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Research Article

Comparison of ultrasound-guided genicular block vs. intrathecal morphine for postoperative analgesia in patients undergoing knee arthroplasty: A randomised prospective study

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ABSTRACT

Aim: Total knee arthroplasty (TKA) is a major orthopedic surgical procedure often necessitating effective postoperative analgesia. This study aimed to compare the analgesic efficacy of ultrasound-guided genicular block (GB) and intrathecal morphine (ITM) in patients undergoing THA under spinal anesthesia.

Method: A prospective, randomized, single-blind study was conducted at Ordu University Training and Research Hospital from October 1, 2022, to April 1, 2023. Eligible patients aged 18 to 90 undergoing knee surgery with spinal anesthesia were randomized into two groups: Group ITM received intrathecal morphine, while Group GB underwent ultrasound-guided triple genicular block. Pain scores, rescue opioid consumption, time to initial mobilization, and Modified Bromage Scale (MBS) scores were assessed at five time points (0, 2, 6, 12, and 24 hours) within the first 24 hours post-surgery.

Results: At the 24-hour mark, cumulative tramadol consumption was significantly lower in Group ITM compared to Group GB (35.45±54.84 vs. 63.37±37.7 mg, respectively, $p = 0.028$). Group ITM also exhibited statistically lower Numeric Rating Scale (NRS) scores at 12 hours ($p = 0.005$) but had similar scores at other time points. Additionally, time to first ambulation and MBS scores were consistent across all intervals ($p < 0.05$).

Conclusions: In patients undergoing knee arthroplasty with spinal anesthesia, those receiving ultrasound-guided genicular blocks demonstrated higher opioid consumption over a 24-hour period compared to those receiving intrathecal morphine. However, regarding postoperative pain scores, both groups exhibited similar outcomes. These findings provide valuable insights into the selection of postoperative analgesic modalities for TKA patients.

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1. Introduction

Total knee arthroplasty is a widely embraced surgical intervention for patients suffering from persistent knee pain and functional limitations, consistently yielding favorable outcomes [1,2]. Wang et al. initially introduced the use of intrathecal morphine for pain management [3]. Originally employed to mitigate acute postoperative discomfort, particularly in cancer-related surgeries, intrathecal morphine has demonstrated efficacy even in extensive orthopedic procedures [4–12]. In the realm of peripheral nerve blocks, the genicular block has emerged as a promising approach to alleviate pain in total knee arthroplasty [13]. This modern peripheral nerve

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block has captured the attention of anesthesia practitioners, who utilize it either independently or in combination with other methods to address postoperative pain following knee arthroplasty [13]. Empirical studies underscore the dual advantages of genicular blocks: reducing opioid consumption in major orthopedic surgeries while also facilitating unrestricted mobilization, thanks to their minimal impact on motor function [14].

The objective of this study was to perform a comparative analysis of postoperative analgesic strategies in patients undergoing knee arthroplasty with spinal anesthesia, specifically comparing ultrasound (US)-guided genicular block (GB) and intrathecal morphine (ITM). Our principal research hypothesis posited that the use of genicular block would result in decreased postoperative opioid consumption while maintaining comparable pain scores to those achieved with intrathecal morphine administration.

2. Materials and Methods

This study was designed as a prospective, randomized, comparative investigation with blinded assessors. It was conducted at Ordu University Training and Research Hospital from October 1, 2022, to April 1, 2023. Ethical approval for the research was obtained from the Ordu University Clinical Research Ethics Committee (Decision no: 2022/247, Date: 16.10.2022) to ensure strict compliance with the principles delineated in the Declaration of Helsinki. Inclusion criteria encompassed patients aged 18 to 85 scheduled for unilateral knee arthroplasty under spinal anesthesia, all of whom provided written informed consent. Exclusion criteria included individuals contraindicated for neuraxial or peripheral blocks, those with ongoing infections or malignancies, individuals with active psychopathological or neurological conditions potentially impacting pain perception, individuals with malnutrition, and those who declined regional anesthesia.

2.1. Randomization and blinding

We employed the sealed envelope method to achieve randomization, guaranteeing an unbiased allocation of participants to the study groups. To uphold the study's integrity, a single-blind protocol was implemented. The anesthesiologist (EC) responsible for administering the blocks remained separate from the subsequent postoperative data collection. A different anaesthesiologist (IC), unaware of the specific block performed, conducted the data collection, ensuring the blinded nature of the assessment.

