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ORIGINAL RESEARCH REGIONAL ANESTHESIA

A randomized clinical trial of addition of IPACK block or selective tibial nerve block to adductor canal block for postoperative pain management after total knee arthroplasty

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ABSTRACT

Background & Objective: Postoperative pain after total knee arthroplasty (TKA) is a significant factor influencing the surgical outcome. Adductor canal block (ACB) has no analgesic effect on the posterior knee capsule, which is innervated by the terminal branches of the tibial nerve and the posterior branch of the obturator nerve. We compared ACB plus IPACK block (infiltration of the interspace between the popliteal artery and the posterior capsule of the knee) versus ACB with selective tibial nerve block (TNB) for pain management after TKA.

Methodology: We enrolled 70 patients, aged 40-80 y, body mass index of 18.5-35 kg/m^2, scheduled for TKA in the study. Patients were randomly allocated to one of the two equal groups; Group 1 to receive ACB with IPACK block and Group 2 to receive ACB with TNB. Duration of sensory block, motor block, time to first rescue analgesic request, time to ambulation, and hospital length were noted in both groups. The 0-10 numeric rating scale (NRS) was used to measure the pain intensity in the patients.

Results: Duration of sensory block, motor block, time to first rescue analgesic request, time to ambulation, and hospital length were significantly increased in Group 2 than in Group 1 ($P < 0.001$). The numeric rating scale was significantly lower in Group 2 at 8 h only but was comparable in other measurements. Range of motion and the strength of quadriceps were comparable between both groups at 24, 48, and 72 h postoperatively.

Conclusions: Adductor canal block with IPACK preserved motor function better and reduced the time to ambulation and hospital stay compared to tibial nerve block with adductor canal block. However, adductor canal block with selective tibial nerve block prolongs sensory block, the time to first analgesia request, and reduces postoperative opioid consumption at first 24 h. Both methods had a comparable effect on quadriceps strength.

Abbreviations: ACB - Adductor Canal Block; IPACK - Infiltration of local anesthetic between the Popliteal Artery and Capsule of the Knee; TNB - Tibial Nerve Block; TKA - Total Knee Arthroplasty

Key words: Total Knee Arthroplasty; Adductor Canal Block; IPACK; Selective Tibial Nerve Block.

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1. INTRODUCTION

Total knee arthroplasty (TKA) is effective for relieving chronic arthritic pain and promoting recovery, but most of the patients suffer from acute postoperative pain. Severe knee pain after TKA surgery has been stated by almost half of the patients.[1] Postoperative pain is a significant factor influencing the surgical outcome, as it may impede rehabilitation and restrict the joint range of motion.[2] Consequently, ideal analgesia for postoperative pain related to TKA is vital to accelerate the mobilization, functional recovery, discharge, and the patient satisfaction.[3]

Regional methods have been applied for pain management after TKA.[4,5] Regional techniques may offer effective pain relief but can weaken the quadriceps muscle after surgery, limiting the patient's ability to walk.[6] Adductor canal block (ACB) is one of the effective methods of pain relief without producing weakness in the quadriceps muscle after TKA. However, it has no pain-relieving effect on the posterior knee capsule, which is innervated by the terminal branches of both the tibial nerve and the posterior branch of the obturator nerve. Therefore, additional analgesia is required with ACB.[7] ACB may be combined with periarticular multimodal drug injection to supplement analgesia.[8]

The sciatic nerve innervates the posterior aspect of the knee. This nerve is not routinely blocked because clinicians are afraid of causing a motor block, which could compromise the postoperative evaluation.[9]

Tibial nerve block (TNB) is recommended as it includes just the tibial nerve component of the sciatic nerve and produces less block of the common peroneal nerve (CPN).[10] However, the proximal distribution of local anesthetic (LA) to the sciatic nerve might result in unwanted motor blockade.[11]

Nowadays, ultrasound (US) guided LA infiltration of the interspace between the popliteal artery and the posterior capsule of the knee (IPACK) provides adequate posterior knee analgesia by targeting only the genicular stems of the sciatic nerve with no effect on the motor function.[12] IPACK block technique is selective for the posterior knee's terminal sensory branches, resulting in effective analgesia with muscle power sparing.[13,14]

Only a few trials assessed ACB with IPACK block and ACB with TNB for pain management after TKA. Therefore, we compared the analgesic efficacy of ACB with IPACK block versus ACB with TNB in TKA.

