ARAŞTIRMA MAKALESİ / *RESEARCH ARTICLE*

Comparison of the Effects of Femoral Nerve Block and Adductor Canal Block on Postoperative Analgesia in Patients to Undergo Unilateral Knee Arthroplasty

Tek Taraflı Diz Artroplastisi Geçirecek Hastalarda Femoral Sinir Bloğu ile Adduktor Kanal Bloğunun Postoperatif Analjezi Üzerine Etkilerinin Karşılaştırılması

Soner Kina[1], Ayse Surhan Cinar[2], Kerim Sahin[3], Onur Demircioglu[2]

[1]Department of Cardiology, Kafkas University School of Medicine, Kars; [2]Hamidiye Etfal Health Training and Research Hospital, Istanbul; [3]Alanya Alaaddin Keykubat Training and Research Hospital, Antalya, Türkiye

ABSTRACT

Aim: *Total knee arthroplasty (TKA) is a major orthopedic procedure often associated with significant postoperative pain. Effective pain management is critical for early mobilization, rehabilitation, and reducing complications such as chronic pain. With the increasing use of ultrasound in regional anesthesia, the frequency of femoral nerve block (FNB) and adductor canal block (ACB) for analgesia after TKA is rising. This study aimed to compare the effects of femoral nerve block and adductor canal block on postoperative analgesia in patients undergoing unilateral knee arthroplasty.*

Material and Methods: *The study was conducted with the approval of the ethics committee, and written consent was obtained from the patients. It was carried out on 70 patients aged 18–70, with an American Society of Anesthesiologists (ASA) score of I-II, who planned to undergo elective TKA surgery. The study was designed as a prospective, randomized, and single-blind trial. Demographic data of the patients were recorded, and routine monitoring and general anesthesia induction were performed. Patients were divided into two groups: those who received FNB (Group F) and those who received ACB (Group A). Both groups were administered 20 mL of 0.375% bupivacaine. Heart rate (HR) and mean arterial pressure (MAP) were recorded intraoperatively before and after induction and every 30 minutes. In the postoperative period, patient-controlled analgesia (PCA) with intravenous tramadol was applied. Total tramadol usage and the number of times analgesia was needed were recorded. HR, MAP, and visual analog scale (VAS) scores were recorded at postoperative 30 minutes, 1, 2, 4, 6, 12, and 24 hours. Complications (nausea/vomiting, hypotension, bradycardia, itching) were recorded for 24 hours.*

Results: *Mean VAS scores were significantly lower in the FNB group at postoperative 0, 1, 2, and 6 hours ($p<0.05$). Total tramadol consumption and bolus requests were higher in the ACB group ($p<0.001$). Both techniques achieved VAS scores below 4, with no significant differences in additional analgesic use or complications. Nausea and vomiting rates were 5% (FNB) and 10% (ACB). No significant differences were observed in perioperative and postoperative MAP or HR between the groups.*

Conclusions: *Femoral nerve block and ACB provide effective analgesia after TKA, with VAS scores below 3 and high patient satisfaction. However, FNB demonstrated superior early postoperative pain control and lower opioid consumption. ACB, as a sensory block, is advantageous for minimizing quadriceps weakness and should be considered part of multimodal analgesia strategies. It was concluded that femoral nerve block is more effective in providing postoperative analgesia for patients undergoing unilateral knee arthroplasty.*

Keywords: *total knee arthroplasty; femoral nerve block; adductor canal block; multimodal analgesia; postoperative analgesia*

ÖZET

Amaç: *Total diz artroplastisi (TDA) sonrası ağrı şiddetlidir ve tedavi edilmediğinde kronikleşebilir. Ultrasonografinin rejyonel anestezide kullanımında artmasıyla beraber TDA sonrası analjezi amacıyla femoral sinir bloğu (FSB) ve adduktor kanal bloğu (AKB) uygulama sıklığı artmaktadır. Çalışmamızda tek taraflı diz artroplastisi geçirecek hastalarda femoral sinir bloğu ve adduktor kanal bloğunun postoperatif analjezi üzerine etkilerinin karşılaştırılmayı amaçladık.*

