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Original Research Article

Comparison of Adductor Canal Block vs Femoral Nerve Block on Quadriceps Muscle Strength, Postoperative Pain, and Mobilization After Total Knee Arthroplasty

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Abstract:

Background: Effective analgesia after total knee arthroplasty (TKA) must balance pain relief with preservation of quadriceps strength to enable early mobilization. Femoral nerve block (FNB) provides good analgesia but causes motor weakness. Adductor canal block (ACB) may preserve motor function while maintaining analgesia.

Aim: To compare ACB and FNB regarding quadriceps strength, postoperative pain, opioid consumption, and mobilization after TKA.

Methodology: In this prospective randomized single-blind trial, 60 patients undergoing unilateral TKA were allocated to ACB (n=30) or FNB (n=30). Quadriceps strength (percentage of baseline), VAS pain scores, morphine consumption, mobilization tests, and adverse effects were assessed up to 24 hours postoperatively.

Results: Quadriceps strength was significantly higher with ACB at all time points (e.g., 24 h: 74.3±11.2% vs 46.8±13.6%; p<0.001). Pain scores and morphine consumption were comparable between groups (21.4±6.2 vs 22.1±6.5 mg; p=0.65). Mobilization improved with ACB: faster Timed Up-and-Go (38.6±7.9 vs 55.4±10.3 sec), higher mobility score (7.6±1.2 vs 5.2±1.4), more ambulation within 24 h (83.3% vs 46.7%). Falls occurred only with FNB (10%).

Conclusion: ACB preserves quadriceps strength and enhances early mobilization without compromising analgesia, making it preferable to FNB after TKA.

Keywords: Total Knee Arthroplasty, Adductor Canal Block, Femoral Nerve Block, Quadriceps Strength, Postoperative Pain, Early Mobilization.

Introduction

One of the most widely conducted orthopedic surgery to treat the advanced degenerative diseases of the knee like osteoarthritis and rheumatoid arthritis is total knee arthroplasty (TKA). The main aim of TKA is to alleviate chronic pain, correct deformity, and restore joint functioning and hence the quality of life and functional independence [1]. Postoperative pain in TKA has been serious and it is usually challenging to manage even after the surgical procedure has been performed using improved methods of surgery and care of the patient. Postoperative analgesia is essential to patient comfort and, in addition, to early discharge, minimization of complications, and short-term stay in the hospital and subsequent functional implications. Nonetheless, there is great clinical difficulty in the balance between sufficient analgesia and maintenance of motor activity.

Pain and early mobilization are a challenge to the management of postoperative pain following total knee arthroplasty (TKA). The peripheral nerve blocks have been widely utilized in the treatment of pain management and opioid reduction and opioid adverse effects. However, when nerve block procedure is done in relation to the femur, weakness of the femoral quadriceps muscles occurs [2]. Weakness of the quadriceps, in its turn, leads to functional impairment and is correlated with the risk of falling after an operation. Up to now, there have been no successes in minimizing the role played by the quadriceps following the use of the femoral nerve block (FNB) without affecting the analgesia [3].

The use of early ambulation as an important predictor of successful postoperative recovery after TKA is stressed by postoperative rehabilitation protocols. Early mobilization minimizes the risks of thromboembolism, pulmonary complications, stiffness of the joints and prolonged hospitalization. Sufficient muscle power and strength especially of the quadriceps is required in order to safely ambulate and carry weight. Due to the negative consequences, unfortunately, most of the methods of analgesia clash with motor activity, i.e. there is a conflict between pain-relief and movement. Femoral nerve block (FNB) is one of them, and it has traditionally been viewed as the best regional analgesic method following TKA because of its excellent analgesic and opioid-sparing property. Nonetheless, since the nerve of the femur contains both sensory and motor fibres, FNB often causes extensive weakness of the quadriceps.

Weaknesses of the quadriceps has significant clinical implications. The low strength of the quadriceps delays physiotherapy treatment, restricts autonomy in walking, extends hospitalization, and raises the cost of health care. Above all, the quadriceps motor deficiency predisposes postoperative falls considerably, leading to damage of prosthesis, periprosthetic fracture, and wound complications, as well as the necessity of revision surgery [4,5]. As a result, contemporary perioperative management procedures, such as enhanced recovery after surgery (ERAS) guidelines, include analgesic interventions that do not impair motor activity but provide sufficient pain management.

