



Original Article

Corresponding Author:
Dr. Prithwiraj Roy

Article History:

Received on: Sep 13, 2026

Revised on: Sep 22, 2026

Accepted on: Oct 01, 2026

Published on: Oct 11, 2026

Single-shot Ropivacaine–Dexmedetomidine versus Ropivacaine–Fentanyl in Ultrasound-Guided Adductor Canal Block after Total Knee Replacement: A Prospective Randomised Controlled Study

Dr. Prithwiraj Roy¹; Dr. Chandan Kumar Pal¹; Dr. Suryabrata Chattopadhyay¹; Dr. Samir Basak¹; Dr. Shaista Tabassum¹; Dr. Samzai Lungalang²

¹Department of Anaesthesiology, Central Hospital, South Eastern Railway, Garden Reach, Kolkata, West Bengal, India

²Department of Anaesthesiology, Christian Institute of Health Sciences & Research, Dimapur, Nagaland, India

Citation: Dr. Prithwiraj Roy *et al.* Single-shot Ropivacaine–Dexmedetomidine versus Ropivacaine–Fentanyl in Ultrasound-Guided Adductor Canal Block after Total Knee Replacement: A Prospective Randomised Controlled Study. *Biomedicine and Chemical Sciences*, 5 (4): 58-65, 2026

Copyright © The Author(s).
Published in *Biomedicine and Chemical Sciences*



This is an Open Access article published under the Creative Commons Attribution 4.0 International (CC BY 4.0) (<https://creativecommons.org/licenses/by/4.0/>) Creative Commons Attribution (CC BY): lets others distribute and copy the article, to create extracts, abstracts, and other revised versions, adaptations or derivative works of or from an article (such as a translation), to include in a collective work (such as an anthology), to text or data mine the article, even for commercial purposes, as long as they credit the author(s), do not represent the author as endorsing their adaptation of the article, and do not modify the article in such a way as to damage the author's honour or reputation

ABSTRACT

Background and Aims: Adductor canal block (ACB) is an established regional analgesic technique after total knee replacement (TKR). This study compared the postoperative analgesic efficacy and adverse-effect profile of ropivacaine–dexmedetomidine with ropivacaine–fentanyl in ultrasound-guided single-shot ACB.

Methods: Eighty adults undergoing unilateral primary TKR were randomised into two equal groups (n=40 each). Group BD received single-shot ultrasound-guided ACB with ropivacaine and dexmedetomidine 0.5 µg/kg, whereas Group BF received ropivacaine and fentanyl 0.5 µg/kg. The primary outcome was time to first rescue analgesia. Secondary outcomes included 24-hour rescue analgesic consumption, serial visual analogue scale (VAS) scores at rest and during movement, postoperative nausea and vomiting (PONV), vomiting, bradycardia, hypotension and maximum Richmond Agitation-Sedation Scale (RSS) score. Continuous outcomes were analysed using Welch's t-test; serial VAS scores were analysed using a population-averaged Gaussian generalized estimating equation (GEE) model.

Results: Time to first rescue analgesia was longer with dexmedetomidine than fentanyl (10.02 ± 1.19 h vs 6.37 ± 1.18 h; mean difference 3.65 h, 95% CI 3.12–4.18; P < 0.001). Twenty-four-hour rescue analgesic consumption was lower with dexmedetomidine (127.50 ± 25.19 mg vs 206.25 ± 32.40 mg; mean difference –78.75 mg, 95% CI –91.68 to –65.82; P < 0.001). Group-by-time interactions were significant for VAS at rest (P < 0.001) and during movement (P < 0.001). PONV occurred in 4/40 versus 9/40 participants (P = 0.225), and vomiting in 2/40 versus 2/40 (P = 1.000).

Conclusion: In this study, single-shot ropivacaine–dexmedetomidine ACB was associated with longer analgesia, lower rescue analgesic consumption and lower postoperative pain scores than ropivacaine–fentanyl ACB after TKR.

