JOURNAL OF CLINICAL MEDICINE OF KAZAKHSTAN (E-ISSN 2313-1519)
Original Article DOI: https://doi.org/10.23950/jcmk/16681

A Study To Compare Ultrasound Guided Modified 4 In 1 Block With Combined Adductor Canal And Injection Between Popliteal Artery And Capsule Of The Knee (IPACK) For Postoperative Analgesia In Total Knee Arthroplasty – A Prospective Randomized Controlled Trial

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Received: 2025-05-29.
Accepted: 2025-06-30.

J Clin Med Kaz 2025; 22(4): 29–36

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Abstract

Introduction: TKA has ensured a better quality of life for geriatric population apropos of eliminating pain, early mobilization and discharge with a better rehabilitation. It is a painful surgery and scarce management of post-operative pain may prolong the hospital stay with increased risk of adverse effects. We compared a modified 4 in 1 block with combined ACB + IPACK for postoperative analgesia after TKA.

Methods: The present randomized trial was conducted on patients between the ages 45 and 75 of either sex belonging to ASA I, II, and III who were posted for TKA under SAB.

Results: Non-Parametric tests were used as data were not normally distributed. Wilcoxon-Mann-Whitney Test was used to compare the two groups at each of the timepoints. The Friedman test was used to examine the changes in parameters over time within each group. The Generalized Estimating Equations method was employed to assess the differences in parameter changes between the two groups over time. The two groups showed significant differences in terms of VAS. at: 8, 16, 24, 36 hours after surgery. Hence Group A patients had better pain relief when compared with Group B (p=<0.001). There was a significant difference in the QMST at 36 Hours (W = 700.000, p = 0.036), with patients in Group A having better range of motion. Majority (80%) of the patients had no pain. Ten patients required single dose of Inj. PCM 500mg IV, out of which six belong to Group B.

Conclusion: ACB + IPACK and modified 4 in 1 block are effective in pain management of TKA patients. The combination of ACB + IPACK provides an excellent analgesia, prompt rehabilitation, and early ambulation of the patients. The modified 4 in 1 still needs to prove its efficacy in varied surgeries and in large population sample.

Keywords: adductor canal, modified 4 in 1, arthroplasty.

Introduction

Osteoarthritis of the knee is a pathological condition characterized by degenerative changes of the cartilage leading to joint destruction. About 40% of the population in the age group > 65 years is suffering the implications of osteoarthritis, and approximately 15% of the patients continue to have knee pain after 3-4 years of undergoing total knee arthroplasty, which is the most promising treatment [1]. The number of joint replacement surgeries in India is steadily increasing, with estimates suggesting that approximately 200,000 knee arthroplasties were performed in 2020[2]. TKA has improved the quality of life for our elderly population. Of eliminating pain, minimal morbidity, mortality, as well as early mobilization and discharge, restoring mobility and function of the knee joint [3].

It is a painful surgery, and scarce management of post-operative pain may prolong the hospital stay with increased risk of adverse effects like pulmonary dysfunction, myocardial ischemia and infarct, urinary retention, paralytic ileus, along with thromboembolism, DVT, as well as mental depression due to chronic pain [4]. The knee joint has a complex nerve supply. The protocol of postoperative pain management following TKA may vary with individual institutes, and myriad options are available. Still, optimal coverage of the complete anatomical supply of the knee joint is an art, and exuberant debates continue to date.

Several methods have pros and cons. Central neuraxial blocks, like epidurals, have debilitating complications such as autonomic disturbances leading to urinary retention and motor blockade. Opioids can cause postoperative nausea and vomiting (PONV), respiratory depression, and pruritus, along with addiction [5]. The precise deposition of drugs near the nerve or plexus under real-time ultrasound guidance has revolutionized Regional anaesthesia, establishing a niche in pain management practice [6].

PNB for TKA includes non-motor-sparing blocks like the femoral nerve block (FNB) and popliteal sciatic nerve block (PSNB), and motor-sparing blocks such as the adductor canal block (ACB), infiltration between the popliteal artery and knee joint capsule (IPACK), 4-in-1 block, and modified 4-in-1 block [4, 7]. FNB is not standard due to quadriceps weakness, causing falls and injuries postoperatively. The ACB's rationale is that the saphenous nerve, a sensory nerve, and part of the obturator nerve traverse the adductor canal [7, 8].

Since 2014, IPACK has been clinically employed. It blocks the superomedial and lateral genicular nerves, branches of the sciatic nerve, and articular branches of the obturator nerve in the popliteal region. This approach provides analgesia to the knee joint's posterior capsule while preserving limb motor function [9].

The newly developed regional techniques, like the USG-guided 4-in-1 block and Modified 4-in-1 blocks, provide effective post-operative analgesia for TKA [10, 11]. In the later, the Nerve to vastus medialis (NVM) is targeted separately through a peripheral nerve stimulator (PNS) guided injection of LA [4, 11].

