

ORIGINAL ARTICLE

Perineural Methylprednisolone Versus Dexamethasone as Ropivacaine Adjuvants in Popliteal Sciatic Nerve Block: A Randomized Double-Blind Superiority Trial

Erma Rosita^{1*}, Taufiq Agus Siswagama¹, Rudy Vitraludyono¹, Buyung Hartiyo Laksono¹¹ Department of Anesthesiology, Faculty of Medicine, Universitas Brawijaya/Dr. Saiful Anwar Regional General Hospital, Malang, Indonesia

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Corresponding author

Erma Rosita
ermarosita87@gmail.com

ABSTRACT

Background. Single-shot popliteal sciatic nerve block (PSNB) gives analgesia for distal lower limb surgery but is time-limited. Dexamethasone, a non-particulate steroid, is the usual adjuvant. Particulate methylprednisolone acetate might act as a depot and prolong analgesia, but this is untested in PSNB.

Objective. To determine whether perineural methylprednisolone prolongs analgesia more than dexamethasone added to 0.5% ropivacaine in PSNB.

Methods. In this double-blind superiority trial, 36 adults (ASA I–III) having distal lower limb surgery were randomized 1:1 to 20 mL of 0.5% ropivacaine with dexamethasone 8 mg (Group D, n = 18) or methylprednisolone acetate 40 mg (Group M, n = 18). The primary outcome was duration of analgesia (time to NRS > 3 or rescue analgesia; superiority margin 4 hours), analyzed by Kaplan–Meier and log-rank tests. Secondary outcomes were onset, pain, rescue tramadol and adverse events.

Results. Mean duration of analgesia was 18.4 ± 3.2 hours in Group D and 19.1 ± 3.5 hours in Group M (difference 0.7 hours, 95% CI –1.6 to 3.0; log-rank p = 0.610), excluding the 4-hour margin. Sensory onset (median 14.5 vs. 15.0 minutes), motor onset (18.0 vs. 19.5 minutes) and NRS (median ≤ 2 at 12, 24 and 48 hours) did not differ. Rescue tramadol was needed by 2 of 18 and 1 of 18 patients (p = 1.000). No rebound pain, neurotoxicity or infection occurred.

Conclusion. Methylprednisolone did not prolong analgesia beyond dexamethasone in PSNB. Dexamethasone remains the preferred adjuvant; methylprednisolone may be considered where it is unavailable, pending larger trials.

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1. Introduction

Acute pain after major surgery of the foot and ankle is difficult to control.¹ Fracture fixation, osteotomy, arthrodesis and forefoot reconstruction combine rich cutaneous innervation with deep pain from bone manipulation, periosteal stripping and hardware.^{2,3} Uncontrolled pain provokes a catabolic stress response, delays rehabilitation and increases the risk of chronic post-surgical pain, reported in up to 30% of patients after major foot and ankle reconstruction.⁴ Ultrasound-guided regional anesthesia has become central to multimodal analgesia,⁵ and the popliteal sciatic nerve block (PSNB) is the standard technique below the knee.⁶ Local anesthetic placed around the sciatic trunk at or just above its bifurcation gives dense sensory block of the foot and ankle and spares only the saphenous territory.⁷ Compared with systemic opioids or neuraxial anesthesia alone, it improves analgesia, reduces opioid-related adverse effects and supports earlier discharge.⁸

A single injection has a limited duration. Even with 0.5% ropivacaine or bupivacaine, effective analgesia rarely exceeds 12 to 16 hours,^{9,10} so the block often regresses during the first postoperative night, when surveillance is reduced.¹¹ Its end can bring rebound pain, an abrupt rise in

pain intensity that may exceed the pain of patients who had no block.¹² Perineural catheters prolong analgesia but add technical failure, dislodgement, infection and cost, which limits their use in high-volume ambulatory and resource-limited centers.¹³

Adjuvants are the simplest way to prolong a single-shot block.¹⁴ Alpha-2 agonists, NMDA antagonists and perineural opioids have been studied,¹⁵ but glucocorticoids have given the most reproducible prolongation of sensory block and analgesia.¹⁶ Proposed mechanisms include suppression of ectopic discharge in C-fibers, inhibition of phospholipase A2 and cytokine transcription, local vasoconstriction and increased potassium channel conductance.¹⁷ Dexamethasone sodium phosphate is water-soluble and non-particulate. It is the standard adjuvant, and meta-analyses report a prolongation of sensory block of about 6 to 8 hours without overt neurotoxicity.¹⁸

Drug supply also influences the choice. In low- and middle-income countries, regional hospitals can run out of preservative-free dexamethasone, whereas methylprednisolone acetate is widely stocked in public formularies because it is used in rheumatology, pain medicine and orthopedics. How the two steroids compare in nerve blockade is therefore of practical interest.

