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Efficiency of femoral nerve block for recovery after primary total knee arthroplasty

Zeki Tuncel Tekgül[1*], Mehmet Uğur Bilgin[1] and Cemil Kayalı[2]

Abstract

Background: Femoral nerve block (FNB) is a suitable option for pain management and recovery after total knee arthroplasty (TKA). It is usually used along with a multimodal analgesia protocol. The major disadvantage of FNB is the risk of quadriceps muscle strength loss. This study aims to compare the efficiency of the FNB with two different concentrations of bupivacaine for recovery after TKA. We primarily aim to provide adequate analgesia with a lower concentration of bupivacaine (0.125%) rather than the usual concentration (0.25%). Secondarily, we aim to compare the degree of motor block, opioid consumption, and ambulation time between the groups. The study was conducted as randomized, controlled, and double-blind. Sixty three patients were randomized into three groups: G125 (*n*:21) received FNB with 20ml of 0,125% bupivacaine, G25 (n:21) received 10ml of 0,25% bupivacaine and GCont (*n*:21) received no block.

Results: For GCont, pain scores were significantly higher at 2nd, 6th, 12th, and 24th hours postoperatively, total opioid consumption was higher (G125: 75 mg, G25: 0 mg, GCont: 280 mg, $p < 0.001$) and first opioid demand time was earlier (G125: 12th hour, G25:21st hour GCont:2nd hour, p: 0.002). First knee flexion time and ambulation time were also delayed for GCont. G25 had lower scores for quadriceps muscle strength (manual test at 6th hour, G25: 3/5, G125: 4/5, GCont:5/5, $p < 0.001$) compared to other groups.

Conclusions: G125 had lower quadriceps muscle strength loss compared to the G25; earlier ambulation and flexion times, low opioid consumption, and low pain scores compared to the control group. In this respect, we believe the femoral nerve block with 0.125% bupivacaine proves to be a suitable option for analgesia with the potential of maintaining enough muscle strength for recovery after TKA.

Trial registration: ClinicalTrials.gov Protocol Registration and Results System, NCT03623230. Registered 09 August 2018, at https://clinicaltrials.gov/ct2/show/NCT03623230

Keywords: Total knee arthroplasty, Recovery, Femoral nerve block, Postoperative analgesia

Background

Pain after total knee arthroplasty (TKA) is a challenging condition that should be approached carefully in terms of both patient comfort and an effective rehabilitation process (Karlsen et al., 2017; Terkawi et al., 2017; O'Donnell & Dolan, 2018). Patients undergo an intensive rehabilitation period after TKA in order to return to a functional life.

Analgesic options for the pain management after TKA are numerous. Although opioids can effectively relieve pain, they carry the risk of side effects such as nausea, vomiting, constipation, sedation, and respiratory depression (Thobhani et al., 2017). Central nerve blocks are capable of providing high-quality analgesia, but the risk of serious complications, dense motor block and

* Correspondence: zekittekgul@yahoo.com
[1]Department of Anesthesiology and Reanimation, University of Health Sciences Izmir Bozyaka Training and Research Hospital, Bahar Mh. Saim Cikrikci St. No. 59 Building D Karabaglar, Izmir, Turkey
Full list of author information is available at the end of the article

interference with postoperative anticoagulant protocols limit their usefulness (Fowler et al., 2008; Berninger et al., 2018). Peripheral nerve blocks may prove to be the most useful analgesic option with minimal side effects, but risk of motor blockade and application difficulties should be considered thoroughly (Terkawi et al., 2017).

Properly utilizing each method is crucial to complete the rehabilitation process in the best manner. Femoral nerve block (FNB) is a proven method to reduce opioid consumption and pain scores after TKA, but it also causes loss of quadriceps muscle strength, increase in ambulation time and risk of falling (Terkawi et al., 2017). In this respect, we believe reducing the degree of motor blockade and maintaining similar analgesic efficacy of FNB may positively contribute to pain management for TKA patients. For this purpose, we tested whether we could provide effective analgesia without causing motor block with a low concentration of local anesthetics (LA) compared to a standart concentration which is proven to be effective for analgesia.