Gereç ve Yöntem: *Çalışma, etik kurulu onayı, hastalardan yazılı izin alınarak, elektif TDA cerrahisi uygulanacak American Society of Anesthesiologists (ASA) skoru I-II olan 18–70 yaş grubu 70 hastada gerçekleştirildi. Çalışma prospektif, randomize ve tek kör olarak planlandı. Hastaların demografik verileri kaydedilerek rutin monitörizasyon ve genel anestezi indüksiyonu uygulandı. Hastalar FSB (Grup F) ve AKB (Grup A) yapılan grup olarak ikiye ayrıldı. Her iki gruba 20 mL %0,375 bupivakain uygulandı. Tüm hastaların kalp atım hızı (KAH) ve ortalama arter basıncı (OAB) indüksiyon öncesi, indüksiyon sonrası ve intraoperatif her 30 dakikada bir kaydedildi. Postoperatif dönemde intravenöz tramadol ile hasta kontrollü analjezi (HKA) uygulandı. Toplam kullanılan tramadol miktarı ve kaç defa analjezi ihtiyacı olduğu kaydedildi. KAH, OAB ve vizüel analog skala (VAS) skoru postoperatif 30 dk, 1, 2, 4, 6, 12 ve 24. saatlerde kaydedildi. Komplikasyonlar 24 saat boyunca (bulantı/kusma, hipotansiyon, bradikardi, kaşıntı) kaydedildi.*

Bulgular: *Demografik verilerde, intraoperatif ve postoperatif hemodinamik verilerde, ek analjezik ihtiyacı ve komplikasyonlar her iki grupta istatistiksel olarak anlamlı fark bulunmadı ($p>0,05$). Postoperatif VAS skorları, kullanılan toplam tramadol miktarı istatiksel olarak Grup F'de anlamlı düşük bulundu.*

Sonuç: *Tek tek taraflı diz artroplastisi geçirecek hastalarda femoral sinir bloğunun postoperatif analjezi üzerine daha etkin olduğunu sonucuna ulaşıldı.*

Anahtar kelimeler: *total diz artroplastisi; femoral sinir bloğu; adduktor kanal bloğu; multimodal analjezi; postoperatif analjezi*

İletişim/Contact: *Soner Kına, Kafkas University School of Medicine, Department of Cardiology, Kars, Türkiye.* • ***Tel:*** *0533 015 94 33* • ***E-mail:*** *sonerkina2@gmail.com* • ***Geliş/Received:*** *28.12.2024* • ***Kabul/Accepted:*** *18.02.2025*

ORCID: *Soner Kına : 0000-0003-3774-9632 • Ayşe Surhan Çınar : 0000-0003-2247-9764 • Kerim Şahin : 0000-0003-3422-6756 • Onur Demircioğlu : 0009-0006-5315-3643 •*

Introduction

Total knee arthroplasty (TKA) is an effective obstetric surgery method with good results for patients with advanced gonarthrosis whose demand for conservative treatment is increasing day by day with the aging population[1,2]. The postoperative period following this major orthopedic procedure is often associated with moderate to severe pain[3]. The primary goals after TKA should include minimizing the patient's pain, accelerating the recovery process, enhancing patient comfort, speeding up mobilization, avoiding or effectively preventing side effects, and reducing treatment costs[4]. To achieve these goals, multimodal analgesia methods, such as epidural catheter-assisted patient-controlled analgesia, intravenous patient-controlled analgesia, peripheral nerve blocks, and intraoperative intra-articular local anesthetic infiltration, can be utilized in postoperative pain management[5]. Traditional pain control methods, including intravenous and oral pain medications, have been associated with unreliable pain control and negative effects such as hypotension, sedation, urinary retention, and nausea[6]. Despite the advantages of epidural blocks in analgesia for knee arthroplasty, serious side effects associated with central blocks (motor block, urinary retention, hypotension, bradycardia, nausea, and/or vomiting, etc.) are acknowledged. Among these methods, peripheral nerve blocks are becoming increasingly popular due to their benefits during the perioperative period and relatively fewer side effects than other techniques.

The commonly used peripheral nerve blocks in TKA perioperative analgesia include femoral, obturator, sciatic, lumbar plexus, and adductor canal nerve blocks[7]. These blocks can be performed as single or combination blockages and administered as single injections or continuous infusions.

With the femoral nerve block (FNB), anesthesia is provided for the anterior and medial aspects of the thigh and knee and part of the medial aspect of the leg and ankle. It can be applied as a single injection or continuously through a catheter. While it can provide analgesic effects for 12–24 hours, this effect can extend to 48 hours[8]. The advantages of this block include reduced opioid usage, earlier mobilization, improved pain scores, and decreased hospital stay. However, the most significant disadvantage is that femoral nerve block may cause quadriceps muscle weakness and increase the risk of falls during the early postoperative period.