The analgesia added by dexamethasone is finite and rarely lasts beyond 24 hours.¹⁹ This has renewed interest in particulate preparations such as methylprednisolone acetate.²⁰ The depot hypothesis proposes that the poorly soluble microcrystalline suspension settles in connective tissue and forms a reservoir.^{21,22} From there it would release steroid slowly over days to weeks and keep perineural concentrations high long after soluble dexamethasone has been cleared.²³ The depot property is used in intra-articular and epidural injections and has been reported in fascial plane blocks such as the transversus abdominis plane (TAP) block.²²

Whether the depot concept applies to a peripheral nerve is unproven.²³ The popliteal fossa differs from a synovial cavity or a fascial plane.²⁴ The sciatic bifurcation lies within Vloka's paraneural sheath, surrounded by loose areolar fat with a rich capillary supply.²⁵ In such tissue, blood flow could wash the vehicle away and macrophages could remove the crystals, shortening the depot.²⁶ Accidental intravascular injection of a crystalline suspension into the vasa nervorum also carries a theoretical risk of embolic ischemic nerve injury, which a clear solution avoids.²⁷ A particulate steroid would therefore be justified only if it clearly prolonged analgesia compared with the safer standard.^{28,29}

We therefore tested the hypothesis that adding methylprednisolone acetate 40 mg to 0.5% ropivacaine prolongs analgesia by at least 4 hours compared with dexamethasone 8 mg in ultrasound-guided PSNB for distal lower limb surgery.³⁰ Secondary aims were block onset, pain scores, rescue opioid use, rebound pain and safety.³¹

2. Methods

2.1. Study design and reporting

This was a single-center, prospective, double-blind, parallel-group, randomized superiority trial with 1:1 allocation, reported according to the CONSORT 2010 statement.³² The allocation sequence was computer-generated (www.randomization.com) in permuted blocks of four.³³ Sequentially numbered, opaque, sealed envelopes kept in the trial pharmacy concealed allocation.

An independent licensed research pharmacist, with no role in clinical care, drug administration or data collection, prepared all study solutions in a separate cleanroom. Methylprednisolone acetate is a milky suspension and dexamethasone a clear solution,³⁴ so each 20 mL solution was drawn into an identical sterile polypropylene syringe, wrapped completely in opaque medical-grade surgical tape and connected to opaque black extension tubing (100 cm). During the block the ultrasound screen faced only the operator and the surgical drape shielded the patient's view. The anesthesiologists who performed the blocks and the research nurse who assessed outcomes did not know the allocation.

Group D received 19 mL of 0.5% ropivacaine hydrochloride plus 1 mL (8 mg) of preservative-free dexamethasone sodium phosphate. Group M received 19 mL of 0.5% ropivacaine hydrochloride plus 1 mL (40 mg) of methylprednisolone acetate suspension.

2.2. Setting

Patients were recruited between March 2025 and September 2025 at Dr. Saiful Anwar Regional General Hospital, a tertiary academic hospital in Malang, East Java, Indonesia.

2.3. Participants and eligibility

Eligible patients were adults aged 18 to 65 years with American Society of Anesthesiologists (ASA) physical status I, II or III, scheduled for elective unilateral distal lower extremity orthopedic surgery that required a PSNB for perioperative analgesia. The operations were open reduction and internal fixation (ORIF) of unstable bimalleolar or trimalleolar ankle fractures, hallux valgus osteotomy (bunionectomy), metatarsal fracture reconstruction and complex calcaneal spur excision. All patients also received spinal anesthesia for surgery (Section 2.6). Exclusion criteria were: (1) contraindications to regional anesthesia, namely refusal, skin infection or ulceration at the popliteal puncture site, active coagulopathy (international normalized ratio [INR] > 1.5, activated partial thromboplastin time ratio > 1.5 or platelet count < 80,000/ μ L) or current therapeutic anticoagulation; (2) pre-existing neurological disease, namely diabetic sensory-motor polyneuropathy, Charcot-Marie-Tooth disease, prior traumatic nerve injury or severe lumbosacral radiculopathy in the operative limb; (3) uncontrolled diabetes mellitus (glycosylated hemoglobin [HbA1c] > 8.0%); and (4) allergy to amino-amide local anesthetics or corticosteroids, chronic opioid use (daily for more than 3 months), systemic corticosteroid therapy within the previous 30 days, or severe hepatic or renal dysfunction.

2.4. Sample size

The calculation was based on an a priori superiority hypothesis.³⁵ Earlier trials of PSNB with 0.5% ropivacaine and dexamethasone suggested a baseline duration of about 18.0 hours with a standard deviation (SD) of 3.5 hours. A difference of at least 4.0 hours was considered necessary to justify a particulate steroid with a theoretical embolic risk. For a two-tailed Student's t-test with alpha 0.05 and power 80%, the submitted text required 16 patients per group. Allowing for 10% dropout or protocol deviation, 18 patients per group (36 in total) were recruited. The trial was powered for superiority and not for equivalence or non-inferiority.