The aim of our study is to evaluate the efficiency of femoral nerve block on recovery after primary total knee arthroplasty. Our primary goal is to provide adequate analgesia with a lower concentration of bupivacaine (0.125%) rather than the usual concentration (0.25%). Primary outcome measure was therefore set as postoperative pain scores (Numeric Rating Scale) comparison between the block groups. The secondary aim is to compare the degree of motor block, side effects, postoperative pain scores, postoperative opioid consumption, ambulation, and discharge times between different concentrations of FNB and control groups.

Methods

The study was conducted as randomized, controlled, and double-blind. After the approval of the local ethics committee with decision number: ……., the patients were enrolled in the study by obtaining their written informed consent. A total of sixty three patients were included in the study with the ClinicalTrial record number……. Patients older than the age of 18, ASA score 1–3 category, who were scheduled to undergo primary unilateral TKA with spinal anesthesia and agreed to participate in the study with no contraindication for spinal or regional anesthesia were included in this study. The criteria for exclusion were history of allergy to LAs, uncontrolled diabetes, peripheral neuropathy, obesity over 35 kg/m^2, coagulopathy, psychological and emotional lability. Patients who needed additional medication for pain during the surgery were also excluded. The enrollment process is further detailed in accordance with the CONSORT 2010 Flow Diagram (Fig. 1).

The study was planned with 3 groups and 63 patients in total. The control group (GCont) did not receive any intervention but faced the same procedures as block groups. All patients were taken to the anesthesia recovery room after the operation and a curtain was used to separate their upper body and lower body and then the FNB application site was dressed behind the curtain even if FNB was not applied. Since patients were still under spinal anesthesia, they did not know whether they received FNB or not. The follow-up team was also unaware of the patients' group because all three groups had dressings at the FNB application site. One of the interventional groups (G125) received 20 ml 0.125% bupivacaine (Buvasin, 0.5%, 20 ml single-use vial; VEM Pharmaceuticals, Istanbul) (5 cc 0.5% bupivacaine and 15cc normal saline (NS)) mixture while the other group (G25) received 10 ml 0.25% Bupivacaine (5cc bupivacaine, 5cc NS) for FNB. This way, both of the block groups received the same dosage of bupivacaine but with different volumes and concentrations.

Prior to the first operation, patients were randomized with a simple dice roll by a resident. The same resident sorted the patient list with allocated group data and tagged the case report forms anonymously with patients' numbers. The patient list with group information was passed to the author responsible for statistical analysis after the study was completed.

Patients received spinal anesthesia in the operation room with bupivacaine 0.5% heavy, while seated with legs hanging off the bed, via a 25 G pencil-point spinal needle. Then, they were taken to the supine position and the operation was allowed if the T6–T9 dermatome blockage was achieved. All patients received 0.02 mg/kg IV midazolam before and 2 lt/min O_2 during surgery.

Surgeries were performed by the same surgeon (who is also the co-author) and his team with the same technique (The medial parapatellar approach with cementing). Patient's demographic and contact information, patient's number (given by the resident in the operating room), operation date, neuraxial block level assessment (evaluated with Pinprick test), and length of operation (time from spinal anesthesia to discharge of the patient from the operating room) were recorded during operation. Numeric Rating Scale (NRS, 0-10) scores (starting to count with the end of femoral nerve block, at 0, 30, 60 min and 2, 6, 12, 24, and 48 h), reverse of the neuraxial anesthesia induced motor block (Starting to count with the end of surgery, ending when Bromage Score is "0") and FNB induced motor block level (quadriceps strength was evaluated by the Oxford Scale for Manual Muscle Test (MMT) at 6th hour) (Fig. 2), nurse controlled opioid administration times and doses, first knee flexion time (voluntarily and pain-free), first 90° knee flexion time and first time of walking without help were recorded postoperatively.