The adductor canal block (ACB) anesthetizes the anterior and medial parts of the knee, the area from the upper pole of the patella to the proximal tibia, the leg, the ankle, and part of the medial aspect of the foot. It can be administered as a single injection or continuously, similar to the femoral nerve block. The analgesic effect is similar to the femoral block for postoperative analgesia. Since it is a sensory block, it does not cause quadriceps weakness[9].

Applications of femoral nerve and adductor canal blocks are gradually becoming more widespread in TKA surgeries. This study prospectively compares the effectiveness, reliability, and postoperative pain control of femoral nerve block and adductor canal block. In this context, our study aims to contribute to the optimal selection of nerve blocks in analgesia management after TKA surgery, providing an important guide for clinical applications.

Material and Methods

This study was conducted in a tertiary-care medical center. Written and verbal informed consent was obtained from patients undergoing elective knee arthroplasty and classified into the ASA I-II group, aged 55 years and above. Ethical approval for the study was obtained from the Ethical Committee of Şişli Hamidiye Etfal Training and Research Hospital on May 14, 2019, with decision number 1247 under the Helsinki Declaration. The study was designed as randomized, prospective, and single-blind. Considering a large effect size (effect size=0.8), the alpha significance level was set at 0.05, and the sample size was calculated to be 70 individuals for 95% power. Patients who did not consent to participate in the study, those in ASA III-IV group emergencies, those with a local anesthetic allergy or allergic reactions after local anesthetic administration, those with infections in the area to be blocked, coagulation disorders, morbid obesity (BMI >40 kg/m^2), severe organ failure, neurological deficits in the past, psychiatric illnesses, and a chronic pain history were excluded from the study. Patients included in the study were informed about patient-controlled analgesia and visual analog scale (VAS) scoring during the preoperative evaluation.

Patients were divided into two groups using the closed envelope randomization method: the femoral nerve block group (Group F, n: 35) and the adductor canal block group (Group A, n: 35). All patients were taken to the regional block application room

for 30 minutes prior the operation for routine monitoring and premedication. The patients' names, ages, heights, weights, and timing of block placement were recorded. A femoral nerve block was performed under the fascia iliaca in Group F in the iliopsoas muscle sulcus. In contrast, in Group A, a saphenous nerve block was performed within the adductor canal. Both groups received 20 ml of 0.375% bupivacaine as a local anesthetic. The success of the block was evaluated in Group F by the absence of motor movements and through the pinprick test in the saphenous nerve area. Group A also assessed this using the pinprick test in the saphenous nerve area. Patients who reported paresthesia after the block were taken to the operating room. Routine monitoring consisting of fingertip saturation, heart rate (HR), and noninvasive mean arterial pressure (MAP) were monitored and recorded. General anesthesia was administered to all patients. Heart rate and noninvasive blood pressure were recorded before induction, after induction, at surgical incision, and every 30 minutes throughout the operation.

For postoperative analgesia, each patient was provided with intravenous patient-controlled analgesia containing tramadol. The total tramadol used and the number of requested versus administered boluses were recorded. Visual analog scale scores, HR, and MAP were recorded at 30 minutes, 1 hour, 2 hours, 4 hours, 6 hours, 12 hours, and 24 hours after the surgery. Complications such as hypotension, bradycardia, and itching were recorded for 24 hours.

Statistical Analysis

Statistical analysis was performed using IBM Statistical Package for Social Sciences (SPSS) program version 15.0 for Windows. Descriptive statistics were presented as numbers and percentages for categorical variables and mean and standard deviation for numerical variables. Comparisons between two independent groups were made using the Student's t-test when numerical variables met the normal distribution conditions and the Mann-Whitney U test when they did not. The Chi-Square Test was used to compare proportions among independent groups. Changes among independent groups during follow-up were analyzed using Repeated Measures ANOVA for changes and level differences. Comparisons of two dependent groups among the groups were conducted using a Paired t-test if the differences met the normal distribution condition or Wilcoxon Analysis if they did not. A significance level of α=0.05 was used, with p-values less than 0.05 considered statistically significant.

