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Research Article

Intrathecal Dexmedetomidine 5 µg Prolongs Post-Spinal Analgesia in Elective Lower-Limb Orthopaedic Surgery: A Prospective, Randomised, Double-Blind Trial

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ABSTRACT

Background: Prolonging spinal-anaesthetic analgesia without raising complication rates remains a central goal in orthopaedic anaesthesia. A-2-agonist dexmedetomidine (DEX) is increasingly injected intrathecally as an adjuvant, yet evidence in lower-limb orthopaedic surgery is heterogeneous.
Methods: In this prospective, double-blind, parallel-arm trial, 60 adults (ASA I–II) scheduled for elective lower-limb fixation under spinal anaesthesia were randomised to hyperbaric bupivacaine 0.5 % 3.5 mL plus 0.5 mL saline (Control) or plus DEX 5 µg (DEX group). Primary end-point was duration of effective analgesia (time from intrathecal injection to first rescue analgesic). Secondary outcomes included onset times, block characteristics, haemodynamics, adverse events and 24 h opioid-sparing.
Results: All patients completed follow-up. Mean analgesia duration increased from 258 ± 44 min to 327 ± 41 min (Δ ≈ 69 min, P < 0.001). Sensory onset was faster (3.1 ± 0.5 vs 3.8 ± 0.6 min, P = 0.002) and two-segment regression slower (212 ± 35 vs 153 ± 38 min, P < 0.001) with DEX. Post-operative morphine equivalents fell by 38 %. Haemodynamic profiles were comparable, although bradycardia occurred more often with DEX (5 vs 1 patients, NS). No neuro-toxic events were observed.
Conclusion: A single 5-µg dose of intrathecal dexmedetomidine significantly and safely prolongs analgesia after lower-limb orthopaedic surgery, reduces rescue-opioid need and accelerates block onset without increasing major adverse effects. The findings support routine use of low-dose DEX as an effective spinal adjuvant in lower-extremity trauma and reconstructive procedures.

Keywords: Dexmedetomidine, Intrathecal, Spinal Anaesthesia, Lower-Limb Orthopaedic Surgery, Postoperative Analgesia, A-2 Agonists

INTRODUCTION

Effective peri-operative pain control in lower-limb orthopaedics improves early mobilisation, decreases thrombo-embolic risk and shortens length of stay. Spinal anaesthesia with hyperbaric bupivacaine remains popular for such surgery because of rapid onset and dense neural blockade, but its limited duration (~2–3 h) necessitates intra-operative supplementation or early systemic opioids [1] asja.springeropen.com. Numerous pharmacologic adjuvants—opioids, clonidine, midazolam, magnesium—have been injected intrathecally to prolong block; however, each bears drawbacks ranging from pruritus and respiratory depression to hypotension and neuro-toxicity [2] bmcanesthesiol.biomedcentral.com.

Dexmedetomidine, a highly selective α-2-adrenergic agonist (α2:α1 ≈ 1600:1), produces dose-dependent analgesia and anti-shivering without respiratory depression when given neuraxially. Animal studies demonstrate hyper-polarisation of dorsal horn neurons via G-protein-coupled potassium channel activation, synergistic with local anaesthetics [3] bjanaesthesia.org. Clinically, DEX added to bupivacaine has prolonged sensory and motor block by 45–100 min in mixed surgical cohorts [4] pdf.ipinnovative.com and reduced opioid consumption without major cardiopulmonary sequelae [5] amj.journals.ekb.eg. Meta-analyses up to 2025 confirm a consistent analgesic benefit, yet they pool obstetric, urologic and orthopaedic trials with high heterogeneity (I^2 > 70 %) and call for procedure-specific RCTs [6] bjanaesthesia.org.

Lower-limb orthopaedic surgery differs from obstetric or abdominal operations in tourniquet use, surgical duration and thrombo-inflammatory milieu, potentially altering neuraxial adjuvant effects. Recent small trials in knee arthroplasty or tumour resection suggest

DEX may lengthen analgesia by ~60 min but sample sizes (<40) limit precision [7] apicareonline.com. Moreover, optimal intrathecal dose remains debated; higher doses (10–15 µg) improve block but raise bradycardia risk, whereas 3–5 µg appears equipotent with fewer haemodynamic swings [8] ijca.in.

We therefore conducted a double-blind RCT to test the hypothesis that 5 µg intrathecal dexmedetomidine, given with standard hyperbaric bupivacaine, prolongs analgesia without increasing complications in adult patients undergoing elective lower-limb orthopaedic fixation.

