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Postoperative analgesic effectiveness of ultrasound guided combined femoral - sciatic nerve block versus combined adductor canal block – I PACK block in patients undergoing total knee arthroplasty: A double- blind randomized study

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ABSTRACT

Background: For successful rehabilitation and optimal functional outcomes after total knee arthroplasty surgery, patients must have effective pain control. Peripheral nerve blocks offer an excellent solution for perioperative multimodal analgesia and are advocated to reduce postoperative opioid consumption.

Objectives: The objective of this study is to compare the efficacy of combined Femoral-Sciatic nerve block and Adductor- interspace between the popliteal artery and the capsule of the posterior knee (IPACK) block in terms of total rescue analgesia dosage and ambulation on the first postoperative day.

Method: This is a prospective, randomized, double-blinded trial was conducted at Ain Shams University Hospital. Sixty patients scheduled for total knee arthroplasty (TKA) were randomly divided into two equal groups: one group received a Femoral-Sciatic nerve block, and the other received an Adductor-IPACK block. Both ultrasound-guided blocks were performed by injecting 20 mL of 0.25% bupivacaine immediately after anaesthesia induction. The postoperative opioid requirement in the first 24 hours was assessed using the visual analogue scale (VAS). Motor power, intraoperative fentanyl consumption, intraoperative hemodynamic changes, procedure time, surgery duration, tourniquet time, and technique complications were also recorded.

Results: Femoral-Sciatic group had lower opioid consumption. The Adductor-IPACK group showed a statistically significant higher Modified Bromage score. However, there was no statistically significant difference between the groups in the postoperative pain score assessed using the VAS.

Conclusion: Based on our study, we conclude that Femoral-Sciatic blocks required a lower dose of rescue analgesia compared to the Adductor-IPACK group. The Adductor-IPACK group also experienced lesser postoperative muscle power impairment.

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Femoral; sciatic; adductor canal block; IPACK; knee surgery; multimodal analgesia

1. Background

Treating postoperative pain following total knee arthroplasty (TKA) presents a challenge, as it requires maintaining motor function while providing adequate analgesia. Patients who undergo a femoral nerve block (FNB) often experience significant weakness in their quadriceps, hindering their participation in early physical therapy [1].

Since its introduction by Krombach and Gray in 2007, ultrasound-guided adductor canal block (ACB) has been shown to enhance postoperative physical therapy effectiveness and provide analgesia comparable to a single-shot FNB [2]. However, discomfort in the posterior compartment of the knee, necessitating additional opioid medication, is common among TKA patients who receive FNB or ACB [3]. Studies have demonstrated that combining sciatic nerve block (SNB) with FNB improves analgesia and reduces the need for opioids [4]. However, the use of SNB increases the risk of falling due to sensory and motor limitations below the knee [5]. An ultrasound-guided local anaesthetic injection at the interspace between the popliteal artery and the posterior knee capsule, known as IPACK block, has been described by Sinha. This technique targets the genicular branches that innervate the posterior knee capsule, thereby reducing the incidence of foot drop [6].

In our institute, femoral nerve block (FNB)and sciatic nerve block (SNB) are considered standard care practices for patients undergoing total knee arthroplasty. While previous studies have demonstrated the superiority of ACB over FNB in terms of its motor-sparing effect, ACB has been found to be inferior to FNB in

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terms of the quality and duration of analgesia. Therefore, we hypothesised that adding an IPACK block to ACB may improve its analgesic efficacy without affecting its motor-sparing effect.

1.1. Aim of work

We conducted this trial to evaluate the efficacy of combined ultrasound-guided FNB-SNB and ACB-IPACK blocks for postoperative analgesia in patients undergoing total knee arthroplasty (TKA).

2. Methods

The Ethical Committee of Scientific Research at our institute approved this study, and we obtained written informed consent from 60 patients, ranging in age from 21 to 80, undergoing elective total knee arthroplasty under general anaesthesia with Physical Status I, III according to the American Society of Anesthesiologists (ASA) score. We exclude patients who refused to participate or who have Physical Status IV according to ASA with a history of previous open knee surgery, Pre-existing lower extremity neurological abnormality, the presence of nearby infection, history of psychiatric illness, history of drug abuse or allergies to drugs used from the study.

Using computer-generated random number tables created by a statistician who was blind to the study, we randomly divided patients into two equal groups of 30 patients. Patients in (F-S group) received ultrasound-guided single-shot femoral-sciatic nerve blocks. While patients in (A-I group) received ultrasound-guided single-shot adductor canal – IPACK blocks immediately after induction of anaesthesia. All blocks were performed by an experienced anesthesiologist. While data was collected by another anesthesiologist who was blinded to the performed technique.

2.1. Sample size

G*power software 3.1.0 was used to estimate the desired sample size. Comparing the mean dose of postoperative analgesia between the two research groups was the principal goal of the current study. A sample size of 30 patients in each study group was required to detect an effect size (Cohen d) of 0.8 in the primary outcome of interest, considering a 20% drop-out rate, and assuming a type 1 error of 0.05 and 80% power.

