Original Article

Comparison of ultrasound-guided genicular nerve block and knee periarticular infiltration for postoperative pain and functional outcomes in knee arthroplasty – A randomised trial

Address for correspondence:
Dr. Tarek A. Mostafa, Department of Anesthesiology and Critical Care, Faculty of Medicine, Tanta University, 1st Elgeish Street, Tanta, Al Gharbia Governate, Postal code - 31527, Egypt.
E-mail: Dr.tarek311@yahoo.com

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Gehan M. Eid, Shiamaa El said Shaban, Tarek A. Mostafa
Department of Anesthesiology and Surgical Intensive Care, Faculty of Medicine, Tanta University, Tanta, Egypt

ABSTRACT

Background and Aims: Optimal analgesia after total knee arthroplasty (TKA) enhances patients' and surgical outcomes. The study investigated the ultrasound-guided genicular nerve block versus the periarticular infiltration in TKA. **Methods:** Eighty-eight patients aged above 50 years scheduled for unilateral TKA were randomised as: Group 1 received intraoperative periarticular infiltration (0.5 mL adrenaline [4.5 μg/mL], 20 mL bupivacaine 0.5% with 89.5 mL saline) and Group 2 received immediate postoperative genicular nerve block (15 mL bupivacaine 0.25% with 2.5 g/mL adrenaline). The postoperative morphine consumption was during the first two postoperative days the primary outcome. The secondary outcomes were time to rescue analgesia, pain scores and functional outcomes. The comparison between groups was performed using the Chi-square test, the Student's *t*-test and the Mann–Whitney U test, as appropriate. **Results:** The postoperative morphine consumption during the first two postoperative days and pain scores at rest at 12 h postoperatively were less in Group 1 than in Group 2 ($P < 0.001$). Pain scores during movement on the first postoperative day were lower in the periarticular group than the genicular group at 6, 12 and 24 h ($P < 0.001$). At 18 h, pain scores were higher in the periarticular group than in the genicular group at rest and movement ($P < 0.001$). Quadriceps motor strength scores were comparable between groups ($P > 0.05$). The knee range of motion and time up and go test during both days showed a statistically significant difference in the periarticular group compared to the genicular group ($P < 0.05$). **Conclusion:** Periarticular infiltration and genicular nerve block yield effective postoperative analgesia and functional outcomes after TKA without motor affection.

Key words: Functional outcomes, genicular nerve block, knee arthroplasty, periarticular infiltration, postoperative pain, rehabilitation, ultrasonography

INTRODUCTION

Pain after total knee arthroplasty (TKA) is recognised as moderate to severe, and optimal postoperative analgesia enhances patients' and surgical outcomes, including relieving osteoarthritis-related pain, improving quality of life and maintaining or improving knee function. An ideal postoperative rehabilitation includes adequate knee motion range, minimal or no pain without motor impairment and easy mobilisation.[1,2]

Peripheral nerve blocks have become the standard, widely accepted alternative to epidural blocks.[3] The regional blocks like adductor canal block (ACB), infiltration between the popliteal artery and the capsule of the knee (IPACK) block, sensory posterior articular

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nerves of the knee (SPANK) block, periarticular infiltration (PAI) and genicular nerves block (GNB) are effective techniques to provide analgesia.[4]

PAI is defined as an intraoperative drug injection in the periarticular fields.[5] Successful chronic knee osteoarthritis pain management can be achieved by GNB and ablation, affecting the sensory branches of the knee joint and maintaining the quadriceps' muscle strength.[6] Postoperative immediate physiotherapy encourages mobilisation, attaining optimal results following TKA.[7]

This study aimed to compare GNB with PAI for postoperative analgesia following TKA. We hypothesised that PAI or GNB could provide effective postoperative analgesia, early knee mobility, optimal rehabilitation and reasonable patient satisfaction without muscle weakness and side effects.

