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Pain management following simultaneous bilateral total knee arthroplasty: genicular nerve blockade versus periarticular injection

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The aim of the present study was to investigate whether the analgesic solution prepared for periarticular injection (PAI) could be utilized as a genicular nerve blockade (GNB) agent in bilateral knee arthroplasty, and to assess the pain control efficacy of this approach in comparison with PAI. This was a retrospective cohort in which patients undergoing simultaneous bilateral total knee arthroplasty (TKA) were evaluated. Thirty patients were enrolled. The standard PAI was used for one knee, while the PAI solution was applied in the form of GNB to the other. Visual Analog Scale (VAS) pain scores were measured and recorded separately for each knee, at rest (static) and during exercise (dynamic). Active range of joint motion (JRM) for both knee joints was measured preoperatively, at postoperatively. Compared to the PAI group, the GNB group had lower VAS scores at 2 and 8 hours ($p = 0.030$ and $p < 0.001$, respectively). The GNB group also had lower dynamic VAS scores at 2, 8, and 24 hours ($p = 0.009$, $p < 0.001$ and $p<0.001$, respectively). Static and dynamic VAS measurements did not demonstrate any differences between groups (GNB vs. PAI) at 48 hours and 30 days ($p>0.05$). When the reduction in VAS scores was assessed, we found that the decrease in both scores was significantly greater in the PAI group compared to the GNB group ($p<0.001$, for both). There were no significant differences between the groups with regard to drainage volume, complications and JRM ($p>0.05$). GNB was found to be more effective for pain control throughout the first postoperative day in patients who underwent simultaneous bilateral TKA.

Keywords: Genicular nerve blockade, periarticular injection, bilateral knee arthroplasty, multimodal analgesia.

INTRODUCTION

Various treatment modalities are utilized for pain control after total knee arthroplasty (TKA). Periarticular injection (PAI) is one such modality that is being used frequently during TKA surgery in many centers. It has proven efficacy against pain while also improving functional results[1]. Moreover, as a result of its widespread renown and efficacy, PAI is often used as a reference pain control method in comparative studies evaluating other approaches[2-5]. PAI is applied to a region including the posterior capsule and the soft tissues surrounding the knee joint, which are innervated by the articular branches of various nerves, including the femoral, common peroneal, saphenous, tibial and obturator nerves. These articular branches around the knee joint are known as the genicular nerves. Choi et al. reported successful pain relief by ablation of three branches of the genicular nerve [the superior lateral (SL), superior medial (SM), and inferior medial (IM) genicular nerves], which were chosen because they pass the periosteal areas connecting the shaft of the femur to the bilateral epicondyles and the shaft of the tibia to the medial epicondyle[6]. Radiofrequency ablation (RFA) and genicular blockade under the guidance of ultrasonography are reported to provide satisfactory results in recipients of osteoarthritis treatment without TKA and patients with painful knee prostheses after TKA[7-10]. However, an increasing number of anatomical studies and systematic reviews are questioning the anatomical sites for needle insertion in such approaches[11-16]. In a recent review on the subject, it has been emphasized that only 3 out of the 12 (or potentially 13) nerves innervating the knee joint were targeted by commonly used RFA techniques[17]. The present study aimed to compare the effects of GNB with an anesthetic cocktail vs classical periarticular injection in terms of pain and function in patients undergoing bilateral TKA.

MATERIALS AND METHOD

This was a retrospective cohort into which patients who underwent simultaneous bilateral knee arthroplasty from December 2019 to March 2020 were included. A total of 46 patient files were evaluated during the study. Patients who underwent simultaneous bilateral TKA with a single dose of spinal anesthesia were included in the study. Patients were excluded from the study if they had severe varus alignment (>20°), secondary osteoarthritis or inflammatory arthritis. Additionally, recipients of epidural or general anesthesia, and those who could not undergo clinical follow-up were excluded. Sixteen patients were excluded for one or more of the above reasons. A total of 60 knees of 30 patients were evaluated (Figure 1). The first group was formed from the GNB knees of patients with bilateral TKA. The second group included the contralateral knees of the same patients, to which standard PAI had been applied. The present study was carried out in accordance with the Principles of the Helsinki Declaration after obtaining the required approvals from the local ethics committee, subject to the decree 2020-10/9, dated June 10, 2020.