When carefully planned, a procedure-specific RA approach can provide effective pain relief without compromising motor function, facilitating early mobilization, faster recovery, and reduced opioid consumption, thereby minimizing associated side effects [6].

IPACK and ACB have proven superior in studies for postoperative analgesia in TKA. The modified 4-in-1 block is a newer option for lower limb surgery. This study compares the modified 4-in-1 block with ACB + IPACK for postoperative analgesia after total knee arthroplasty (TKA), hypothesizing that the modified 4-in-1 block may provide better pain management and reduce analgesic needs without excessive motor weakness or side effects.

The primary objective was to compare the differences in VAS scores between the two groups for 72 hours after surgery. The Secondary objectives were to study the duration of postoperative analgesia using VAS up to 72 hours of surgery, the site of pain, whether it is medial, lateral or upper side of knee, the amount and type of rescue analgesia required, the extent of ambulation and quadriceps strength after 24 hours of surgery, patients overall experience score and the complications if any.

Methods

The present prospective, randomized, single-blind study was conducted in the Department of Anaesthesiology and Critical Care at Pt. B. D. Sharma PGIMS, Rohtak, from July 2023 to September 2024, after institutional biomedical research ethical committee approval (BREC/Th/20/Anesth12). The trial was registered (CTRI/2022/07/043759). Patients aged 45 to 75 years of either sex, classified as ASA I, II, or III, who were scheduled for TKA under subarachnoid block (SAB), were included in the study. Patients with known hypersensitivity or allergy to the study drugs, bleeding disorders, infections at the site of the block, uncontrolled diabetes mellitus, hypertension, a history of cardiac, liver, or kidney disease, and those who declined to participate in the study were excluded.

Randomization and group allocation

Our estimated sample size is determined using the VAS score across groups. For this calculation, we defined a mean difference of 0.6 and a standard deviation of 0.75. We calculated the sample size using a 95% confidence interval, 80% power, and an alpha level of 0.05. The resulting sample size is 35.

The patients were divided into two groups of 35 each using a randomization table. Random numbers were printed and placed into labeled, opaque, sealed envelopes, opened only during the procedure, assigning patients to a group on surgery day. Group-A: Patients received USG-guided combined adductor canal and IPACK block with 12 ml and 10 ml of 0.25% bupivacaine, respectively, with 8mg dexamethasone as an adjuvant. Group B: Patients received USG-guided modified 4 in 1 block with 20 ml of 0.25% bupivacaine and 2 ml of dexamethasone (total 22ml).

Preparation of patients

All patients underwent a clinical history assessment and physical exam one day before surgery. Any history of hypertension, diabetes, cardiovascular issues, renal problems, or liver disease was noted. Medications like NSAIDs, aspirin, and opioids were recorded. Routine blood tests were done as needed. All patients provided informed written consent after the procedure was explained in detail. Patients were educated on the pain score and asked to rate their average pain using VAS, where 0 is no pain and 10 is the worst pain imaginable. They were instructed to specify the exact site of pain after surgery. All patients received tab Pantocid 40 mg and tab Alprazolam 0.5 mg the night before surgery. Tab paracetamol (650 mg) was given on the morning of surgery at 6 AM with a sip of water.

Anaesthesia Technique

Patients were moved to the pre-op room, and emergency

drugs and airway management equipment were prepared. Vital monitors were attached, and the I/V line secured. The procedure followed strict aseptic precautions. A linear high-frequency probe (Sonosite M-Turbo by Fujifilm Sonosite, United States) was utilized. The block was administered per the randomization number generated. Patients were monitored in the preoperative room until they were taken to the operating room theater.

Details of blocks

Modified 4 in 1 block. The technique of Roy et al was [11]. The Modified 4 in 1 block seeks to target four nerves (saphenous, obturator, nerve to vastus medialis, and sciatic) with one injection point, extending to the adductor canal in the mid-thigh and down to the popliteal area fossa. The patient lay supine with the same-side leg in external rotation, slightly abducted, and knees positioned slightly apart, flexed. Using a high-frequency linear probe, the medial femoral condyle was marked (Figure 1). The probe was placed over the femoral condyle, allowing for the identification and proximal scanning of the vastus medialis muscle. Upon locating the junction of the vastus and sartorius muscles, the probe was moved proximally until the superficial femoral artery became visible in the adductor region hiatus. As we moved proximally, the descending genicular artery, a branch of the superficial femoral artery (SFA), was identified. This point was located 8–10 cm above the femoral condyle, and at this location, the superficial structures were re-visualized. The needle, attached using PNS (Stimuplex DIG, BBraun, Germany), was directed into the Vastus medialis muscle until it stimulated the NVM, causing a contraction at a threshold current of 0.4-0.5 mA. At this stage, 5 mL of the drug was administered following verification of negative blood aspiration and absence of excessive pressure during the injection. The needle was carefully directed in a plane from the lateral to the medial side to access the perivascular area. After confirming negative aspiration again, the remaining 17 mL of the drug was injected, successfully visualizing it pushing against the femoral artery posteriorly. The patient was monitored in the pre-op room till shifted to OT.