2.5. Variables and operational definitions

The primary outcome was the duration of analgesia, defined as the time in hours from the end of the block injection to the first report of pain above 3 on the 11-point Numeric Rating Scale (NRS; 0 = no pain, 10 = worst imaginable pain) in the operative limb or the first request for rescue analgesia, whichever came first.³⁶ Secondary outcomes were sensory onset time, motor onset time, resting and dynamic NRS at 12, 24 and 48 hours after the block, the number of patients receiving rescue tramadol, rebound pain and safety. Rebound pain was defined a priori as a rise in NRS from below 3 to above 7 within 2 hours of sensory block regression. Safety outcomes were local anesthetic systemic toxicity (LAST), injection-site hematoma or infection, neurological deficit or paresthesia lasting more than 7 days, and steroid-induced hyperglycemia needing medical treatment.

2.6. Data sources and measurement

Patients were monitored with 5-lead electrocardiography, non-invasive blood pressure and pulse oximetry. Midazolam (0.03 to 0.05 mg/kg) and fentanyl (0.5 to 1.0 μ g/kg) were titrated for anxiolysis while patients remained responsive to voice. Patients lay in the lateral decubitus position with the operative limb uppermost and the knee flexed about 20 degrees. The popliteal fossa was cleaned with 2%

chlorhexidine gluconate in 70% isopropyl alcohol and draped under sterile conditions.

Blocks were performed with a Logiq e ultrasound system (GE Healthcare, Chicago, IL, USA) and a 10–15 MHz linear transducer in a sterile sheath.³⁷ The probe was placed transversely at the popliteal crease to identify the popliteal vessels and moved cephalad to the tibial and common peroneal nerves, which were followed to their junction into the sciatic nerve within Vloka's paraneural sheath.³⁸ The sciatic bifurcation varies: in about 75% of people it lies 5 to 7 cm above the popliteal crease and in about 25% it is higher, in the mid-thigh.³⁷ After skin infiltration with 2 mL of 1% lidocaine, a 22-gauge, 100-mm insulated echogenic needle (Stimuplex Ultra, B. Braun Medical, Melsungen, Germany) was advanced in-plane from the lateral thigh with continuous tip visualization. Entry into the subparaneural space was recognized by a faint tactile click. A 1 mL test injection showed low injection pressure (< 15 psi) and circumferential fluid spread without intraneural distension.³⁸ After negative aspiration, the 20 mL solution was injected in 5 mL aliquots with aspiration after every 3 mL. The end-point was circumferential spread of fluid around the tibial and common peroneal nerves within the intact sheath (the “donut sign”). For incisions reaching the medial malleolus, an ultrasound-guided adductor canal block with 10 mL of 0.375% ropivacaine without steroid was added.

Sensory onset was tested by pinprick with a 24-gauge blunt needle over the sural and superficial peroneal dermatomes every 2 minutes until sensation was lost completely. Motor onset was the loss of foot dorsiflexion and plantarflexion against resistance, assessed every 2 minutes. After the block, patients were taken to the operating theater and received spinal anesthesia with 10 to 12.5 mg of hyperbaric 0.5% bupivacaine through a 25-gauge Whitacre needle at L3–L4, to provide immobility and to relieve tourniquet pain; once it wore off, the PSNB served as the main postoperative analgesic.³⁹

All patients received the same scheduled analgesia: intravenous paracetamol 1000 mg every 8 hours for 24 hours, then oral paracetamol 1000 mg every 8 hours; intravenous

ketorolac 30 mg every 8 hours for the first 24 hours (if renal function was normal), then oral ibuprofen 400 mg every 8 hours; and intravenous tramadol 50 mg on demand for breakthrough pain above NRS 3. A research nurse unaware of the allocation recorded all postoperative assessments.

2.7. Statistical analysis

Analyses followed the intention-to-treat principle with a two-tailed alpha of 0.05. Continuous variables are given as mean $\pm$ SD (compared with Student's t-test) or as median [interquartile range, IQR] (Mann-Whitney U test). Categorical variables are given as number (%) and compared with Fisher's exact test or the Pearson chi-square test. Time to the primary event was analyzed with Kaplan–Meier curves and the log-rank (Mantel–Cox) test. A multivariable linear regression of duration of analgesia on group, age, sex, body mass index and duration of surgery was done as an exploratory analysis.

2.8. Ethics

The protocol was approved by the Institutional Review Board and Health Research Ethics Committee of the Faculty of Medicine, Universitas Brawijaya / Dr. Saiful Anwar Regional General Hospital, Malang, Indonesia (reference 400/082/KEPK/302/2025). The study followed the Declaration of Helsinki, and all participants gave written informed consent after verbal and written explanation of the objectives, procedures and possible adverse reactions.

3. Results

3.1. Participant flow and baseline characteristics

Forty consecutive adults were screened between March 2025 and September 2025. Four were excluded before randomization: 2 declined to take part and 2 were receiving therapeutic anticoagulation. The remaining 36 were randomized to Group D ($n = 18$) or Group M ($n = 18$). All 36 received the allocated intervention, completed follow-up without protocol deviation and were analyzed (Figure 1).

