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ORIGINAL INVESTIGATION

Analgesic effect of continuous adductor canal block versus continuous femoral nerve block for knee arthroscopic surgery: a randomized trial

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Nerve block;
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Abstract
Background and objectives: Anterior cruciate ligament reconstruction (ACLR) is one of the most frequently performed orthopedic procedures. The ability to perform ACLR on an outpatient basis is largely dependent on an effective analgesic regimen. The aim of the study was to compare the analgesic effect between continuous adductor canal block (cACB) and femoral nerve block (cFNB) during arthroscopy guided ACLR.
Method: In this prospective, randomized, controlled clinical trial, 60 ASA I/II patients for arthroscopic ACLR were recruited. Patients in Group I received cACB and those in Group II cFNB. A bolus dose of 20 cc 0.5% levobupivacaine followed by 0.125% 5 $mL.h^{-1}$ was started for 24 hours. Rescue analgesia in the form of paracetamol 1 g intravenous (IV) was given. Parameters assessed were time of first rescue analgesia, total analgesic requirement in 24 hours, and painless range of motion of the knee (15 degrees of flexion to further painless flexion).
Results: The time-to-first postoperative analgesic request (hours) was earlier in Group II (14.40 ± 4.32) than Group I (16.90 ± 3.37) and this difference was statistically significant ($p < 0.05$). The cumulative 24-h analgesic consumption (paracetamol in g) was 0.70 ± 0.47 in Group I and 1.70 ± 0.65 in Group II ($p < 0.001$). The painless range of motion (degree) was 55.67 ± 10.40 in Group I and 40.00 ± 11.37 in Group II ($p < 0.001$).
Conclusion: The findings of this study suggest that continuous adductor canal block provides superior analgesia in patients undergoing arthroscopic ACLR when compared to continuous femoral nerve block.

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Introduction

Anterior cruciate ligament reconstruction (ACLR) is a common orthopedic procedure.[1] ACLR reconstruction done on outpatient basis requires effective analgesic regimen with minimal adverse effects and effective mobilization.[2] Immediate weight-bearing postoperatively has shown to decrease pain.[3] Although the use of peripheral nerve blocks for ACLR has increased in recent years, consensus around the optimal pain management strategy after ACLR is lacking.[4] The advantage of continuous motor-sparing peripheral nerve blocks include decrease in ''rebound pain'' and early discomfort.[5,6] Continuous femoral nerve block (cFNB) is commonly used for postoperative analgesia. It may result in early and potentially prolonged quadriceps muscle weakness,[7,8] leading to concerns about early mobilization and risk of postoperative falls.[9,10] Continuous adductor canal block (cACB) has emerged as an alternative to cFNB, because it produces a sensory nerve block of the saphenous nerve. It provides comparable analgesia to cFNB without loss of quadriceps muscle strength.[11] This might be particularly useful in outpatient ACLR reconstruction which requires short stay and immediate mobilization.[10,12]

Our hypothesis was that cACB would result in improved analgesia for knee arthroscopic surgeries, without any increase in adverse effects. The primary outcome was time of first analgesic requirement. Secondary outcomes included 24-hour analgesic consumption and painless range of motion of the knee joint (15 degrees of flexion to further painless flexion).

Methods

This prospective, randomized, double-blind, controlled clinical trial was conducted from September 2017 to January 2020. This was done after clearance from the institutional ethical committee and registration in Clinical Trials Registry-India (CTRI/2017/08/009552).

Inclusion criteria

Sixty (60) American Society of Anesthesiologists (ASA) physical status I/II patients, between the age group of 15 to 60 years scheduled for knee arthroscopic procedures (anterior cruciate ligament repair) were recruited.

Exclusion criteria

Exclusion criteria included patients having coagulopathy, infection at puncture site, patients on chronic analgesic therapy, polytrauma patients, and those with fixed deformities of the knee joint hampering evaluation. Patients who refused to undergo surgery under general anesthesia were also excluded from the study.