2. METHODOLOGY

This randomized, single-blind trial was conducted in 70 patients, aged 40-80 y, with a body mass index (BMI) of 18.5-35 kg/m^2, ASA 1, 2, or 3, scheduled for TKA, at Tanta University Hospitals, Egypt, from January 2022 to June 2022. The study was performed after approval from the Ethical Committee (Approval code: 35151/12/21) and registration at clinicaltrials.gov (NCT05473559). All patients gave informed written consent.

The sample size calculation was done by G*Power 3.1.9.2 (Universitat Kiel, Germany). We performed a pilot study on 10 patients in each group) and found that the mean ± SD of postoperative morphine consumption at 24 h (the primary outcome) was 3.6 ± 1.9 in Group A and 2.1 ± 1.45 in Group B. Based on the following: 0.90 effect size, 0.05 α error, 90% power of the study, group ratio 1:1 and fourteen patients were added to each group to overcome dropout. Therefore, 35 patients were enrolled in each group.

Exclusion criteria were patients with hepatic or renal insufficiency, allergy to any study medications, diabetes mellitus, any contraindication to neuraxial and/or regional anesthesia, and neuropathy of lower limb at the site of surgery.

Randomization was conducted using opaque, sealed envelopes that indicated the assigned group. Group 1 (n = 35) to receive ACB with IPACK block, and Group 2 (n = 35) to receive ACB with selective TNB. The outcome assessor was blinded. All patients underwent complete history taking, clinical examination, and routine laboratory investigations.

2.1. Procedure

In the holding area, a 20-gauge IV cannula was passed and the patients were preloaded with Ringer's lactate solution (10 ml/kg). Spinal anesthesia was performed with 3 ml of 0.5% hyperbaric bupivacaine administered via the L3-4 or L2-3 vertebral interspaces. All blocks were performed by a 6 MHz curvilinear US probe (Philips US model cx 50).

The transducer located the adductor canal in the middle of the thigh, halfway between the inguinal crease and the patella. Superficial femoral artery, adductor longus muscle, sartorius muscle, and adductor magnus muscle were identified. The target injection site was located

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anterolateral to the artery as a hyperechoic structure (saphenous nerve and nerve to vastus medialis nerve). A 22-gauge, 100 mm needle was inserted in a lateral to medial direction under the US guidance. Inj. 0.25% bupivacaine 15 mL was administrated after ensuring the correct needle placement (Figure 1).

2.2. IPACK block technique

The knee of the effected side was flexed to 90 degrees, and after popliteal vessels identification, a 22-gauge, 100 mm needle was placed from medial to lateral into the space between the popliteal artery and the capsule of the posterior knee; 20 ml of bupivacaine 0.25 % was injected along the entire space.

2.3. Tibial nerve block technique

Lateral decubitus position was made of the patients. A curvilinear ultrasound probe was placed at the popliteal crease to visualize the popliteal vessels in the short axis. The tibial nerve was observed as an oval, hyperechoic structure located posterior to the popliteal vessels, then cephalad, and the convergence of the CPN and tibial nerve were detected. TNB was done near the popliteal crease, where the nerve could be clearly defined. A 22-gauge, 100 mm needle was advanced in a medial to anterolateral direction toward the target nerve by in-plane approach, and 20 mL of 0.25% bupivacaine were injected to encircle the target nerve. If necessary, the site of the block needle was modified to reach the circumneural distribution of the LA (Figure 2).

2.4. Assessment of outcomes

Block duration till the return of the sensorimotor function to the level of the non-operated leg was assessed. The numeric rating scale (NRS) (0-10) was recorded at 2, 4, 6, 8, 12, 18, 24, 36, 42, and 48 h postoperatively at rest. If NRS > 3, 3 mg IV morphine was administered. The first analgesic request was noted. Paracetamol 1 g was given every 8 h to all patients orally.

Time to ambulation, length of hospital stay, tests of range of motion (ROM), and quadriceps muscle strength were assessed preoperatively, 24, 48, and 72 h postoperative. Quadriceps muscle strength was measured on a numeric scale of 1-5, at 24, 48, and 72 h postoperatively.