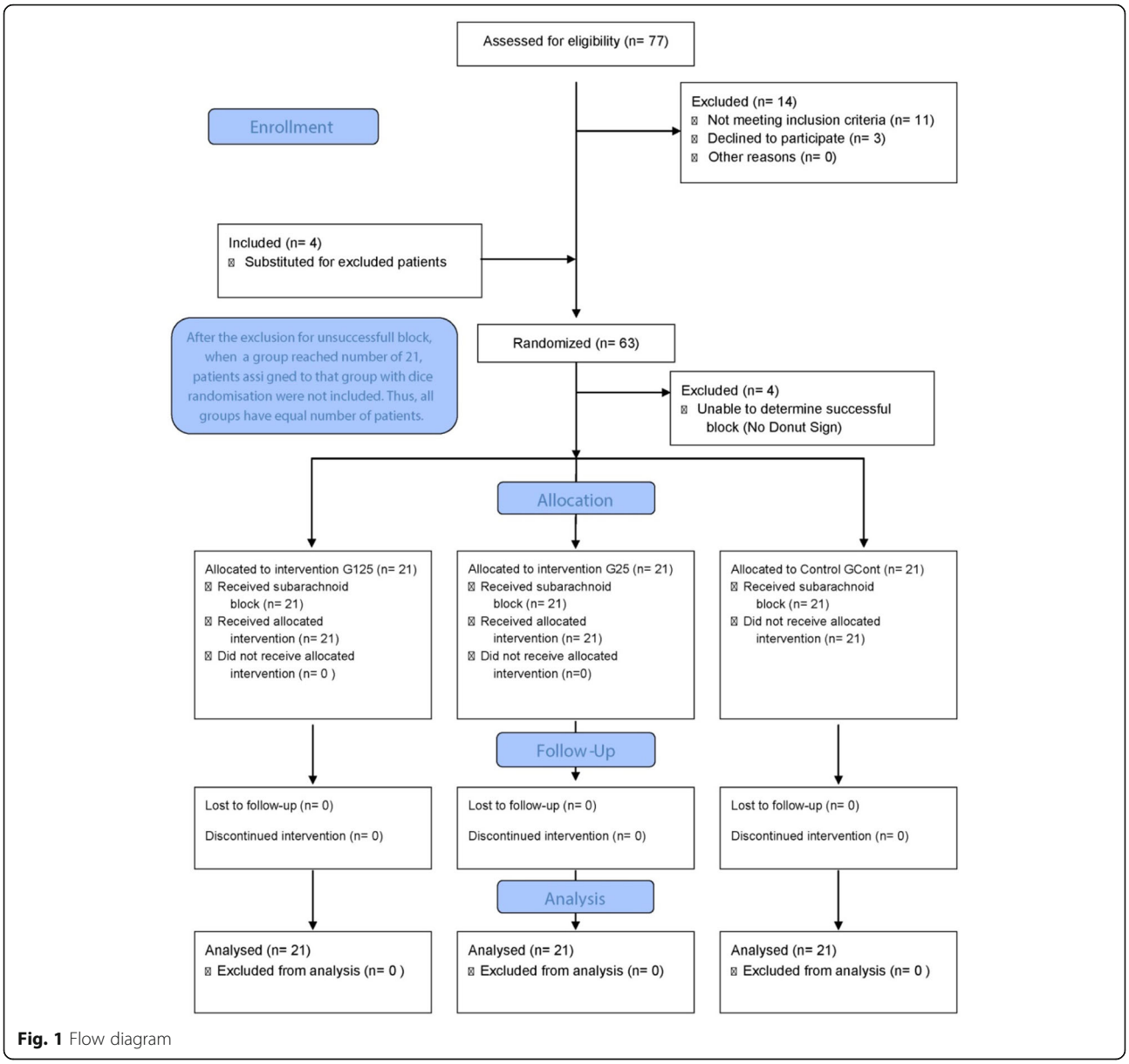

Fig. 1 Flow diagram

"NRS", "Bromage Scale" and "MMT" were performed preoperatively (During pre-operative anaesthetic assessment for ASA score) for each patient in order to increase the patient-health worker concordance during data collection as well as to identify abnormal patients. It was questioned whether they could perform knee flexion and 90° knee flexion (for both knees) or walk on their own. Patients who had issues detected in these tests and interrogations, who had extensive pain scores, contralateral knee or other problems related to ambulation were not included in the study (Fig. 1).

Femoral nerve block was performed in the anesthesia recovery room by an anesthesiologist who has experience of more than 10 years and 500 times of practice with FNB. While patients were laying in supine position, sterile conditions were provided where artery pulsations were identified in the level of the femoral crease. Femoral artery, vein, and nerve were detected with the help of ultrasonography (SonoScape S6 Ultrasound; SonoScape Medical Corp, Guangdong, China) and linear ultrasound probe (L741 10.0--5.0 MHz Transducer; SonoScape Medical Corp., Guangdong, China). The needle (Stimuplex A 22Gx2" Insulated Needle; Braun, Melsungen, Germany) was connected to a nerve stimulator (Stimuplex HNS 12; Braun, Melsungen, Germany) which was set up to deliver 0.32 mA current with 1 Hz frequency and 0.1 ms length to avoid intraneural injection (O'Flaherty et al., 2018). The probe was placed in transverse plane and the needle was approached in-plane aspect from lateral to medial. With the performing

