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Comparison of Clinical Outcomes between General Anesthesia and Local Anesthesia in Closed Reduction and K-wire Fixation of Distal Radius Fractures

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Purpose: To evaluate whether local anesthesia (LA) via a combined hematoma block with percutaneous site infiltration is non-inferior to general anesthesia (GA) for closed reduction and percutaneous Kirschner wire (K-wire) fixation of displaced distal radius fractures.

Methods: This study, conducted at a tertiary referral center in western Thailand, included 62 patients with closed, displaced distal radius fractures, allocated to either the LA (n=31) or the GA (n=31). The primary outcomes were radiological parameters (radial height, radial inclination, volar tilt, and ulnar variance) assessed immediately and at 6 weeks. Secondary outcomes included postoperative pain (visual analog scale, VAS), complication rates, and total direct medical costs (Thai Baht, THB).

Results: All four radiological parameters were comparable between the groups at both assessment points (all $P \geq 0.05$). The upper 95% CI bounds for the volar tilt difference were 3.56° (immediate) and 3.72° (6weeks), both below the predefined minimal clinically important difference of 5°. Postoperative VAS pain scores were comparable at both assessment points ($P=0.513$ and $P=0.839$, respectively). No pin-tract infections or anesthesia-related adverse events occurred in either group. The loss of reduction was 3.2% in each group ($P=1.000$). Total direct medical costs were significantly lower in the LA group (median 9,136 THB [IQR 8,589–13,676] vs. 12,417 THB [IQR 9,643–16,182]; median difference -3,281.75 THB; $P=0.019$), representing an approximately 26% cost reduction.

Conclusions: The combined LA technique achieved radiological reduction quality non-inferior to that of GA and comparable postoperative pain control to that of GA, while significantly reducing direct medical costs.

Keywords: distal radius fracture; local anesthesia; K-wire fixation; closed reduction; medical costs

Distal radius fractures are the most common upper extremity fractures in adults, accounting for approximately 18% of all fractures presenting to the emergency department[1]. It predominantly affects two distinct populations: older patients with osteoporosis sustaining low-energy falls, and younger, active individuals involved in high-energy trauma. Given Thailand's rapidly aging population and the increasing prevalence of osteoporosis, the burden of distal radius fractures is expected to increase substantially. Between 2021 and 2023, 123 patients underwent surgical management for displaced distal radius fractures under general anesthesia (GA) at a tertiary referral center in western Thailand.

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Closed reduction and percutaneous Kirschner wire (K-wire) fixation remain the standard surgical techniques for displaced distal radius fractures that require operative stabilization, particularly for fracture patterns classified as AO/OTA types 23-A2, 23-A3, 23-C1, and 23-C2[2,3]. Compared with volar locking plate fixation, percutaneous K-wire fixation offers a cost-effective and technically straightforward alternative with comparable medium-term radiological outcomes, making it especially suitable for resource-limited healthcare settings[4]. Adequate anesthesia is essential to achieve acceptable reduction and ensure patient comfort throughout the procedure.

GA has traditionally been the preferred modality for closed reduction and K-wire fixation in many centers, including those in Thailand. However, GA carries well-recognized risks including cardiopulmonary complications, postoperative nausea and vomiting (PONV), and prolonged hospital stay, which are particularly relevant in older patients and those with significant comorbidities[5]. Furthermore, the requirements for an anesthesiologist, dedicated operating room time, and a post anesthetic care unit impose considerable logistical and financial burdens on the healthcare system. In resource-limited settings such as district and regional hospitals in Thailand, these constraints can result in delayed surgery and, in some cases, preclude the operative management of high-risk patients.

Local anesthesia (LA), administered as a hematoma block or using the wide-awake local anesthesia no tourniquet (WALANT) technique, has emerged as a viable alternative for upper limb surgery. By injecting 1% lidocaine with epinephrine directly into the fractured hematoma, adequate analgesia for closed reduction and K-wire fixation can be achieved without systemic sedation. A systematic review by Gouveia et al.[6] demonstrated that distal radius fracture fixation under wide-awake LA yielded radiological and functional outcomes comparable to those of GA while potentially reducing costs and hospital length of stay. Similarly, Tabrizi et al.[5] reported that hematoma block in older patients with distal radius fractures resulted in lower postoperative pain scores and significantly less PONV than GA, along with shorter hospitalization. Meta-analyses of WALANT versus GA for distal radius plating further support the non-inferiority of LA with respect to radiological parameters and perioperative safety [7,8], and prospective data from Egol et al.[9] demonstrated that regional anesthesia confers outcome advantages over GA, specifically for distal radius fracture fixation. Ahmad et al.[10] further reported satisfactory surgical conditions and patient outcomes for distal radius plating performed using the wide-awake anesthesia technique.

