meta-analysis of randomized controlled trials. Anesthesiology. 2010;113:1144-62.

4.Albrecht E, Guyen O, Jacot-Guillarmod A, Kirkham KR. The analgesic efficacy of local infiltration analgesia vs femoral nerve block after total knee arthroplasty: a systematic review and meta-analysis. Br J Anaesth. 2016;116:597-609.

5.Ilfeld BM, Duke KB, Donohue MC. The association between lower extremity continuous peripheral nerve blocks and patient falls after knee and hip arthroplasty. Anesth Analg. 2010;111:1552-4.

6.Nader A, Kendall MC, Manning DW, Beal M, Rahangdale R, Dekker R. Single-dose adductor canal block with local infiltrative analgesia compared with local infiltrate analgesia after total knee arthroplasty: a randomized, double-blind, placebo-controlled trial. Reg Anesth Pain Med. 2016;41(6):678-84.

7.Jiang X, Wang QQ, Wu CA, Tian W. Analgesic efficacy of adductor canal block in total knee arthroplasty: a meta--analysis and systematic review. Orthop Surg. 2016;8(3):294-300.

8. McLeod GA, Burke D.Levobupivacaine.Anaesthesia.2001;56:331-41.

9.Stein C, Machelska H. Modulation of peripheral sensory neurons by the immune system: implications for pain therapy. Pharmacol Rev. 2011;63(4):860-81.

10.Kampitak W, Tanavalee A, Ngarmukos S, et al. Does adductor canal block have a synergistic effect with local infiltration analgesia for enhancing ambulation and improving analgesia after total knee arthroplasty? Knee Surg Relat Res. 2018;30(2):133.

11.Enneking FK, Chan V, Greger J, Hadzic A, Lang SA. Lower extremity peripheral nerve blockade: essentials of our current understanding. Reg Anesth Pain Med 2005;30:4-35.

12.Slover J, Riesgo A, Payne A, Umeh U. Modern Anesthesia for Total Joint Arthroplasty. Ann Orthop Rheumatol.2014;2:1026.

13.Sharma S, Iorio R, Specht LM, Davies-Lepie S, Healy WL. Complications of femoral nerve block for total knee arthroplasty. Clin Orthop Relat Res. 2010;468:135-40.

14. Feibel RJ, Dervin GF, Kim PR, Beaulé PE. Major complications associated with femoral nerve catheters for knee arthroplasty: a word of caution. J Arthroplasty. 2009; 24:132-37.

15. Memtsoudis SG, Danninger T, Rasul R, Poeran J, Gerner P. Inpatient falls after total knee arthroplasty: the role of anesthesia type and peripheral nerve blocks. Anesthesiology 2014;120:551-63.

16.Lund J, Jenstrup MT, Jaeger P, Sørensen AM, Dahl JB. Continuous adductor-canal-blockade for adjuvant post-operative analgesia after major knee surgery: preliminary results. Acta Anaesthesiol Scand. 2011;55:14-9.

17.Shah NA, Jain NP. Is continuous adductor canal block better than continuous femoral nerve block after total knee arthroplasty? Effect on ambulation ability, early functional recovery and pain control: A randomized controlled trial. J Arthroplasty 2014;29:2224-29.

18.Wall PDH, Sprowson AP, Parsons N. Protocol for a single-centre randomised controlled trial of multimodal periarticular anaesthetic infiltration versus single-agent femoral nerve blockade as analgesia for total knee arthroplasty: perioperative Analgesia for Knee Arthroplasty (PAKA). BMJ Open. 2015;5(12):e009898.

19.Hatfield A, Bodenham A. Ultrasound: an emerging role in anaesthesia and intensive care. *Br J of Anaesth*. 1999; 83(5):789–800.

20.Koscielniak-Nielsen ZJ. Ultrasound-guided peripheral nerve blocks: what are the benefits? *Acta Anaesthesiol Scand*. 2008;52(6):727–737.

21.Hanson NA, Derby RE, Auyong DB, Salinas FV, Delucca C, Nagy R. Ultrasound-guided adductor canal block for arthroscopic medial meniscectomy: A randomized, double-blind trial. Can J Anaesth. 2013;60:874-80.

22. Egeler C, Jayakumar A, Ford S. Motor-sparing knee block - description of a new technique. Anaesthesia. 2013;68(5):542-3.