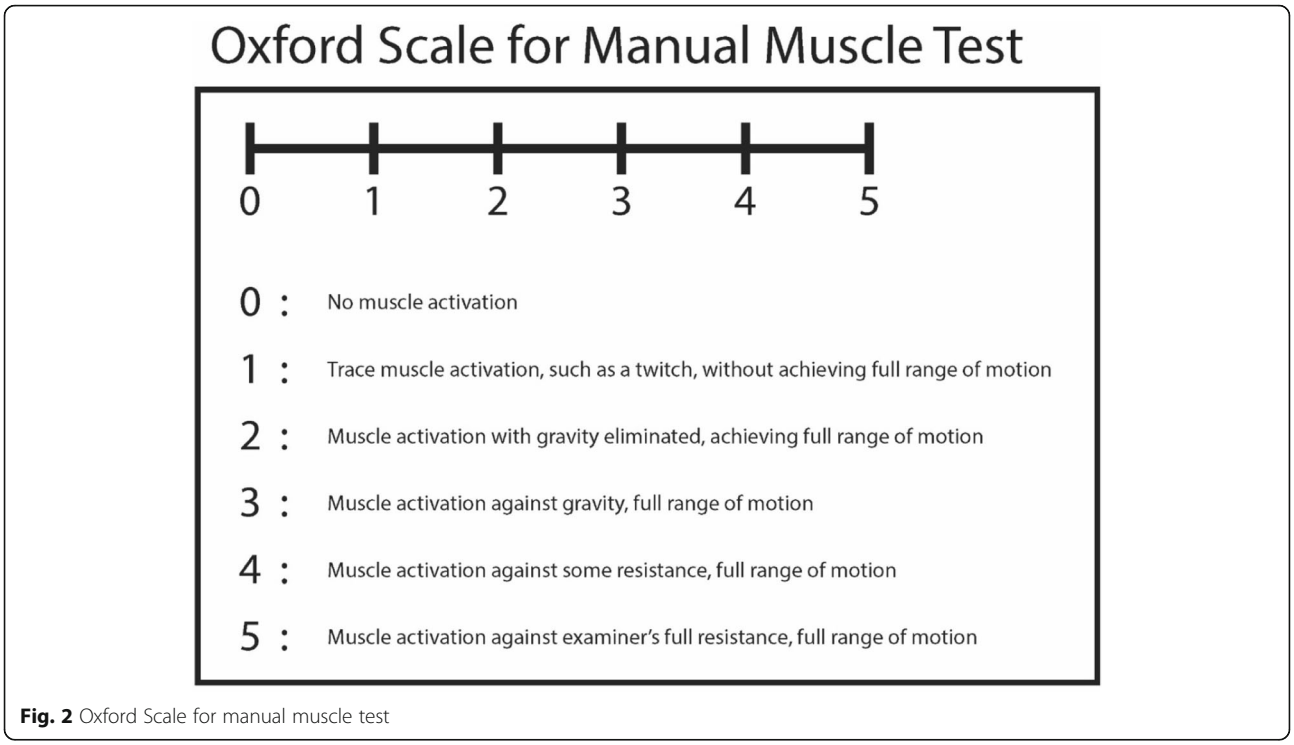

Fig. 2 Oxford Scale for manual muscle test

physician's instructions, half of the solution was injected at 06:00 and the other half at 12:00 direction by the resident who performed randomization. This way, the blindness of the performer was provided for the volume of the local anesthetic solutions. Full circle coverage (Donut Sign) was recognized as a successful block sign. LA solutions were prepared by the hospital pharmacist for each patient before the procedure. The physician who followed the cases was informed about the successful completion of the procedure.

Standart analgesic protocol (diclofenac 3 × 50 mg IV) was administered to all patients in the study for 2 days postoperatively. For the purpose of rescue analgesia, intravenous Tramadol (1 mg/kg) was ordered with "On Demand" footnote and the service nurse was informed about the study and told to administer the medication on patient's request. Patients were periodically visited and were questioned for pain scores (NRS) and motor blockade.