All procedures were conducted by the same surgeon. TKA was conducted via standard midline incision and medial parapetallar arthrotomy. Fixed insert, posterior-stabilized prostheses were used in all patients [Anthem (Smith+Nephew®), Columbus® (Braun)]. The analgesic cocktail mixture consisted of 100 mg bupivacaine (0.5%, 20 ml), 40 mg methylprednisolone (2 ml), 300 mg 1:1000 epinephrine (0.3 ml), 750 mg cefuroxime (10 ml) and 1 mg morphine sulfate (0.1 ml). The solution was brought to a volume of 60 ml using sterile saline.

In the GNB knees, three equal-volume aliquots (20 ml) of the prepared solution were infiltrated as follows: (i) The syringe injector was advanced to the intersection of the femur medial epicondyle with the posterior cortex, and was infused after performing aspiration to ensure non-vessel injection. (ii) The syringe injector was advanced to the intersection of the lateral epicondyle with the posterior cortex, and infused as described above. (iii) The final aliquot was infused after the syringe injector was advanced to the intersection point of the tibia plateau with the posterior cortex[6] (Figures 2a, 2b, 2c). Only anatomical landmarks were referenced to position the needles prior to injection; fluoroscopy or ultrasound were not used.

In the PAI knees, the first 10 ml was injected into the posterior capsule before arthroplasty. The second 20 ml was injected into the soft tissue surrounding the

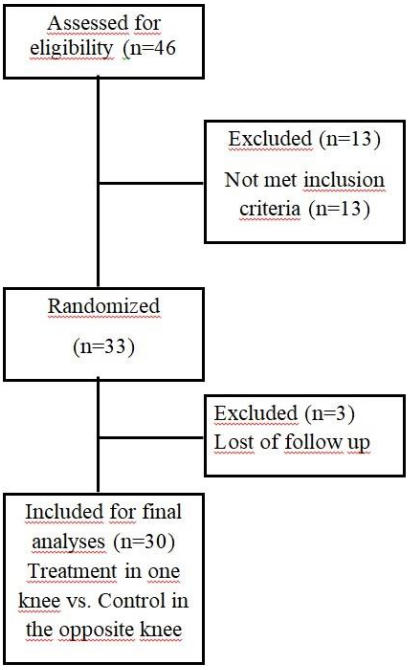

Figure 1. — Study flowchart.

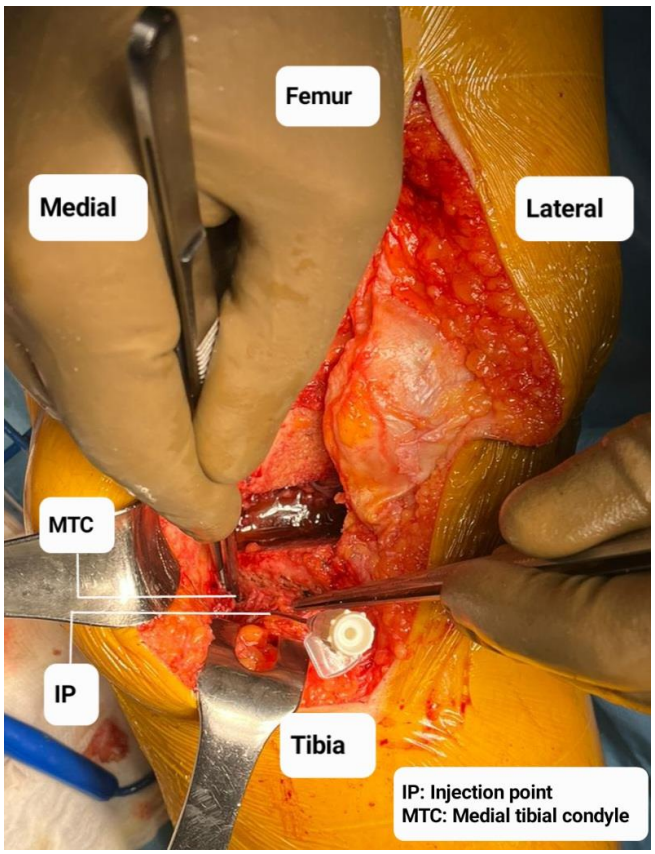

Figure 2a. — Genicular nerve blockade application points in surgery

medial (10 ml) and lateral (10 ml) collateral ligaments after implantation of the arthroplasty components. The third 20 ml was injected into the retinacular tissues, pes