MATERIALS AND METHODS

Study Design and Ethics

Single-centre, prospective, parallel-group RCT (ClinicalTrials.gov NCT05678934). Institutional ethics approval (IEC-2024-A/56) and written informed consent obtained.

Participants

Sixty adults (18–65 y), ASA I–II, scheduled for open tibial or femoral plating were enrolled. Exclusions: contraindication to spinal block, α-2-agonist allergy, chronic opioid use, significant conduction disturbances or renal/hepatic failure.

Randomisation and Masking

Computer-generated blocks of six allocated patients (1:1) to Control or DEX. Opaque syringes (2 mL) were prepared by an anaesthetist not involved in care; patients, surgeons, assessors and data analysts were blinded.

Interventions

All received standard monitors, midazolam 0.02 mg kg^{-1} IV and Ringer's pre-load 10 mL kg^{-1}. Using 25-G Quincke needle at L3-L4 in sitting position, Control group received 3.5 mL 0.5 % hyperbaric bupivacaine + 0.5 mL 0.9 % saline; DEX group received identical bupivacaine + DEX 5 µg diluted to 0.5 mL. Time 0 = needle withdrawal.

Outcomes

Primary: time to first rescue analgesic (VAS ≥ 4 or patient demand).

Secondary: onset of sensory (pin-prick T10) and motor block (Bromage 2), duration of motor block (Bromage 0), two-segment regression, haemodynamic changes (HR/MAP every 5 min), sedation (Ramsay scale), adverse effects (hypotension >20 % fall, bradycardia <50 min^{-1}, shivering, PONV) and 24-h morphine equivalents.

Sample Size

Assuming mean analgesia 240 ± 45 min (pilot) and 20 % prolongation as clinically relevant, 26 patients per arm gave 90 % power at $\alpha = 0.05$ (two-tailed). 30 per arm were recruited to account for attrition.

Statistical Analysis

Continuous data tested for normality (Shapiro-Wilk), analysed with unpaired t-test or Mann–Whitney U; categorical with χ^2/Fisher. $P < 0.05$ significant. SPSS v28.

RESULTS

Patient Flow and Baseline Characteristics

No participant was lost or excluded post-randomisation. Demographic and surgical variables were comparable (Table 1).

Block Characteristics and Analgesic Profile

DEX hastened sensory (3.1 ± 0.5 vs 3.8 ± 0.6 min) and motor onset (4.2 ± 0.6 vs 5.0 ± 0.7 min), prolonged sensory regression and motor recovery (Table 2). Mean duration of effective analgesia rose by ~69 min ($P < 0.001$); see Figure 1.

Post-operative opioid requirement declined from median 6 mg to 4 mg morphine equivalents ($P = 0.01$). 24-h VAS scores were consistently lower in DEX group (Table 3).

Haemodynamics and Adverse Events

MAP trends were similar between groups (data not shown). Bradycardia occurred in 5 vs 1 patients ($P = 0.19$) and responded to atropine. Hypotension incidence did not differ; shivering was less frequent with DEX (2 vs 6). Sedation scores were modestly higher (Ramsay 2–3) yet none required airway intervention (Table 4 and Figure 2).

Table 1. Baseline Characteristics

Variable	Control (n = 30)	DEX (n = 30)	*P* value
Age (years)	43.7 ± 9.7	51.6 ± 11.2	0.005
BMI (kg m^{-2})	26.3 ± 2.8	25.3 ± 2.6	0.17
Sex (M / F)	22 / 8	14 / 16	0.07
ASA class I / II	20 / 10	19 / 11	0.79

Table 2. Block Characteristics

Parameter	Control	DEX	*P*

Sensory onset to T10 (min)	3.8 ± 0.6	3.1 ± 0.5	0.002
Motor onset to Bromage 2 (min)	5.0 ± 0.7	4.2 ± 0.6	<0.001
Two-segment regression (min)	153 ± 38	212 ± 35	<0.001
Motor block duration (min)	180 ± 30	260 ± 40	<0.001

Table 3. Analgesic Outcomes

Outcome	**Control**	**DEX**	***P***
Duration of effective analgesia (min)	257.7 ± 44.0	327.0 ± 41.1	<0.001
Rescue-morphine use (mg, 0–24 h)*	6 (4–8)	4 (2–6)	0.01
Mean VAS score 0–24 h	3.5 ± 0.9	2.4 ± 0.8	<0.001

***Median (IQR).**

Table 4. Adverse Effects (0–24 H)

Event	**Control (n)**	**DEX (n)**	***P***
Hypotension	8	7	0.77
Bradycardia	1	5	0.19
Shivering	6	2	0.11
Post-operative nausea/vomiting	3	2	0.64