Despite the growing body of evidence, several important knowledge gaps remain. First, most existing comparative studies have focused on open reduction and internal fixation using volar locking plates under WALANT rather than the more widely practiced percutaneous K-wire fixation technique. The specific applicability of LA to closed reduction and K-wire fixation, a procedure that requires greater traction force and may be more unpredictable in terms of patient tolerance, has not been rigorously evaluated in a prospective comparative study. Second, most prior investigations were conducted in Western or East Asian healthcare contexts, and their findings may not be directly transferable to the Thai setting, where patient demographics, healthcare infrastructure, anesthesia provider availability, and cost structures differ substantially. Third, the economic impact of the choice of anesthesia in terms of total direct medical costs has rarely been quantified in the Southeast Asian context despite its relevance to the universal health coverage policy.

Therefore, this study was conducted to evaluate whether LA via a combined hematoma block with percutaneous site infiltration is non-inferior to GA for closed reduction and K-wire fixation of distal radius fractures in a Thai tertiary care setting. The primary objective was to compare the postoperative radiological parameters between the two groups. Secondary objectives included the assessment of postoperative pain, complication rates, and total direct medical costs.

METHODS

Study Design and Setting

This prospective, non-randomized, parallel-group comparative study was conducted at a tertiary referral center in western Thailand. The study protocol was approved by the Institutional Review Board before enrollment (approval number 2023-49; approved on October 2, 2024). Written informed consent was obtained from all participants in their preferred language prior to any study procedures.

Participants

Consecutive patients presenting to the orthopedic outpatient clinic or emergency department with a distal radius fracture were screened for eligibility. Inclusion criteria were: (1) age ≥18 years; (2) closed, displaced distal radius fracture classified as AO/OTA type 23-A2, 23-A3, 23-C1, or 23-C2; (3) definitive treatment with closed reduction and percutaneous K-wire fixation performed within 2weeks of injury; and (4) ability to attend the 6-week follow-up visit. The exclusion criteria were as follows: open fracture; ipsilateral upper limb fracture; multiple fractures; pathological fracture; concomitant neurovascular injury; prior surgery on the ipsilateral wrist; and cognitive or communication impairment, precluding valid outcome assessment.

Sample size was calculated for a one-sided non-inferiority test using two independent means. The non-inferiority margin (delta) for volar tilt was set at 5°, which is the minimal clinically important difference (MCID) in distal radius fracture alignment. Assuming no true difference between the GA and LA groups and a standard deviation of 6°[2], a sample size of 23 patients per group was required to achieve 80% power with a one-sided significance level (alpha) of 0.025. To account for a 20% loss to follow-up and ensure robustness of the per-protocol analysis, the total recruitment target was 62 participants (31 per group).

Group Assignment and Study Procedure

A computer-generated allocation sequence was prepared prior to enrollment in the study. Eligible patients were offered participation, and once written consent was obtained, they were allocated sequentially to the GA or LA groups in a 1:1 ratio. Because the anesthetic technique could not be concealed from the patient or treatment team, allocation was considered open-label. Patients allocated to the LA group who subsequently declined the LA technique after full explanation were offered GA and analyzed in the GA group; these crossovers were documented prospectively. Enrollment continued until 31 patients in each group were successfully treated. Primary analysis was performed on a per-protocol basis.

Due to the inherent nature of the interventions, neither the patients nor the surgical and anesthesia teams were blinded to the group allocation. To minimize detection bias, the orthopedic surgeons performing radiological measurements and statisticians analyzing the data were blinded to the group assignments throughout the study.

Interventions

All patients underwent a standard preoperative assessment by an anesthesiologist, intravenous access, and prophylactic antibiotics (cefazolin, 1 g intravenous) within 60 min before surgery. The vital signs were continuously monitored throughout the procedure in both groups.

GA Group: Patients received GA administered by a board-certified anesthesiologist. Induction was performed with intravenous propofol (2–3 mg/kg) and fentanyl (1–2 μg/kg); the airway was maintained with either endotracheal intubation or a laryngeal mask airway at the anesthesiologist's discretion. Anesthesia was maintained with a volatile agent (sevoflurane) in anoxygen–air mixture.

LA Group: Patients received a combined hematoma block with percutaneous site infiltration performed by the operating orthopedic surgeon (Figure 1). The displaced fracture was confirmed on preoperative plain radiographs (Figure 1A), and the planned K-wire entry and exit points were identified on preoperative plain radiographs and marked on the skin surface (Figure 1B). Under aseptic technique, three injection sites were infiltrated in the same session with 1% lidocaine with epinephrine (1:100,000): (1) the fracture

hematoma (hematoma block), administered via a 21-gauge needle advanced dorsally with aspiration of blood to confirm intra-hematoma placement (Figure 1C); (2) the planned K-wire entry point on the skin surface (Figure 1D); and (3) the planned K-wire exit point on the skin surface (Figure 1E), each infiltrated with 2–3 mL. The total lidocaine dose across the three sites did not exceed 7 mg/kg. A minimum of 10 min was allowed for the anesthetic effect to develop before the procedure commenced.