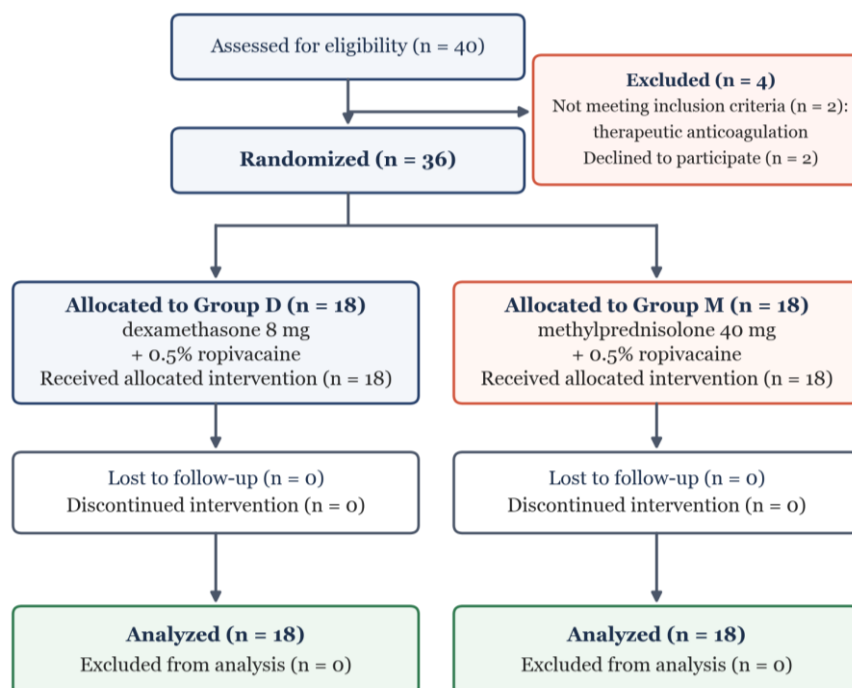


Figure 1. Flow of participants through the trial (CONSORT 2010).

Baseline characteristics were well balanced (Table 1). Mean age was 45.2 ± 11.4 years in Group D and 47.1 ± 10.8 years in Group M, and mean body mass index was 24.5 ± 3.1 and 25.1 ± 2.8 kg/m². Group D had 8 men and 10 women, and Group M had 11 men and 7 women. ASA status

Table 1. Baseline demographic, anthropometric and surgical characteristics (n = 36)

Characteristic	Group D (dexamethasone, n = 18)	Group M (methylprednisolone, n = 18)
Age, years	45.2 ± 11.4	47.1 ± 10.8
Sex, male / female, n (%)	8 (44.4) / 10 (55.6)	11 (61.1) / 7 (38.9)
Body mass index, kg/m ²	24.5 ± 3.1	25.1 ± 2.8
ASA physical status, n (%)		
I	8 (44.4)	7 (38.9)
II	9 (50.0)	9 (50.0)
III	1 (5.6)	2 (11.1)
Duration of surgery, min	85.4 ± 15.2	82.1 ± 18.5
Surgical procedure, n (%)		
ORIF of ankle fracture	10 (55.6)	9 (50.0)
Hallux valgus osteotomy	4 (22.2)	4 (22.2)
Metatarsal reconstruction	3 (16.7)	3 (16.7)
Calcaneal spur excision	1 (5.6)	2 (11.1)

Notes: Values are mean ± SD unless stated. No significance tests were applied to baseline characteristics. ASA, American Society of Anesthesiologists; ORIF, open reduction and internal fixation.

3.2. Primary outcome

Duration of analgesia did not differ between the groups (Table 2, Figure 2). It was 19.1 ± 3.5 hours in Group M and 18.4 ± 3.2 hours in Group D, a mean difference of 0.7 hours

(95% CI –1.6 to 3.0; Student's $t = 0.63$, $df = 34$, $p = 0.535$), well below the prespecified 4.0-hour margin. The log-rank test showed no difference between the survival curves ($\chi^2 = 0.26$, $df = 1$, $p = 0.610$).

Table 2. Primary and secondary pharmacodynamic outcomes

Outcome	Group D (n = 18)	Group M (n = 18)	Difference (95% CI)	p
Duration of analgesia, h, mean ± SD	18.4 ± 3.2	19.1 ± 3.5	0.7 (–1.6 to 3.0)	0.535 ^a
Log-rank test (Kaplan–Meier)			$\chi^2 = 0.26$, $df = 1$	0.610
Sensory onset, min, median [IQR]	14.5 [12.0–18.0]	15.0 [12.0–19.0]		0.520 ^b
Motor onset, min, median [IQR]	18.0 [15.0–22.0]	19.5 [16.0–24.0]		0.340 ^b

Notes: Duration of analgesia is the primary outcome; onset times are secondary outcomes. Difference is Group M minus Group D. ^aStudent's t -test ($t = 0.63$, $df = 34$), recalculated from the printed means and SDs. ^bMann-Whitney U test. CI, confidence interval; IQR, interquartile range. [Author query: median duration from the Kaplan–Meier estimate; confirm t and p against the raw data.]