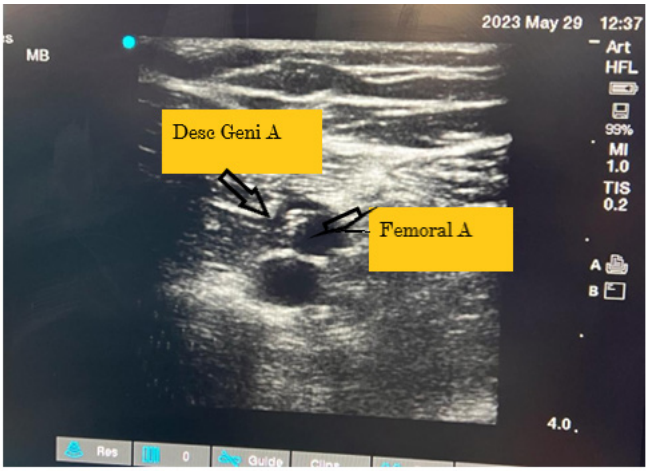

Figure 1 – Sonoanatomy of Modified 4 in 1 block

Adductor canal block (Figure 2). The patient was positioned supine, with the ipsilateral leg externally rotated, slightly abducted, and the knees slightly flexed—a high-frequency linear probe located the Adductor canal at mid-thigh, beneath the sartorius muscle. The probe advanced until the superficial femoral artery (SFA) was visible in the canal, nestled between the vastus medialis and adductor longus muscles. Then,

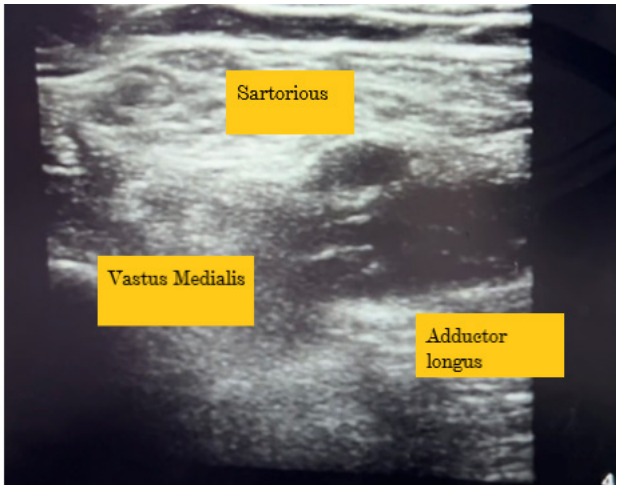

Figure 2 – Sonoanatomy of the Adductor Canal Block

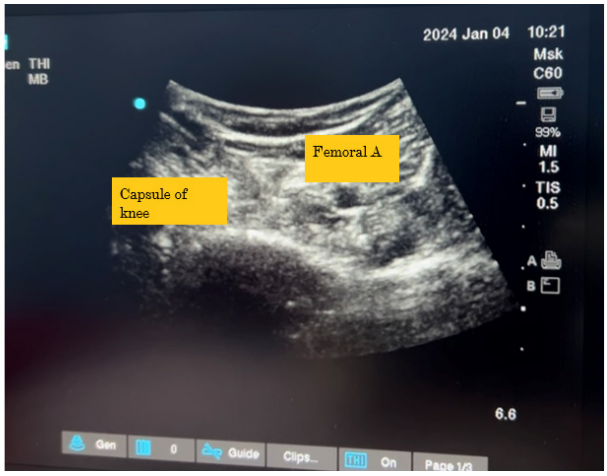

Figure 3 – Sonoanatomy of IPACK

a 22-gauge spinal needle was inserted laterally to medially to access the perivascular area. After negative aspiration, 12 ml of the drug was injected, displacing the femoral artery.

IPACK block (Figure 3). The patient was positioned in the frog leg position with a blanket roll under the thigh for support. The curved transducer was chosen for its depth of penetration and ability to visualize all structures in one window. Following strict aseptic precautions, the transducer was placed on the lower third of the medial thigh to image the femur and femoral vessels in cross-section. It was then moved caudally to view the femoral artery (FA) extending into the popliteal fossa through the adductor hiatus, becoming the popliteal artery. The transducer was adjusted posterior-inferiorly to view the area between the popliteal artery and the femur shaft, just above the femoral condyles. The needle was inserted in-plane from the anterior side, following a medial-to-lateral trajectory and remaining parallel to the femur's acoustic shadow. The needle tip was placed 2 cm past the artery's lateral border. After negative aspiration, 10 ml of the drug was injected in divided doses as the needle was advanced and withdrawn. The patient was moved to OT after 30 minutes of monitoring. Surgery proceeded under SAB.