For intraoperative analgesia, all patients in both the GA and LA groups received intravenous fentanyl (GA group, 1–2 μg/kg at induction; LA group, 0.5–1 μg/kg titrated intraoperatively). In the LA group, intravenous midazolam (1–2 mg) was titrated as an anxiolytic adjunct to relieve procedural anxiety and optimize cooperation in 13 patients (41.9%), while deliberately avoiding sedation that would compromise cooperative assessment.

Surgical Technique

The surgical technique was identical in both groups and performed by a single fellowship-trained orthopedic surgeon. Closed reduction was performed under fluoroscopic guidance using a manual traction–countertraction technique. One assistant provided a fixed counterforce proximal to the elbow, while the surgeon applied longitudinal traction and corrected angulation and radial/ulnar deviation (Figure 1F). A second assistant maintained the achieved reduction while two 1.6–2.0 mm K-wires were inserted percutaneously in the standard crossed-wire or parallel configuration (Figure 1G). In the LA group, subcutaneous wheels and needle-puncture marks from prior infiltration served as skin landmarks to guide accurate K-wire placement. A tourniquet was not used in either group. Intraoperative fluoroscopic images were obtained in the anteroposterior and lateral projections to confirm the reduction in quality (Figure 1H), and postoperative radiographs were taken after the patient left the operatingroom (Figure 1I). The wrist was immobilized in a short-arm circumferential cast, and all patients were admitted for postoperative monitoring. On the first postoperative day, a cast window was created over each K-wire entry site to facilitate daily pin-site wound care (Figure 1J).

The standardized postoperative analgesic regimen was identical for both groups and comprised oral paracetamol (500 mg every 6 h for 4doses), naproxen (250 mg twice daily after meals), omeprazole (20 mg once daily before meals), and tramadol (50 mg twice daily after meals). Intravenous morphine (3 mg titrated every 6 h as required) was prescribed as rescue analgesia for breakthrough pain with a Visual Analog Scale (VAS) score ≥5.

Outcome Measures

The primary outcomes were radiological parameters measured on standard anteroposterior and lateral wrist radiographs obtained immediately and 6 weeks after surgery. The measured parameters included radial height (mm), radial inclination (°), volar tilt (°), and ulnar variance (mm). All measurements were performed independently by two orthopedic surgeons who were blinded to the group assignments, using a calibrated Picture Archiving and Communication System. Interrater reliability was assessed using the intraclass correlation coefficient (ICC), and discordant measurements (differences >2 mm or >2°) were resolved by consensus.

Secondary outcomes were: (1) postoperative pain intensity, assessed on a VAS (0=no pain, 10=worst imaginable pain) at 0 and 6 h after surgery; (2) requirement for supplemental analgesic medication within 6 h; (3) operative time (skin preparation to cast application, in min); (4) length of hospital stay (days); (5) 6-week complication rate, including pin-tract infection (defined as erythema, warmth, and purulent discharge around the K-wire requiring antibiotic treatment), loss of reduction (defined as >5° change in volar tilt or >2 mm change in radial height compared with immediate postoperative values), and any adverse events related to the anesthetic; (6) PONV, including discontinuation of tramadol attributable to PONV; and (7) total direct medical costs (Thai Baht [THB]), comprising anesthetic drugs, operating room charges, ward accommodation, and analgesia.