METHODS

This double-blinded, randomised trial was approved by the Faculty of Medicine's Research Ethics Committee (approval ID: 33818/5/20, dated May 2020). The trial was registered on clinicaltrial.gov before the first patient enrolment (ID: NCT04419701, https://clinicaltrials.gov/study/NCT04419701). The study was conducted from June 2020 to January 2021. All eligible patients signed a written informed consent with full details, including using the patient data for research and educational purposes. The study comprised 88 patients of either gender, aged above 50 years, belonging to the American Society of Anesthesiologists (ASA) physical status I–III and scheduled for unilateral TKA. The study was guided by the principles outlined in the Declaration of Helsinki, 2013 and the Consolidated Standards of Reporting Trials (CONSORT) 2010 randomised controlled trial (RCT) statement.

Patients scheduled for revision knee arthroplasty or those who had a past history of previous surgery or trauma to the knee or medical history of allergy to local anaesthetics (LA), regular narcotic use, and those with renal and/or hepatic impairments, neuromuscular disorders and coagulopathy disorders were excluded from the study.

History taking, clinical examination and routine laboratory investigation were performed preoperatively. The Numerical Rating Scale (NRS) was used to assess pain intensity. Preoperatively, all study subjects were trained to use NRS pain scores.

In the operating room, a peripheral 20-G intravenous (IV) cannula was inserted. The baseline parameters of five-lead electrocardiogram (ECG), non-invasive blood pressure and peripheral oxygen saturation were recorded. IV midazolam 0.02 mg/kg was administered. The spinal block was performed using either a 25- or 27-G spinal needle in the sitting position at the L3–L4 or L4–L5 intervertebral space with a 2.5–3 mL hyperbaric bupivacaine 0.5%. The sensory block (to cold and pinprick) to the 10th thoracic dermatome or above was the target of the spinal block to start the surgery. Hypotension was defined as ≥20% decrease in blood pressure from baseline measurements and managed by IV phenylephrine100 μg boluses.

An independent data manager of computer-generated software was responsible for randomisation, assigning the patients to the groups using sequentially numbered, sealed, opaque envelopes containing computer-generated random numbers, accessible only to the anaesthesiologist performing the block. The subjects were randomly allocated to one of the two groups.

Group PAI: Adrenaline 0.5 mL (4.5 μg/mL) at a concentration of 1:2,00,000, 20 mL bupivacaine 0.5% combined with 89.5 mL saline was administered for PAI. PAI was performed by having the LA cocktail divided into seven doses, equivalent to 10–15 mL each. Each anatomical area was infiltrated with a single dose. The anatomical areas were injected as before inserting the prosthesis, after executing the tibial and femoral cuts and ligament balancing: areas 1 (medial collateral ligament and medial meniscus capsular attachment), 2 (posterior capsule) and 3 (lateral collateral ligament and lateral meniscus capsular attachment were infiltrated with LA). After implant placement, areas 4 (lateral retinaculum), 5 (medial retinaculum), 6 (patellar tendon and fat pad) and 7 (cut ends of the quadriceps muscle and tendon) were infiltrated [Figure 1].

Group GNB (ultrasound-guided GNB): Fifteen mL of bupivacaine 0.25% with 2.5 g/mL adrenaline at a concentration 1:4,00,000 was administered immediately following skin closure. GNB was performed by placing the transducer to scan the long bone shaft with up and down movement to recognise the epicondyle of the tibia and femur. The junctions