Patients were moved to recovery. Suppose VAS > 4, Fentanyl 20 mcg IV was administered. For the first three postoperative days, PCM 500 mg was given every 8 hours. Suppose VAS > 4, rescue analgesia with IV PCM (500 mg) and Tramadol 50 mg IV (after a wait of half an hour if pain persisted) was provided. A second dose was repeated if pain persisted.

Patients were encouraged to move the joint after surgery, particularly after 24 hours, to support early physiotherapy and rehabilitation. Physiotherapy was recommended every 6 hours. Patients received 4 mg IV Ondansetron to prevent PONV. Measures were implemented to avoid postoperative falls. Episodes of hypotension, urinary retention, local anaesthetic systemic toxicity (LAST), infection, and 30-day readmission were evaluated and documented.

The following parameters were noted. The primary objective was to achieve a VAS score over 72 hours. The secondary objectives were: Time to perform the block: T1: starting point was lifting the probe before local anaesthetic in the Modified 4-in-1 block. T2a: The process began with selecting the probe and continued to administering local anesthetic ACB. T2b: The starting point was picking up the probe to administer local anaesthetic in the IPACK block. Pain during drug administration was assessed using VAS at 6, 8, 10, 12, 16, 24, 36, 48, and 72 hours after surgery. The exact site of pain (medial, lateral, or upper part of the knee) was noted. The amount and type of rescue analgesia required, as well as the patient satisfaction, were documented.

The quadriceps muscle strength was measured after 24 hours of surgery using the quadriceps strength test (QMST), the thigh of the operated limb was kept at the edge of the bed or table and in sitting position with leg hanging, the patient was asked to extend the knee, where, 1 = complete resistance(normal quadriceps strength) 2 = moderate resistance (mild quadriceps weakness) 3 = poor resistance (severe quadriceps weakness)

Any complications or side effects of the procedure or drug were reported according to the SAE format by ICMR.

Statistical analysis

SPSS version IBM 28.0. was used for statistical analysis of the data. Non-parametric tests were utilized for statistical inference due to the non-normal distribution of the data. The Wilcoxon-Mann-Whitney Test was applied to compare the heart rates, respiratory rates, and VAS of the two groups at each time point. The Friedman test examined the changes in parameters over time within each group. Additionally, Generalized Estimating Equations were employed to assess the difference in parameter changes between the two groups over time.