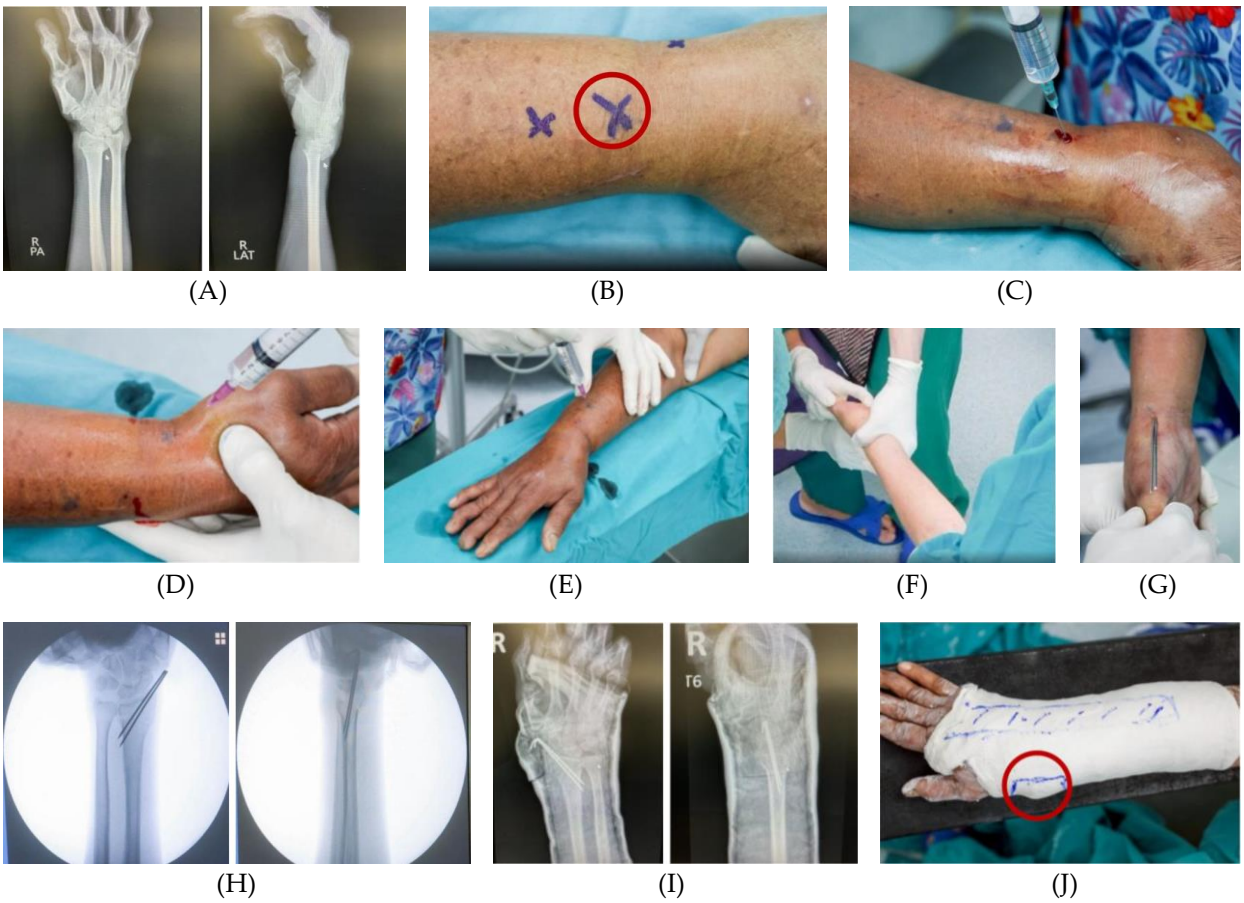

Fig. 1 Surgical procedure of local anesthesia (LA) via a combined hematoma block with percutaneous site infiltration. (A) Preoperative plain radiographs (anteroposterior and lateral views) demonstrate a displaced distal radius fracture before reduction. (B) Three planned injection sites marked on the skin surface: fracture hematoma entry point (circle), planned K-wire entry point (×), and planned K-wire exit point (×). (C) Hematoma block injection administered via a 21-gauge needle advanced dorsally into the fracture hematoma. (D) Percutaneous infiltration at the planned K-wire entry point. (E) Percutaneous infiltration at the planned K-wire exit point. (F) Closed reduction performed under manual traction–countertraction technique. (G) Percutaneous K-wire fixation with wires in situ. (H) Intraoperative fluoroscopic images confirm acceptable fracture reduction and K-wire placement. (I) Postoperative plain radiographs (anteroposterior and lateral views) demonstrate satisfactory reduction. (J) Short-arm circumferential cast with two windows marked on the cast surface: a longitudinal window along the K-wire track (dashed line, to facilitate rail-road slit for pressure relief) and a circular window over each K-wire entry site (circle, for daily pin-site wound care).

Statistical Analysis

Analyses were performed on a per-protocol basis using R (version 4.3.1). Continuous variables were assessed for normality (Shapiro–Wilk test) and summarized as mean ± SD or median (IQR); categorical variables as frequency (%). Independent-samples *t*-test or Mann–Whitney *U* test was used to compare continuous outcomes, and chi-square or Fisher's exact test was used to compare categorical variables. Mean or median differences with 95% confidence intervals (CIs) are reported. Interrater reliability was assessed using two-way mixed-effects ICC (absolute agreement). Statistical significance was defined as a two-tailed *P*-value <0.05.

To address the exclusion of two patients (one per group) who underwent revision for loss of reduction, an intention-to-treat (ITT) sensitivity analysis of the 6-week radiological parameters was performed by carrying the immediate-postoperative values forward (last-observation-carried-forward) for these patients (n=31 per group). As no patients crossed over between the groups, the as-treated and ITT populations were otherwise identical.

RESULTS

Eighty-four patients were assessed for eligibility during the study period. Twenty-two patients were excluded: five were aged <18 years, four had an open fracture, three had an ipsilateral upper limb fracture, five had multiple fractures, zero had a pathological fracture, zero had a concomitant neurovascular injury, and five had cognitive or communication impairment. None of the eligible patients refused participation. The remaining 62 patients were allocated to either the GA (n=31) or LA (n=31) group (Figure 2). None of the LA patients declined the technique after allocation, and no LA patient required intraoperative conversion to GA.

Baseline characteristics

Baseline characteristics are summarized in Table 1. The two groups were comparable with respect to age, body mass index, mechanism of injury, injured side, and ASA of Anesthesiologists classification (P>0.05). However, the LA group had a significantly higher proportion of female patients (87.1% vs. 54.8%, P=0.012). The distribution of fracture types according to the AO/OTA classification was comparable between the two groups (P=1.000).