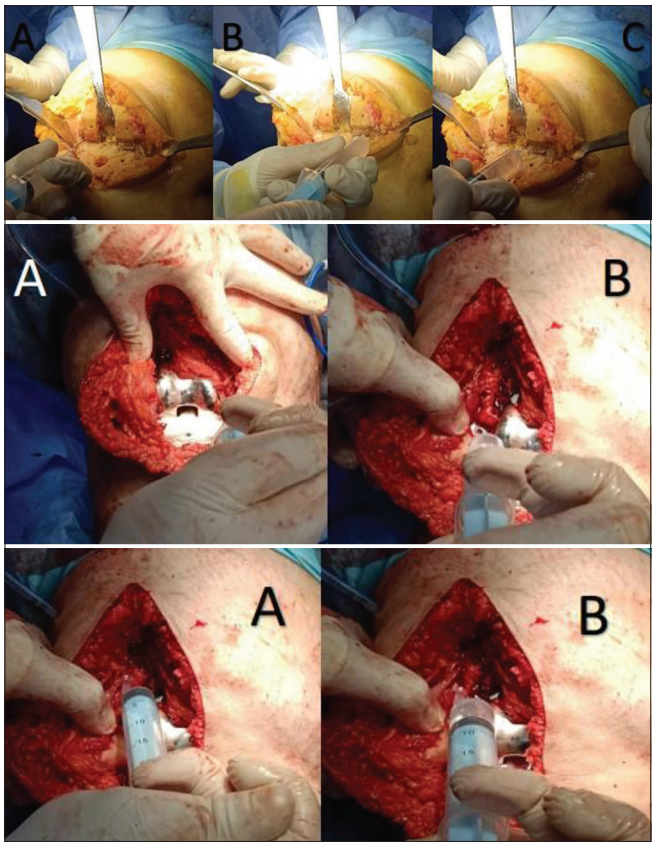

Figure 1: Injection of local anaesthetic cocktail (I) before the implant placement. (A) Injection of cocktail at the medial collateral ligament and medial meniscus capsular attachment. (B) Injection of cocktail at the lateral collateral ligament and lateral meniscus capsular attachment. (C) Injection of cocktail at the posterior capsule of knee. (II) after the implant placement at the medial and lateral retinaculums retinacula. (A) Injection of cocktail at the lateral retinaculum, (B) Injection injection of cocktail at the medial retinaculum. (III) After the implant placement at the patellar tendon, fat pad, and the cut ends of quadriceps muscle and tendon. (A) Injection of cocktail at the patellar tendon and fat pad, (B) Injection injection of cocktail at the cut ends of the quadriceps tendon

between the epicondyle and the shafts of the femur and tibia are where the genicular arteries are located; these junctions were defined as the periosteal areas. The superior lateral, superior medial and inferior medial genicular arteries accompany each genicular nerve. After confirmation of the genicular artery by colour Doppler, the needle was introduced using the in-plane approach and presented in the long-axis view. The target point of the needle insertion was the needle tip beside a genicular artery. Then, a 5-mL volume was administered after gentle aspiration to prevent a faulty intra-arterial injection at three target locations: the superior lateral, superior medial and inferior medial genicular nerves [Figure 2-4].

The investigator and the patients were blinded about the technique and the method of allocation concealment. A curtain was applied at a level higher than the umbilicus level away from the surgical site to maintain infection control and sterilisation, separating the patient from the surgical and block areas obscuring the patient about the block technique and onset.

The primary outcome was the total postoperative morphine consumption during the first two postoperative days. The period between the end of surgery and the first request for rescue analgesia (NRS >3) was considered the time to the first request.

Postoperative analgesia, IV paracetamol (1 g/6 h) and IV ketorolac (30 mg/8 h), was administered to all patients. The pain was assessed at rest and during movement using NRS (metric score 0–10 for pain severity assessment: mild pain = 1–3, moderate = 4–7 and severe = 8 and above) on the first and second days. When NRS was >3, rescue analgesia (morphine 3 mg IV) was given and repeated whenever required.

Postoperative functional outcomes and knee rehabilitation parameters included quadriceps motor strength score measured by straight leg raising (SLR), knee range of motion (ROM) and time up and go (TUG) test. SLR was assessed on a scale ranging from 0 to 5 as follows: 0 = unable to contract muscles, 1 = muscles twitch, the limb does not move, 2 = able to move the limb with gravity elimination and passive assistance, 3 = able to move the limb against gravity without resistance (no cuff weights weight wrapped around your thigh just above your kneecap), 4 = move the limb against some resistance (cuff weights weight wrapped around your thigh just above your kneecap) and 5 = normal motor strength against resistance.[8] ROM was assessed as the active assisted knee extension and flexion ROM measured by a long-arm goniometer while the patients were supine. Active assisted ROM was defined as how much distance the knee muscles can move the leg but with some help from a therapist. Normal ROM ranged from 0 to 135°.[9] TUG is a performance test to measure functional mobility. The test requirements were presented as the subject rises from a chair, walks 3.0 m easily to reach a mark placed on the floor, turns around at the 3.0-m mark, returns to the starting point and sits on the chair.[8,10] The time the subject takes to complete the test is defined as the TUG score. Patients' movement with aid within 24 h was encouraged when the motor strength was at least