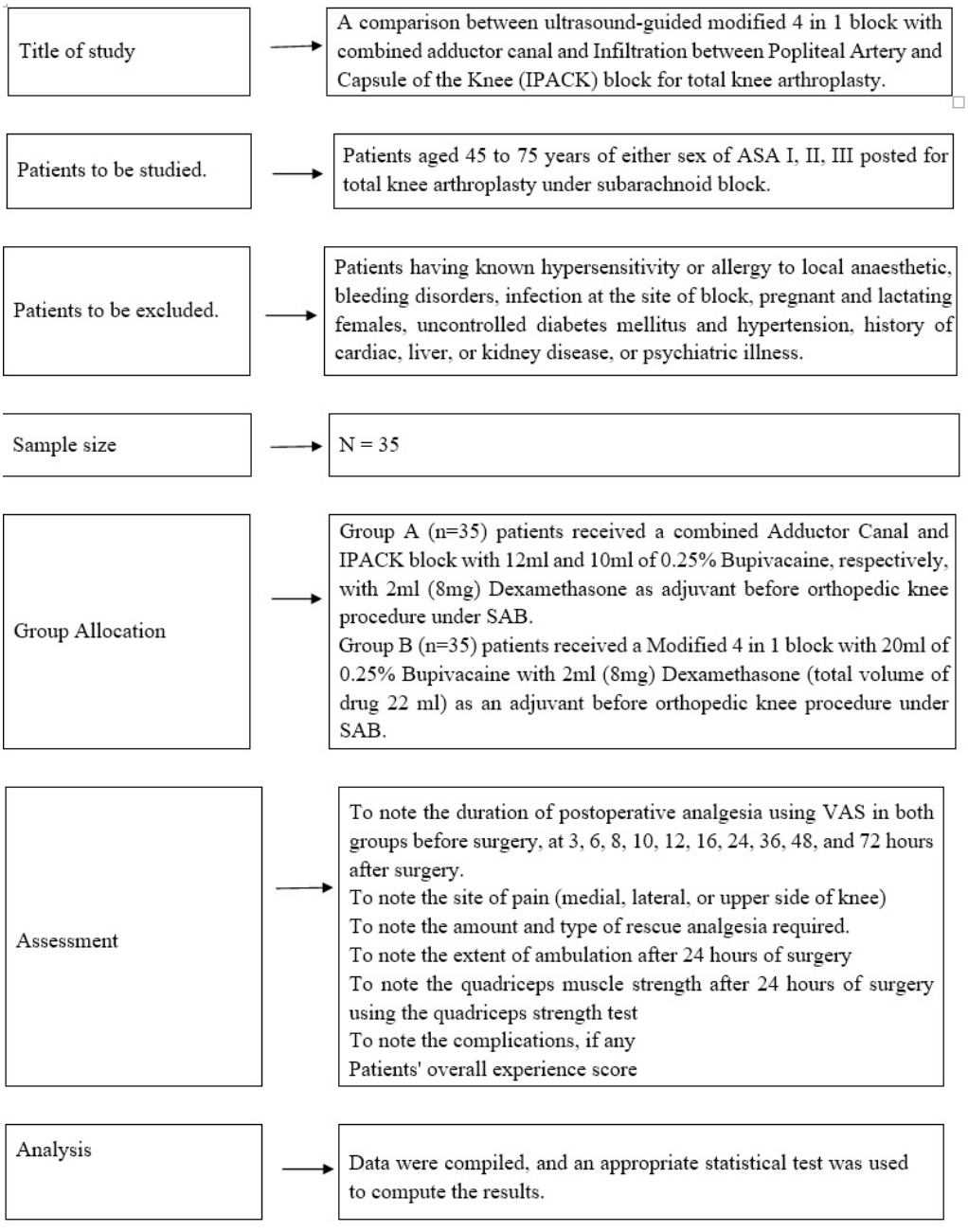

Figure 4 – Flow chart of study

Results

Eighty-six patients were screened for the study, with nine dropouts due to non-compliance with the inclusion criteria. Four patients were lost to follow-up due to early discharge, and three did not consent to the procedure. Seventy patients were included in the statistical analysis, and demographic variables were comparable (Table 1). The Wilcoxon-Mann-Whitney U Test facilitated group comparisons. We used the Generalized Estimating Equations method to compare overall changes in haemodynamic variables over time between the two groups, finding no significant differences (Figure 5, 6).

All participants in both groups were successfully given blocks in the first attempt. There was a significant difference between the two groups in terms of time taken for block (W = 1225.000, p = <0.001), with the median being highest in Group A (range in Group A 6-9 minutes, Group B 3-5 minutes) (Table 2).

VAS changes over time were compared between the two groups using Generalized Estimating Equations. A significant difference in VAS trends was noted (p = <0.001). The groups significantly differed in VAS at 8-, 16-, 24-, and 36-hours post-surgery (Table 3, Figure 7). Therefore, Group A patients experienced better pain relief than Group B (p <0.001).

The two groups differed in QMST at 36 hours (W = 700.000, p = 0.036), with Group A showing better motion (Figure 8). No significant difference in QMST trends over time was noted. Most patients (80%) had no pain. Ten patients received one dose of Inj. PCM 500mg IV, including six from Group B and four from Group A. Only one patient from Group B required a second dose of rescue analgesia. There was no significant difference in Rescue Analgesia distribution (p = 0.513). Group A patients were more satisfied with analgesia, though not statistically significant ($\chi 2 = 4.510$, p = 0.229) (Figure 9). No complications like hypotension, PONV, or LAST occurred.

Table 1 Demographic parameters

Parameter	Group A	Group B	Pvalue
Age	**52.14 5.56**	**51.03 4.82**	**0.524 (Mann-Whitney U test)**
Gender (M/F)	27/8	26/9	0.780 (Fisher's exact test)
ASA grade (I/II/III)	2/26/7	0/23/12	0.193 (Chi Squared test)