Intraoperative and postoperative follow-ups were performed by health professionals and anesthesiologists who were not associated with the study. Femoral nerve block was performed by the anesthesiologist who carried out the study.

Power analysis was conducted in line with the preliminary study included 30 patients in total with the same settings as the main study. Postoperative 6th-hour NRS scores (G125: 2.8, G25:2.1, and GCont: 4.7; error variance: 2.1) were taken into consideration since it was the most distinctive outcome and G*Power Version 3.1 (α-error probability: 0.05 and power: 0.95) was used to determine the total sample size. The total sample size was found to be 60 patients but 63 patients were enrolled taking into consideration of a possible dropout rate of 5%. Statistical Package for Social Sciences (SPSS) Version 18 was used for statistical analysis. Parametric test results were presented as mean and standard deviation and non-parametric test results as number and percentage or median and interquartile range (IQR) or total range. The normal distribution of the data was evaluated by the Kolmogorov-Smirnov test. The comparison of quantitative data to normal distribution was performed with one-way ANOVA. The Tukey HSD test was used to determine the difference between groups and the Kruskal-Wallis H test was used to compare the non-normal distributed quantitative parameters. Mann Whitney U test was used to determine the group that caused the difference. A chi-square test was used to compare the qualitative data. The significance level was determined as $p < 0.05$ for 95% confidence interval.

Results

Enrollment of patients occurred between August 10, 2018, and December 12, 2018. Three eligible patients disagreed to enroll in the study, 11 patients were discarded due to unfitting the including criteria, and 4 patients discarded due to unsuccessful FNB (When Donut sign was not identified) (Fig. 1).

Table 1 Demographic data

	GCont *n*: 21	G125 *n*: 21	G25 *n*: 21	*P* value
Age	67.3 ± 7.5	71.2 ± 8.2	65.3 ± 9.9	0.089
Weight (kg)	75,4 ± 10.1	73.7 ± 11.6	74.7 ± 14.6	0.897
Height (cm)	164.3 ± 6.3	166.1 ± 8	167.7 ± 8.3	0.359
BMI*	27.9 ± 3.5	26.6 ± 3.3	26.4 ± 3.7	0.298
[A]Male/female	4/17 19%/81%	7/14 33.3%/67.7%	4/17 19%/81%	0.455
Education level**	1/10/3/7/0	1/13/2/5/0	0/11/3/7/0	0.912
[A]ASA 1/2/3	0/20/1 0%/95.2%/4.8%	0/21/0 0%/100%/100%	2/18/1 9.5%/85.7%/4.8%	0.264

Data shown as "mean ± SD" if not stated otherwise
[A]Count and percentage
* Body mass index
**Not literate/illiterate or elementary school graduate/secondary school graduate/high school graduate/university graduate

Demographic, educational, gender, ASA classification data, and comparison of groups were presented in Table 1. All groups were homogeneous in these aspects.

Assessment of neuraxial blockade level, length of operation, and reverse of the neuraxial anesthesia induced motor block were observed and found to be homogeneous among groups (Table 2).

Postoperative pain scores (NRS) were recorded at certain time intervals and groups were compared by their pain scores as in Table 3. GCont had significantly higher pain scores from 2nd to 24th hours postoperatively compared to G125 and G25. No differences between G125 and G25 were demonstrated.

It was recorded whether the patients needed postoperative opioid (intravenous tramadol), and if so, the time and amount of administered rescue analgesia. Total opioid use was recorded in milligrams and milligrams/kilogram. 52.5% of the patients who demanded rescue analgesia was in GCont. Total consumption was 280 mg, 75 mg, and 0 mg in GCont, G125, and G25, respectively, as median values. GCont had significantly higher consumption ($p < 0.001$) and requested analgesia earlier than the block groups. (at 2nd hour compared to 12th and 21st hour in G125 and G25, respectively, p: 0.002). Comparison of the groups in terms of these data was shown in Table 4.

The first knee flexion and the first 90° knee flexion time of the patients and postoperative hour of ambulation were recorded and compared between the groups and these data were presented in Table 4. While 90° knee flexion time was not significantly different, first knee flexion time and ambulation time was significantly longer for GCont (Table 4).

Results of the manual test for quadriceps muscle and comparison of the groups were presented in Table 4. Quadriceps muscle strength (MMT) was found to be significantly less in G25. (GCont: 5, G125: 4, G25 3, $p < 0.001$)

Day of discharge and comparison of the groups in terms of this data were shown in Table 4.