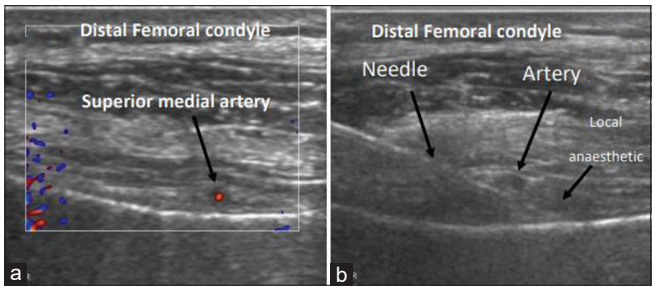

Figure 2: Ultrasound-guided identification of the superior medial genicular artery and local anaesthetic cocktail injection to the nerve accompanying the artery presented at the knee's long-axis view at the distal femoral condyle level. (a) Ultrasound-guided identification of the superior medial genicular artery by colour Doppler study (the probe was positioned medially for scanning). (b) Needle insertion with in-plane mode of the ultrasound probe in the long-axis view next to the artery with local anaesthetic cocktail injection

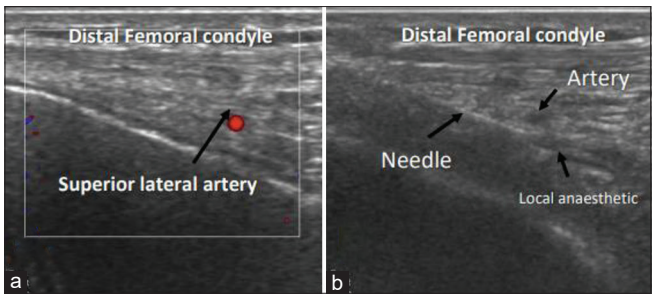

Figure 3: Ultrasound-guided identification of the superior lateral genicular artery and local anaesthetic cocktail injection to the nerve accompanying the artery presented at the knee's long-axis view at the distal femoral condyle level. (a) Ultrasound-guided identification of the superior lateral genicular artery by colour Doppler study (the probe was positioned laterally for scanning). (b) Needle insertion with in-plane mode of the ultrasound probe in the long-axis view next to the artery with local anaesthetic cocktail injection

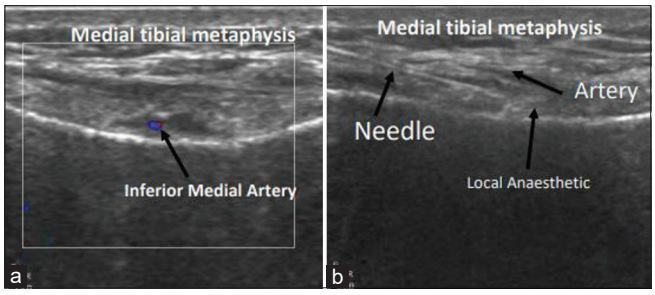

Figure 4: Ultrasound-guided identification of the inferior medial genicular artery and local anaesthetic cocktail injection to the nerve accompanying the artery presented at the long-axis view of the knee at the level of the medial tibial metaphysis. (a) Ultrasound-guided identification of the inferior medial genicular artery by colour Doppler study (the probe was positioned medially for scanning). (b) Needle insertion with in-plane mode of the ultrasound probe in the long-axis view next to the artery with local anaesthetic cocktail injection

two.[8,10] The postoperative patient satisfaction and incidence of adverse effects were recorded. Patient satisfaction was measured by a self-administered satisfaction scale (very satisfied, somewhat satisfied, somewhat dissatisfied, very dissatisfied).[11]