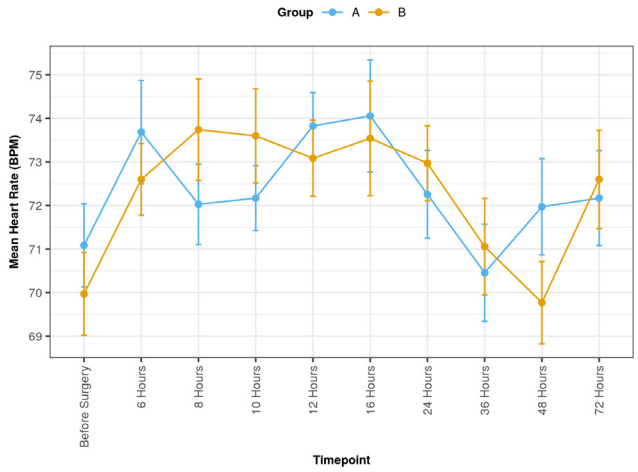

Figure 5 – Change in Heart Rate (BPM) Over Time

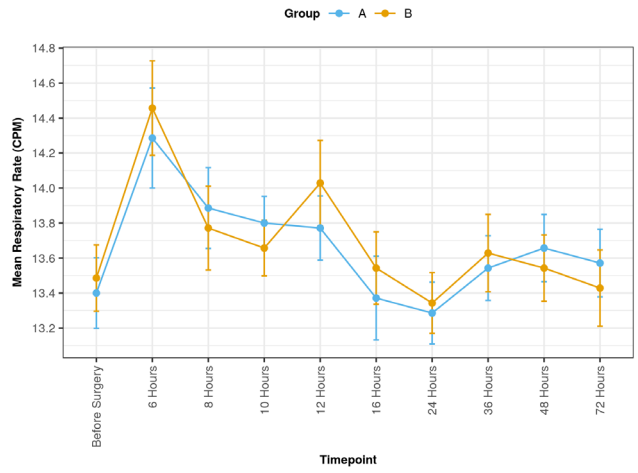

Figure 6 – Line diagram depicting the change in Respiratory Rate (CPM) over time in the two groups.

Table 2 Summary Table for Association between Group and Parameters

Parameters	Group		p value
	A (n = 35)	B (n = 35)	
Number of Attempts for Block (1st attempts)	35 (100.0%)	35 (100.0%)	1.0003
Time Taken for Block (minutes)***	7.09 ± 0.89	4.27 ± 0.65	<0.0011
Total Analgesic Consumption (IV Paracetamol)			0.4982
1000mg	2 (5.7%)	5 (14.3%)	
1500mg	0 (0.0%)	1 (2.9%)	
500mg	2 (5.7%)	1 (2.9%)	
Nil	31 (88.6%)	28 (80.0%)	
QMST (24 Hours)	1.34	1.30	0.8671
QMST (36 Hours)***	1.0	1.12	0.036
QMST (48 Hours)	1.00	1.00	-
QMST (72 Hours)	1.00	1.00	-
Type Of Pain			0.1952
Dull	1 (2.9%)	4 (11.4%)	
None	31 (88.6%)	25 (71.4%)	
Sharp	3 (8.6%)	6 (17.1%)	
Complications: Hypotension	0 (0.0%)	0 (0.0%)	1.0003
Rescue Analgesia			0.5132
None	31 (88.6%)	28 (80.0%)	
Inj PCM 500mg	4 (11.4%)	6 (17.1%)	
Inj PCM 1000mg	0 (0.0%)	1 (2.9%)	
Patients Overall Experience			0.2292
Score 2	0 (0.0%)	3 (8.6%)	
Score 3	2 (5.7%)	4 (11.4%)	
Score 4	2 (5.7%)	3 (8.6%)	
Score 5	31 (88.6%)	25 (71.4%)	

****Significant at p<0.05, 1: Wilcoxon-Mann-Whitney U Test, 2: Fisher's Exact Test, 3: Chi-Squared Test*

Table 3 Comparison of the two Groups in Terms of change in VAS over time

VAS	Group		P value for comparison of the two groups at each of the timepoints (Wilcoxon-Mann-Whitney Test)
	A	B	
	Mean (SD)	Mean (SD)	
Before Surgery	3.63 (1.42)	3.97 (1.50)	0.380
6 Hours after surgery	0.09 (0.28)	0.14 (0.36)	0.462
8 Hours after surgery	0.31 (0.47)	0.63 (0.60)	0.023
10 Hours after surgery	0.66 (0.59)	1.03 (0.89)	0.089
12 Hours after surgery	1.57 (0.98)	1.83 (1.10)	0.312
16 Hours after surgery	1.74 (0.61)	2.74 (1.09)	<0.001
24 Hours after surgery	2.17 (0.62)	2.60 (0.69)	0.015
36 Hours after surgery	2.06 (0.68)	2.43 (0.74)	0.033
48 Hours after surgery	2.49 (0.74)	2.43 (0.78)	0.772
72 Hours after surgery	2.29 (0.57)	2.49 (0.66)	0.168
change in VAS over time within each group (Friedman Test)	<0.001	<0.001	
Comparison of change in VAS over time be-tween the two groups (Generalized Estimat-ing Equations)	<0.001		