Keywords: adductor canal block; dexmedetomidine; fentanyl; ropivacaine; total knee replacement; ultrasound-guided regional anaesthesia; postoperative analgesia.

INTRODUCTION

Total knee replacement is associated with substantial acute postoperative pain, which may interfere with early mobilisation and rehabilitation and increase the requirement for systemic analgesics. Contemporary perioperative care therefore relies on multimodal analgesia combining systemic agents with regional techniques.

Ultrasound-guided adductor canal block provides predominantly sensory analgesia by targeting the saphenous nerve and accompanying sensory branches within the adductor canal, while generally producing less quadriceps motor impairment than femoral nerve blockade. ACB has consequently become an important component of analgesic pathways for TKR.^{1–4}

The duration of single-shot ACB may be prolonged by the addition of adjuvants. Dexmedetomidine, an α_2 -adrenergic agonist, has been evaluated as an adjuvant to ropivacaine in ACB. Goyal et al. reported prolonged analgesia and reduced tramadol consumption when dexmedetomidine 0.50 $\mu\text{g/kg}$ was added to ropivacaine for ACB in patients undergoing simultaneous bilateral TKR.¹ Dose-comparison data have further supported the analgesic activity of dexmedetomidine as an ACB adjuvant.²

Fentanyl is an opioid analgesic that has also been incorporated into perioperative analgesic strategies for TKR. However, published studies involving fentanyl and ACB have often used systemic fentanyl rather than fentanyl as a perineural adjuvant, limiting direct comparison with an adjuvant-containing single-shot block.⁷

Accordingly, the present study compared single-shot ultrasound-guided ACB using ropivacaine with either dexmedetomidine or fentanyl in patients undergoing TKR, with time to first rescue analgesia as the primary outcome.

MATERIALS AND METHODS

Study design and setting

This prospective randomised controlled study was conducted at Central Hospital, South Eastern Railway, Garden Reach, Kolkata, West Bengal, India. Eighty adult patients undergoing unilateral primary TKR were included and allocated equally to two treatment groups (40 participants per group).

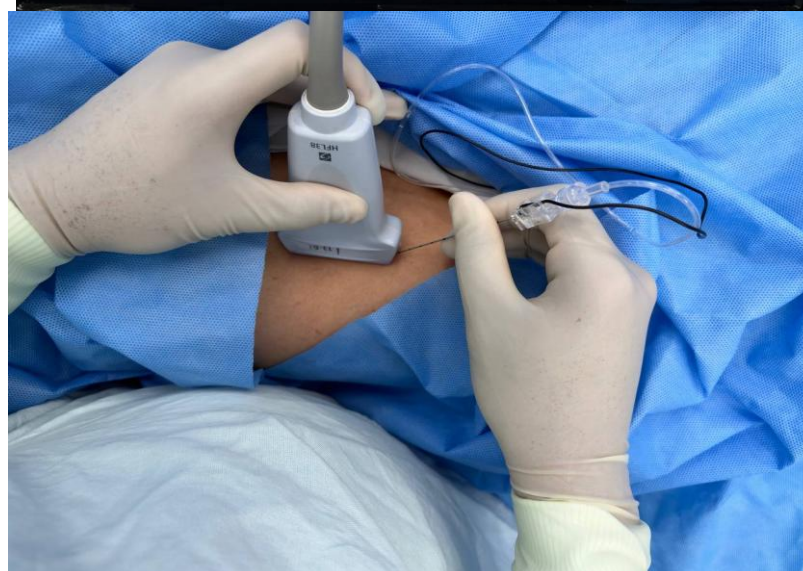
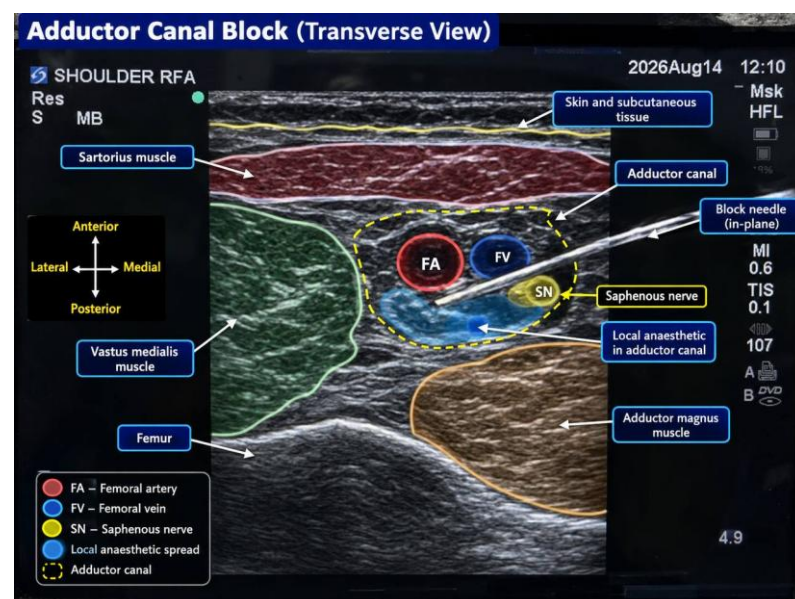
Participants