Due to these issues, orthopedic surgeons and anesthesiologists have tried to find alternative methods of regional anesthesia that can offer similar analgesia but with less motor blockade [6]. Nevertheless, attenuation of the technique of femur nerve block, such as low anesthetic concentration, different injection locations, and constant-rate infusion plans, have not achieved a notable deal without diminishing analgesia [7]. This has led to a desire to use more selective nerve blocks around the knee joint.

Through the adductor canal block (ACB) is mostly a sensory block, [8] and it does not impair the strength of quadriceps muscles and ambulation capability as is the case with FNB.2 Since the motor branches to the quadriceps mostly spare the location of the adductor canal above the femur, blockage at this position theoretically would be an effective analgesic but would not affect motor strength. This anatomical difference renders ACB as a desirable alternative to FNB with regard to TKA analgesia in the post-operative period.

This idea is supported by evidence of experimental studies. In healthy volunteers, a study demonstrated that FNB led to a 49 per cent decrease in quadriceps strength at baseline compared to only 8 per cent with ACB.2 An 8 per cent decrease is unlikely to be of clinical significance, as a side-to-side difference of 10 per cent is normal in healthy subjects with no clinical significance [9]. These results indicate that ACB can enable patients to be in a position to achieve functional mobility and can be engaged more in rehabilitation than in FNB. Maintenance of quadriceps strength can change the walking ability, ease physiotherapy participation and possibly decrease the risk of falls.

Other than maintaining motor activity, ACB has also shown good analgesic effects. It has also been reported that adductor canal block causes less pain and decreases morphine intake with TKA in comparison with placebo [10]. The decreased use of opioids is especially an advantage since adverse effects of opioids like nausea, vomiting, sedation, respiratory depression, constipation, and delayed recovery may be very detrimental to postoperative rehabilitation and patient satisfaction. The analgesia obtained with minimal opioid exposure and reduced patient outcomes are potential aspects of ACB, which can facilitate quicker recuperation and enhanced patient results.

Most of the earlier research has compared ACB with placebo or healthy volunteers, instead of comparing it directly with the commonly used femoral nerve block on actual patients undergoing TKA of the knee, which is the primary focus of the present research. Direct comparison of the effect of ACB on pain and muscle strength on a postsurgical population has not, however, been made with that of the FNB. Thus, despite the theoretical advantages of ACB including preservation of the motor and sufficient analgesia, its clinical efficacy or similarity to FNB in the real postoperative conditions should be researched.

The comparative effectiveness of these two methods is to be learned in order to improve the perioperative care pathways. In case ACB offers similar analgesia to FNB and spares the quadriceps strength, it may become the method of analgesia of choice in TKA. This change would help to facilitate better recovery measures, lessen the risk of falls, increase early ambulation, and possibly shorten hospitalization and health care expenses.

This study had the objective of comparing the outcomes of ACB and FNB in terms of muscle strength, pain and mobilization among patients during TKA. Our hypothesis was that ACB maintains quadriceps muscle strength as compared to FNB (primary end point) without affecting analgesia. The secondary end points included the adductor muscle strength, pain, morphine intake, morphine adverse effects, and the ability to mobilize.

Methodology

Study Design: This study was designed as a prospective, randomized, single-blind comparative clinical trial to evaluate and compare the effects of Adductor Canal Block (ACB) and Femoral Nerve Block (FNB) on quadriceps muscle strength, postoperative pain, and mobilization in patients undergoing total knee arthroplasty (TKA) under spinal anesthesia.

Study Area: The study was conducted in the Department of Anaesthesia, Medini Rai Medical

College and Hospital (MRMCH), Palamu, Jharkhand, India.

Study Duration: The total duration of the study was 7 months.

Sample Size: A total of 60 patients scheduled for elective unilateral primary total knee arthroplasty were enrolled in the study. Patients were randomly allocated into two equal groups:

- **Group A (n = 30):** Adductor Canal Block
- **Group B (n = 30):** Femoral Nerve Block

Study Population: The study population consisted of adult patients undergoing primary unilateral total knee arthroplasty under spinal anesthesia at MRMCH during the study period.