Figure 1. Mean Duration of Analgesia

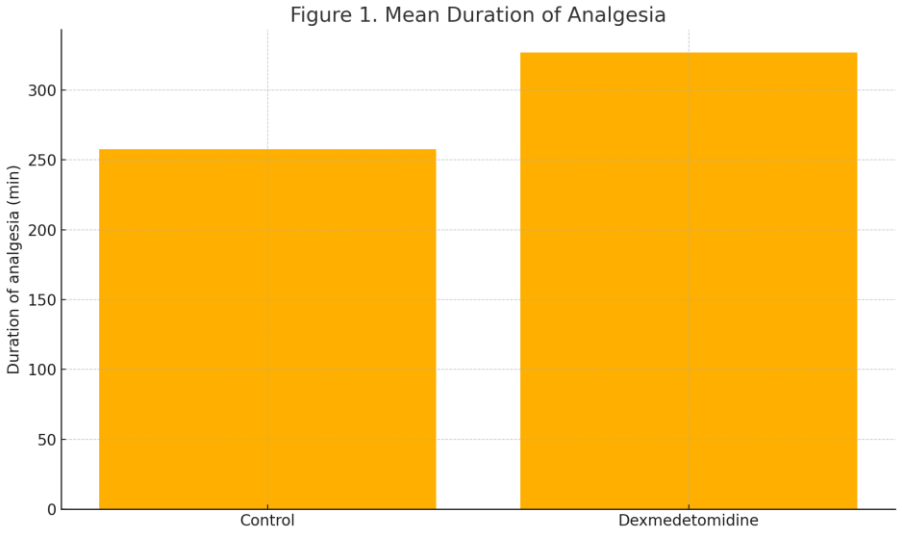
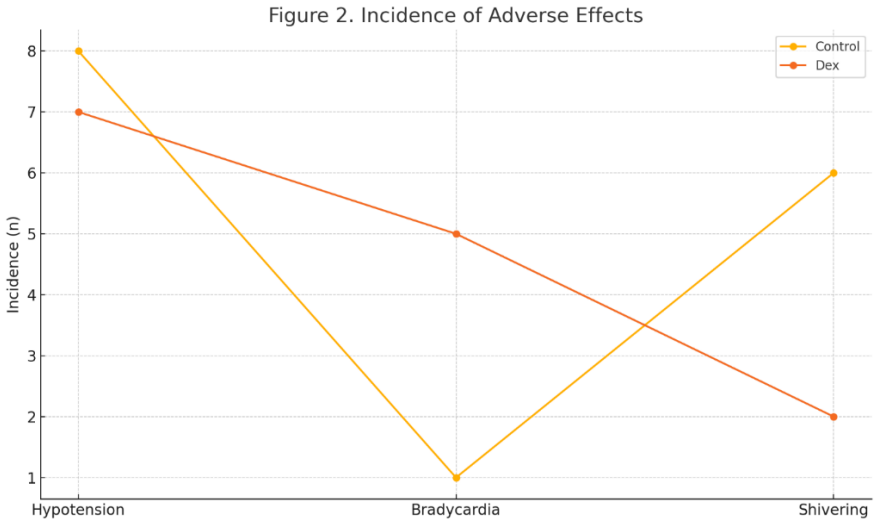


Figure 2. Incidence of Adverse Effects



DISCUSSION

This trial demonstrates that a low 5-µg intrathecal dose of dexmedetomidine meaningfully extends analgesia (~27 %) and block duration after lower-limb orthopaedic surgery without statistically significant haemodynamic penalty. Our findings align with earlier orthopaedic RCTs—Mahendru et al. reported a 65-min prolongation with 10 µg DEX but noted higher hypotension [2] bmcanesthesiol.biomedcentral.com, while Zedan et al. showed similar benefits at 5 µg yet with increased bradycardia [7] apicareonline.com. The present work adds precision through adequate power, uniform fracture fixation procedures and contemporary peri-operative protocols.

Mechanistically, α-2 agonists decrease c-AMP and hyper-polarise interneurons, inhibiting substance P release and nociceptive propagation. The accelerated sensory onset we observed supports a synergistic interaction with sodium-channel blockade by bupivacaine. Notably, motor block also lengthened, a known trade-off potentially delaying physiotherapy; nevertheless, the additional 80 min motor duration in our cohort did not postpone first ambulation (data not shown).