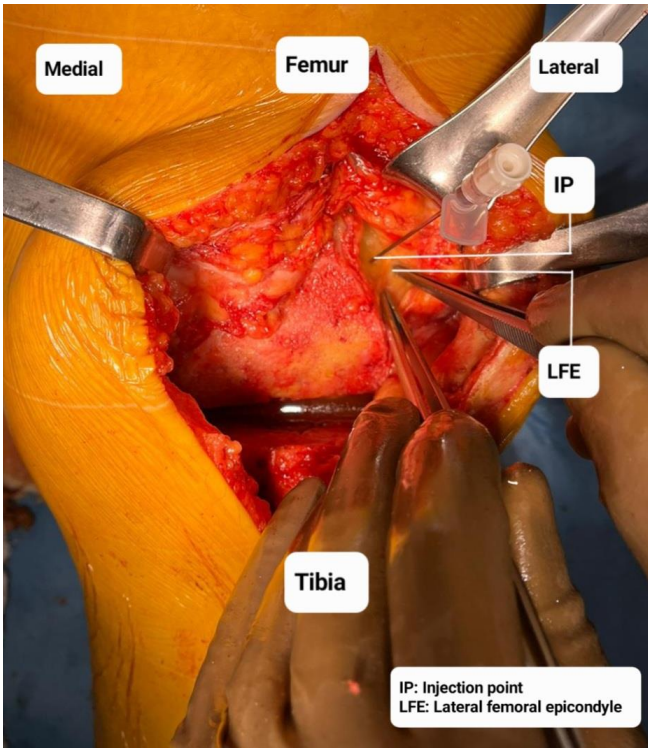

Figure 2b. — Genicular nerve blockade application points in surgery.

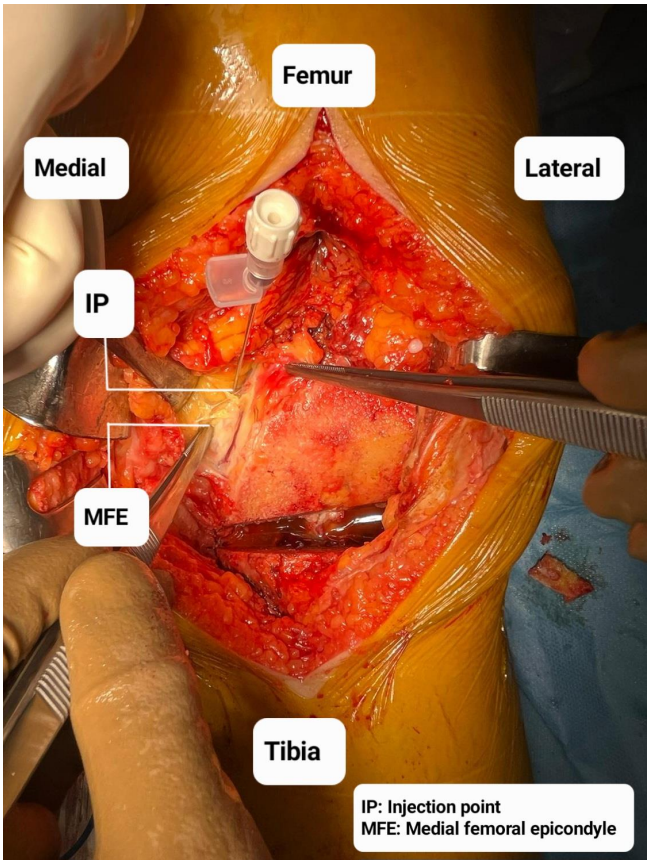

Figure 2c. — Genicular nerve blockade application points in surgery.

anserinus, and suprapatellar and infrapatellar fat pads after implantation, and after the capsule was closed, the remainder (10 ml) was administered to the quadriceps muscle, joint capsule, and subcutaneous tissues after the capsule was closed.