Nausea and vomiting were assessed at 2, 24, and 48 h postoperatively and treated with intravenous ondansetron 4 mg. Complications of tibial nerve block, such as (intravascular injection/hematoma/infection) were recorded. Any adverse effects were recorded throughout the procedure and treated as required. Hypotension was managed by IV ephedrine, and bradycardia was managed by IV atropine.

Patient satisfaction was also recorded on a 5-point scale (5 = very satisfied, 4 = satisfied, 3 = neutral, 2 = dissatisfied, 1 = very dissatisfied).

Our primary outcome was the total morphine consumption in the first 24 h postoperatively. Secondary outcomes were sensory and motor blockage, first analgesic request, cumulative morphine consumption till 48 h, NRS from 2 to 48 h, and any adverse effects.

2.5. Statistical analysis

IBM SPSS v26 (Chicago, Illinois, United States) was utilized to conduct the statistical analysis. The normality of data distribution was verified using the Shapiro-Wilks test and histograms. Numerical parametric data were

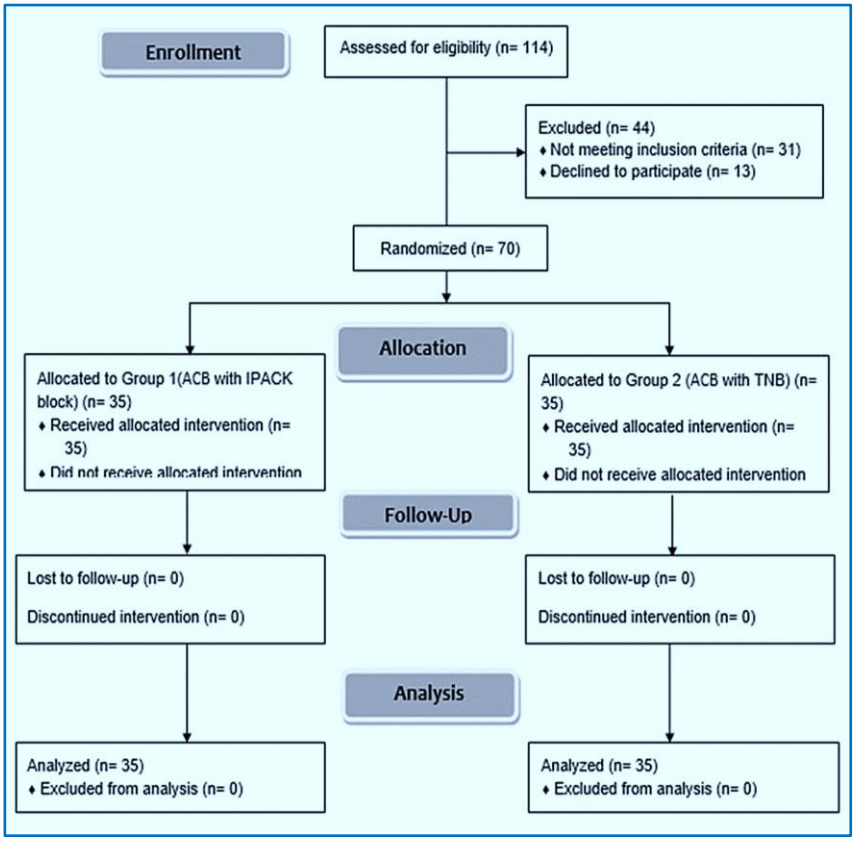

Figure 1: CONSORT flow diagram of enrolled patients.

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Table 1: Patient characteristics duration of surgery and preoperative NRS of the studied groups

Parameter		Group 1 (n = 35)	Group 2 (n = 35)	P value
Age (y)		58.9 ± 11.66	56.8 ± 12.15	0.448
BMI (kg/m^2)		30.7 ± 2.58	29.8 ± 3.74	0.214
Sex	Male	15 (42.86)	13 (37.14)	0.807
	Female	20 (57.14)	22 (62.86)	
ASA physical status	I	12 (34.29)	12 (34.29)	0.405
	II	15 (42.86)	19 (54.29)	
	III	8 (22.86)	4 (11.43)	
Duration of surgery (min)		131.1 ± 19.51	132.2 ± 16.16	0.790
Preoperative NRS	At rest	1.6 ± 1.04	1.9 ± 1.03	0.252
	At movement	5.5 ± 1.15	5.7 ± 1.16	0.606

Data are presented as mean ± SD or frequency (%), BMI: body mass index, ASA: American Society of Anesthesiologists, NRS: numerical rating scale. P value ≤ 0.05 is considered significant.