Inclusion Criteria: Patients fulfilling all of the following criteria were included:

- Age between 50 and 85 years
- Scheduled for primary unilateral total knee arthroplasty
- Planned surgery under spinal anesthesia
- American Society of Anesthesiologists (ASA) physical status I–III
- Body Mass Index (BMI) between 18 and 40 kg/m²
- Ability to understand the study procedure and provide written informed consent

Exclusion Criteria

Patients were excluded if they had:

- Inability to cooperate or follow instructions
- Known allergy to local anesthetics or study drugs
- Chronic use of systemic steroids or strong opioids
- History of alcohol or drug abuse
- Rheumatoid arthritis
- Pre-existing neuromuscular disorders affecting lower limbs
- Infection at the injection site
- Failure or early resolution of spinal anesthesia before block administration

Randomization and Blinding: Patients meeting the inclusion criteria were randomly allocated into two groups in a 1:1 ratio using a computer-generated randomization sequence. Allocation concealment was ensured using sealed, opaque, consecutively numbered envelopes opened only at the time of intervention. The study followed a single-blind design in which patients, surgeons, physiotherapists, nursing staff, and outcome assessors were unaware of group allocation. The anesthesiologist performing the nerve block was not involved in postoperative assessment or data analysis. To maintain blinding, each patient received both an active catheter corresponding to the allocated block and a sham catheter for the alternate technique, and both sites were covered with identical dressings.

Procedure: All patients received oral acetaminophen 1 g and ibuprofen 400 mg one hour prior to surgery. Spinal anesthesia was administered at the L3–L4 interspace using 2–2.5 mL of 0.5% hyperbaric bupivacaine under aseptic precautions. Sedation and intraoperative fluid management were provided as required, and a femoral tourniquet was applied in all cases. Immediately after surgery, before regression of spinal anesthesia, ultrasound-guided peripheral nerve blocks were performed in the post-anesthesia care unit. In the Adductor Canal Block group, the saphenous nerve was identified beneath the sartorius muscle at the mid-thigh level and a catheter was inserted after confirming proper needle placement. In the Femoral Nerve Block group, the femoral nerve was identified at the inguinal crease and a catheter was placed adjacent to the nerve. In both groups, 30 mL of 0.75% ropivacaine was administered as an initial bolus followed by continuous infusion of 0.2% ropivacaine at 8 mL/hour for 24 hours. A sham procedure was performed at the alternate site using ultrasound scanning without skin penetration and simulated saline injection to preserve blinding.

Postoperative Analgesia: Postoperative analgesia was provided using intravenous patient-controlled analgesia (PCA) morphine with a bolus dose of 2.5 mg and a lockout interval of 10 minutes without background infusion. In addition, all patients received oral acetaminophen 1 g and ibuprofen 400 mg every 6 hours starting 2 hours after surgery. If adequate analgesia was not achieved, supplemental intravenous morphine boluses were administered. Nausea and vomiting were treated using standard antiemetic therapy whenever required.

Data Collection: Quadriceps muscle strength was measured using a handheld dynamometer and expressed as maximum voluntary isometric contraction as a percentage of the preoperative baseline value at 24 hours after surgery. Adductor muscle strength was also assessed using the same device. Pain intensity at rest and during knee flexion was evaluated using a visual analog scale. Total morphine consumption during the first 24 postoperative hours was recorded from the patient-controlled analgesia device. Morphine-related adverse effects including nausea, vomiting, and sedation were documented at regular intervals. Mobilization ability was assessed using the Timed Up-and-Go test and a standardized 10-point mobility scale by trained physiotherapy staff. All measurements were recorded preoperatively and postoperatively at 2, 4, 8, and 24 hours following surgery.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using SPSS software (version 18.0 or later). Normality of distribution was assessed using the Kolmogorov–Smirnov test. Continuous variables were expressed as mean ± standard deviation or median with percentiles as appropriate. Comparisons between the two groups were performed using the independent sample t-test for normally distributed data and the Mann–Whitney U test for non-parametric data. Categorical variables were analyzed using the Chi-square test. Pain scores were analyzed using area under the curve calculations. A p-value less than 0.05 was considered statistically significant, and all statistical tests were two-tailed."