2.2. Spinal anesthesia procedure

During the preoperative phase, no premedication was administered. Upon entering the operating room, patients underwent routine monitoring, which included pulse oximetry, electrocardiography, and noninvasive blood pressure measurement. Vascular access was established by inserting a 20 G intravenous cannula into the dorsum of both hands. Hydration was maintained by intravenously infusing a 0.9% NaCl solution at a rate of 4 ml/kg/h.

Subsequent to preparatory measures and sterile draping, a 25-Gauge spinal needle was utilized to administer 15 mg of hyperbaric bupivacaine for spinal anesthesia. Typically, this injection was performed at either the L2-L3 or L3-L4 vertebral level to achieve the targeted sensory blockade. Upon attaining the desired level of sensory block, patient comfort was enhanced through the intravenous administration of midazolam at a dose of 0.07 mg/kg .Patients assigned to the intrathecal morphine group (Group ITM) received an additional 400 mcg of intrathecal morphine, concurrently with 15 mg of hyperbaric bupivacaine. This administration was meticulously conducted using the same sterile syringe to uphold optimal aseptic conditions. For patients in the genicular block group (Group GB), only 15 mg of hyperbaric bupivacaine was injected into the intrathecal space.

2.3. Ultrasound guided genicular nerve block

In this study, genicular block interventions were performed after inducing spinal anesthesia with 15 mg hyperbaric bupivacaine. In the genicular block group (Group GB), a 5 ml solution of 0.25% bupivacaine was carefully administered to each of the three genicular nerves under ultrasound guidance. The procedure involved blocking the superior medial genicular nerve (SMGN), inferior medial genicular nerve (IMGN), and superior lateral genicular nerve (SLGN).

For SMGN blockade, anatomical landmarks were identified, including the medial femoral epicondyle and adductor tubercle, and the block needle was guided towards the superior medial genicular artery. For IMGN blockade, landmarks such as the medial tibial epicondyle and distal medial collateral ligament were used, guiding the needle towards the inferior medial genicular artery. The SLGN blockade involved visualizing the lateral femoral epicondyle and the deep edge of the vastus lateralis muscle, with the needle directed near the superior lateral genicular artery. This meticulous and standardized approach ensured precise nerve blockade for effective pain management.

2.4. Postoperative analgesia management and the evaluation of outcomes

All patients received scheduled analgesia comprising intravenous paracetamol (3x1 g) and tenoxicam (2x20 mg). Following surgery, all patients from both study groups were connected to a patient-controlled analgesia device enabling the administration of tramadol (20 mg) via bolus injection, without continuous infusion. The cumulative tramadol consumption within the first 24 hours post-surgery was meticulously recorded, providing valuable insights into postoperative pain management dynamics.

Critical parameters were systematically documented for each patient during the initial 24-hour postoperative period, including pain scores, tramadol consumption, time to initial mobilization, and Modified Bromage Scale

(MBS) scores. Numeric Rating Scale (NRS) scores were used for pain intensity assessment and diligently recorded at various time intervals, commencing with the baseline (0 h) in the postoperative recovery room. Subsequent assessments occurred at 2 hours, 6 hours, 12 hours, and 24 hours after the patient's transfer from the recovery room to the ward.

Concurrently, MBS scores were consistently evaluated at corresponding time points (0, 2, 6, 12, and 24 hours), categorized as follows: 0 = no motor block, 1 = inability to fully extend the leg while retaining knee flexion, 2 = inability to flex the knee but with unrestricted foot movement, 3 = complete block, indicating no movement of the leg or foot. Furthermore, meticulous documentation encompassed the quantification of opioid consumption during the initial 24 hours following surgery, along with the time taken for the initial mobilization of patients."

2.5. Sample size estimation

Sample size determination for this study relied on opioid consumption data obtained from a previous study [12]. Calculations were performed using the G*Power V. 3.1.9.6 software. A total of 40 cases, distributed evenly with 20 cases in each group, were determined as necessary for this study, considering a 95% confidence level (1-α), an 80% test power (1-β), and an effect size of d = 0.812. To account for potential data losses and dropouts, it was prudent to initially screen a total of 50 patients, representing a 25% increase over the calculated sample size.