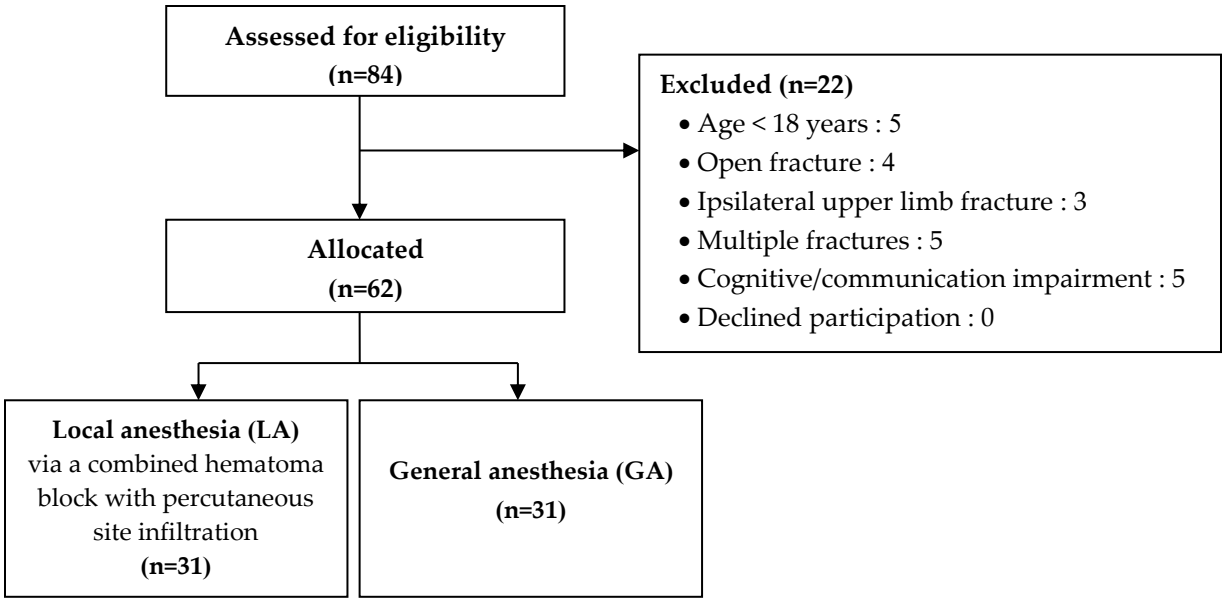

Fig. 2 Flow diagram.

Primary Outcomes

Radiological Parameters

Both groups achieved comparable immediate postoperative radiological parameters (Table 2). There were no statistically significant differences in radial height (mean difference [MD] -0.85 mm, 95% CI -2.03 to 0.32; P=0.150), radial inclination (MD -1.03°, 95% CI -2.72 to 0.66; P=0.226), volar tilt (MD 0.06°, 95% CI -3.43 to 3.56; P=0.971), or ulnar variance (MD 0.32 mm, 95% CI -0.03 to 0.67; P=0.072) at the immediate postoperative assessment. These findings were maintained at 6weeks; none of the four radiological parameters differed significantly between groups (all P≥0.05). The

narrow confidence intervals for volar tilt at both time points (immediate: 95% CI -3.43 to 3.56°; 6-week: 95% CI -3.39 to 3.72°) are well within the predefined MCID of 5°, supporting the non-inferiority of LA with respect to reduction quality.

Table 1 Baseline Characteristics of the Sample (n=62).