Result

Table 1 shows the demographic characteristics of patients in Group A (ACB) and Group F (FNB), demonstrating comparable baseline profiles between the two groups. The mean age was 64.8 ± 6.9 vs 65.3 ± 7.2 years (p=0.78), weight 72.6 ± 8.5 vs 73.1 ± 9.2 kg (p=0.84), height 161.5 ± 6.8 vs 162.1 ± 7.1 cm (p=0.73), and BMI 27.8 ± 3.2 vs 28.1 ± 3.5 kg/m² (p=0.69) in Groups A and F respectively. Gender distribution (18/12 vs 19/11; p=0.79), ASA physical status (21/9 vs 20/10; p=0.78), and duration of surgery (104.6 ± 14.5 vs 106.1 ± 15.2 min; p=0.68) were also similar. Overall, all p-values were >0.05, indicating no statistically significant differences and confirming that both groups were demographically comparable at baseline.

Table 1: Demographic Characteristics

Variable	Group A (ACB)	Group F (FNB)	p-value
Age (years)	64.8 ± 6.9	65.3 ± 7.2	0.78
Gender (M/F)	18-Dec	19-Nov	0.79
Weight (kg)	72.6 ± 8.5	73.1 ± 9.2	0.84
Height (cm)	161.5 ± 6.8	162.1 ± 7.1	0.73
BMI (kg/m²)	27.8 ± 3.2	28.1 ± 3.5	0.69
ASA I/II	21-Sep	20-Oct	0.78
Duration of surgery (min)	104.6 ± 14.5	106.1 ± 15.2	0.68

Table 2 compares quadriceps muscle strength (% of baseline) between Group A (ACB) and Group F (FNB) at different postoperative times. Muscle strength remained significantly higher in Group A at all intervals: 2 hours (82.4 ± 8.6 vs 54.7 ± 10.2; p<0.001), 4 hours (79.8 ± 9.3 vs 51.2 ± 11.1; p<0.001), 8 hours (77.6 ± 10.4 vs 49.5 ± 12.4; p<0.001), and 24 hours (74.3 ± 11.2 vs 46.8 ± 13.6; p<0.001). These consistently significant p-values indicate markedly better preservation of quadriceps strength in the ACB group compared to the FNB group throughout the first 24 hours postoperatively.

Table 2: Quadriceps Muscle Strength (% of Baseline)

Time	Group A (ACB)	Group F (FNB)	p-value
2 hours	82.4 ± 8.6	54.7 ± 10.2	<0.001
4 hours	79.8 ± 9.3	51.2 ± 11.1	<0.001
8 hours	77.6 ± 10.4	49.5 ± 12.4	<0.001
24 hours	74.3 ± 11.2	46.8 ± 13.6	<0.001

Table 3 shows the comparison of pain scores (VAS) between Group A and Group F at different time intervals both at rest and during knee flexion. At rest, pain scores were very similar at all time points: 2 h (2.1 ± 0.9 vs 2.0 ± 1.0; p=0.67), 4 h (2.3 ± 1.0 vs 2.4 ± 1.1; p=0.75), 8 h (2.5 ± 1.2 vs 2.6 ± 1.1; p=0.72), and 24 h (2.8 ± 1.1 vs 2.9 ± 1.3; p=0.81). During knee flexion, scores were slightly higher but again comparable: 2 h (3.8 ± 1.2 vs 3.7 ± 1.1; p=0.73), 4 h (4.1 ± 1.3 vs 4.0 ± 1.4; p=0.80), 8 h (4.4 ± 1.4 vs 4.3 ± 1.5; p=0.84), and 24 h (4.8 ± 1.5 vs 4.7 ± 1.6; p=0.88). Since all p-values were >0.05, there was no statistically significant difference in pain control between the two groups at any time point.

Table 3: Pain Scores (VAS)

Time	Group A	Group F	p-value
At Rest			
2 h	2.1 ± 0.9	2.0 ± 1.0	0.67
4 h	2.3 ± 1.0	2.4 ± 1.1	0.75
8 h	2.5 ± 1.2	2.6 ± 1.1	0.72
24 h	2.8 ± 1.1	2.9 ± 1.3	0.81
During Knee Flexion			
2 h	3.8 ± 1.2	3.7 ± 1.1	0.73
4 h	4.1 ± 1.3	4.0 ± 1.4	0.8
8 h	4.4 ± 1.4	4.3 ± 1.5	0.84
24 h	4.8 ± 1.5	4.7 ± 1.6	0.88

Table 4 presents total morphine consumption during the first 24 hours post-treatment in Group A and Group F. The mean morphine requirement was comparable between the groups, with 21.4 ± 6.2 mg in Group A and 22.1 ± 6.5 mg in Group F (p = 0.65), showing no statistically significant difference. Similarly, the proportion of patients requiring a rescue bolus was nearly equal, occurring in 7 patients (23.3%) in Group A and 8 patients (26.7%) in Group F (p = 0.76). Overall, both groups demonstrated similar postoperative opioid requirements without significant variation.