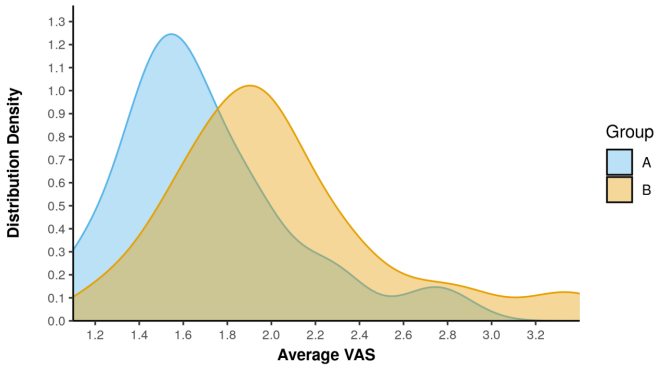

Figure 7 – The density plot below depicts the distribution of Average VAS in the two groups

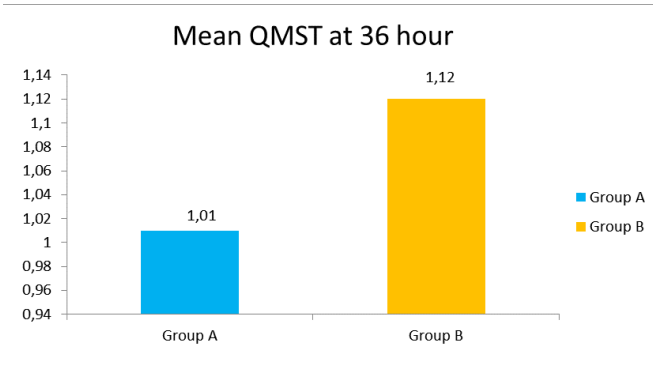

Figure 8 – Line diagram depicting the change in Respiratory Rate (CPM) over time in the two groups.

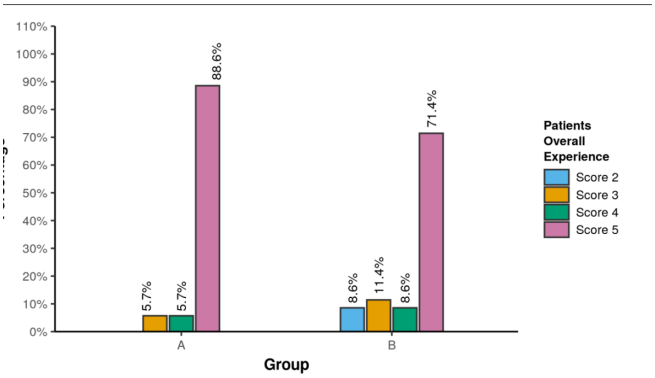

Figure 9 – Association between Group and Patients' Overall Experience

Discussion

This study found that the ACB + IPACK block outperformed the modified 4 in 1 block in terms of VAS scores at 8, 16, 24, and 36 hours, as well as patient satisfaction. The effectiveness of an analgesia regimen is assessed by analyzing the dynamic range of motion (ROM) and the ability to undergo early rehabilitation with minimal complications. While the ACB and IPACK blocks are established techniques, the modified 4 in 1 provides similar analgesic efficacy.

Among various RA techniques, selecting the most appropriate, procedure-specific, motor-sparing, and opioid-sparing options that align with enhanced recovery after surgery (ERAS) protocols is challenging. ACB does not block the articular branches of the femoral nerve innervating the knee joint capsule, so it does not provide adequate pain relief alone [9, 11]. For consistent TKA patient care, ACB + IPACK is attractive. Kandarian et al. 13 emphasized IPACK's importance as part of MMA for TKA. Given its anatomical coverage and simplicity, IPACK should be integral to TKA patient care [12, 13].

NVM's intramuscular, extra muscular, and genicular branches innervate the medial aspect of the knee [14]. The saphenous nerve innervates the knee via the superficial patellar, posterior, and deep genicular nerves. The lateral knee is innervated by the sciatic nerve's genicular branches, primarily from the peroneal nerve division. The popliteal plexus at the back of the knee receives its supply from genicular branches of the obturator and tibial divisions of the sciatic nerve. Cutaneous branches from the femoral and saphenous nerves primarily innervate the skin around the knee [15, 16].

Wong W et al. conducted a cadaveric study. They delineated the exact location of the adductor canal, which was distal to the mid-thigh level (i.e., the point between the ASIS and the base of the patella) [20].

The saphenous nerve exists in the adductor canal. The medial femoral cutaneous nerve runs in the femoral triangle and joins the subsartorial plexus between the vastoadductor membrane and sartorius muscle, just below the apex of the femoral triangle [17, 18]. The adductor canal is covered by the

VAM, making the proximal border the anatomical starting point of the AC. The study revealed that the NVM, which innervates the anteromedial knee, the typical surgical incision site, lies within the VAM's fascial sheath [18–21]. Thus, the modified 4-in-1 block targets NVM along with the saphenous, obturator, and sciatic nerves [11].