Assessment and execution

Written informed consent was obtained from all subjects. Patients of Group I were administered continuous adductor canal block (cACB) while those in Group II were administered continuous femoral nerve block (cFNB). The patients were examined on the day before surgery and were familiarized with a standard visual analogue scale (VAS) for pain (0 = no pain, 10 = worst pain imaginable). Premedication in the form of oral alprazolam 0.5 mg was given at bedtime on the day before surgery. On arrival in the operating room, standard monitors like electrocardiography, pulse oximeter, and noninvasive blood pressure were connected. An IV line was secured and infusion of lactated Ringer's solution started as maintenance. General anesthesia was administered in a standardized manner (propofol 2 $mg.kg^{-1}$, fentanyl 2 $\mu g.kg^{-1}$, vecuronium 0.08 $mg.kg^{-1}$) intravenously and endotracheal intubation done. Anaesthesia was maintained with air in oxygen and isoflurane (MAC = 1). At the end of the surgery, the patients received ultrasound (US) guided adductor canal block or femoral nerve block with catheter insertion.

Intervention

(1) **Continuous Adductor Canal Block:** After sterile preparation and draping, at the midthigh level, adductor canal was visualized using a high-frequency linear array transducer (6 to 13 MHz; SonoSite M-Turbo). The transducer was placed transverse to the longitudinal axis of the extremity to identify the adductor canal underneath the sartorius muscle. The femoral artery was first identified as visible pulsations, with the vein just inferior and the saphenous nerve just lateral to the artery (Fig. 1). From the lateral side of the transducer a 10-cm, 18G Tuohy needle (Braun Medical, Melsungen, Germany) was inserted in plane, through the Sartorius muscle. With the tip of the Tuohy needle placed just lateral to the artery and the saphenous nerve, a bolus dose of 20 cc 0.5% levobupivacaine was injected to expand the adductor canal. A 20G catheter was inserted 4 cm through the cannula. To obtain the correct position of the catheter tip, the catheter was slowly retracted during injection of bolus dose under US guidance, until an expansion between the fascia and the vessels could be visualized followed by 0.125% levobupivacaine 5 $mL.h^{-1}$ was started.

(2) **Continuous Femoral Nerve Block:** After sterile preparation and draping, a high-frequency linear array transducer (6 to 13 MHz; SonoSite M-Turbo) probe was placed parallel and slightly caudal to the inguinal crease and adjusted as necessary to visualize the femoral nerve in short axis. The femoral artery, vein, and iliopsoas muscle were identified (Fig. 1). The femoral nerve was sought within a triangular hyperechoic region, deep to the fascia iliaca, lateral to the femoral artery, and superficial to the iliopsoas muscle. The FNB was performed using a 10-cm, 18G Tuohy needle (Braun Medical, Melsungen, Germany) which was inserted in plane with the ultrasound probe and advanced a lateral-to-medial approach until the needle tip was adjacent to the femoral nerve. A bolus dose of 20 cc 0.5% levobupivacaine was injected to expand the triangular hyperechoic region deep to the fascia iliaca. A 20G catheter was then inserted 4 cm through the cannula. To obtain the correct position of the catheter tip, the catheter was slowly