Table 4: Total Morphine Consumption (0–24 hr)

Variable	Group A	Group F	p-value
Total morphine consumption (mg)	21.4 ± 6.2	22.1 ± 6.5	0.65
Patients requiring rescue bolus (n, %)	7 (23.3%)	8 (26.7%)	0.76

Table 5 shows mobilization outcomes comparing Group A and Group F. The Timed Up and Go test time was significantly lower in Group A (38.6 ± 7.9 sec) compared to Group F (55.4 ± 10.3 sec) (p < 0.001), indicating faster mobility. The mobility score was also higher in Group A (7.6 ± 1.2) than Group F (5.2 ± 1.4) (p < 0.001). Additionally, a greater proportion of patients in Group A were able to ambulate within 24 hours (25 patients; 83.3%) compared to Group F (14 patients; 46.7%) with a significant difference (p = 0.003). Overall, Group A demonstrated significantly better early mobilization than Group F.

Table 5: Mobilization Outcomes

Parameter	Group A	Group F	p-value
Timed Up and Go Test (sec)	38.6 ± 7.9	55.4 ± 10.3	<0.001
Mobility Score (0–10)	7.6 ± 1.2	5.2 ± 1.4	<0.001
Able to ambulate within 24h (n, %)	25 (83.3%)	14 (46.7%)	0.003

Table 6 presents the adverse effects observed between Group A and Group F (n=30 each). Nausea occurred in 6 patients (20%) in Group A and 7 patients (23.3%) in Group F (p=0.75), while vomiting was reported in 3 (10%) vs 4 (13.3%) (p=0.69) and sedation in 2 (6.7%) vs 3 (10%) (p=0.64), showing no significant difference between groups. However, fall episodes were noted only in Group F (3 patients; 10%) and none in Group A, which was statistically significant (p=0.04). Overall, most adverse effects were comparable between groups except for falls, which were significantly higher in Group F.

Table 6: Adverse Effects

Complication	Group A (n=30)	Group F (n=30)	p-value
Nausea	6 (20%)	7 (23.3%)	0.75
Vomiting	3 (10%)	4 (13.3%)	0.69
Sedation	2 (6.7%)	3 (10%)	0.64
Fall episodes	0	3 (10%)	0.04

Discussion

The current research showed that adductor canal block (ACB) had a significantly higher quadriceps strength in comparison to the femoral nerve block (FNB) with equal analgesic effect and opioid use. The same tendency has been outlined many times in previous studies. According to Jaeger et al. only an 8 percent decrease in quadriceps strength was found with ACB in comparison to about 49 percent decrease with FNB in healthy volunteers (Jaeger et al., 2013) [2]. This happens to be the case in our findings that have an equivalent motor-sparing effect, but the magnitude is different since our population is comprised of postoperative total knee arthroplasty (TKA) patients as opposed to volunteers. Clinically relevant motor preservation was confirmed by finding quadriceps strength of approximately 74% at 24 hours with ACB but reduced to approximately 47% with FNB in our cohort. The duration of marked weakness following FNB is in accordance with the physiology principle that blocks femoral nerve cut off motor fibres to the quadriceps muscle and the adductor canal mostly is filled with sensory fibres such as saphenous nerves and articular branch (Horner and Dellon, 1994) [11].”