Patients aged 40–75 years, with American Society of Anesthesiologists (ASA) physical status I or II and body mass index (BMI) 18–35 kg/m^2 , scheduled for unilateral primary TKR under spinal anaesthesia were eligible. Patients with known allergy to study drugs, chronic opioid use, psychiatric illness affecting pain assessment, contraindication to regional anaesthesia, or inability to understand the VAS were excluded.

Procedure

Participants were randomly allocated in a 1:1 ratio to Group BD or Group BF. All participants received ultrasound-guided single-shot ACB. Group BD received 20ml of 0.2% ropivacaine with dexmedetomidine 0.5 $\mu\text{g/kg}$ as the study adjuvant, while Group BF received 20ml of 0.2% ropivacaine with fentanyl 0.5 $\mu\text{g/kg}$. The same local anaesthetic regimen was used in both groups.

Spinal anaesthesia was performed using 3 mL of 0.5% hyperbaric bupivacaine without any adjuvants. Patients were fully awake and no anxiolytics/sedatives were used throughout the procedure. The ACB was performed under dynamic ultrasound guidance at the mid-thigh level. The adductor canal was identified in the short-axis view and the block solution was deposited around the target structures within the canal.



Postoperative analgesia and outcome assessment

Postoperative analgesia followed a multimodal institutional protocol, with paracetamol 1 g IV every 8 hours and rescue analgesia administered on demand. Rescue analgesia will be administered with tramadol 1 mg/kg intravenously when the Visual Analogue Scale (VAS) pain score is ≥ 4 . The total tramadol dose should be restricted to a predefined maximum of 200 mg iv in 24 hours, including all rescue doses. A minimum interval of 6 hours should be maintained between two consecutive tramadol rescue doses. Time to first rescue analgesia and cumulative rescue analgesic consumption during the first 24 hours were recorded.

Pain intensity was assessed using a 0–10 visual analogue scale at rest and during movement at 0, 2, 4, 6, 8, 12, 18 and 24 hours after surgery. Secondary safety outcomes included PONV, vomiting, bradycardia, hypotension and the maximum Richmond Agitation-Sedation Scale score recorded during the observation period.

Statistical analysis

Continuous variables are presented as mean $\pm$ standard deviation (SD). Between-group comparisons of continuous variables were performed using Welch's independent-samples t-test, with mean differences and 95% confidence intervals (CIs); Hedges' g was used as the standardised effect size for key continuous outcomes. Categorical variables were compared using Fisher's exact test. Serial VAS measurements were analysed using a population-averaged Gaussian generalized estimating equation with group, time and group-by-time interaction terms and an exchangeable working correlation structure. Pairwise comparisons at individual time points were adjusted using Holm's method. All tests were two-sided,

and $P < 0.05$ was considered statistically significant. Statistical analysis was performed on all 80 participants with complete outcome data.