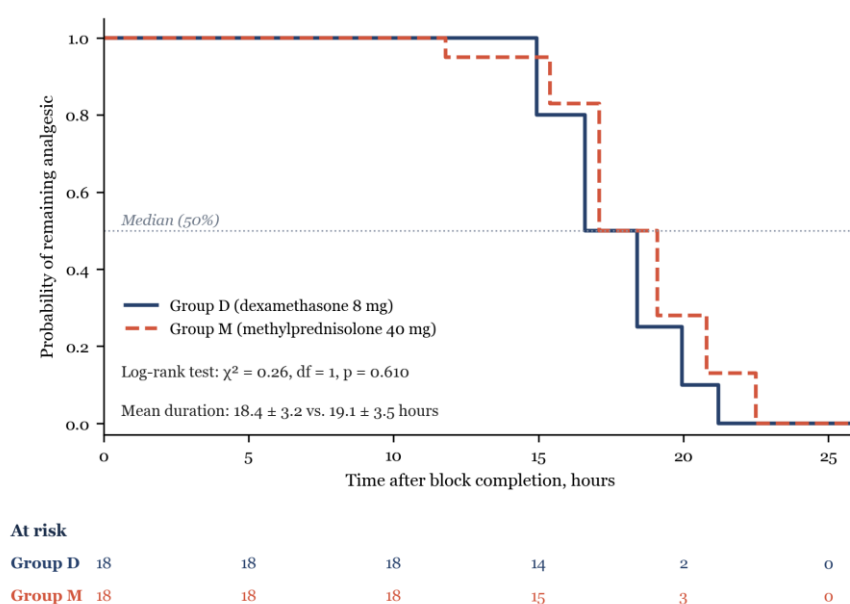


Figure 2. Kaplan–Meier curves of the duration of analgesia in Group D (dexamethasone) and Group M (methylprednisolone), with the number of patients at risk. Log-rank $\chi^2 = 0.26$, $df = 1$, $p = 0.610$.

3.3. Secondary and exploratory analyses

Onset times were similar (Table 2, Figure 3). Median sensory onset was 14.5 minutes [IQR 12.0–18.0] in Group D

and 15.0 minutes [12.0–19.0] in Group M (Mann-Whitney $U = 142.5$, $p = 0.520$), and median motor onset was 18.0 minutes [15.0–22.0] and 19.5 minutes [16.0–24.0] ($U = 135.0$, $p = 0.340$).

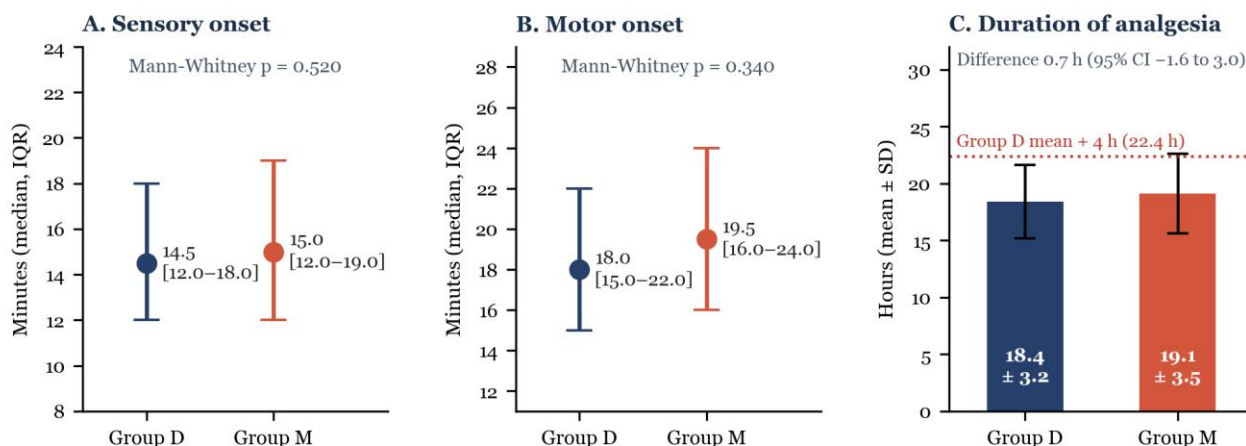


Figure 3. Block onset and duration of analgesia. (A) Sensory onset and (B) motor onset, median with interquartile range; (C) duration of analgesia, mean with SD ($n = 18$ per group). Dashed line, mean of Group D plus the 4-hour superiority margin (22.4 hours). Values are taken from Table 2.

Pain remained low in both groups (Table 3, Figure 4A). Median resting NRS was 2.0 [1.0–3.0] in both groups at 12 hours ($U = 148.5$, $p = 0.550$) and at 24 hours ($U = 132.0$, p

$= 0.150$) and 1.0 [0.0–2.0] at 48 hours ($U = 162.0$, $p = 1.000$). The median peak NRS over 48 hours was 3.0 [2.0–4.0] in both groups ($p = 0.780$).