Results

A total of 70 patients were included in the study. When comparing the characteristics and surgical times of the patients, no statistically significant differences were found between the groups (Table 1). In perioperative mean arterial pressure (Figure 1) and heart rate (Figure 2), there was no statistically significant difference in follow-up means between both groups ($p>0.05$). In within-group analysis, statistically significantly higher arterial pressure and heart rate levels were found when comparing the baseline values with all measured time points ($p<0.001$). For postoperative mean arterial pressure (Figure 3) and heart rate (Figure 4), no statistically significant difference was observed in follow-up means between the two groups ($p>0.05$). In within-group evaluations, statistically significantly higher mean arterial pressure and heart rate levels were observed when comparing the baseline values with all measured hours ($p<0.001$).

Table 1. *Characteristics of patients and duration of operation*

	Adductor canal block		Femoral block		
	Mean±SD	Median	Mean±SD	Median	p
Age	63.1±4.7	63	63.9±3.8	64	0.421
Weight	84.4±8.4	85	85.7±5.6	86	0.442
Height	162.8±8.2	161	162.7±5.6	162	0.946
BMI	31.9±3.3	32.0	32.4±2.7	33.1	0.472
Time	126.7±9.6	125	131.7±17.2	125	0.440

Data were expressed as Mean±SD. P<0.05 was considered significant.

Table 2. *VAS score averages*

		Adductor canal block		Femoral block		
		Mean±SD	Median	Mean±SD	Median	p
VAS	Postoperative 0.min	2.97±0.62	3	2.63±0.55	3	0.021*
	Postoperative 1.hr	2.66±0.48	3	2.23±0.49	2	0.001*
	Postoperative 2.hr	2.46±0.51	2	2.17±0.51	2	0.027*
	Postoperative 4.hr	2.23±0.43	2	2.06±0.34	2	0.070
	Postoperative 6.hr	2.26±0.44	2	1.97±0.51	2	0.019*
	Postoperative 12.hr	2.06±0.34	2	1.86±0.55	2	0.666
	Postoperative 24.hr	1.71±0.57	2	1.54±0.51	2	0.227

Data are expressed as Mean±SD. *Statistically high. P<0.05.