JRM exercises were started immediately after the patient was transferred to the ward, with 20 passive repetitions per hour. The knee pump exercise, femur set exercises, and straight leg lifts were each performed 20 times per hour. Patients were mobilized in their rooms given that they would use supportive walkers. During the first night after surgery, patients were woken up a minimum of 4 times and were asked to walk for as long as they could tolerate. Medical dressings were applied and refreshed as routine, and the patients wore knee compression socks. Prophylactic antibiotic administration was terminated at postoperative 48 hours. Analgesia treatment after the surgery was administered with intravenous acetaminophen (1000 mg, infused for 8 hours) throughout hospitalization. Patients with Visual Analog Scale (VAS) scores greater than 5 were administered petidine hydrochloride at 1 mg/kg.

Postoperative drainage volume and pain assessments were conducted by service nurses blinded to patient groups. Pain assessments were performed using a 10-cm paper-strip VAS, with scores ranging from 0 (indicates no pain) to 10 (indicates worst pain imaginable). VAS pain scores were measured at postoperative day 0 (2 and 8 hours), 1st and 2nd days (24 and 48 hours), and 1st month (30 days) postoperatively. Separate scores were sought for each knee while resting (static) and exercising (dynamic). Active joint range of motion (JRM) for both knee joints was measured during the preoperative period and on the postoperative first and second days (24 and 48 hours) and on the first postoperative month (30 days). Other data were acquired from the hospital record system.

All analyses were performed on IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY, USA). The distribution characteristics of continuous variables were investigated by the Shapiro-Wilk test. Continuous data are given as mean ± standard deviation or median (minimum - maximum) according to normality of distribution. Categorical data are summarized with frequency (percentage). Hemoglobin and hematocrit were analyzed with the repeated measures analysis of variance. Erythrocyte sedimentation rate and C-reactive protein (CRP) were analyzed with the Friedman's analysis of variance by ranks. Amount of drainage was analyzed with the

Table I. — Demographic data and laboratory measurements of the patients

Age	64 (39-72)
Sex	
Male	8 (26.67%)
Female	22 (73.33%)
Height, cm	161.90 ± 6.78
Weight, kg	84.47 ± 9.98
Body mass index, kg/m^2	32.23 ± 3.36
GNB side	
Right	15 (50.00%)
Left	15 (50.00%)
Hemoglobin	
Preoperative	13.24 ± 1.54
24th hour	10.82 ± 1.45 †#
30th day	11.37 ± 1.47 †
p (within groups) [1]	**<0.001**
Hematocrit	
Preoperative	40.33 ± 3.85
24th hour	33.15 ± 4.10 †#
30th day	34.96 ± 4.08 †
p (within groups) [1]	**<0.001**
Sedimentation	
Preoperative	16 (4 - 57)
24th hour	26.5 (9 - 55)
30th day	37.5 (10 - 71) †
p (within groups) [2]	**<0.001**
C reactive protein	
Preoperative	3.6 (1.6 - 14.6)
24th hour	50.15 (17.7 - 91.3) †#
30th day	8.75 (2.3 - 79.0) †
p (within groups) [2]	**<0.001**

Data are given as mean ± standard deviation or median (minimum-maximum) for continuous variables according to normality of distribution and as frequency (percentage) for categorical variables. [1] Repeated measures analysis of variance, [2] Friedman's analysis of variance by ranks. † Significantly different from Preoperative, #: Significantly different from 30th day.

Student's t-test. Outcome measures (VAS scores and JRM values–flexion and extension) were analyzed with the two-way repeated measures analysis of variance. Between groups analyses of outcome measures were performed with the Mann-Whitney U test if group effect was found to be significant. Repeated (within groups) analyses of outcome measures were performed with Friedman's analysis of variance by ranks if time effect was found to be significant. Between groups analyses of outcome measures and all pairwise comparisons were adjusted by the Bonferroni correction method. Statistical significance was accepted in the presence of a two-sided p value lower than 0.05.

RESULTS

Median age was 64 (39-72) years and 73.3% of patients were female. Demographic data and laboratory measurements of the patients are shown in Table I.