Discussion

The primary aim of our study was to provide adequate analgesia with different concentrations of bupivacaine (0,125% vs. 0,25%) for the FNB after TKA surgery. As shown in Table 3, pain scores (NRS) in block groups (G125 and G25) were as low as 3 and below 3 in the first 48 h postoperatively. Compared to the control group, NRS scores of the patients in the block groups were significantly lower at the 2nd, 6th, 12th, and 24th hours. These results are correlated with many studies on this subject (Karlsen et al., 2017; Terkawi et al., 2017; Paul et al., 2018; Choi et al., 2016; Chan et al., 2014). However, the femoral block shows its analgesic properties in minutes, but we detected no difference in NRS scores between the groups in the first 2 h after the application (Casati et al., 2000). We believe that the spinal anesthesia sensory block is associated with this

Table 2 Perioperative data

	GCont *n*: 21	G125 *n*: 21	G25 *n*: 21	*P* value
Spinal anesthesia block level (pinprick)	T8 (T6–T9)	T8 (T6–T9)	T8 (T7-T9)	0.776
Length of operation (min.)	110 [28]	100 [25]	105 [30]	0.494
Reverse of the neuraxial anesthesia ınduced motor block (min)	60 [73]	60 [63]	60 [45]	0.973

Data shown as "median (min–max) or [IQR]"

Table 3 Pain numeric rating scale (NRS) scores for 48 h postoperatively

	GCont *n*: 21	G125 *n*: 21	G25 *n*: 21	*P* value
Control	0 [0]	0 [0]	0 [0]	0.389
0th minute	0 [0]	0 [0]	0 [0]	0.362
30th minute	0 [0]	0 [1]	0 [0]	0.283
1st hour	1 [3]	0 [1]	1 [2]	0.474
2nd hour	3 [3.5]*	2 [1]	1 [1]	0.032
6th hour	5 [3.5]*	2 [0.5]	2 [1.5]	< 0.001
12th hour	4 [3.5]*	2 [1]	2 [1]	< 0.001
24th hour	5 [2]*	2 [1]	2 [1]	0.001
48th hour	3 [3]	3 [1]	3 [2]	0.302

Data shown as "median [IQR]"
*Denotes statistical significance

indifference between the groups. We also detected no difference at the 48th hour. Therefore, we can conclude that the US-guided femoral nerve block with 0.125% 20 ml or 0.25% 10 ml bupivacaine solution provides better analgesia compared to nurse controlled analgesia for at least 24 h after the application for primary total knee arthroplasty. However, it would be more appropriate to investigate the correct onset and duration of femoral nerve block applied with different LA concentrations and volumes in a patient population that were followed at more precise time intervals and that did not undergo any anesthesia method which could be confused with femoral nerve block efficacy.

In the recovery process after TKA, reducing opioid use has become one of the main objectives and NSAIDs and paracetamol are often included in the analgesia protocols. Peripheral nerve blocks are proven to reduce the opioid need, therefore opioid-related side effects and to increase patient comfort (Paul et al., 2018). Our results show that, compared to block groups (G125 and G25), GCont consumed more opioids (75 mg and 0 mg to 280 mg, $p < 0.001$, respectively) and demanded rescue analgesia earlier (12th and 21st hour to 2nd hour, p: 0.002, respectively). Both LA concentrations in our study significantly caused lower opioid consumption compared to the control group. In addition to this, early need for opioid is critical due to the risk of delayed recovery from anesthesia and delayed discharge from postanesthesia care unit (PACU), increased postoperative nausea and vomiting (PONV) and further decreased respiratory drive which is already affected by the sedative medication from earlier. But, since we did not follow any of these side effects, it is not possible to point out any differences regarding these situations. For 48 h postoperatively, all patients in the control group requested rescue analgesia at least for once. On the other hand, only 8 and 12 patients requested rescue analgesia for G25 and G125 groups, respectively. GCont is found to be statistically different from block groups (p<0,001). In this respect, it is in our view that both concentrations used in FNB reduce opioid consumption for TKA patients, but more studies are needed to compare the opioid-related side effects.