Based on a previous study,[12] sample size calculation revealed that at least 39 patients were required in each group to detect at least a 40% significant reduction in postoperative morphine consumption during the first postoperative day (primary outcome) at 0.05 α value, 85% power of the study, with an allocation ratio of 1:1 (postoperative morphine consumption was mean [standard deviation {SD}] = 31 [18]). Forty-four patients were selected in each group to overcome dropout cases. The data analysis was performed by Statistical Package for the Social Sciences (SPSS) Version 24 program (IBM Corporation, Armonk, NY, USA). The categorical variables such as gender, surgery side, ASA class and adverse effects were expressed by absolute numbers and percentages, while the continuous variables such as age, surgery and tourniquet times, morphine consumption, first time of rescue analgesia, NRS, patient satisfaction scores and ROM and TUG test were presented as either mean values with SD or medians with an interquartile range as appropriate. As appropriate, a comparison between groups was performed using the Chi-square test, the Student's *t*-test and the Mann–Whitney U test. A statistically significant difference was achieved when the *P* value was <0.05.

RESULTS

In this study, 103 patients were evaluated and 88 were found eligible [Figure 5]. Patient characteristics, including age, gender, ASA physical status and clinical data related to surgery, were comparable ($P > 0.05$) [Table 1].

PAI consumed lower postoperative morphine than GNB during the first two postoperative days ($P < 0.001$). The first-time rescue analgesia request of PAI was significantly longer than that of GNB ($P < 0.001$). Both groups had an insignificant difference regarding postoperative patient satisfaction and incidence of adverse effects ($P = 0.202$ and 0.524, respectively) [Table 2].

Significantly lower pain scores at rest during the first postoperative day were observed in PAI compared to GNB at 12 h ($P < 0.001$). At the 6- and 24-h postoperative recordings, pain scores at rest between the two groups were comparable ($P = 0.09$ and 0.252, respectively). But NRS during movement was lower in PAI than GNB at 6, 12 and 24 h ($P < 0.001$). While at the 18-h postoperative recordings at rest and movement,

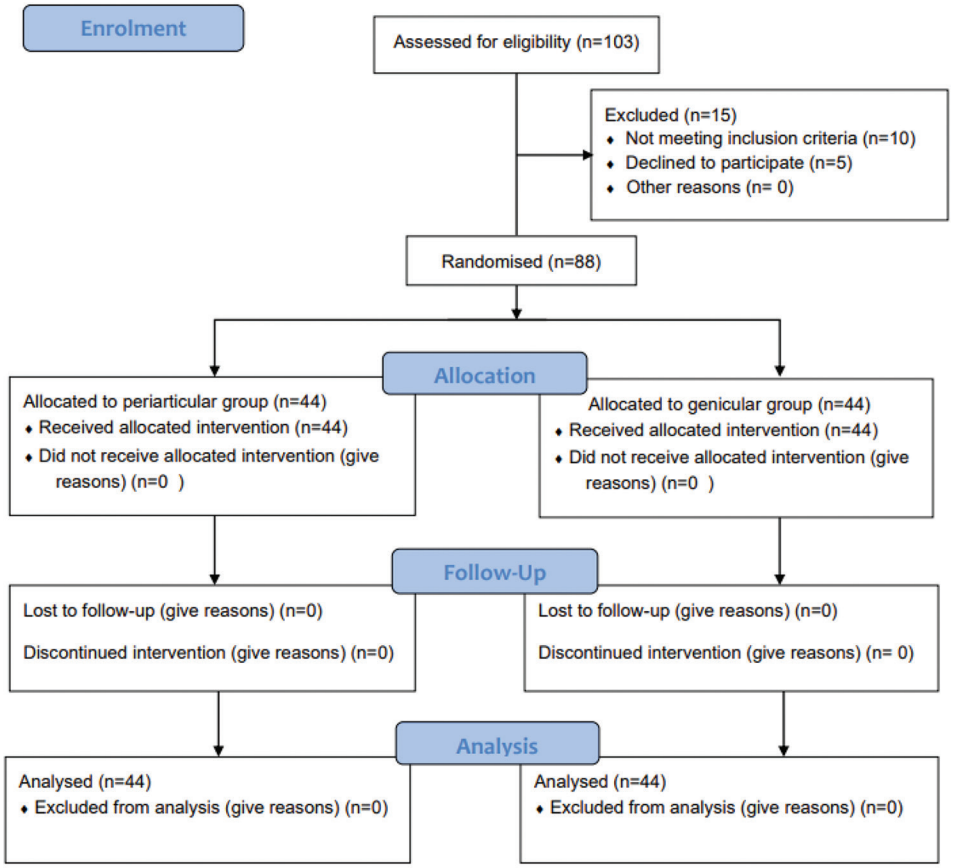

Figure 5: Consolidated Standards of Reporting Trials (CONSORT) flow diagram of the studied groups