Table 3. Postoperative resting pain scores (NRS) over 48 hours

Time point	Group D ($n = 18$)	Group M ($n = 18$)	Mann-Whitney U	p
12 hours, median [IQR]	2.0 [1.0–3.0]	2.0 [1.0–3.0]	148.5	0.550
24 hours, median [IQR]	2.0 [1.0–3.0]	2.0 [1.0–3.0]	132.0	0.150
48 hours, median [IQR]	1.0 [0.0–2.0]	1.0 [0.0–2.0]	162.0	1.000
Peak score, 0–48 hours, median [IQR]	3.0 [2.0–4.0]	3.0 [2.0–4.0]	155.0	0.780

Notes: NRS, Numeric Rating Scale (0 = no pain, 10 = worst imaginable pain); IQR, interquartile range.

Two of 18 patients (11.1%) in Group D and 1 of 18 (5.6%) in Group M received rescue tramadol (Fisher's exact test, $p = 1.000$; Table 4, Figure 4B). No patient had rebound pain,

LAST, a persistent neurological deficit, infection or hyperglycemia needing treatment.

Table 4. Rescue analgesia and adverse events

Outcome	Group D ($n = 18$)	Group M ($n = 18$)	Test	p
Rescue tramadol, n (%)	2 (11.1)	1 (5.6)	Fisher's exact	1.000
Rebound pain (NRS > 7), n (%)	0 (0.0)	0 (0.0)	—	—
Local anesthetic systemic toxicity, n (%)	0 (0.0)	0 (0.0)	—	—
Persistent neurological deficit (> 7 days), n (%)	0 (0.0)	0 (0.0)	—	—
Injection-site infection, n (%)	0 (0.0)	0 (0.0)	—	—
Hyperglycemia needing treatment, n (%)	0 (0.0)	0 (0.0)	—	—

Notes: Tramadol 50 mg was given intravenously for breakthrough pain (NRS > 3). Rebound pain was a rise from NRS < 3 to NRS > 7 within 2 hours of block regression. Tests were not applied where no events occurred. The upper 95% confidence limit for zero events in 18 patients is 16.7% (3/18). The cumulative tramadol dose was omitted (see text).

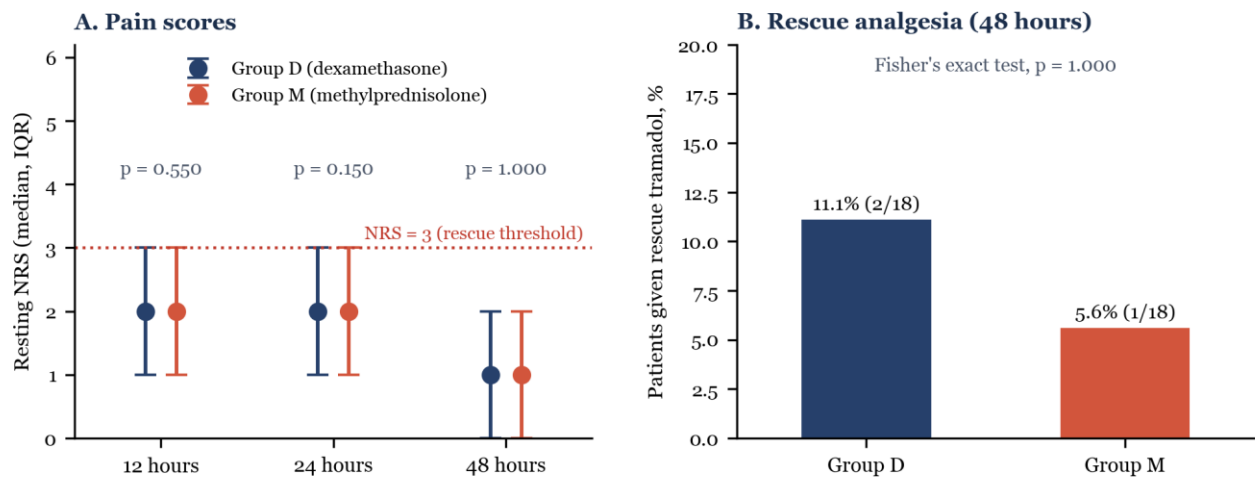


Figure 4. Secondary outcomes. (A) Median resting NRS with interquartile range at 12, 24 and 48 hours. (B) Percentage of patients receiving rescue tramadol (n/18).

In an exploratory multivariable linear regression (Table 5), the model explained little of the variance in duration of analgesia ($R^2 = 0.048$, adjusted $R^2 < 0$, $F(5, 30) = 0.299$, $p = 0.909$). Group was not an independent predictor ($B =$

0.684, $SE = 1.112$, 95% CI -1.584 to 2.952 , $p = 0.543$), and neither were age ($p = 0.415$), sex ($p = 0.787$), body mass index ($p = 0.544$) or duration of surgery ($p = 0.662$).

Table 5. Exploratory multivariable linear regression of duration of analgesia (hours)

Predictor	B	SE	Standardized β	95% CI for B	p
Group (methylprednisolone vs. dexamethasone)	0.684	1.112	0.103	-1.584 to 2.952	0.543
Age, per year	-0.042	0.051	-0.138	-0.146 to 0.062	0.415
Sex (female vs. male)	-0.312	1.145	-0.047	-2.650 to 2.026	0.787
Body mass index, per kg/m^2	0.118	0.192	0.104	-0.274 to 0.510	0.544
Duration of surgery, per minute	-0.015	0.034	-0.076	-0.084 to 0.054	0.662

Notes: B, unstandardized coefficient; SE, standard error; CI, confidence interval. Model: $R = 0.218$, $R^2 = 0.048$, adjusted $R^2 = -0.111$, $F(5, 30) = 0.299$, $p = 0.909$. The model has 5 predictors for 36 patients and is exploratory.