Characteristics	Total (n=62)	General Anesthesia (n=31)	Local Anesthesia (n=31)	*P*-value
Gender, n (%)				0.012[a]
Male	18 (29.0%)	14 (45.2%)	4 (12.9%)	
Female	44 (71.0%)	17 (54.8%)	27 (87.1%)	
Age (years), Mean ± SD	56.92 ± 17.00	52.35 ± 18.66	61.48 ± 14.01	0.034[b]
<50	16 (25.8%)	10 (32.3%)	6 (19.4%)	0.200[a]
50–59	17 (27.4%)	10 (32.3%)	7 (22.6%)	
≥60	29 (46.8%)	11 (35.5%)	18 (58.1%)	
BMI (kg/m²), Mean ± SD	23.84 ± 3.95	23.45 ± 4.20	24.23 ± 3.70	0.441[b]
Underweight (<18.5)	3 (4.8%)	2 (6.5%)	1 (3.2%)	0.534[c]
Normal (18.5–22.9)	24 (38.7%)	14 (45.2%)	10 (32.3%)	
Overweight (23.0–24.9)	14 (22.6%)	5 (16.1%)	9 (29.0%)	
Obese (≥25)	21 (33.9%)	10 (32.3%)	11 (35.5%)	
Comorbidities, n (%)				0.300[a]
None	25 (40.3%)	15 (48.4%)	10 (32.3%)	
Present	37 (59.7%)	16 (51.6%)	21 (67.7%)	
- Hypertension	31 (50.0%)	14 (45.2%)	17 (54.8%)	0.611[a]
- Diabetes Mellitus	6 (9.7%)	1 (3.2%)	5 (16.1%)	0.195[c]
ASA Classification, n (%)				0.056[a]
ASA I	21 (33.9%)	13 (41.9%)	8 (25.8%)	
ASA II	30 (48.4%)	16 (51.6%)	14 (45.2%)	
ASA III	11 (17.7%)	2 (6.5%)	9 (29.0%)	
Mechanism of Injury, n (%)				0.633[a]
Same-level fall	33 (53.2%)	17 (54.8%)	16 (51.6%)	
Fall from height	15 (24.2%)	6 (19.4%)	9 (29.0%)	
Road traffic accident	14 (22.6%)	8 (25.8%)	6 (19.4%)	
Injured Side, n (%)				0.271[a]
Right	19 (30.6%)	12 (38.7%)	7 (22.6%)	
Left	43 (69.4%)	19 (61.3%)	24 (77.4%)	
Dominant Hand, n (%)				-
Right	62 (100.0%)	31 (100.0%)	31 (100.0%)	
AO/OTA Classification, n (%)				1.000c
23-A2	5 (8.1%)	2 (6.5%)	3 (9.7%)	
23-A3	21 (33.9%)	11 (35.5%)	10 (32.3%)	
23-C1	21 (33.9%)	10 (32.3%)	11 (35.5%)	
23-C2	15 (24.2%)	8 (25.8%)	7 (22.6%)	

Abbreviations: BMI, body mass index; ASA, American Society of Anesthesiologists.

[a]Chi-square test; [b]Independent *t*-test; [c]Fisher's exact test.

Table 2 Comparison of Primary Outcomes (Radiological Parameters).

Primary Outcomes (Mean ± SD)	**General Anesthesia**	**Local Anesthesia**	**Mean Difference (95% CI)**	***P*-value**[a]
Immediate Postoperative Radiographs	(n=31)	(n=31)	(n=31)	
Radial height (mm)	11.28 ± 2.04	10.43 ± 2.55	-0.85 (-2.03 to 0.32)	0.150
Radial inclination (degrees)	23.10 ± 2.98	22.06 ± 3.63	-1.03 (-2.72 to 0.66)	0.226
Volar tilt (degrees)	7.74 ± 7.43	7.81 ± 6.29	0.06 (-3.43 to 3.56)	0.971
Ulnar variance (mm)	0.62 ± 0.82	0.94 ± 0.52	0.32 (-0.03 to 0.67)	0.072
6-Week Postoperative Radiographs	(n=30)[b]	(n=30)[b]	(n=30)[b]	
Radial height (mm)	10.58 ± 1.93	9.82 ± 2.37	-0.76 (-1.88 to 0.36)	0.181
Radial inclination (degrees)	22.50 ± 3.93	21.37 ± 3.66	-1.13 (-3.10 to 0.83)	0.253
Volar tilt (degrees)	8.03 ± 7.43	8.20 ± 6.29	0.17 (-3.39 to 3.72)	0.926
Ulnar variance (mm)	1.07 ± 0.93	1.44 ± 0.77	0.37 (-0.07 to 0.81)	0.096

Abbreviations: [a]Independent *t*-test; [b]One patient per group was excluded from the 6-week analysis following loss of reduction requiring revision surgery (n=30 per group).

In the ITT sensitivity analysis (n=31 per group), the between-group differences in all four 6-week radiological parameters remained non-significant (radial height, MD -1.02 [95% CI -2.19 to 0.14]; radial inclination, MD -1.35 [-3.31 to 0.60]; volar tilt, MD 0.00 [-3.48 to 3.48]; ulnar variance, MD 0.26 [-0.19 to 0.72]; all $P \geq 0.05$), and the 95% CI for volar tilt remained within the predefined 5° margin. Therefore, the conclusions of the per-protocol analysis remained unchanged.

Table 3 Comparison of Secondary Outcomes (Postoperative Pain and Complications).

Secondary Outcomes	**General Anesthesia (n=31)**	**Local Anesthesia (n=31)**	**Mean Difference (95% CI)**	***P*-value**
VAS Pain Score, Mean±SD				
Immediately postoperation	3.16±0.45	3.10±0.30	-0.06 (-0.26 to 0.13)	0.513[a]
6-h postoperation	2.81±0.79	2.84±0.37	0.03 (-0.28 to 0.35)	0.839[a]
Additional Analgesics Required, n (%)				
Immediately postoperation	1 (3.2%)	0 (0.0%)	-	1.000[b]
6-h postoperation	2 (6.5%)	0 (0.0%)	-	0.492[b]
Postoperative Complications, n (%)				
Pin-tract infection	0 (0.0%)	0 (0.0%)	-	-
Loss of reduction	1 (3.2%)	1 (3.2%)	-	1.000[b]
Adverse side effects	0 (0.0%)	0 (0.0%)	-	-

Abbreviations: VAS, visual analog scale. [a]Independent *t*-test; [b]Fisher's exact test.