Table 1: Demographic data of the studied groups

	Group PAI (*n*=44)	Group GNB (*n*=44)
Age (years)	61.43 (7.58)	58.86 (9.59)
Gender (F:M)	27:17	24:20
Duration of the surgery (min)	145.23 (34.23) (134.82–155.63)	136.23 (29.14) (127.37–145.09)
Tourniquet time (min)	125.82 (34.08) (115.46–136.18)	119.84 (1.35) (111.1–128.58)
American Society of Anesthesiologists class I:II:III	5:30:9	6:31:7
Surgery side (right:left)	19:25	21:23

Data expressed as mean (standard deviation) (95% confidence interval) or number. GNB=Genicular nerves block, PAI=Periarticular infiltration

PAI showed higher pain scores than GNB ($P < 0.001$). During the second postoperative day, pain scores at rest and movement were lower in PAI than in GNB, with statistically significant differences ($P = 0.027$ and 0.001, respectively) [Table 3].

Regarding functional outcomes, quadriceps motor strength scores during the first and second postoperative days were insignificantly different between groups ($P = 0.371$ and 0.138, respectively). Knee ROM degrees and TUG tests during both days showed a statistically significant difference in PAI compared to GNB ($P < 0.0001$) [Table 4].

DISCUSSION

In our study, GNB and PAI effectively reduced pain following TKA. PAI consumed less morphine overall during the first two postoperative days than GNB.

The pain score concerned with PAI started to increase at 18 h postoperatively, especially with frequent rehabilitation and physiotherapy exercises, pain score, which required rescue analgesia, while the pain score concerned with GNB started to increase at postoperative duration ranging from 10 to 12 h; so, the patients received rescue analgesia at this duration, effectively relieving pain for the subsequent hours, especially with physiotherapy. The authors. presented the postoperative significant 18 hr effective analgesia and reduced opioid consumption of PAI over GNB.

Poor pain control leads to extended hospital stays, increased opiod use and side effects.[13,14] Wall

Table 2: Characteristics of postoperative rescue analgesia, patient satisfaction score and postoperative adverse effects of the studied groups			
	Group PAI (*n*=44)	Group GNB (*n*=44)	*P*
Postoperative morphine consumption (mg)			
First day	5.18 (1.35) (4.77–5.59)	10.23 (1.87) (9.66–10.79)	<0.001
Second day	10.77 (2.08) (10.14–11.4)	17.18 (2.69) (16.36–18)	<0.001
First time of recue analgesia (min)	15.78 (2.41) (15.05–15.74)	10.61 (1.32) (10.21–11.01)	<0.001
Patient satisfaction score			
Very satisfied	27	21	0.202
Somewhat satisfied	17	23	
Somewhat dissatisfied	0	0	
Very dissatisfied	0	0	
Postoperative adverse effects			
None	37	39	0.524
Nausea	5	4	
Vomiting	2	1	
Infection	0	0	
Local anaesthetic toxicity	0	0	

Data expressed as mean (standard deviation) (95% confidence interval) or number. GNB=Genicular nerves block, PAI=Periarticular infiltration

Table 3: Postoperative NRS of the studied groups at rest and movement			
NRS	Group PAI (*n*=44)	Group GNB (*n*=44)	*P*
6 h			
At rest	1 (1-2)	2 (1-2)	0.090
At movement	2 (2-2)	3 (2-3)	<0.001
12 h			
At rest	2 (2-2)	3.5 (3-4)	<0.001
At movement	2 (2-2)	5 (4-5)	<0.001
18 h			
At rest	4 (3-4)	3 (2-3)	<0.001
At movement	4 (4-5)	3 (2-4)	<0.001
18 h			
At rest	3 (3-3)	4 (3-3)	0.252
At movement	3 (3-4)	4 (3-4)	0.001
Second day			
At rest	2 (2-3)	3 (2-4)	0.027
At movement	3 (3-4)	4 (3-5)	0.001