RESULTS

Participant characteristics

Eighty participants were analysed, with 40 in each group. The mean age was 56.67 ± 7.14 years in Group BD and 57.00 ± 5.96 years in Group BF. Female participants comprised 28/40 (70.0%) in BD and 29/40 (72.5%) in BF. Baseline age, weight, BMI, sex distribution and ASA physical status were comparable between groups. All participants had successful ACB.

Table 1. Baseline characteristics of study participants.

Variable	BD (n=40)	BF (n=40)	P value
Age, years	56.67 ± 7.14	57.00 ± 5.96	0.826
Weight, kg	64.33 ± 8.18	66.40 ± 7.75	0.248
BMI, kg/m ²	25.99 ± 2.55	25.42 ± 2.65	0.330
Female, n (%)	28 (70.0)	29 (72.5)	1.000
Male, n (%)	12 (30.0)	11 (27.5)	
ASA I, n (%)	15 (37.5)	13 (32.5)	0.815
ASA II, n (%)	25 (62.5)	27 (67.5)	
Successful ACB, n (%)	40 (100)	40 (100)	—

Primary and secondary analgesic outcomes

Time to first rescue analgesia was significantly longer in Group BD than in Group BF (10.02 ± 1.19 h vs 6.37 ± 1.18 h; mean difference 3.65 h, 95% CI 3.12–4.18; $P < 0.001$; Hedges' $g=3.05$). Twenty-four-hour rescue analgesic consumption was significantly lower in Group BD (127.50 ± 25.19 mg vs 206.25 ± 32.40 mg; mean difference -78.75 mg, 95% CI -91.68 to -65.82 ; $P < 0.001$; Hedges' $g=-2.69$).

Table 2. Primary and selected secondary outcomes. Mean differences are calculated as BD minus BF.

Outcome	BD (n=40)	BF (n=40)	Mean difference (95% CI)	P value	Hedges' g
Time to first rescue analgesia, h	10.02 ± 1.19	6.37 ± 1.18	3.65 (3.12 to 4.18)	<0.001	3.05
24-h rescue analgesic consumption, mg	127.50 ± 25.19	206.25 ± 32.40	-78.75 (-91.68 to -65.82)	<0.001	-2.69
Maximum RSS	2.30 ± 0.46	2.23 ± 0.42	0.07 (-0.12 to 0.27)	0.452	0.17

Serial pain scores

VAS scores were lower in the dexmedetomidine group throughout follow-up. The group-by-time interaction was statistically significant for VAS at rest (GEE Wald $\chi^2=416.90$, $df=7$; $P < 0.001$) and during movement (Wald $\chi^2=257.04$, $df=7$; $P < 0.001$). At 2–24 hours, between-group differences favoured dexmedetomidine at every recorded time point; Holm-adjusted pairwise P values remained statistically significant.

Table 3. Serial VAS scores at rest. Values are mean $\pm$ SD; P values are Holm-adjusted between-group comparisons at each time point.

Time (h)	BD: mean $\pm$ SD	BF: mean $\pm$ SD	Holm-adjusted P
0	0.00 ± 0.00	0.00 ± 0.00	—
2	1.05 ± 0.50	1.90 ± 0.63	<0.001
4	1.98 ± 0.62	3.10 ± 0.59	<0.001
6	2.05 ± 0.50	2.95 ± 0.50	<0.001
8	1.98 ± 0.66	3.02 ± 0.73	<0.001
12	1.88 ± 0.61	3.00 ± 0.64	<0.001
18	1.00 ± 0.64	1.93 ± 0.53	<0.001
24	1.02 ± 0.53	2.05 ± 0.60	<0.001

Table 4. Serial VAS scores during movement. Values are mean $\pm$ SD; P values are Holm-adjusted between-group comparisons at each time point.