2.6. Statistical analysis

The analysis of the study data was performed using IBM SPSS version 23. Normality of the data was assessed using the Shapiro-Wilk Test. For parameters displaying a normal distribution, comparisons between groups were conducted using the Independent Samples t-Test. Conversely, for parameters deviating from a normal distribution, the Mann-Whitney U Test was employed to ensure robust analysis across all data types. Regarding categorical data, group comparisons were made utilizing Yates's correction and Fisher's Exact Test, as deemed appropriate. Categorical variables were depicted through median and min-max, while quantitative variables were presented as both mean ± standard deviation. The predefined threshold for statistical significance was established at $p < 0.050$. Additionally, given that NRS and MBS scores were measured at five separate time frames, Bonferroni correction was applied, and NRS and MBS assessments were considered statistically significant at $p<0.001$.

3. Results

In this study, 50 patients were initially enrolled, but 5 of them were subsequently excluded for various reasons. Consequently, a total of 45 patients were included in the analysis, with 22 in Group ITM and 23 in Group GB. Fig. 1, displayed as the CONSORT diagram, delineates the enrollment process for this study.

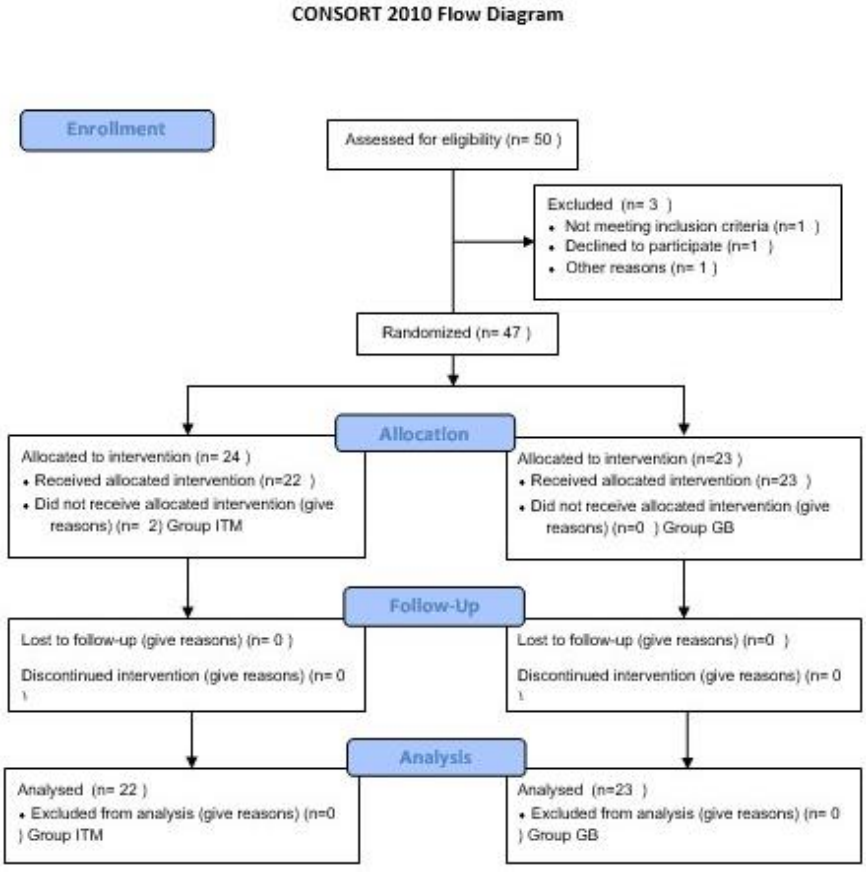

Fig. 1. CONSORT flow diagram of the study.

When groups compared for descriptive, no significant differences were observed between the groups in ASA class and gender (p>0.05). However, a significant disparity was evident between the groups concerning the age variable, with Group ITM exhibiting a younger patient population. Furthermore, the ITM group displayed shorter operation times, tourniquet times, and block application times (p values: p=0.019, p=0.016, p<0.001, respectively) as summarized in Table 1.

When comparing the groups based on Numeric Rating Scale (NRS) scores at various time intervals, a divergence in NRS scores was observed solely at the 12-hour mark, with Group ITM exhibiting lower scores than Group GB (p=0.002). However, the groups displayed similarity in terms of pain scores at all other time intervals (Table 2). The median values of the MBS scores, assessed at various time intervals, did not exhibit statistically significant variations between the groups (p>0.050) (Table 2).