Compared to the PAI group, the GNB group had lower static VAS scores at the 2nd hour (median [min – max]: 1 [0-2] vs 2 [0-3], p = 0.030) and 8th hour (2 [1-2] vs 2 [1-3], p < 0.001). Additionally, dynamic VAS score was lower in the GNB group at the 2nd hour (2 [0-4] vs 3 [0-5], p = 0.009), 8th hour (4 [2-5] vs 5 [3-6], p < 0.001), and 24th hour (4 [3-5] vs 5 [3-6], p < 0.001) in (Figure 3). Temporal comparisons in both groups showed that both static and dynamic VAS scores increased significantly at the 8th hour compared to the 2nd hour (p < 0.001, for both), and decreased significantly on the 30th day (p < 0.001, for both) (Figure 4). The decrease in both static and dynamic VAS was significantly greater in the PAI group compared to the GNB group (p < 0.001, for both) (Table II).

Compared to preoperative values in the GNB and PAI groups, extension JRM was significantly higher at the 24th hour (0 [-10-0] for both groups), 48th hour (0 [-5-0] for both groups), and 30th day (0 [-5-0] for both groups) (p < 0.001, Figure 5). When postoperative flexion JRM values were compared to preoperative values, they were found to demonstrate significant decreases at the 24th and 48th hours (in both groups), while a significant increase was determined at 30 days (p<0.001, Figure 6). The amounts of change in extension JRM and flexion JRM values over time were similar in the two groups (p = 1.000, p = 0.856, respectively) (Table III).

With respect to complications, none of the patients had experienced surface or deep infection, deep vein thrombosis, major hemorrhage or pulmonary emboli by the final follow-up. Drainage volume was 265.33 ± 56.92 ml in the GNB group, and 265.33 ± 56.92 ml in the PAI group (p = 0.891).

DISCUSSION

The current study comparing the efficacy of GNB of one knee and standard PAI of the other knee in patients undergoing simultaneous bilateral TKA showed that GNB can reduce postoperative pain at rest and during exercise at postoperative 2, 8 and 24 hours. Moreover, it appears that these improvements

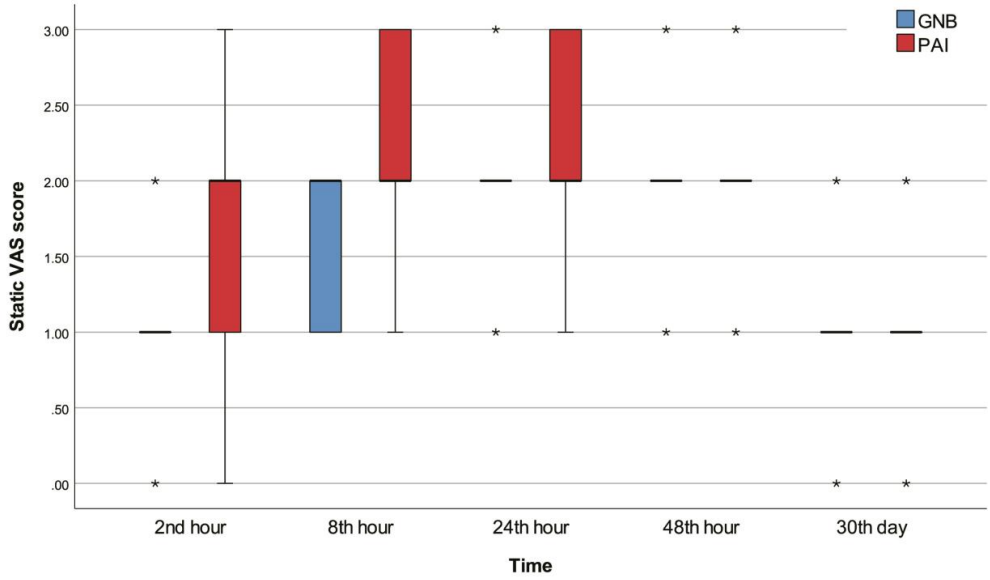

Figure 3. — VAS pain score at rest (Static VAS score).