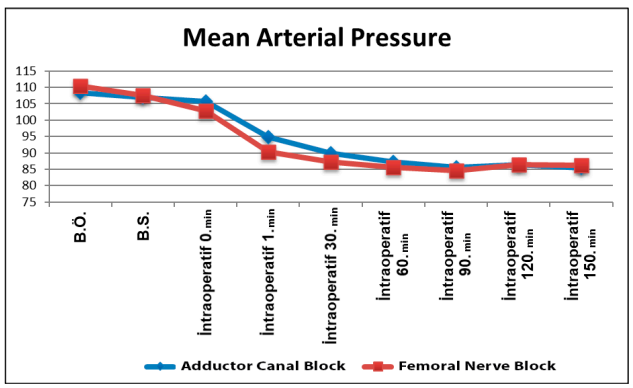

Figure 1. *Perioperative mean arterial pressure.*

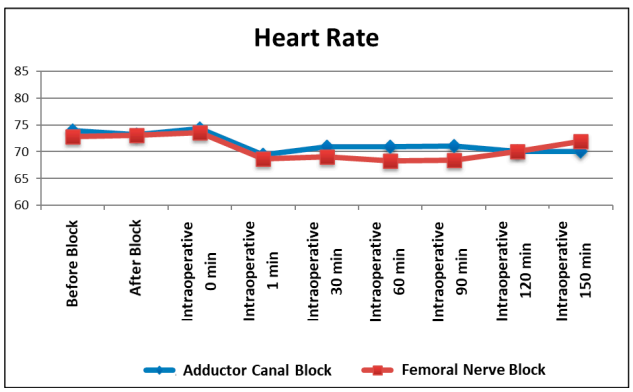

Figure 2. *Perioperative heart rate.*

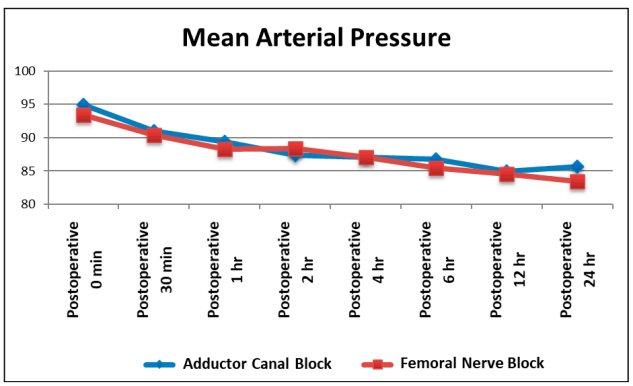

Figure 3. *Postoperative mean arterial pressure.*

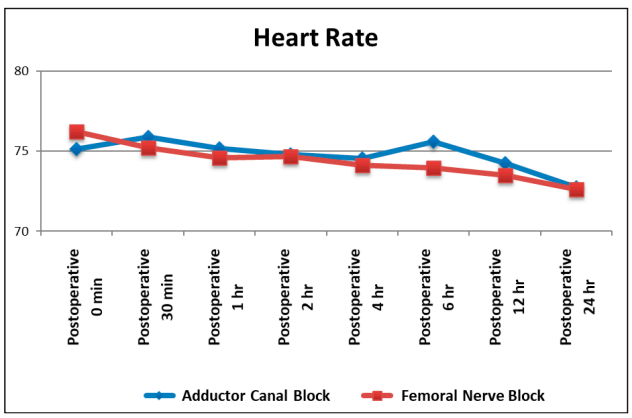

Figure 4. *Postoperative heart rate.*

Mean VAS values for the adductor canal block group were statistically significantly higher than those of the femoral block group at postoperative 0., 1., 2., and 6. hours (p>0.05) (Table 2). In within-group evaluations, VAS values at 2., 4., 6., 12., and 24. hours were statistically significantly lower compared to the VAS values at postoperative 0. hour in the adductor canal block (p<0.001). In the femoral block group, the VAS values were statistically significantly lower in all time intervals when compared to the VAS values at postoperative 0. hour (p<0.001). In terms of patient-controlled analgesia use, the requested boluses, administered boluses, and total tramadol doses were all found to be higher in the adductor canal block group compared to the femoral block group (p<0.001) (Table 3). No statistically significant differences were found regarding the use of additional analgesics between the groups. No statistically significant differences were observed in the complication rates between the groups (p>0.05) (Table 4).

Table 3. *Use of patient controlled analgesia*

	Adductor canal block		Femoral block		
	Mean±SD	Median	Mean±SD	Median	p
Requested bolus	15.3±2.1	15	11.7±2.2	11	<0.001*
Delivered bolus	12.4±1.3	12	9.3±1.8	9	<0.001*
Total tramadol	248.6±25.3	240	185.7±35.2	180	<0.001*

Data are expressed as Mean±SD. *Statistically high. P<0.05.

Table 4. *Complication incidence rates*

	Adductor canal block		Femoral block		
	n	%	n	%	p
Nausea/vomiting	4	11.4	2	5.7	0673
Hypotension	0	0.0	0	0.0	-
Bradycardia	0	0.0	1	2.9	1.000
Toxicity	0	0.0	0	0.0	-

Data are expressed as a percentage. P<0.05 is significant.

Discussion

The postoperative period following total knee arthroplasty (TKA), one of the major orthopedic interventions, is very painful, and many methods and medications have been tried to eliminate this pain, resulting in numerous studies. Optimal pain management and proper physiotherapy promote joint mobility, accelerating functional recovery processes[4,10]. Today, multimodal analgesia is recognized as an effective method for pain management after TKA[4]. Multimodal analgesia is a technique that provides quality analgesia, reduces opioid-related side effects, and delivers sufficient analgesia through additive or synergistic effects among different analgesics[11]. Peripheral nerve blocks are utilized as part of preemptive and multimodal analgesia[12].

A limited number of studies have evaluated the effects of preoperative block application on perioperative and postoperative hemodynamics[13]. In the literature, blocks have mostly been performed during the postoperative period. Our study evaluated the effects of preemptive peripheral nerve blocks on hemodynamics by recording HR and MAP data before the block, after induction, and every 30 minutes. No significant differences were observed between the groups in the preoperative and postoperative periods.

Zhen et al. (2018) applied ACB and FNB to patients undergoing TKA[14]. They studied VAS scores over the postoperative 72 hours. While the VAS scores measured in the first 24 hours were significantly lower in the FNB group, they found that the scores were similar at 48 and 72 hours. Thacher et al. (2017) examined the risk of knee collapse/falls in patients undergoing TKA in a retrospective study comparing femoral nerve block with adductor canal block and found similar VAS scores[15]. Karkhur et al. performed a meta-analysis of 13 articles on postoperative analgesia with adductor canal and femoral nerve blocks in TKA and found similar VAS scores among patients[10]. Another meta-analysis conducted in 2017 compared 12 randomized controlled trials and found similar postoperative VAS scores[16]. Kim H et al., in a prospective randomized controlled study, found the pain scores, especially at the postoperative 6th and 8th hours, to be lower in the group receiving FNB but observed a similarity in the VAS scores at the 48th hour[17]. In our study, VAS scores were below 4 in both groups during the first 24 hours. Although the VAS values were lower in the femoral nerve block group during the first 6 hours compared to the adductor canal block group, only 1 patient in the FNB group and 3 in the ACB group received rescue analgesics. In our study, we primarily focused on VAS values and opioid consumption during the first 24 hours postoperatively, while other studies investigated VAS values for 48 or even 72 hours postoperatively.