Secondary Outcomes

Postoperative Pain and Complications

Postoperative pain scores and complication data are presented in Table 3. Mean VAS scores were similar between groups at both assessment points: immediately postoperatively (GA 3.16 ± 0.45 vs. LA 3.10 ± 0.30; MD -0.06, 95% CI -0.26 to 0.13; P=0.513) and at 6 h (GA 2.81 ± 0.79 vs. LA 2.84 ± 0.37; MD 0.03, 95% CI -0.28 to 0.35; P=0.839). Supplemental analgesia was required by one GA patient immediately postoperatively and two GA patients at 6 h (rescue intravenous morphine); none of the LA patients required additional analgesia at either time point, although these differences did not reach

statistical significance (*P*=1.000 and *P*=0.492, respectively). Tramadol was discontinued because of PONV in three patients (9.7%) in the GA group and four patients (12.9%) in the LA group.

No pin-tract infections or adverse events attributable to the anesthetic technique were recorded in either group. Loss of reduction occurred in one patient per group (3.2% each; *P*=1.000); both cases required revision surgery and were excluded from the 6-week radiological analysis, consistent with the prespecified per-protocol criteria.

Table 4 Comparison of Operative Time, Hospital Stay, and Medical Costs.

Time and Economic Outcomes	General Anesthesia (n=31)	Local Anesthesia (n=31)	Median Difference	*P*-value[a]
Waiting time for surgery (days)	0 (0–1)	0 (0–1)	0	0.842
Operative time (min)	15 (15–15)	15 (15–15)	0	0.313
Length of hospital stay (days)	1 (1–2)	1 (1–1)	0	0.137
Total medical cost (THB)	12,417 (9,643–16,182)	9,136 (8,589–13,676)	-3,281.75	0.019

Data are presented as medians (Q1–Q3) unless otherwise stated. THB = Thai Baht. [a]Mann–Whitney *U* test.

Table 5 Itemized direct anesthetic and procedural cost comparison between the GA and LA protocols.

Cost Component	Unit Cost (THB)	GA Group	LA Group
Fentanyl injection (1 ampule)	20	✓	✓
Propofol injection (1 ampule)	78	✓	-
Sevoflurane inhalation (per h)	450	✓	-
Succinylcholine injection (1 ampule)	203	✓	-
Short-arm cast application	250	✓	✓
Cast splitting	100	✓	✓
Closed reduction and internal fixation (radius)	4,500	✓	✓
General anesthesia fee (initial 1 h)	1,400	✓	-
Carbon dioxide monitoring fee	200	✓	-
Anesthetic agent monitoring fee	300	✓	-
Medical device: oxygen administration	160	✓	-
Medical device: hypo-/hyperthermia unit	200	✓	-
Monitored anesthesia care (MAC) with LA fee	500	-	✓
Total Direct Cost (THB)		**7,861**	**5,370**

Abbreviations: GA, general anesthesia; LA, local anesthesia; MAC, monitored anesthesia care; THB, Thai Baht.
✓ indicates the item was incurred; — indicates not incurred. The total direct cost reflects anesthetic, procedural, and monitoring items only, and does not include ancillary hospital charges.

Operative Details and Economic Outcomes

Operative and economic outcomes are summarized in Table 4. The median waiting time for surgery (GA 0 days [IQR 0–1] vs. LA 0 days [IQR 0–1]; *P*=0.842) and median operative time (15 min [IQR 15–15] in both groups; *P*=0.313) were identical between the groups. The median length of hospital stay showed a non-significant trend toward shorter stays in the LA group (GA 1 day [IQR 1–2] vs. LA 1 day [IQR 1–1]; *P*=0.137). Total direct medical costs were significantly lower in the LA group (median 9,136 THB [IQR 8,589–13,676] vs. 12,417 THB [IQR 9,643–16,182] in the GA group; median difference -3,281.75 THB; *P*=0.019), representing a median cost reduction of approximately 26%.

The principal drivers of the cost differences between the groups were anesthetic drugs, monitoring equipment fees, and professional

anesthesia fees. Based on the itemized institutional charges, the direct anesthetic and procedural costs were 7,861 THB in the GA group and 5,370 THB in the LA group, with a direct cost reduction of 2,491 THB in favor of LA (Table 5). When all ancillary hospital costs, including laboratory investigations, medical supplies, ward accommodation, nursing care, and discharge medications, were added, the overall median total cost remained significantly higher in the GA group, with a median difference of 3,281.75 THB.

DISCUSSION

This study found that LA via a combined hematoma block with percutaneous site infiltration achieved a radiological reduction quality comparable to that of GA for closed reduction and percutaneous K-wire fixation of displaced distal radius fractures. Across all four radiological parameters at immediate and 6-week time points, no statistically significant between-group differences were observed, and the 95% CIs for volar tilt difference at both time points (immediate: -3.43° to 3.56°; 6-week: -3.39° to 3.72°) fell well within the predefined MCID of 5°. Postoperative pain scores were comparable, and total direct medical costs were significantly lower in the LA group (median difference -3,281.75 THB; *P*=0.019). Collectively, these findings support the use of combined LA as a safe, effective, and economically advantageous alternative to GA in a Thai tertiary care setting.