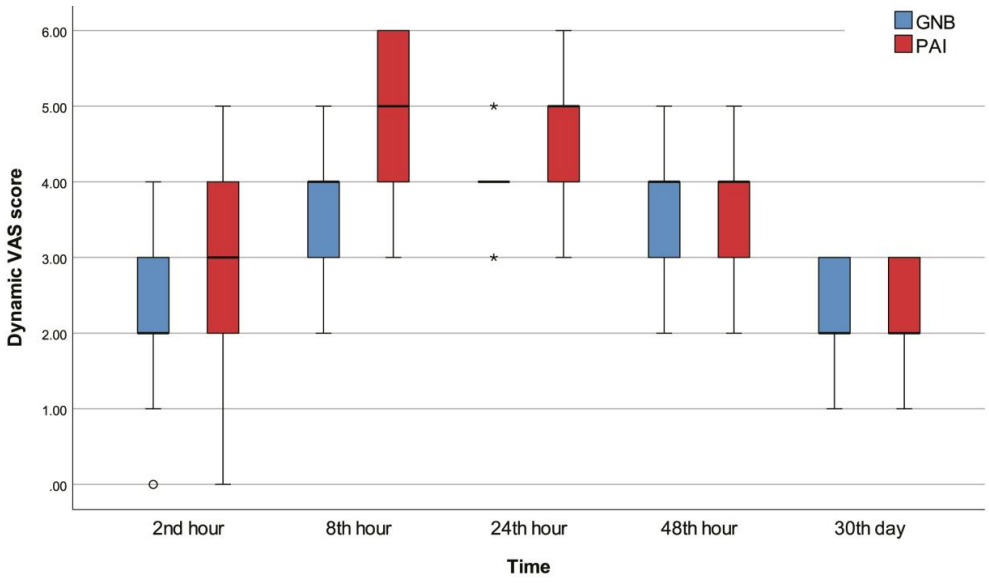

Figure 4. — VAS pain score during activity (Dynamic VAS score).

were significantly better compared to PAI. However, GNB knees had similar VAS results to those receiving PAI at postoperative 48 hours and 30 days. Both approaches yielded similar drainage and none of the patients suffered from local or systemic complications. In addition, no differences were observed between the two modalities in terms of JRM. According to these results, it appears that GNB may be an alternative to standard PAI application, particularly due to its better pain control in the early postoperative period.

Previous studies examining different pain management approaches exist. For instance, Cheng et al. carried out a study in which they administered analgesic cocktails via PAI to one knee and via intraarticular injection to the other knee of patients who underwent bilateral knee arthroplasty in the same session, with a randomized controlled design[18]. In another study, the authors divided patients who underwent simultaneous bilateral knee arthroplasty into two groups formed according to the injection of the PAI solution into the rear or front compartments, and compared the pain and functional results[19]. In the present study, we also injected the prepared analgesic cocktail into the genicular nerves in one knee and into the standard

Table II. — Comparisons of pain levels in both groups.

	GNB	PAI	p (between groups) [2]	p [1]
Static VAS score				
2nd hour	1 (0 - 2)	2 (0 - 3)	**0.030**	p(Time)<0.001 p(Group)=0.003 p(Time*Group)<0.001
8th hour	2 (1 - 2) †#	2 (1 - 3) †#	**<0.001**	
24th hour	2 (1 - 3) †#	2 (1 - 3) †#	0.146	
48th hour	2 (1 - 3) †#	2 (1 - 3) #	1.000	
30th day	1 (0 - 2)	1 (0 - 2)	1.000	
p (within groups) [3]	**<0.001**	**<0.001**		
Dynamic VAS score				
2nd hour	2 (0 - 4)	3 (0 - 5)	**0.009**	p(Time)<0.001 p(Group)=0.001 p(Time*Group)<0.001
8th hour	4 (2 - 5) †#	5 (3 - 6) †§#	**<0.001**	
24th hour	4 (3 - 5) †#	5 (3 - 6) †§#	**<0.001**	
48th hour	4 (2 - 5) †#	4 (2 - 5) #	1.000	
30th day	2 (1 - 3)	2 (1 - 3)	1.000	
p (within groups) [3]	**<0.001**	**<0.001**		

Data are given median (minimum - maximum) for continuous variables according to normality of distribution. [1] Two-way repeated measures analysis of variance, [2] Mann Whitney U test adjusted by Bonferroni correction, [3] Friedman's analysis of variance by ranks. † Significantly different from 2nd hour, § Significantly different from 48th hour, # Significantly different from 30th day.