Time (h)	BD: mean $\pm$ SD	BF: mean $\pm$ SD	Holm-adjusted P
----------	-------------------	-------------------	-----------------

0	0.00 ± 0.00	0.00 ± 0.00	—
2	1.65 ± 0.66	2.45 ± 0.81	<0.001
4	2.52 ± 0.85	3.67 ± 0.80	<0.001
6	2.58 ± 0.75	3.65 ± 0.70	<0.001
8	2.48 ± 0.78	3.60 ± 0.81	<0.001
12	2.42 ± 0.78	3.65 ± 0.77	<0.001
18	1.57 ± 0.81	2.75 ± 0.71	<0.001
24	1.68 ± 0.76	2.60 ± 0.78	<0.001

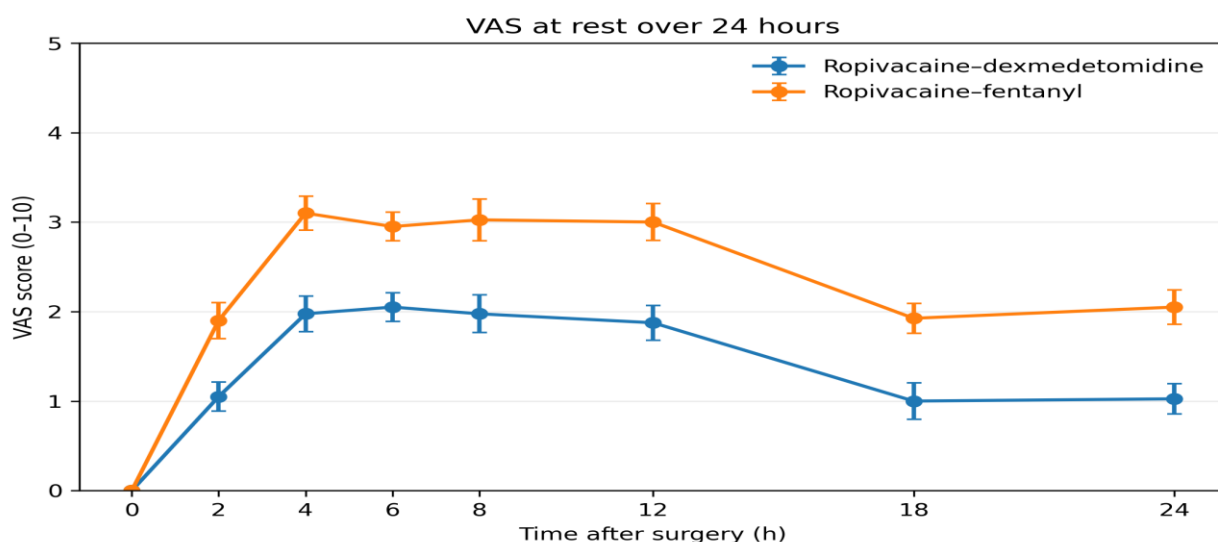


Figure 2. Mean VAS scores at rest over 24 hours. Error bars represent 95% confidence intervals.