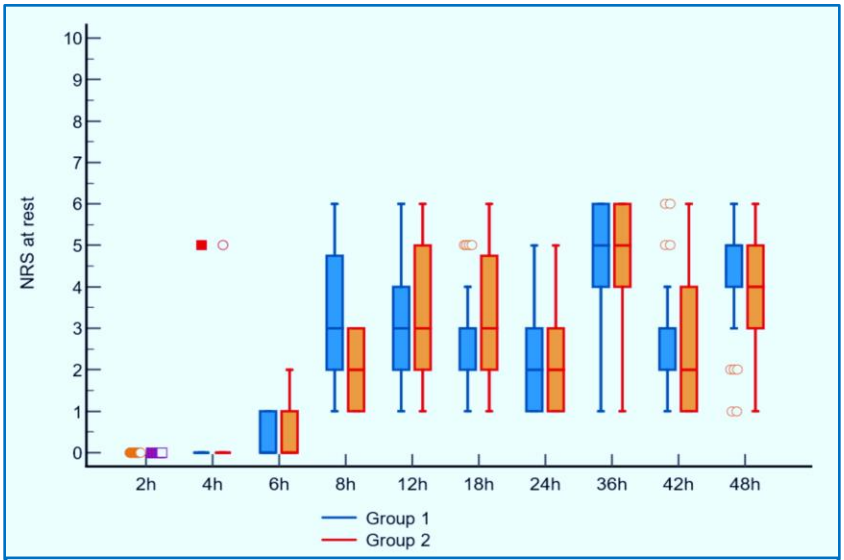

Figure 2: Numeric rating scale (NRS) at rest of the studied groups

described as mean and standard deviation (SD) and compared by the unpaired Student's t-test. Non-parametric numerical data were described as median and interquartile range (IQR) and compared by Mann-Whitney test. Qualitative parameters were described as numbers and percentages and compared by chi-square test. A P ≤ 0.05 was statistically significant.

3. RESULTS

In our trial, 97 patients were eligible for assessment; 19 patients did not meet the criteria for inclusion, and eight refused to participate. Therefore, 70 patients were assessed for follow-up and analysis (Figure 1).

Demographic data, duration of surgery, and preoperative NRS were comparable between both groups (Table 1).

NRS at rest and movement was significantly lower in Group 2 than Group 1 at 8 h (P < 0.001) and was comparable between both groups at other times (Figure 2).

The mean sensory block duration was 7.94 ± 1.59 h in Group 1 and 11.86 ± 2.85 h in Group 2. The motor block duration was 3.04 ± 1.9 h in Group 1 and 8.84 ± 2.66 h in Group 2. Duration of sensory and motor blocks were significantly more in Group 2 than in Group 1 (P < 0.001) (Table 2).

The mean time to first rescue analgesia was 9.71 ± 1.81 h in Group 1 and 13.8 ± 3.28 h in Group 2. Time to first rescue analgesia was significantly delayed in Group 2 than in Group 1 (P < 0.001) (Table 2).

Total postoperative morphine consumption in first day was significantly less in Group 2 than in Group 1 (P = 0.043) and was comparable between both groups in 2nd day and after first 48 h (Table 2).

The mean time to ambulation was 4.77 ± 1.75 h in Group 1 and 11.8 ± 2.13 h in Group 2. Time of ambulation and hospital stay were significantly delayed in Group 2 than in Group 1 (P < 0.001). Range of motion, and quadriceps strength were insignificantly different between both

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Table 2: Duration of sensory and motor blockade, and morphine consumption of the studied groups

Parameter		Group 1 (n = 35)	Group 2 (n = 35)	P value
Duration of sensory block (h)		7.94 ± 1.59	11.86 ± 2.85	**< 0.001**
Duration of motor block (h)		3.04 ± 1.9	8.84 ± 2.66	**< 0.001**
Time to first rescue analgesia (h)		9.71 ± 1.81	13.8 ± 3.28	**< 0.001**
Postoperative morphine consumption (mg)	1st day	3 [3-6]	3 [3-3]	**0.043**
	2nd day	6 [6-6]	6 [6-6]	0.622
	1st 48 h	9 [9-12]	9 [9-9]	0.085

Data are presented as mean ± SD, and median [IQR]. P value ≤ 0.05 is considered significant.