The femoral nerve block is a proven technique to prevent pain after total knee arthroplasty (Terkawi et al., 2017; O'Donnell & Dolan, 2018; Thobhani et al., 2017; Choi et al., 2016; Chan et al., 2014), but it may also

Table 4 Postoperative follow-ups

	GCont *n*: 21	G125 *n*: 21	G25 *n*: 21	*P* value
[A]First knee flexion time	8.5 ± 5.1*	4.3 ± 2.9	5.0 ± 3.8	0.020
First 90° knee flexion time	20 [3]	18 [5]	20 [4]	0.174
Ambulation time	24 [5]*	18 [2]	20 [5]	< 0.001
Manuel test at 6th hour	5 [1]	4 [1]	3 [1]*	< 0.001
[B]Rescue analgesia yes/no	21/0* 100%/0%	12/9 57.1%/42.9%	8/13 38.1%/61.9%	< 0.001
First time of rescue analgesia (hour)	2 [4,5]* *n*: 21	12 [18] *n*: 12	21 [47] *n*: 8	0.002
Total opioid consumption (mg)	280 [75]* *n*: 21	75 [75] *n*: 21	0 [75] *n*: 21	< 0.001
Total opioid consumption (mg/kg)	3.8 [1.13]*	0.9 [1.12]	0 [0.90]	< 0.001
Discharge (day)	5 [1]*	3 [1]	4 [1]	0.001

Data shown as "median [IQR]" if not stated otherwise
[A]Mean ± standard deviation
[B]Count and percentage
*Denotes statistical significance

cause quadriceps muscle weakness which may affect the recovery process (Webb et al., 2018; Shah et al., 2017). Thus, trying to avoid motor block has potential benefits for TKA patients. Using lower concentrations and higher volumes without increasing the dose of bupivacaine for FNB may increase the duration of analgesic action and reduce muscle weakness in the quadriceps muscle. In a prospective experimental study to determine effective concentration for FNB, the minimum effective concentration (MEC) was determined as 0.160% (Moura et al., 2016). But studies such as this one investigate data on anesthetic efficacy of the block for the intraoperative period, not analgesia for the postoperative period. There are studies which used 0.125% bupivacaine solution for infusion with FNB catheter and it's reported that this concentration does not prevent ambulation (Beebe et al., 2014). We believe a concentration as low as 0.125% bupivacaine for single shot FNB shows potential for early ambulation while maintaining adequate analgesia. Our results show that there is no significant difference in the analgesic efficacy and opioid consumption between G25 and G125 group and both drug concentrations provided better outcomes than the control group. In terms of postoperative recovery, patients in the block groups (G25 and G125) were able to move their operated knees earlier (5 and 4.3 h, respectively: GCont: 8.5 h, p: 0.020) and ambulated earlier without assistance (20th and 18th hours, respectively, GCont: 24 h, $p < 0.001$) (Table 4). Controversial to the fact that FNB has motor block effect, we believe, delay of ambulation in GCont is caused by pain. Some studies show that quadriceps weakness after FNB for TKA can delay ambulation (Webb et al., 2018; Shah et al., 2017). However, many factors may affect ambulation after TKA (Chua et al., 2017; Ibrahim et al., 2013). These can be related to the surgical procedure, patient and anesthesia management. Factors that are associated with anesthesia management may be the anesthesia technique used, the number of invasive procedures and the quality of postoperative pain management. In any case, early ambulation after TKA is associated with early discharge time and has been shown to prevent venous thromboembolism (Pearse et al., 2007; Hebl et al., 2008). However, in order to assess actual causes of delayed ambulation, more comprehensive studies are necessary.

As mentioned earlier, motor block and delayed ambulation are still some of the major concerns when peripheral nerve blocks are the chosen method for postoperative analgesia after TKA. According to the results of the manual test for quadriceps muscle strength, G125 had slightly less scores than the control group and this difference was not statistically significant (Table 4). The same test was found to be significantly lower in the G25 group compared to the control and G125 group ($p < 0.001$). Even though both groups received the same amount of bupivacaine for FNB, G125 experienced less muscle weakness which is statistically significant. We believe this was due to the concentration effect of the LA solution. Despite the difference in muscle strength between the control group and the G125 group, which was statistically not important but clinically important, early ambulation of the G125 group could be interpreted that FNB with 0.125% bupivacaine may have reduced the muscle strength of the quadriceps, but this effect was not potent enough to prevent ambulation. In fact, it may even facilitate knee flexion and ambulation by relieving pain in the recovery process. On the other hand, femoral block application with 0.25% bupivacaine caused significant quadriceps muscle weakness (Table 4).