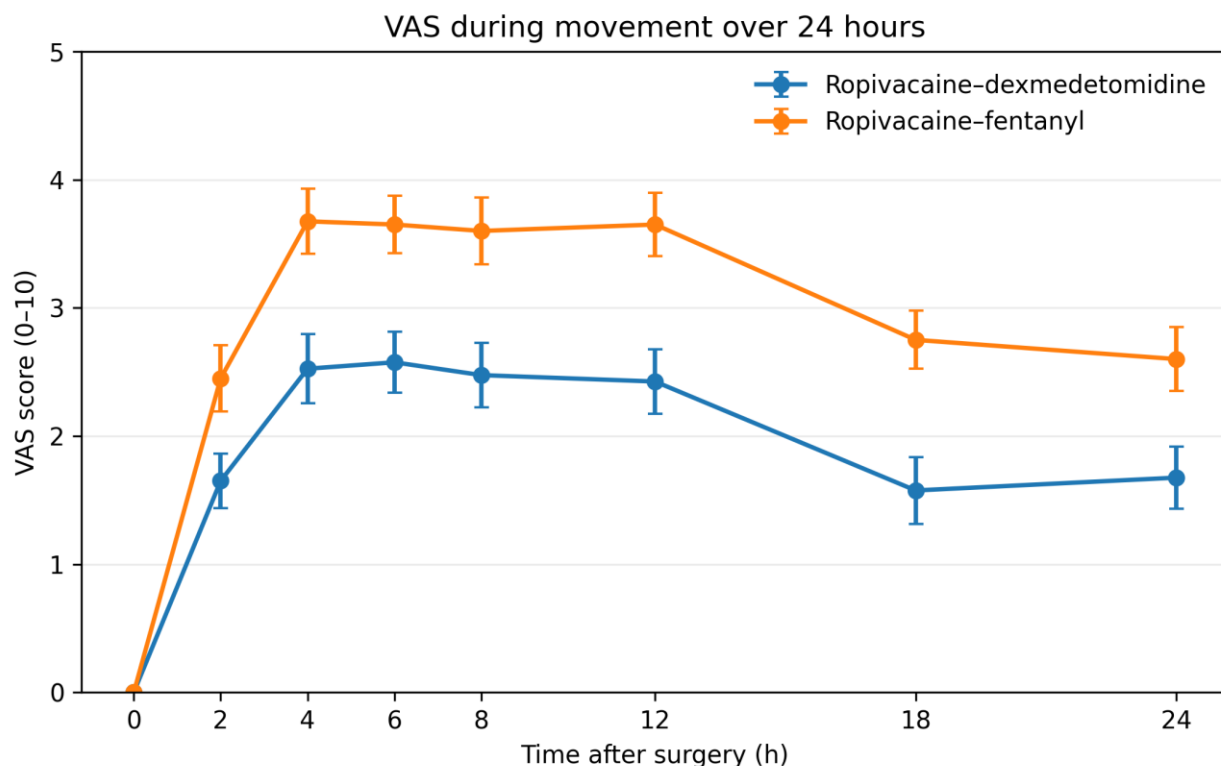


Figure 3. Mean VAS scores during movement over 24 hours. Error bars represent 95% confidence intervals.

Adverse events

PONV occurred in 4/40 (10.0%) participants in BD and 9/40 (22.5%) in BF ($P = 0.225$). Vomiting occurred in 2/40 (5.0%) participants in each group ($P = 1.000$). Bradycardia occurred in 3/40 (7.5%) participants in BD and none in BF ($P = 0.241$). Hypotension occurred in 1/40 (2.5%) participant in each group ($P = 1.000$). Maximum RSS was not significantly different between groups ($P = 0.452$).

Table 5. Postoperative adverse events.

Outcome	BD (n=40), n (%)	BF (n=40), n (%)	P value
PONV	4 (10.0)	9 (22.5)	0.225
Vomiting	2 (5.0)	2 (5.0)	1.000
Bradycardia	3 (7.5)	0	0.241
Hypotension	1 (2.5)	1 (2.5)	1.000