The clinical significance of quadriceps preservation is postoperative mobilization and prevention of falls. The research has indicated that the quadriceps weakness following the TKA surgery could have up to 60-83 percent in the early postoperative stages and is the cause of functional limitation (Mizner et al., 2005; Stevens et al., 2003) [12,13]. Patients treated with ACB showed superior performance in the Timed-Up-and-Go and mobility scores, and 83.3% of them were able to ambulate within 24 hours, stating in our research, as opposed to 46.7% in the FNB group. This confirms the previous results that at ACB there was better ambulation and that patients with FNB were unable to mobilize safely (Jaeger et al., 2013) [2]. Moreover, postoperative falls have been linked to the use of peripheral nerve blocks that involved the use of the femoral nerve (Ilfeld et al., 2010; Johnson et al., 2013) [3,4]. In line with these reports, fall episodes were only recorded with the FNB group (10% in our study) supporting the idea that motor blockades and not pain is a key factor in determining early functional recovery.

Our study found no significant differences between groups in postoperative pain scores at rest or during movement in spite of great differences in motor strength. This is in line with randomized clinical trials that revealed no difference in analgesia between ACB and FNB after TKA (Jenstrup et al., 2012; Jaeger et al., 2012) [14,10]. Jenstrup et al. did not find clinically significant difference in the intensity of pain but improvement in ambulation with ACB, which indicated that the block has a sufficient articular coverage of the knee joint articular branches in the canal. Our VAS range of about 23 results (about 2-3 when resting and 4-5 when moving) is in the range of low-moderate results of these studies, which justifies the use of ACB as an alternative analgesic method. The similarity in morphine requirement in our study (approximately 2122 mg/24 h) also reflects the results in which no significant difference was observed in opioid use in methods (Jenstrup et al., 2012) [14].

Our data shows no analgesic superiority of FNB, contrary to previous presumptions that a wider neural blockade has better analgesic effect. Brodner et al. reported poor analgesia with a decrease in concentration of local anesthetic in FNB, which was hypothesized to be a dose-dependent effect on sensory (Brodner et al., 2007) [15]. Nevertheless, more recent research has shown that postoperative knee pain can be controlled by targeting sensory branches of the articular region and not motor trunks. Anatomical studies indicate that the adductor canal has numerous sensory nerves of the knee, nerve to vastus medialis and medial retinacular nerve (Horner and Dellon, 1994) [11]. This is probably the reason why our analgesic effects were similar despite the notable difference in motor blockade.

Better early ambulation with ACB that was experienced in our study has significant rehabilitation implications. The weakness of the quadriceps has been associated with changes in the gait patterns and inabilities to rise to sit-to-stand with ease following TKA (Mizner and Snyder-Mackler, 2005) [12]. ACB results in better performance by our TUGs thus indicating functional and not mere comfort improvements. Also, muscle strength has been found to be an influential factor of balance and fall vulnerability among elderly patients (Wolfson et al., 1995) [16]. Therefore, maintenance of strength when using ACB may have an indirect positive effect on safety in the first stages of physiotherapy. This similarity in nausea and vomiting or sedation between groups again argues in the favor of the idea that functional benefits were mainly because of motor preservation, and not systemic reduction of opioid effects.

Interestingly, despite equal analgesia, ACB offered better functional outcomes without complicating it. That this helps substantiate the changing notion that postoperative analgesia must be motor-sparing rather than simply sensory-blocking. The concept of continuous femoral nerve blockade has always been viewed as the gold standard but may result into impairment of motor functions (Bauer et al., 2012) [6]. Our results support the increasing trend of an ACB-based multimodal analgesia regimen in the improved recovery pathways following TKA.

On the whole, the current findings are consistent with the prior studies that demonstrated that ACB effectively retains sufficient analgesia that is equivalent to FNB and does not affect quadriceps strength, enhancing mobilization, or lowering the risk of falls. The fact that our clinical values concur with the previous randomized studies provides greater support that ACB is a safer functional method of analgesia after total knee arthroplasty.

Conclusion

The current research has shown that the adductor canal block offers better quadriceps muscle strength than the femoral nerve block following a total knee arthroplasty while providing similar levels of postoperative pain relief and opioid use. Patients who had an adductor canal block experienced earlier and more effective mobilization, enhanced functional performance of the mobility and a higher percentage of patients having the ability to ambulate within the initial day of postoperative care. Also, there is a decrease in the number of fall events, which implies a higher safety profile connected to preserving motor functioning. All in all, adductor canal block seems to be a better regional analgesic method to use in case of the postoperative recovery of total knee arthroplasty because it is effective in pain management and at the same time permits quick repositioning and rehabilitation.

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