A statistically significant difference was observed in opioid consumption between the groups (p=0.028). However, the median values for the time to the first mobilization did not exhibit statistically significant differences between the groups (p=0.102). (Table 3). Furthermore, no complications, such as nausea, vomiting, or itching, were reported in any of the cases within the initial 24 hours postoperatively.

Table 1. Comparison of quantitative sociodemographic characteristics between groups.

	Group ITM	Group GB	P value
Age (year)	64.09 ± 11.47	70.57 ± 7.6	0.043*
Weight (kg)	83.27 ± 17.77	83.52 ± 15.26	0.555
Height (cm)	170.18 ± 8.59	171.87 ± 10.78	0.566
Operation time (min)	65.91 ± 19.13	80.22 ± 23.33	0.019*
Duration of tourniquet application (min)	59.91 ± 18.71	73.39 ± 21.21	0.016*
Block administration time (min)	3.82 ± 2.79	12.39 ± 3.17	<0.001*
Gender (n, %)			
Male	12 (54.5)	14 (60.9)	0.899
Female	10 (45.5)	9 (39.1)	
ASA (n, %)			
2	20 (90.9)	15 (65.2)	0.071
3	2 (9.1)	8 (34.8)	

The data are presented as mean ± standard deviation or number (%).
*p<0.05

Table 2. Comparison of NRS and MBS scores between groups.

	Group ITM	Group GB	P value
Baseline NRS	0 (0 - 0)	0 (0 - 0)	1.000
2-hour NRS	0 (0 - 2)	0 (0 - 5)	0.978
6-hour NRS	0 (0 - 6)	1 (0 - 8)	0.115
12-hour NRS	1 (0 - 5)	2 (0 - 8)	0.005
24-hour NRS	0 (0 - 7)	1 (0 - 6)	0.027
Baseline MBS	3 (3 - 3)	3 (3 - 3)	1.000
2-hour MBS	1 (0 - 3)	1 (0 - 3)	0.925
6-hour MBS	0 (0 - 1)	0 (0 - 2)	0.625
12-hour MBS	0 (0 - 1)	0 (0 - 2)	0.311
24-hour MBS	0 (0 - 0)	0 (0 - 0)	1.000

The data are presented as min-max.
NRS: Numeric rating score; MBS: Modified bromage score.

Table 3. Comparison of time to first mobilization and amount of tramadol consumption between groups.

	Group ITM	Group GB	P value
Time to first mobilization (hour)	13.05 ± 5.96	16.39 ± 7.37	0.102
Tramadol consumption (mg)	35.45 ± 54.84	60 ± 37.17	0.028

The data are presented as mean ± standard deviation.

4. Conclusions

Based on the findings from our study, it was evident that tramadol consumption within the initial 24-hour period was notably lower in ITM group when compared to GM group. Moreover, the Numeric Rating Scale (NRS) scores exhibited a similar pattern in both groups, with no substantial differences observed at the 0, 2, 6 and 24 hours intervals during the measured. However, it is significant that a distinct difference in NRS scores emerged at the 12th hour mark, with the ITM group displaying significantly lower scores compared to the GM group.In a study on the prophylactic use of pentoxyphiline to preserve postoperative organ functions in elderly patients undergoing cardiac surgery, liver, kidney, and endothelial damage was found to be less in patients [6].

In a comprehensive study centered on knee arthroplasties, femoral and sciatic nerve blocks were ingeniously combined with a genicular block [15]. Within the femoral and sciatic block group, notably lower Numeric Rating Scale (NRS) scores and reduced opioid consumption were observed by the researchers. While our study did not directly compare two distinct peripheral nerve block techniques, certain similarities exist between our findings and the outcomes reported by Gümüşkanat et al. [15]. Specifically, our study demonstrated a discernible reduction in opioid consumption in the intrathecal morphine group when compared to the genicular block group.

Expanding beyond the genicular block, a spectrum of pain management options after total knee arthroplasty extends to techniques like the interspace between the popliteal artery and the capsule of the posterior knee (iPACK) block, selective tibial nerve block, adductor canal block, and even combinations of these distinct blocks [16–20].

In a notable anatomical study by Fonkoué et al. [21], the intricate distribution of knee joint nerves was meticulously explored using 21 lower limbs dissected from 21 cadavers. Their study shed light on the comprehensive innervation of various knee joint components, demonstrating that the medial portion of the knee capsule and the retinaculum find their innervation from multiple sources, including the vastus medialis nerve, saphenous nerve, anterior branch of the obturator nerve, and the inferior medial genicular nerve taking origin from the sciatic nerve. Innervation of the superolateral aspect of the knee joint is attributed to the sciatic nerve and the vastus lateralis nerve, while the inferolateral portion receives its supply from the fibular nerve. The posterior aspect of the knee capsule, in turn, receives innervation from the tibial nerve, a terminal branch of the sciatic nerve, and the posterior branches of the obturator nerve [21].