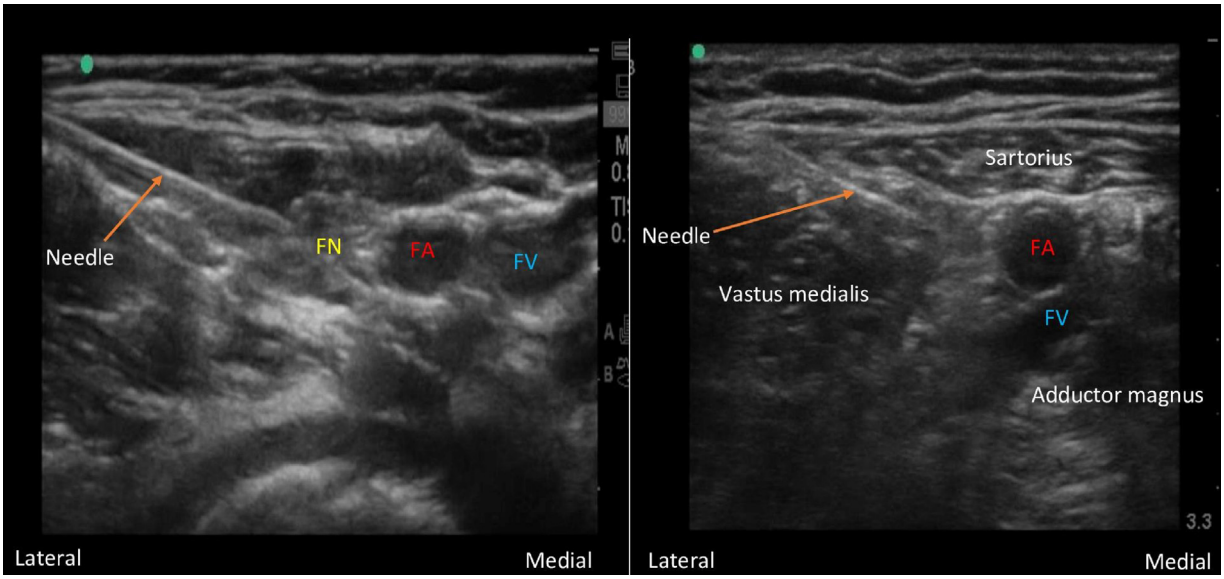

Figure 1 In-plane approach of femoral nerve block and Adductor canal block. FN, femoral nerve; FA, femoral artery; FV, femoral vein.

retracted during injection of bolus dose under US guidance, until an expansion between the fascia and the vessels could be visualized followed by 0.125% levobupivacaine 5 mL.h^{-1} was started. The femoral catheter was tunneled subcutaneously just below and parallel to the inguinal crease. A clear sterile dressing was placed over the catheter insertion site and femoral catheter.

In both groups patients were given a loading dose of 20 cc injection levobupivacaine 0.5% followed by 0.125% levobupivacaine 5 mL.h^{-1} was started for 24 hours. Pain was assessed hourly (VAS score) till 24 hours. Rescue analgesia in the form of paracetamol 1 g IV was administered as per requirement. Parameters like time of first analgesic requirement, total analgesic requirement in the first 24 hours, painless range of motion of the knee (15 degrees of flexion to further painless flexion) were assessed in both groups. Any adverse effects like inadvertent vascular puncture, hematoma, or adverse effect of systemic local anesthetic toxicity like seizure, arrhythmia and persistent paresthesia were also noted.

Randomization, blinding method, and sample size

Randomization: Computer-generated random numbers allocated the patients into two groups of 30 patients. The random allocation sequence was concealed in opaque, sealed envelopes until a group was assigned. **Blinding:** Anesthesiologists experienced in ultrasound-guided nerve blocks performed all the interventions. They subsequently refrained from any further contact with the patient or the assessor. All the postoperative assessments were made by on floor pain nurses who were unaware of the group assigned.

The sample size was calculated on the basis of our preliminary results on 6 patients, the timing of first rescue analgesia in femoral catheter patients was 8.64 ± 1.78 hours. Anticipating a 20% increase in timing of first requirement of rescue analgesia with adductor canal block, alpha error of 5% and power of 90, we calculated a sample size of 22 in each group. To overcome the dropout rate, we increased the sample size further to 30 in each group.

Statistical analysis

Statistical analysis was performed using IBM SPSS Statistics version 20 (IBM, Armonk, New York, USA). Data distributions were initially evaluated for normality using the Kolmogorov-Smirnov test. Continuous variables were expressed as mean ± standard deviation (SD) or median with interquartile range (IQR) depending on data distribution. For normally distributed data, Student's *t*-test was used to compare the differences between two independent groups. Otherwise, Mann-Whitney U test was used. *P*-values below 0.05 were taken to signify statistical significance.