In patients undergoing total knee arthroplasty receiving ACB, they were divided into two groups; one group received a single administration of 30 cc of 0.25% bupivacaine, while the other group received continuous infusion through a catheter; it was shown that in the continuous infusion group, pain scores, analgesic consumption, and the pain scores were lower[18]. Shah, Jain et al. demonstrated that the adductor canal can be filled with 30 cc of local anesthetic[19]. Lund et al. also showed that the adductor canal could be filled with 30 cc when imaged with MRI[20]. Our study used 20 cc of 0.375% bupivacaine under ultrasound guidance in both nerve blocks. While sufficient analgesia was provided with these local anesthetic volumes in both blocks, VAS values were lower in the femoral group during the first 6 hours, and analgesic consumption was lower during the first 24 hours.

In studies where general anesthesia and spinal anesthesia techniques were applied with FNB and ACB,

postoperative follow-ups showed that opioid consumption and VAS scores were higher in patients receiving general anesthesia for both block technique[21]. In our study, general anesthesia was preferred after the block application. Due to our hospital's physical conditions and insufficient technical equipment, only 24-hour monitoring was possible. In this case, the choice of general anesthesia was made to avoid repeating invasive interventions and because inadequate feedback would be obtained during the 24-hour monitoring period.

Studies comparing FNB and ACB have found that morphine is usually used as an analgesic in patient-controlled analgesia applications. They found the amount of morphine consumed to be similar in both groups[22]. Our study chose tramadol in patient-controlled analgesia due to the absence of respiratory depression, itching, and vesicular glob formation. The average tramadol consumption was 185 mg in the femoral group and 245 mg in the adductor group.

Other studies have shown that in patients who exclusively used opioids for analgesia following total knee arthroplasty, the incidence of nausea and vomiting has increased[23]. The incidence of nausea and vomiting has decreased due to the reduced postoperative opioid consumption with regional techniques. In studies comparing FNB and ACB, although there was a 10% incidence of nausea and vomiting in studies applying patient-controlled morphine postoperatively, the incidence of nausea and vomiting was found to be similar for both techniques[10,16,24]. In our study, nausea and vomiting were detected in 2 patients (5%) in the femoral group and 4 patients (10%) in the adductor canal block group, but no significant difference was observed. We attributed the reduced perioperative and postoperative opioid consumption to the use of regional techniques despite the severe pain experienced in TKA surgeries.

The 24-hour follow-up for patients may be viewed as a significant limitation of our study. A longer duration is necessary to evaluate potential postoperative complications. Since mobilization was not permitted within the first 24 hours by the orthopedic clinic, complications related to quadriceps weakness could not be evaluated. Additionally, due to the lack of permission for ambulation, only resting VAS scores could be assessed.

There has been no consensus in studies regarding the type of anesthetic agents, dosages, and timing. Due to the heterogeneity of studies and their results, there is no agreement on the optimal anesthetic agent, dosage, method of application, and duration[22,25–27].

In our study, finding VAS values below 3 and high patient satisfaction in operations like TKA, which are associated with high postoperative pain intensity, demonstrates that both can be used as effective postoperative analgesia methods.

Conclusion

In major orthopedic procedures such as TKA, where severe postoperative pain is observed and can transform into chronic pain if untreated, either type of block can be performed for effective analgesia. Given that early mobilization, ambulation, and physical therapy following TKA accelerate the functional recovery process, the adductor canal block, which is sensory only and does not cause quadriceps weakness, should be considered a part of multimodal analgesia. In our study, the total opioid consumption, VAS scores, and incidence of complications such as nausea and vomiting were lower in the group receiving preoperative femoral nerve block compared to the group receiving adductor canal block. For these reasons, we believe femoral nerve block to be more effective than adductor canal block for patients with planned TKA.

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