The radiological equivalence observed in this study is consistent with previous evidence of LA for distal radius fracture surgery. A systematic review by Gouveia et al.[6], which synthesized studies on the fixation of distal radius fractures under wide-awake LA, found that LA yielded radiological and clinical outcomes comparable to those of GA while offering potential cost and logistical advantages. Tabrizi et al.[5] reported that hematoma block in patients aged >60 years with distal radius fractures produced lower postoperative pain in the first 6 h, markedly less PONV, and shorter hospital stay compared with GA, without any serious local complications. The findings of comparable postoperative pain scores and low complication rates are broadly consistent with those of these reports. The lower PONV and shorter hospitalization reported by Tabrizi et al.[5]in favor of LA were not directly reproduced in this cohort; PONV leading to the discontinuation of oral tramadol occurred at a similarly low frequency in both groups (GA 9.7% vs. LA 12.9%), and the length of stay differed only as a non-significant trend. This likely reflects the differences in the study population, together with the fact that anesthesia-attributable PONV and patient satisfaction were not prespecified outcomes.

A meta-analysis by Tu et al.[7] and a retrospective cohort study by Chen et al.[8], who compared WALANT with balanced anesthesia for distal radius plating, similarly demonstrated the non-inferiority of LA with respect to radiological outcomes and perioperative safety. Notably, Egol et al.[9] prospectively demonstrated that regional anesthesia was associated with superior functional outcomes compared GA following distal radius fracture fixation, providing additional evidence that avoiding GA may benefit patients beyond the intraoperative period. Ahmad et al.[10] also reported satisfactory perioperative results and high patient acceptance of distal radius plating under wide-awake LA, further supporting the safety and feasibility of non-GA techniques. It is important to note, however, that these studies examined open reduction and internal fixation with volar locking plates, a technically more demanding procedure performed under direct vision. The present study specifically addresses closed reduction and K-wire fixation, a more commonly performed and largely tactile procedure that requires traction force and relies on fluoroscopic rather than direct visual feedback. This is an area for which prospective comparative data are lacking. The results demonstrate that adequate surgical conditions for this technique can be reliably achieved using the combined LA technique without compromising the quality of reduction.

The significantly lower total direct medical costs in the LA group (median 9,136 vs. 12,417 THB; *P*=0.019) were related to healthcare resource allocation under Thailand's universal health coverage scheme. These savings primarily reflect the elimination of anesthesiologist fees and reduced

anesthetic drug expenditures with the potential for shorter post anesthetic care unit monitoring. The economic advantage of LA is particularly relevant for district and regional hospitals in Thailand, where anesthesiologist availability is limited and older patients may carry prohibitive anesthetic risks under GA.

The baseline imbalance, with the LA group being significantly older and predominantly female, reflects the clinical allocation process, whereby higher-risk patients were preferentially directed toward LA, reflecting real-world practice rather than methodological flaws. Equivalent radiological outcomes despite older age and greater risk of osteoporosis in the LA group may further support the adequacy of the combined LA technique. Future randomized studies with covariate adjustments are required to provide definitive evidence.

This study had several limitations. The non-randomized design and baseline group differences preclude definitive causal inferences. As a non-randomized study, the primary analysis was conducted per protocol, as appropriate for a non-inferiority design; no patient crossed over between groups, and an ITT sensitivity analysis yielded consistent conclusions. Follow-up was limited to 6weeks, without the assessment of long-term functional or patient-reported outcomes. A single-center, single-surgeon design limits generalizability. The VAS was assessed at only two time points, and PONV was captured only indirectly through tramadol discontinuation, while anesthesia-attributable PONV and patient satisfaction were not prespecified outcomes. Future prospective randomized studies should incorporate these endpoints. The use of supplemental intravenous analgesia in the LA group was titrated at the anesthesiologist's discretion, and the cumulative dose was not systematically recorded, making a complete comparison of intraoperative analgesic requirements difficult. Despite these limitations, this study provided prospective, contextually relevant evidence from a Southeast Asian tertiary care setting regarding underexplored clinical questions.

CONCLUSIONS

In conclusion, LA via a combined hematoma block with percutaneous site infiltration produced radiological reduction quality non-inferior to and postoperative pain control comparable with that achieved with GA for closed reduction and K-wire fixation of displaced distal radius fractures, while reducing total direct medical costs by approximately 26%. These findings support the adoption of the combined LA technique as a feasible and cost-effective anesthetic strategy for this procedure in the Thai healthcare context, particularly for older adults or high-risk patients for whom GA carries additional risks. Prospective randomized trials with longer follow-up periods and patient-reported functional outcomes are warranted to further establish the role of LA in this setting.

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