Results

We assessed 64 patients for eligibility, of which 4 did not meet the inclusion criteria (two patients refused general anesthesia while the other two peripheral nerve catheter insertion). Fig. 2 depicts the CONSORT flow diagram of patient progress through the study. All the patients enrolled for the study (cACB group: n = 30; cFNB group: n = 30) completed the study. Data was complete for the primary outcomes assessed; only minimal secondary outcome data was missing.

Patient demographics: Enrolled patients had similar demographic characteristics, and no clinically important differences existed between the study groups (Table 1). Block success was confirmed in all study participants.

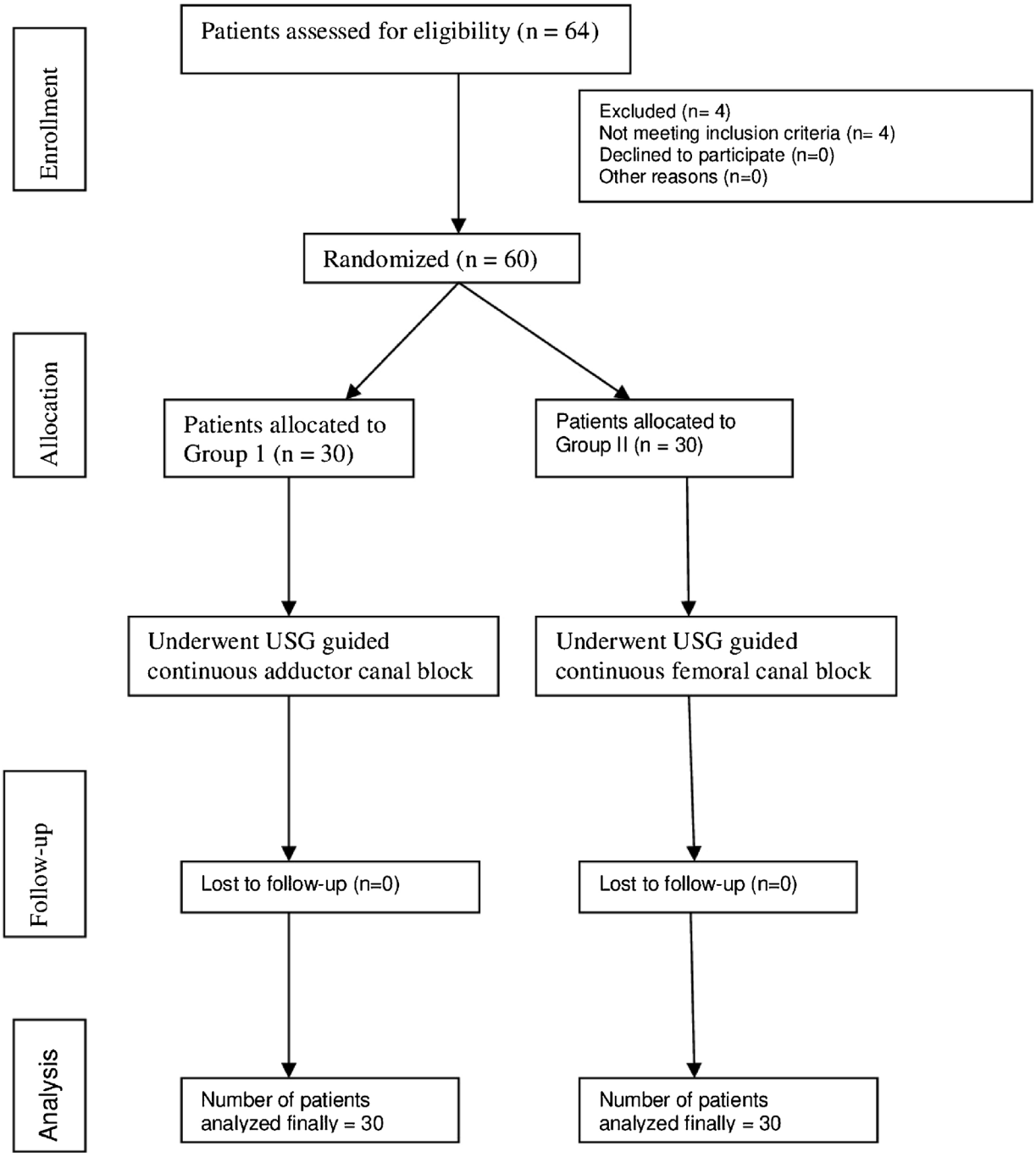

Figure 2 Consort flow chart.