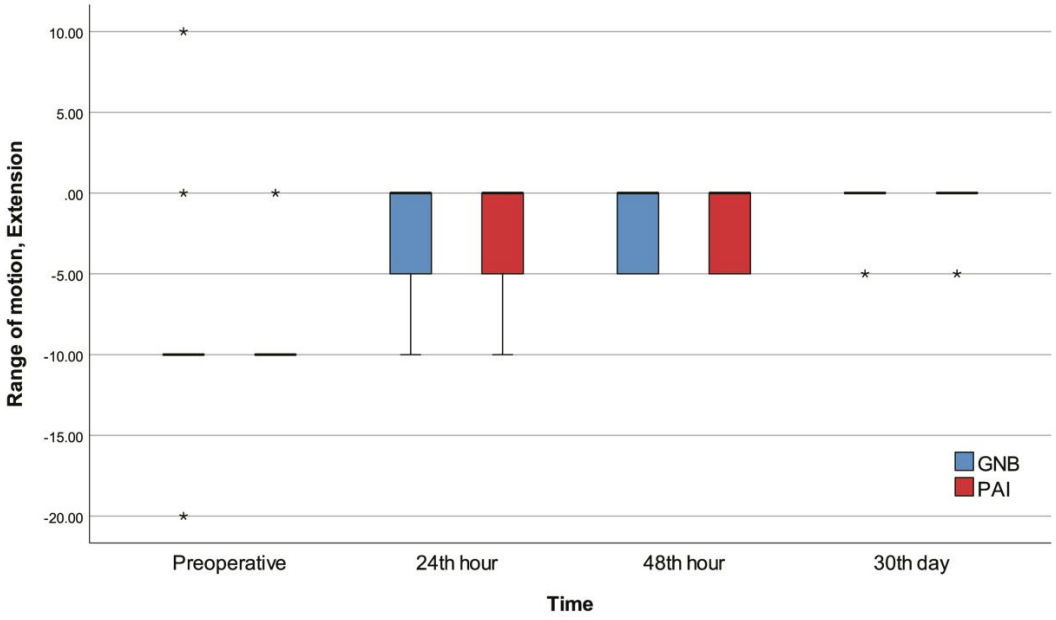

Figure 5. — Knee extension degrees in both groups.

PAI regions in the other knee to assess the pain and functional results. We think that this study is important because it is the first study to compare GNB and PAI procedures in simultaneous bilateral knee arthroplasty.

This study was planned with inspiration from genicular nerve RFA treatment and GNB applications applied in patients who did not undergo TKA or who had long-term pain after TKA. The technique was described in 2011 by Choi et al.[6]. In our study, we referenced the bone landmarks defined by Choi et al.[6]; however, since the publication of this study, researchers have suggested the need to optimize the landmarks proposed by Choi et