4. Discussion

4.1. Principal findings

In this randomized trial of 36 adults, adding methylprednisolone acetate 40 mg to 0.5% ropivacaine did not prolong analgesia after PSNB compared with dexamethasone 8 mg (19.1 ± 3.5 vs. 18.4 ± 3.2 hours; difference 0.7 hours, 95% CI -1.6 to 3.0). The 4-hour margin lay outside the confidence interval, so superiority was not demonstrated. Block onset, pain scores, rescue tramadol use and adverse events did not differ significantly, and no rebound pain or neurological complication occurred in either group.

4.2. Comparison with the published literature

Perineural dexamethasone prolongs analgesia in published meta-analyses,¹⁸ and a perineural methylprednisolone depot formulation lowered opioid consumption after knee arthroplasty in a retrospective study.²¹ Fascial plane block reports occasionally describe a modest prolongation with particulate methylprednisolone or triamcinolone compared with dexamethasone.²² Our result differs: in a nerve-sheath block, a particulate steroid gave no additional duration.

4.3. Interpretation and possible mechanisms

We measured duration, onset, pain, rescue use and adverse events. We did not measure drug concentrations, tissue persistence of crystals or nerve physiology. The following explanations are therefore hypotheses (Figure 5).

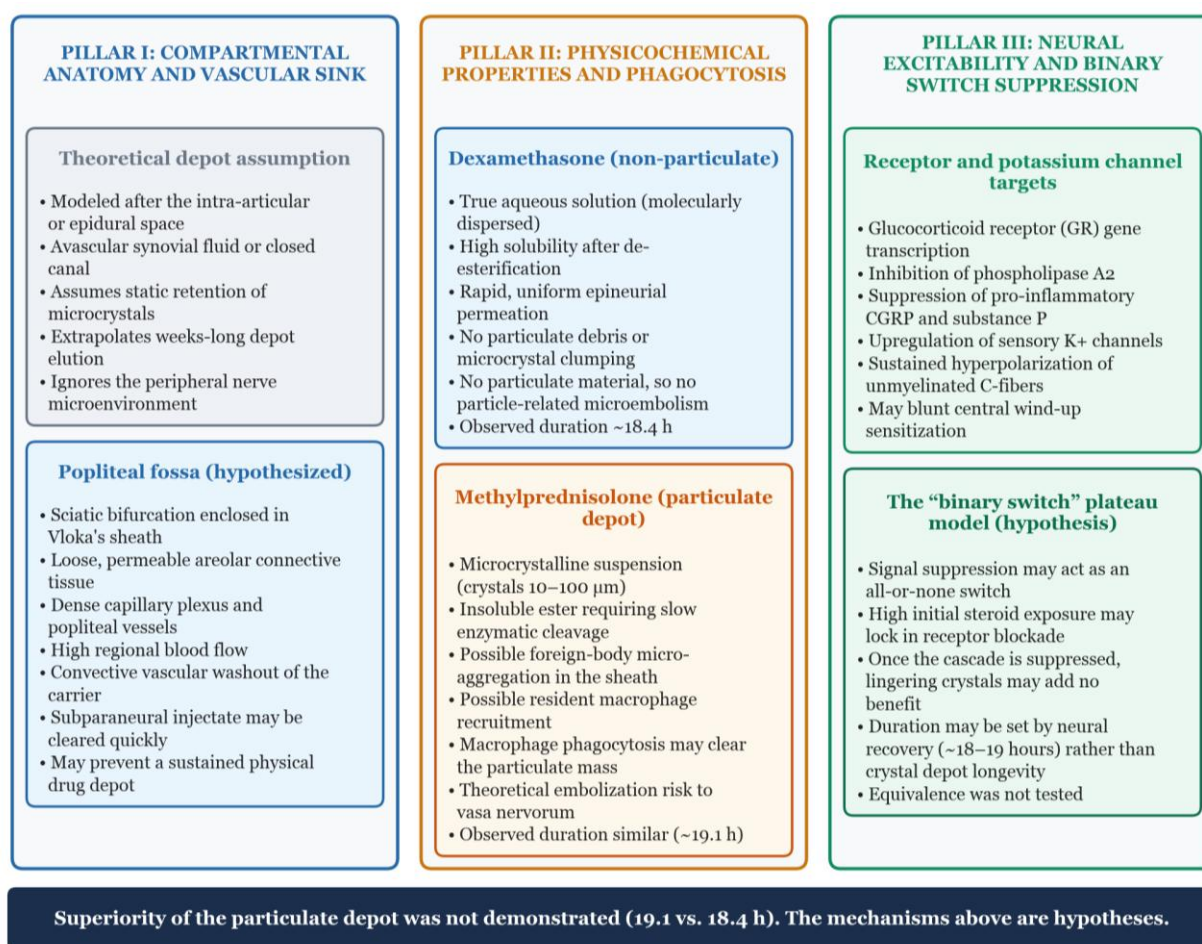


Figure 5. Hypothesized perineural mechanisms by which particulate and non-particulate steroids might differ. The pathways are drawn from the literature and were not measured in this trial.