Table 1 Demographic parameters.

Variables	Group I		Group II		*p*-value
	Mean	SD	Mean	SD	
Age (years)[a]	29.43	4.30	28.93	4.19	0.65
Weight (kg)[a]	60.07	7.80	59.63	6.44	0.81
Duration of surgery (min)[a]	72.13	6.69	72.30	7.54	0.92

SD, standard deviation.
[a] Student's t-test.

Table 2 Analgesic requirement, total analgesic consumption, and range of motion.

Variables	Group I		Group II		*p*-value
	Mean	SD	Mean	SD	
Total analgesic (paracetamol) consumption (g)[a]	0.70	0.47	1.70	0.65	0.0001[b]
Time of first analgesic required (h)[a]	16.90	3.37	14.40	4.32	0.0153
Painless range of motion (>15º flextion)[a]	55.67	10.40	40.00	11.37	0.0001[b]

SD, standard deviation.
[a] Unpaired t-test.
[b] *p*-value highly significant.

Primary outcomes

The time-to-first postoperative analgesic request (hours) was earlier in Group II (14.40 ± 4.32) than Group I (16.90 ± 3.37) and this difference was statistically significant ($p < 0.05$) (Table 2).

Secondary outcomes

The cumulative 24-hour analgesic (paracetamol) consumption (g) in the study groups was 0.70 ± 0.47 in Group I and 1.70 ± 0.65 in Group II (Table 2). The difference between two groups was highly significant ($p < 0.001$). Consequently, cACB was found superior to cFNB in cumulative 24-hour postoperative analgesic consumption after ACLR.

Pain (rest) severity VAS scores for the two groups during the first 24 hours postoperatively were plotted over time (Fig. 3). The difference in VAS between both groups was insignificant for the most of the time periods ($p > 0.05$). Consequently, cACB was found to be similar to cFNB in postoperative rest pain severity scores during the first 24 hours after ACLR. The painless range of motion (degree) was 55.67 ± 10.40 in Group I and 40.00 ± 11.37 in Group II (Table 2). The difference between the two groups was highly significant ($p < 0.001$). These findings suggest that cACB provides superior analgesia up to 24 hours postoperatively and preserves quadriceps muscle strength when compared with cFNB in patients undergoing ACLR. There was no inadvertent vascular puncture or adverse effect of systemic local anesthetic toxicity in either group.

Discussion

This study demonstrates that cACB is a better alternative to cFNB in patients undergoing ACLR, as it provides better postoperative analgesia cFNB that is as effective as that of cFNB.

Knee arthroscopy is a diagnostic and therapeutic approach for various knee pathologies.[13] The knee joint is supplied by the femoral, sciatic, and obturator nerves.[14] Different block combinations of these nerves have been used for knee arthroscopy.[15] Peripheral nerve block improves the recovery profile and allows early discharge.[15] The femoral nerve innervates the majority of the joint and the skin at the medial portal site.[14] Hence, its successful block is important for painless knee surgery. The sciatic nerve supplies both the knee joint (via six articular branches) and the skin at the lateral portal site (via the lateral sural cutaneous nerve).[14] Though blockade of all the three nerves is required for adequate analgesia, it might not be feasible.

In our study, the analgesic consumption with cACB was less than cFNB (0.70 ± 0.47 vs. 1.70 ± 0.65) 24 hours postoperatively. The range of motion produced in cACB group was more compared with FNB, and this difference was statistically significant. This might be due to the spread of a large amount of local anesthetics into the popliteal fossa, blocking the popliteal nerve plexus which contributes to afferent knee-pain conduction in cACB. Genicular branches from the posterior obturator and the tibial nerves, innervating the intra-articular and posterior knee region, mainly form popliteal nerve plexus.