All blocks were completed in a single attempt by the same experienced consultant. Group A had two separate injection sites, which took longer to perform, despite the simplicity of the technique (W = 1225.000, p = <0.001). Abdullah FW et al reported similar block procedure times. A successful procedure must be reliable, effective, and executed quickly [17]. The modified 4 in 1 technique is a single injection method that covers relevant knee joint innervations, leading to improved block performance times.

The median Average VAS was highest in Group B; the ACB plus IPACK group showed better postoperative pain control. Roy et al found that at 12 hours post-surgery, VAS scores were significantly lower in the Modified 4 in 1 group compared to the IPACK + ACB group ($p < 0.05$) [13]. These findings contrast with our study. Roy et al4 used Ropivacaine (0.2%) with dexmedetomidine as an adjuvant, with total drug volumes ranging from 32 to 40ml, although the exact dose was undefined, presenting methodological limitations. Yin W et al reported significantly lower pain scores in the ACB + IPACK group than the placebo group, supporting our study. Several others also align with our results [13, 18, 19].

Adequate muscle strength is essential for early discharge and fall prevention. All patients regained quadriceps muscle power, but Group A exhibited better knee joint ROM. None had quadriceps weakness postoperatively, similar to our findings, though their research didn't specify numbers. Other authors reported similar results [19, 20].

There was no significant difference between the two groups regarding pain type and site. No patients in either group had complications in this study. Other authors reported similar results [13, 17, 18]. Most patients (84.3%) did not need rescue analgesia, but about 30% developed significant postoperative pain requiring opioids or rescue blocks [3]. They identified the probable cause by evaluating the pain's type and location. Pain often occurred in the proximal thigh, suggesting tourniquet-related pain due to spinal regression level. Tourniquet pain requires perioperative anti-inflammatory medications. We found no significant correlations between thigh pain and the tourniquet's duration or pressure during surgery. Other authors back our findings [12].

For an adult weighing up to 60kg, approximately 48 ml of 0.25% Bupivacaine corresponds to the safe maximum limit of about 120 mg. In this study, 20 ml of 0.25% Bupivacaine (50 mg) is within the safe dosage. Wong et al. support this, stating that 0.25% LA provides adequate analgesia with minimal side effects in their ACB research with various LA doses (Ropivacaine) [20].

A multidisciplinary approach with multimodal analgesia (MMA) is crucial for surgical success. This approach is key for managing postoperative pain by targeting inflammation and neuropathic pain, reducing pain intensity [13, 21]. This warrants the regular use of PCM postoperatively. We would like to stress the importance of ACB and IPACK in ERAS protocols for TKA, as it has proved to be superior to the modified 4 in 1 block in terms of better pain control, reduced surgical stress, and early rehabilitation by speedy recovery postoperatively (retaining muscle strength). Adequate training of residents is a good option, and the blocks are relatively simple, with a lower learning curve and safer when used with USG guidance.

Our study has several limitations; the absence of a control group may affect the analgesic efficacy of our blocks. We did not assess rebound pain from either block. Additionally, quadriceps strength evaluation was limited to 72 hours post-surgery due to immobilization, preventing the assessment of delayed motor weakness and the length of motor blockade in both groups. Recent findings suggest that post-surgical pain might cause quadriceps weakness, possibly because the analgesic effects of the blocks diminish. Further studies with larger sample sizes are needed to validate our findings. Lastly, our results apply specifically to the groups and type of surgery in this study and may not generalize to other procedures or populations.

Conclusions

This study highlights the promising future of ACB + IPACK and the modified 4 in 1 block, vital for regional analgesia. They improved post-operative analgesia with no motor effects or significant complications. ACB + IPACK provides excellent analgesia, quick rehabilitation, and early ambulation for patients.

The modified 4 in 1 must still prove its efficacy in further surgeries and RCTs with larger populations. Nonetheless, this study suggests its use in TKA patients for effective pain management, as indicated by lower postoperative VAS scores, cumulative rescue analgesia, and early discharge. Both blocks enhanced patient activity without complications.

Author Contributions: Conceptualization, P. B.; methodology, P. B., M. C.; validation, P. B., S. D., K. B.; formal analysis P. B., K. B.; investigation P. B., M. C.; resources M. C.; data curation P. B., S. D. writing – original draft preparation, P. B., S. D., M. C.; writing – review and editing, P. B., N. S. and K. B.; supervision, P. B.; project administration, P. B. All authors have read and agreed to the published version of the manuscript.

Disclosures: There is no conflict of interest for all authors.

Acknowledgments: Special gratitude to my loving patients for their full trust in the authors. Gratitude to Theatre Master Dinesh Bauji, without whose cooperation this work would be difficult.

Funding: None.

Data availability statement: The corresponding author can provide the data supporting the study's conclusions upon request. Due to ethical and privacy constraints, the data are not publicly accessible.

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