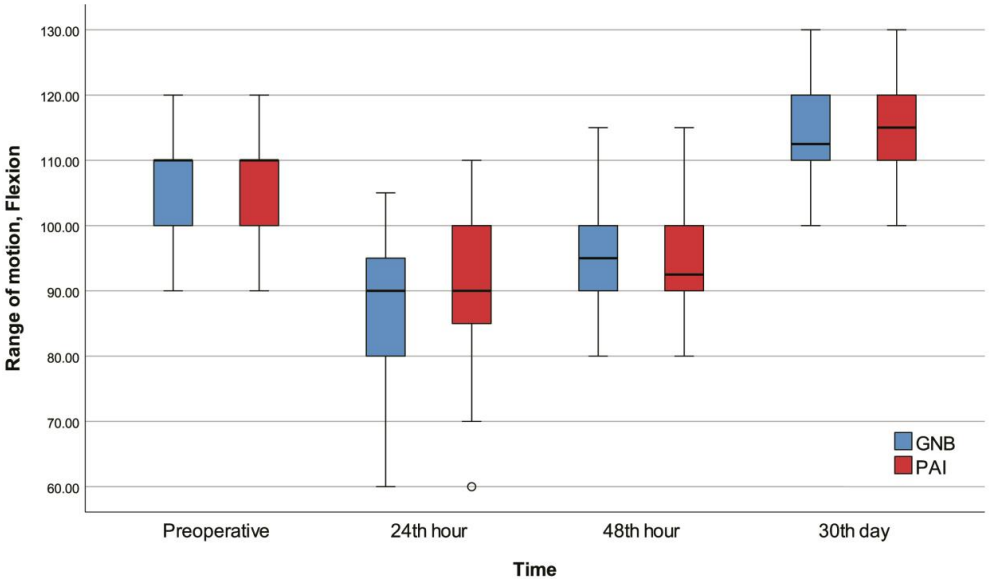

Figure 6. — Knee flexion degrees in both groups.

Table III. — Comparisons of joint range of motion in both groups

	GNB	PAI	p (between groups) [2]	p [1]
Extension				
Preoperative	-10 (-20 - 10)	-10 (-10 - 0)	-	p(Time)<0.001 p(Group)=1.000 p(Time*Group)=1.000
24th hour	0 (-10 - 0) †	0 (-10 - 0) †	-	
48th hour	0 (-5 - 0) †	0 (-5 - 0) †	-	
30th day	0 (-5 - 0) †	0 (-5 - 0) †	-	
p (within groups) [3]	**<0.001**	**<0.001**		
Flexion				
Preoperative	110 (90 - 120)	110 (90 - 120)	-	p(Time)<0.001 p(Group)=0.901 p(Time*Group)=0.856
24th hour	90 (60 - 105) †#	90 (60 - 110) †#	-	
48th hour	95 (80 - 115) †#	92.5 (80 - 115) †#	-	
30th day	112.5 (100 - 130) †	115 (100 - 130) †	-	
p (within groups) [3]	**<0.001**	**<0.001**		

Data are given as median (minimum - maximum) for continuous variables according to normality of distribution. [1] Two-way repeated measures analysis of variance, [2] Between groups analyses were not performed due to p(Group)>0.05, [3] Friedman's analysis of variance by ranks. †: Significantly different from Preoperative, #: Significantly different from 30th day.

al.[11-13,16,20]. Fonkoue et al. in their randomized controlled study, compared classical target points with revised target points in terms of GNB and reported significant pain reduction in both groups until the 12th week after the procedure. While the differences in results with the classical technique for GNB are relatively small, they may be more important in the case of RFA, where there exists a need for greater precision in anatomical positioning. They also declared that, during GNB, the large injection volume could somewhat compensate the anatomical ambiguity of classical landmarks[21]. Since our application involved a high volume of injection (20 ml) to each area, we preferred to utilize the classical landmarks in the present study.

In a study with a similar aim, Cunat et al. evaluated postoperative results obtained from intra-procedural local infiltration analgesia and GNB applications in TKA. They reported that the amount of local anesthetic

used and the level of pain in the first 24 hours were significantly lower in the GNB group, and concluded that GNB was a good alternative for pain management in TKA[22]. In another similar study, Pierangela et al. found GNB to be a reasonable alternative in TKA, in line with the results of this study[23]. In agreement with the aforementioned studies on comparable patient groups, we determined that GNB could be a good alternative to PAI in TKA operations.

Our study has some limitations. Due to the retrospective design of the study, different parameters that could affect the results could not be evaluated. Fluoroscopy or ultrasound were not used to guide needle placement during GNB application, instead we used the classical landmarks due to the high volume of injection. However, as mentioned before, researchers have recommended an update of these landmarks due to limitations experienced during application[14,21]. Thus, despite administering a high volume and having a single surgeon performing the procedures, our results may have been impacted by potential variations. Another limitation of this study, the absence of randomization in the choice of the knee to be allocated to one of the groups or to the other in the same patient.

CONCLUSION

In this study, GNB (with the same cocktail and volume used for standard PAI) was found to be more effective for pain control throughout the first 24 hours after surgery in patients who underwent simultaneous bilateral TKA, as demonstrated by measurements at the postoperative 2nd, 8th and 24th hours. In addition, knees receiving GNB were found to have similar results to standard PAI recipients in terms of JRM and complications. More studies with a higher level of evidence are needed to better analyze the efficacy of this procedure.

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