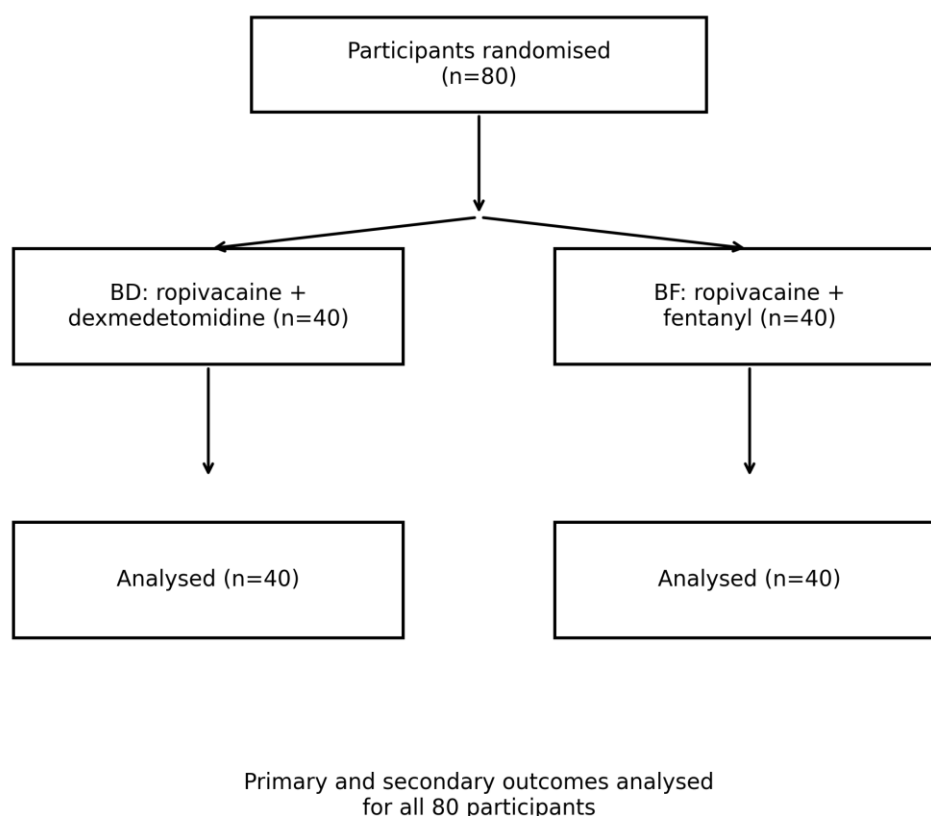


Figure 1. Participant flow and analysis population

DISCUSSION

The principal finding of this study was that single-shot ropivacaine–dexmedetomidine ACB provided a longer duration of analgesia and reduced rescue analgesic requirements compared with ropivacaine–fentanyl ACB after TKR. The difference was accompanied by consistently lower pain scores at rest and during movement throughout the 24-hour observation period.

The analgesic effect observed with dexmedetomidine is biologically plausible. Dexmedetomidine is an α_2 -adrenergic agonist with opioid-sparing properties. In a randomised controlled trial of ACB for simultaneous bilateral TKR, Goyal et

al. found that addition of 0.50 µg/kg dexmedetomidine to ropivacaine prolonged analgesia and reduced tramadol consumption compared with ropivacaine alone.¹ The present findings are directionally consistent with those observations.

Other clinical studies have examined dexmedetomidine as an ACB adjuvant. Karthik et al. compared two dexmedetomidine doses with ropivacaine in patients undergoing unilateral TKR and demonstrated differences in postoperative analgesic duration and rescue analgesia requirements.² These findings support the concept that dexmedetomidine can meaningfully modify the duration and quality of ACB analgesia.

Interpretation of the fentanyl comparison requires attention to the route of administration. Kim et al. evaluated continuous ACB against a single-shot ACB combined with intravenous fentanyl patient-controlled analgesia; their study therefore does not constitute a direct comparison of perineural fentanyl with perineural dexmedetomidine.⁷ The present study addresses a different clinical question by comparing two adjuvant-containing single-shot ACB strategies.

Previous randomised studies comparing single-shot and continuous ACB have shown that prolonging the block can improve early pain control, although the effect on functional recovery and opioid use has varied across trials.^{5,6} Systematic reviews similarly demonstrate that continuous ACB can reduce pain scores compared with single-shot techniques, while differences in rescue analgesic consumption are less consistent.^{3,4} The present study is therefore relevant to the practical question of whether optimisation of the single-shot injectate with an adjuvant can provide meaningful analgesia without the logistical requirements of a catheter-based technique.