The genicular nerve block, traditionally used for managing chronic knee pain related to osteoarthritis, has recently gained significance in postoperative pain management after knee surgery within multimodal analgesic strategies [20]. Yasar et al. [22] conducted anatomical dissections on 6 cadavers, consistently visualizing nerves in 12 dissections focused on superior medial genicular nerve and inferior medial genicular nerve blocks. These ultrasound-guided blocks, guided by anatomical landmarks, were found to be viable and successful for these specific nerves. In our study, Group GB demonstrated effective pain relief during most of the measured time intervals (0, 2, 6 hours) compared to Group ITM. Only at the 12 and 24-hour marks did Group ITM report lower Numeric Rating Scale (NRS) scores. This difference in pain perception could be attributed to the extended half-life of morphine. Importantly, our results align with existing literature, affirming the efficacy of genicular blocks in postoperative pain management following knee surgery.

In a study by Kukreja et al. [13] involving 52 cases of primary knee arthroplasty, 26 patients received an adductor canal block, while an equivalent number underwent a combination of adductor canal block along with superolateral, superomedial, and inferomedial genicular nerve blocks. Interestingly, the group that received the combined genicular nerve and adductor canal block showed significantly lower Numeric Rating Scale (NRS) scores six hours after surgery. Moreover, there was a notable reduction in morphine consumption observed in the 6 to 12-hour period among patients who received the combined block [13]. In our study, our approach diverged as we independently administered blocks to the inferior medial, superior medial, and superior lateral genicular nerves, rather than combining them as done by Kukreja et al. However, akin to their results, we also observed lower NRS scores in the intrathecal morphine group at the 12 and 24-hour intervals. Essentially, our observed analgesic duration for the genicular block aligns with the findings detailed in the study by Kukreja et al.

In clinical practice, opioids have long held the esteemed status of being the 'gold standard' for postoperative pain management, with morphine playing a prominent role in this domain [23]. Among these opioids, intrathecal administration of morphine emerges as a particularly appealing regional technique, setting it apart from its epidural counterpart. Notably, this approach is characterized by its simplicity, expediency, and significantly reduced susceptibility to technical complications and infection risks when compared to epidural administration [24]. Synthesizing findings across diverse studies, a collective narrative emerges that underscores the utility of intrathecal opioids in reducing postoperative

pain, as demonstrated by a decrease in Numeric Rating Scale (NRS) scores. Simultaneously, it diminishes the necessity for supplementary analgesic interventions among patients [25–27].

In a placebo-controlled study by Kaczocha et al. [28] involving total knee arthroplasty, two groups were formed. One group received intrathecal morphine, while the other received intrathecal saline as a placebo, with all patients undergoing general anesthesia. The study revealed reduced postoperative pain scores in the intrathecal morphine group. Additionally, the results indicated that morphine influenced endogenous cannabinoid and cortisol levels, impacting immune functions by attenuating leukocyte activities.

There are several limitations to our study that should be acknowledged. One constraint arises from our focus on monitoring patients solely within the initial 24 hours postoperatively, which prevented us from assessing the potential long-term effects of the administered blocks on pain scores and complications. Extending our postoperative observations to a 48-hour period could have provided a more comprehensive perspective. Furthermore, our study was conducted with a relatively restricted patient population, and the absence of a larger sample size might be considered another limitation.

In conclusion, we observed that intrathecal morphine administration led to a more substantial reduction in cumulative rescue opioid consumption at 24 hours compared to genicular block. However, NRS scores remained similar between the two groups throughout all time periods except for the 12-hour mark. These results suggest that genicular block can be deemed a viable alternative within the realm of multimodal analgesia techniques for knee arthroplasty, offering potential benefits in postoperative pain management.

Author Contributions

All authors have made significant contributions to the design or data acquisition or analysis and interpretation of data; were involved in the drafting or critical review for important intellectual content; gave final approval of the version to be published.

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Conflict of Interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this manuscript.

Data Availability

The datasets created and/or analyzed during the current study are not publicly available, but are available from the corresponding author upon reasonable request.

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