Table 3: Ambulation outcome, range of motion, and quadriceps strength full extension of the studied groups

	Group 1 (n = 35)	Group 2 (n = 35)	P value
Time of ambulation (h)	4.77 ± 1.75	11.8 ± 2.13	**< 0.001**
Hospital stay (days)	4 [3-4]	4 [3-5]	**< 0.001**
Range of motion (degree)			
Preoperative	109.03 ± 1.67	109.63 ± 1.61	0.131
24 h postoperatively	105.09 ± 1.82	104.17 ± 2.6	0.093
48 h postoperatively	111.71 ± 2.02	110.94 ± 2	0.133
72 h postoperatively	114.09 ± 1.72	113.69 ± 1.73	0.335
Quadriceps strength full extension (Kg)			
Preoperative	6.19 ± 1.82	5.49 ± 1.39	0.076
24 h postoperatively	5.57 ± 2.28	5.18 ± 1.93	0.444
48 h postoperatively	6.31 ± 1.75	6.03 ± 1.42	0.465
72 h postoperatively	6.9 ± 2.4	6.12 ± 2.08	0.149
Quadriceps strength 45° flex (Kg)			
Preoperative	8.59 ± 2.69	7.83 ± 2.76	0.249
24 h postoperatively	6.41 ± 2.46	5.41 ± 2.14	0.076
48 h postoperatively	7.79 ± 2.7	6.69 ± 2.49	0.082
72 h postoperatively	7.92 ± 2.44	7.1 ± 1.84	0.117
Quadriceps strength 90° flex (Kg)			
Preoperative	11.44 ± 3.81	10 ± 3.7	0.113
24 h postoperatively	9.67 ± 3.81	8.43 ± 3.76	0.175
48 h postoperatively	10.95 ± 3.98	9.43 ± 4.1	0.119
72 h postoperatively	11.47 ± 3.84	9.89 ± 3.78	0.087

Data are presented as mean ± SD and median [IQR], P value ≤ 0.05 is considered significant.

groups preoperatively, and at 24, 48, and 72 h postoperatively (Table 3).

Regarding patient satisfaction, 51.43% of patients were very satisfied, and 48.57% were satisfied in Group 1;

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Table 4: Adverse effects of the studied groups

		Group 1 (n = 35)	Group 2 (n = 35)	P value
Patient satisfaction	Very satisfied	18 (51.43)	19 (54.29)	1.00
	Satisfied	17 (48.57)	16 (45.71)	1.00
	Neutral	0 (0.0)	0 (0.0)	---
	Dissatisfied	0 (0.0)	0 (0.0)	---
	Very dissatisfied	0 (0.0)	0 (0.0)	---
Nausea and vomiting	2 h	2 (5.71)	1 (2.86)	1.00
	24 h	1 (2.86)	0 (0.0)	1.00
	48 h	1 (2.86)	0 (0.0)	1.00
Local anesthetic toxicity		0 (0.0)	0 (0.0)	---
Tibial nerve block complications	Intravascular injection	0 (0.0)	0 (0.0)	---
	Hematoma	0 (0.0)	0 (0.0)	
	Infection	0 (0.0)	0 (0.0)	
	CPN block	0 (0.0)	0 (0.0)	---

Data are presented as frequency (%), CPN: common peroneal nerve. P value ≤ 0.05 is considered significant.

whereas 54.29% were very satisfied, and 45.71% were satisfied in Group 2.

Nausea and vomiting occurred in 2 (5.71%) patients in Group 1 versus 1 (2.86%) patient in Group 2 at 2 h and occurred in1 (2.86%) patients in Group 1 versus 0 (0.0%) patient in Group 2 at 24 h and occurred in1 (2.86%) in Group 1versus 0 (0.0%). Nausea and vomiting were comparable between both groups in all measurements. LA toxicity and TNB complications such as (Intravascular injection, hematoma, infection, and CPN block) did not occur in any patient (Table 4).