In contrast to earlier work,[16–19] our findings favor the cACB in the setting of ACLR. In the first study, Espelund et al.[16] found no analgesic benefit when ACB was compared to placebo. The study was designed to detect change in pain score (50%) at a single time point: 2 hours, with the patient in a standing posture. The study was not powered enough to detect difference in opioids consumption and resting pain scores. In another study, El Ahl[17] compared single shot ACB to FNB and observed pain scores up to 12 hours postoperatively. He concluded that ACB provides inferior analgesia based on differences in pain scores and analgesic consumption. The time interval studied by them was 12 to 24 hours and possibly the block would have worn out by that time. In another study ACB was found to be similar to placebo for rest pain during the first 90 minutes after ACL reconstruction.[18]

Abdallah et al.[19] compared ACB with FNB and suggested that ACB preserves quadriceps strength and provides noninferior postoperative analgesia for outpatients undergoing anterior cruciate ligament reconstruction. In our study, there was no difference between the groups in mobilization ability 24 hours after surgery.

Gao et al.[20] performed a meta-analysis of 7 randomized controlled trials comparing cACB to cFNB after total knee arthroplasty and found no difference in early postoperative pain scores or opioid use. The possible reason for similar analgesic effect between the groups is that most of the nerves in adductor canal are sensory (medial femoral cutaneous nerve, articular branches from the obturator nerve, as well as the medial retinacular nerve) dominating knee joints in addition to saphenous nerve. These nerves innervate the medial, lateral, and anterior aspects of the knee.[21]

Patel et al.[22] compared FNB vs ACB in patients undergoing ACLR and found no differences in postoperative narcotic requirements on days 1 to 4. Holland et al.[23] found no difference in analgesic effect between two groups with similar

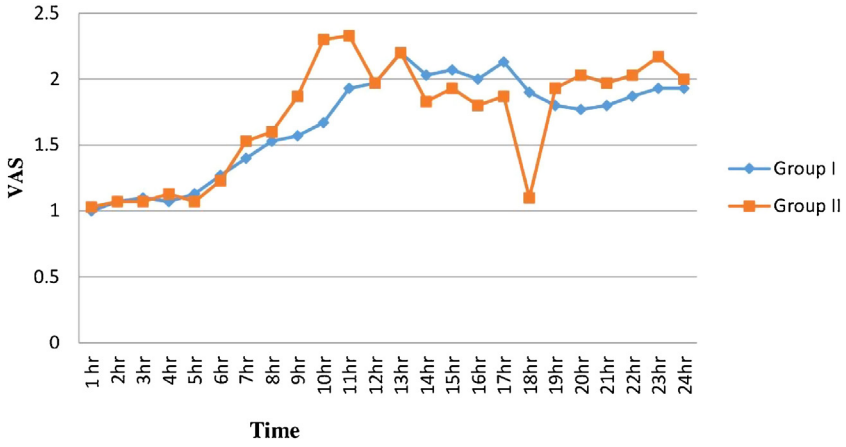

Figure 3 Trend of VAS scores over time.

opioid consumption and satisfaction scores. They speculated that the possible mechanism would be blockade of sensory nerve supply to knee joint in the adductor canal. Thus, cACB seemed to provide similar pain relief, along with early rehabilitation exercise when compared with femoral nerve block. But in our study, the postoperative analgesia was superior with cACB. This could be due to spread of the local anesthetic into popliteal fossa.

Limitations

The limitations of this study could be limited sample size, the anesthesiologist performing the blocks were not blinded to treatment, although they refrained from further contact with the patient. We did not assess drug spread to popliteal fossa in cACB group (Group I).

Conclusion

Study findings suggest that continuous adductor canal block (cACB) provide superior analgesic modality to continuous femoral nerve block (cFNB) in patients undergoing anterior cruciate ligament reconstruction.

Conflicts of interest

The authors declare no conflicts of interest.

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