Adductor canal block (ACB) is proven to have less quadriceps muscle strength loss in some studies while providing adequate analgesia which is comparable to FNB after TKA. But FNB is our choice of postoperative analgesia because it's easier to visualize and apply even with an old and low-resolution US device. Another reason is, dressings applied after TKA usually reaches higher than the level of middle or low adductor canal block. Therefore, we aimed to find a solution for the possible negative effects of FNB on quadriceps muscle strength.

One of the limitations of our study originated from the anesthesia method we chose. Confirmation of successful FNB was not convenient as the effect of the spinal anesthesia could continue for hours after surgery. Thus, we had to exclude patients, after the administration of the block, if donut sign for FNB was not identified via ultrasonography (USG). We believe this is also the reason why the majority of the patients did not report any pain in first 2 h after the operation.

Another issue is, even though statistical analysis showed no significant difference between the block groups for "first rescue time", this data may actually be clinically important. G125 required intravenous tramadol earlier than G25. This could be due to the number of the patients who demanded tramadol post-operatively was lower than the total sample size (n: 12 for G125 and n: 8 for G25)

Results showed that discharge times of the control group was significantly longer than other groups. However, the discharge policy of our clinic is not consistent. Discharge decision may vary depending on the weekend or holidays. Socioeconomic status of the patients could also affect this decision. Thus, we believe this data cannot be evaluated properly.

We failed to obtain and compare the data regarding the preoperative analgesic use of the patients. Preoperative use of analgesic medication such as opioid or pregabalin could affect postoperative pain scores and rescue

analgesic needs. Although homogeneity in "Control Pain Scores" could mean homogeneity in preoperative analgesic use, we can not interpret this to be correlated accurately.

Conclusions

Among all three groups, G125 group had lower quadriceps muscle strength loss compared to the G25 group and shortened the ambulation time, earlier flexion times, low opioid consumption and low pain scores compared to the control group. In this respect, we believe that the femoral nerve block with 0.125% bupivacaine solution proves to be a suitable option for analgesia with the potential of maintaining enough movement for recovery after total knee arthroplasty.

Abbreviations

ACB: Adductor canal block; ASA : American Society of Anaesthesiologists; MEC: Minimum effective concentration; FNB: Femoral nerve block; G: Gauge; G125: 0.125% bupivacaine applied intervention group; G25: 0.25% bupivacaine applied intervention group; Gcont: Control group with no block; Hz: hertz; IQR: Interquartile range; IV: Intravenous; kg: Kilogram; kg/m^2: Kilogram/square meters; LA: Local anesthetics; lt: Liter; lt/min: Liter/minute; m: Meter; mA: Milliampere; mg: Milligram; mg/kg: Milligram/kilogram; min: Minute; MMT: Manual muscle test; ms: Milliseconds; n: Number; NRS: Numeric Rating Scale; NS: Normal saline; NSAID: Non-steroidal anti-inflammatory drug; PACU: Postanesthesia care unit; PONV: Postoperative nausea and vomiting; SPSS: Statistical Package for Social Sciences; TKA: Total knee arthroplasty; US: Ultrasound; USG: Ultrasonography

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Authors' contributions

ZTT and MUB drafted and wrote the manuscript. MUB carried out the Femoral Nerve Block. CK contributed the idea, designed and conceptualized the paper. All authors provided critical revision of the manuscript for important intellectual content and provided detailed suggestions for revisions. All authors read and approved the final version of this document.

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Availability of data and materials

Not applicable

Declarations

Ethics approval and consent to participate

Ethical approval was obtained from the ethics committee of the University of Health Sciences Izmir Bozyaka Training and Research Hospital Ethics Committee for Clinical Trials (ID 21032018-02). All procedures involving human participants were in accordance with the 1964 Helsinki Declaration and its later amendments. Written informed consent was obtained from all participants.

Consent for publication

Not applicable

Competing interests

All authors declare that there is no conflict of interests.

Author details

[1]Department of Anesthesiology and Reanimation, University of Health Sciences Izmir Bozyaka Training and Research Hospital, Bahar Mh. Saim Cikrikci St. No. 59 Building D Karabaglar, Izmir, Turkey. [2]Department of Orthopaedics and Traumatology, University of Health Sciences Izmir Bozyaka Training and Research Hospital, Izmir, Turkey.

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