4. DISCUSSION

ACB has lately been a popular pain management technique because it does not differ much from femoral nerve block (FNB) in its ability to control pain and does not cause quadriceps muscle weakening, allowing quick rehabilitation. However, neither FNB nor ACB are particularly efficient at reducing pain in the posterior knee.[15]

Our study revealed that in comparison to TNB, IPACK was able to maintain normal motor function. As the duration of motor and sensory block was delayed in TNB compared to IPACK block, therefore, time to ambulation and hospital stay was significantly delayed in TNB than to IPACK block. This could be explained by the fact that the IPACK block primarily targets the terminal branches of the sciatic nerve that directly supply the posterior capsule of the knee, which theoretically has lower motor and sensory blockade.[16]

Supporting our results, Kampitak et al. observed that the duration of motor and sensory block was significantly delayed in the TNB group than in the proximal and distal IPACK injection.[16] Therefore, the hospital stay with IPACK was also less than that of the TNB patients. Moreover, Zheng et al. stated that the IPACK with ACB had a mild effect on postoperative muscle strength that can accelerate the rehabilitation process after TKA.[17]

Niesen et al. established a cadaveric study to assess the injectate spread in the IPACK block.[18] They reported that it spreads throughout the popliteal fossa without proximal sciatic involvement. With a potential spread to the tibial or CPN. The spread to the middle genicular artery is the probable analgesic mechanism for the IPACK block by sensory block.

In a previous study, when SNB was combined with FNB or ACB it provided an efficient analgesic effect with lower pain scores and total morphine consumption after TKA but delayed the return of sensory and motor sensation distal to the knee postoperatively.[19]

The partial block of the CPN has resulted from the cephalad spread of LA solution from the site of TNB. It may be responsible for the weakness of dorsiflexion with a reduction in the sensation on the dorsal aspect of the foot.[20] Moreover, the peroneal motor block may have an unpleasant effect on patients and encourage surgeons to seek no need for block. Weak dorsiflexion may permit

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serial postoperative monitoring to detect peroneal dysfunction development or recovery.[21]

We observed that the pain score was significantly lower in TNB than IPACK block at 8 h, with delayed time to first analgesic request in TNB than IPACK block. Total postoperative morphine consumption at 24 h was significantly lower in TNB compared to IPACK block, with no difference between both groups at 48 h.

Confirming our results, Kampitak et al. noticed no differences in postoperative pain scores after one day postoperatively that were observed between TNB and IPACK.[16]

Thobhani et al. investigated ACB with IPACK for TKA and stated that ACB with IPACK produced sufficient analgesia with similar pain scores between groups and quadriceps strength. They concluded that IPACK with ACB did not lower opioids consumption.[22] However, Patterson et al. demonstrated that using IPACK in conjunction with ACB in TKA improves pain scores only in the immediate postoperative period and has no effect on subsequent pain intensity or opioid consumption.[23]

A previous systematic review hypothesized that combining the IPACK block with ACB would be effective in pain management and lower the risk of muscle weakness.[24] Earlier studies reported satisfactory postoperative pain control for both blocks.[25]

5. LIMITATIONS

This trial has some limitations. First, it is a single-center study with a relatively small sample size. Second, we did not include a control group. Third, it has a short duration of follow-up due to early discharge.

6. CONCLUSION

Adductor canal block with IPACK preserved motor function and reduced the time to ambulation and hospital stay compared to tibial nerve block with adductor canal block alone. However, tibial nerve block with adductor canal block prolongs sensory block, the time of analgesia request, and reduces postoperative opioid consumption at 1st 24 h. Both methods had a comparable effect on quadriceps strength.

7. Data availability

The numerical data generated during this research is available with the authors.

8. Conflict of interest

The study utilized the hospital resources only, and no external or industry funding was involved.

9. Ethical approval and registration

We obtained Ethical Committee approval (Approval code: 35151/12/21) and registered the study at clinicaltrials.gov (NCT05473559).

10. Authors' contribution

MAA, SWZ, WMA: Concept, design of the research, collection and analysis of data
MAA, WMA: Manuscript writing and revisions
All authors provided feedback, reviewed and approved the final manuscript.

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