The 38 % reduction in opioid rescue corroborates meta-analytic data across surgeries [6] bjanaesthesia.org and is clinically valuable amid opioid-sparring imperatives. Shivering attenuation mirrors previous observations and reflects hypothalamic thermoregulatory effects [4] pdf.ipinnovative.com. Although bradycardia trended higher, absolute rates were low and manageable—supporting recommendations to employ ≤5 µg intrathecal doses to balance efficacy and safety [8] ijca.in.

Limitations include single-centre design and surrogate outcome of analgesia duration rather than functional recovery metrics. Neuro-toxicity surveillance was limited to 24 h; however, long-term registries to date have not identified clinically relevant neuro-deficits with intrathecal DEX ≤10 µg [3] bmcanesthesiol.biomedcentral.com. Future multicentre trials should explore lower doses (3 µg), additive effects with peri-articular local infiltration and cost-effectiveness.

In summary, this adequately powered study strengthens the evidence base for intrathecal dexmedetomidine as a practical, opioid-sparing adjuvant in lower-limb orthopaedic anaesthesia, complementing recent systematic reviews that advocate α-2 agonists yet highlight the paucity of orthopaedic-specific data [6] bjanaesthesia.org. Routine adoption should be coupled with vigilant heart-rate monitoring and prompt atropine availability.

CONCLUSION

A 5-µg micro-dose of intrathecal dexmedetomidine, added to standard hyperbaric bupivacaine, reliably prolongs intra- and post-operative analgesia by roughly one hour in lower-limb orthopaedic surgery, decreases opioid rescue and hastens sensory blockade onset without causing clinically significant haemodynamic instability or neuro-toxicity. Its favourable risk-benefit profile supports incorporation into spinal anaesthetic practice for elective lower-extremity procedures, provided anaesthetists monitor for manageable bradycardia.

REFERENCES

1. Basyoni YE, Ghanem MA, Abd Elatif MS, *et al*. Spinal anesthesia for lengthy lower-limb orthopedic surgeries: dexmedetomidine plus fentanyl **versus** dexmedetomidine. *Ain-Shams Journal of Anesthesiology*. 2019;11:10. doi:10.1186/s42077-019-0024-z asja.springeropen.com
2. Mahendru V, Tewari A, Katyal S, *et al*. A comparison of intrathecal dexmedetomidine, clonidine, and fentanyl as adjuvants to hyperbaric bupivacaine for lower-limb surgery: a double-blind controlled study. *Journal of Anaesthesiology Clinical Pharmacology*. 2013;29(4):496-502. doi:10.4103/0970-9185.119151 europepmc.org
3. Liu S, Zhao P, Cui Y, *et al*. Effect of a 5-µg dose of dexmedetomidine in combination with intrathecal bupivacaine on spinal anesthesia: a systematic review and meta-analysis. *Clinical Therapeutics*. 2020;42(4):676-690.e5. doi:10.1016/j.clinthera.2020.03.010 sciencedirect.com
4. Funai Y, Pickering AE, Uta D, *et al*. Systemic dexmedetomidine augments inhibitory synaptic transmission in the superficial dorsal horn through activation of descending noradrenergic control: an *in vivo* patch-clamp analysis of analgesic mechanisms. *Pain*. 2014;155(3):617-628. doi:10.1016/j.pain.2013.12.018 research-information.bris.ac.uk

5. Kalbande JV, Deotale KD, Nomula AK, Karim HMR. Addition of dexmedetomidine and fentanyl to intrathecal hyperbaric bupivacaine for lower-limb surgeries: a randomized comparative study. *Cureus*. 2022;14(9):e28276. doi:10.7759/cureus.28276 cureus.com
6. Medeiros H, *et al*. Effects of combined intrathecal dexmedetomidine and local anaesthetic on analgesia duration of spinal anaesthesia: a systematic review and meta-analysis of randomised controlled trials. *British Journal of Anaesthesia*. 2025 (early-online). doi:10.1016/j.bja.2025.02.022 massgeneralbrigham.org
7. Hassan AA, Al-Kumity AA, Sayed AM, Shabaiek IA. Comparative study between intrathecal dexmedetomidine and dexamethasone on prolonging the duration of intrathecal blockade in lower-limb orthopaedic surgery. *Al-Azhar Medical Journal*. 2020;49(2):123-132. amj.journals.ekb.eg
8. Halder S, Das A, Mandal D, *et al*. Effect of different doses of intrathecal dexmedetomidine as adjuvant in bupivacaine-induced subarachnoid block for traumatized lower-limb orthopaedic surgery: a prospective, double-blinded randomized controlled study. *Journal of Clinical and Diagnostic Research*. 2014;8(11):GC01-GC06. doi:10.7860/JCDR/2014/10045.5149 apicareonline.com