A depot may persist in a closed, poorly perfused space such as a joint or a fascial cleft.^{16,17,22} The popliteal fossa is an open compartment of loose areolar and adipose tissue with a rich microvascular supply,²⁵ where vascular washout of the vehicle and phagocytosis of crystals by macrophages could shorten any depot.^{26–30} Glucocorticoids may also act as a threshold (“binary switch”) mechanism: once receptor-mediated suppression of nociceptive sensitization and potassium-channel-mediated hyperpolarization of C-fibers are established, lingering crystals might add little,^{17,31–33} so that block duration would be set by ropivacaine clearance and recovery of neural excitability.

4.4. Implications for practice

Dexamethasone remains the preferred adjuvant for PSNB. A difference of less than 1 hour in a block lasting about 19 hours would probably not change nursing care or discharge,⁴⁰ although the confidence interval does not exclude a larger difference. Safety should guide the choice between the two steroids.⁴¹ Intravascular injection of particulate steroid has caused spinal cord infarction in interventional pain medicine,⁴² and a similar mechanism in the vasa nervorum is theoretical.⁴³ No adverse event occurred in 36 patients, which still leaves an upper 95% confidence limit for the complication rate of 8.3% (3/36; 16.7% in each group).⁴⁴ Methylprednisolone acetate may be considered when dexamethasone is unavailable, with ultrasound guid-

ance, negative aspiration, fractional injection and low injection pressure,^{23,45} but this trial was not designed to show non-inferiority and cannot establish safety.

4.5. Strengths

Strengths are the randomized double-blind design with concealed allocation, an independent pharmacist, masked syringes and tubing, a blinded outcome assessor, a uniform multimodal analgesic regimen, a prespecified superiority margin and reporting according to CONSORT.

4.6. Limitations

The trial was small, and the confidence interval does not exclude a benefit of methylprednisolone of up to about 3 hours or a difference in rare complications. It was single-center and had no steroid-free control group, so an effect of either steroid cannot be inferred. All patients had a concurrent spinal anesthetic and some an adductor canal block, which may have masked small differences in duration. The scheduled multimodal analgesia produced a floor effect in pain scores, which probably biased differences toward the null. We took no plasma samples, so absorption and washout were not measured. The regression was exploratory with 5 predictors in 36 patients. The NRS assessment schedule and the relation between the primary endpoint and rescue use are unclear. Findings may not apply to other blocks, doses or populations.

4.7. Recommendations for future research

A larger multicenter trial should include a no-steroid control, use a prespecified non-inferiority margin if equivalence is to be claimed, standardize NRS assessment, and follow neurological outcomes. Studies of perineural drug concentrations or imaging, and dose-ranging studies of methylprednisolone, would test the mechanisms proposed here.

5. Conclusion

In adults having distal lower limb surgery, adding methylprednisolone acetate 40 mg to 0.5% ropivacaine did not prolong analgesia beyond dexamethasone 8 mg in PSNB (difference 0.7 hours, 95% CI –1.6 to 3.0), and block onset, pain scores, rescue opioid use and adverse events were similar. Dexamethasone should remain the preferred adjuvant. Methylprednisolone may be considered when dexamethasone is unavailable, but this needs confirmation in larger trials designed for non-inferiority and safety.

6. Declarations

Ethical approval and consent to participate. The study was approved by the Institutional Review Board and Health Research Ethics Committee of the Faculty of Medicine, Universitas Brawijaya / Dr. Saiful Anwar Regional General Hospital, Malang, Indonesia (reference 400/082/KEPK/302/2025). Written informed consent was obtained from all participants.

Consent for publication. Not applicable; no individually identifiable data are presented.

Availability of data and materials. The de-identified datasets analyzed during this study are available from the corresponding author on reasonable request.

Artificial intelligence (AI) use statement. The authors declare that no generative artificial intelligence tool was used in the preparation of this manuscript. The authors reviewed and edited all content and take full responsibility for the integrity, originality and accuracy of the work.

Author contribution statement. E.R. conceived the study, performed the blocks, acquired and analyzed the data and wrote the original draft (Conceptualization, Investigation, Data curation, Formal analysis, Writing – original draft). T.A.S. contributed to patient recruitment and data acquisition and reviewed the manuscript (Investigation, Validation, Writing – review & editing). R.V. contributed to the methodology and supervised the study (Methodology, Supervision, Writing – review & editing). B.H.L. conceived and supervised the study and administered the project (Conceptualization, Supervision, Project administration, Writing – review & editing). All authors approved the final version.

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Conflict of interest (competing interests) statement. The authors declare that they have no competing interests.

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