The adverse-event profile in the present cohort did not demonstrate statistically significant between-group differences. Bradycardia was observed only in the dexmedetomidine group, although the difference was not statistically significant. The sample size and low event counts limit the precision of safety comparisons.

The study was conducted at a single centre and included 80 participants. Functional outcomes such as quadriceps strength, ambulation distance, range of motion and length of hospital stay were not assessed in the available outcome dataset. The study therefore primarily addresses the analgesic efficacy and early adverse events rather than broader functional recovery. Larger multicentre trials incorporating functional outcomes and longer follow-up would strengthen the evidence.

CONCLUSION

Single-shot ultrasound-guided ACB with ropivacaine–dexmedetomidine 0.5 µg/kg was associated with longer time to first rescue analgesia, lower 24-hour rescue analgesic consumption and lower serial pain scores than ropivacaine–fentanyl 0.5 µg/kg after total knee replacement. Dexmedetomidine may therefore be a useful adjuvant for extending the analgesic benefit of single-shot ACB in this setting.

Acknowledgement

The authors acknowledge the assistance of the patients, anaesthesia team, and institutional staff involved in the conduct of the study. The authors also acknowledge the investigators whose work informed the study design and interpretation.

Declarations

- Ethics approval and consent to participate: Approval was obtained from the institutional research and ethics committee. Written informed consent was obtained from all participants.
- Conflict of interest: None declared.
- Funding: No external funding was reported.

REFERENCES

1. Goyal R, Mittal G, Yadav AK, Sethi R, Chattopadhyay A. Adductor canal block for post-operative analgesia after simultaneous bilateral total knee replacement: A randomised controlled trial to study the effect of addition of dexmedetomidine to ropivacaine. *Indian J Anaesth.* 2017;61(11):903-909. doi:10.4103/ija.IJA_277_17.
2. Karthik NM, Das SG, Johny J, George M, Issac E, Vasudevan A. Comparison of postoperative analgesia with two different doses of dexmedetomidine as an adjuvant to ropivacaine in adductor canal block for unilateral total knee replacement surgery: A randomized double-blinded study. *J Anaesthesiol Clin Pharmacol.* 2022;38(3):428-433. doi:10.4103/joacp.JOACP_493_20.
3. Sercia QP, Bergeron JJ, Pelet S, Belzile EL. Continuous vs. single-shot adductor canal block for pain management following primary total knee arthroplasty: A systematic review and meta-analysis of randomized controlled trials. *Orthop Traumatol Surg Res.* 2022;108(8):103290. doi:10.1016/j.otsr.2022.103290.

4. Hussain N, Brull R, Zhou S, Schroell R, McCartney C, Sawyer T, Abdallah FW. Analgesic benefits of single-shot versus continuous adductor canal block for total knee arthroplasty: A systematic review and meta-analysis of randomized trials. *Reg Anesth Pain Med.* 2023;48(2):49-60. doi:10.1136/rapm-2022-103756.
5. Shah NA, Jain NP, Panchal KA. Adductor canal blockade following total knee arthroplasty—continuous or single shot technique? Role in postoperative analgesia, ambulation ability and early functional recovery: A randomized controlled trial. *J Arthroplasty.* 2015;30(8):1476-1481. doi:10.1016/j.arth.2015.03.006.
6. Canbek U, Akgun U, Aydogan NH, Kilinc CY, Uysal AI. Continuous adductor canal block following total knee arthroplasty provides a better analgesia compared to single shot: A prospective randomized controlled trial. *Acta Orthop Traumatol Turc.* 2019;53(5):334-339. doi:10.1016/j.aott.2019.04.001.
7. Kim MK, Moon HY, Ryu CG, Kang H, Lee HJ, Shin HY. The analgesic efficacy of the continuous adductor canal block compared to continuous intravenous fentanyl infusion with a single-shot adductor canal block in total knee arthroplasty: a randomized controlled trial. *Korean J Pain.* 2019;32(1):30-38. doi:10.3344/kjp.2019.32.1.30.