Data expressed as median (interquartile range). GNB=Genicular nerves block, NRS=Numerical Rating Score, PAI=Periarticular infiltration

et al. found that compared to the femoral nerve block, PAI required less rescue morphine up to 24 h after surgery. Our results and the findings of Wall *et al*. confirmed the advantage of lower opioid consumption related to PAI.[15] The Kulkarni *et al*. reported that PAI offers a more significant reduction of pain scores compared with other regional blocks such as ACB. These findings were in context with our study[16]

GNB carries the theoretical advantage of being less invasive to the surgical field than PAI. Many surgeons might not prefer PAI because of the fear of infections. GNB is characterised as a motor-sparing block. These features drew the researchers' attention to GNB as the subject of a comparative investigation to figure out its function in the best therapy.[6] In our study, the inferolateral genicular block was avoided due to the risk of unintended motor weakness or probable foot drop by unintentionally blocking the common peroneal nerve branch. Akesen *et al*.[17] suggested that GNB reduced postoperative morphine consumption, enhancing ROM within 12 h in the postoperative period. Tabur *et al*. found that femoral and sciatic nerve blocks were superior to GNB in TKA. Moreover, GNB does not cause motor weakness with lower visual analogue scores. Tabur *et al*.'s[18] study had a different methodological design with preoperative performance. Tabur *et al*. revealed that rescue analgesia consumption was significantly higher with GNB. Tabur *et al*. explained these differences due to the longer operation and tourniquet times in GNB, increasing postoperative pain measurements and opioid requirements.

The results of Cuñat *et al*.[19] within context with our results also concluded the reduction of total opioid consumption provided by PAI when compared with GNB. NRS at 24 h was lower in GNB than in PAI. The study of Cuñat *et al*. revealed no statistical differences in comparisons of first-time of rescue analgesia and ROM. NRS, first time of rescue analgesia and ROM results of Cuñat *et al*. were against our results. This was explained by numerous factors. Cuñat *et al*. performed five GNB, not three GNB as in this study methodology. This may lead to a block of the common

Table 4: Postoperative knee rehabilitation parameters of the studied groups (QMS score, knee range of motion degree and the TUG test

	Group PAI (*n*=44)	Group GNB (*n*=44)	*P*
QMS score			
First day	4 (4-5)	4 (4-5)	0.371
Second day	4 (4-5)	5 (4-5)	0.138
Knee range of motion degree			
First day	92.3 (5.54) (90.61–93.98)	77.02 (6.38) (75.08–78.96)	<0.001
Second day	100.66 (6.70) (98.62–102.7)	87.5 (6.55) (85.51–89.49)	<0.001
TUG test			
First day	49.0 (7.96) (46.58–51.42)	58.05 (8.34) (55.51–60.58)	<0.001
Second day	35.43 (7.65) (33.11–37.76)	48.84 (7.33) (46.61–51.07)	<0.001

Data expressed as mean (standard deviation) (95% confidence interval) or median (interquartile range). GNB=Genicular nerves block, IQR=Interquartile range, PAI=Periarticular infiltration, QMS=Quadriceps motor strength, TUG=Timed up and go

fibular nerve with a problematic foot drop, obscuring early physiotherapy and rehabilitation. With its large volumes, PAI could block cutaneous innervation of the surgical site and the knee capsule. However, GNB did not block this cutaneous innervation and capsule. The study of Cuñat *et al*.[19] also concluded that GNB offers a feasible alternative technique to PAI.

Our study has some limitations, which include the relatively small sample size without a control group. The surgical team was not blinded to the approach of the pain management methodology with different LA doses. Another limitation is that the long-term outcomes of PAI or GNB need to be studied further.

CONCLUSION

The study concluded that GNB can be considered a safe, effective and promising alternative to PAI for postoperative analgesia and effective functional outcome in TKA.

Study data availability

De-identified data may be requested with reasonable justification from the authors (email to the corresponding author) and shall be shared after approval as per the authors' institution policy.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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