All patients underwent a comprehensive preoperative clinical evaluation, including routine laboratory tests. The patients fasted for 8 hours prior to surgery. We provided patients with information about the visual analogue score (VAS), where 0 indicates no pain and 100 represents the worst imaginable pain. In the operating room, we established intravenous access and connected full standard monitors, including electrocardiography, non-invasive blood pressure, pulse oximetry, and capnography throughout the entire procedure.

To induce anaesthesia, we administered intravenous midazolam (0.02 mg/kg), granisetron (1 mg), Fentanyl (1 µg/kg), propofol (2 mg/kg), and atracurium (0.5 mg/kg). We inserted an oral endotracheal tube for airway management. Anesthesia was maintained using a 1.2% concentration of isoflurane in a 50:50 oxygen-air mixture, and muscle relaxation was maintained with atracurium (0.1 mg/kg). 0.5 ug/kg fentanyl was planned to be given if HR or MAB increases by 20% from the baseline. Atropine 0.01 mg/kg was administered to treat bradycardia if the heart rate is below 60 beats per minute or falls more than 20% below baseline, and 3 mg incremental doses of ephedrine are given to treat hypotension if the blood pressure drops more than 20% from the baseline

In the F-S group, patients received a femoral nerve block (FNB) as depicted in Figure 1A. We positioned them in a supine position and, under strict aseptic measures, used a linear transducer (13–6 MHz) to visualize the femoral nerve lateral to the Common Femoral Artery, approximately 2 cm caudally from the

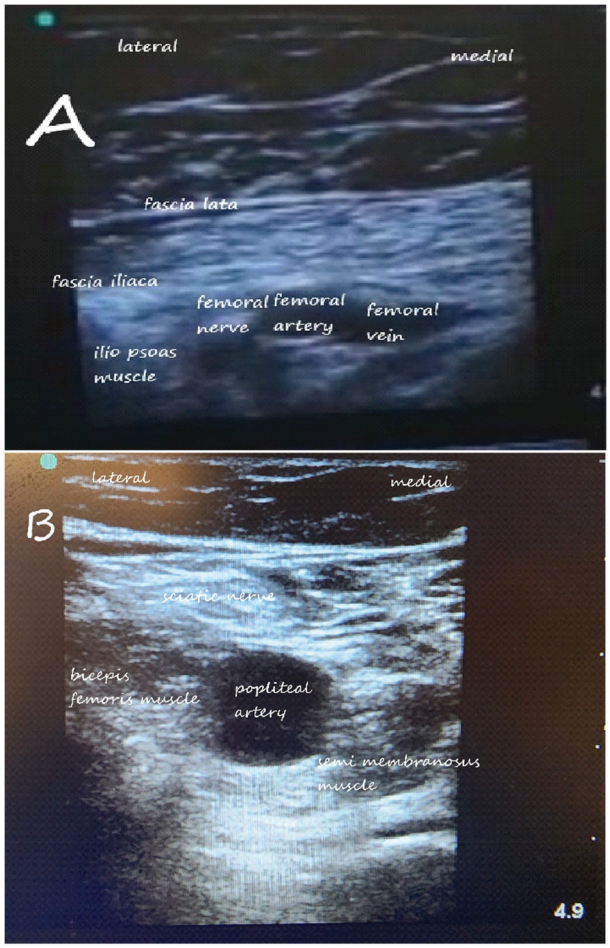

Figure 1. Sonographic view of the femoral and gluteal regions (A) femoral nerve (B) sciatic nerve.

midpoint of the inguinal ligament. With the in-plane method, we inserted a 22-gauge, 100-mm needle (B-Braun Medical Inc., Bethlehem, PA, USA) and administered 20 mL of 0.25% bupivacaine after ensuring careful aspiration to prevent intravascular injection.

For the sciatic nerve block (SNB) shown in Figure 1B, patients were placed in a supine position with leg elevation and, under strict aseptic precautions, a linear probe (6–13 MHz) was used to identify the sciatic nerve as a hyper-echoic rounded structure between the semitendinosus and semimembranosus muscles anteriorly and the biceps femoris muscle posteriorly. Utilizing the in-plane method, we inserted the same 22-gauge needle from the lateral aspect of the thigh until it passed the perineural sheath, and after careful aspiration, we administered 20 mL of 0.25% bupivacaine around the sciatic nerve.

In the A-I group, patients received an adductor canal block (ACB) as depicted in Figure 2A. We positioned them in a supine position with externally rotated legs and slightly flexed knees (frog-leg position). With a linear transducer (6–13 MHz) at the intersection of the medial condyle and inguinal crease, we visualized the saphenous nerve, which appeared as a hyper-echoic structure lateral to the femoral artery. Using the in-plane method, we inserted the same 22-gauge needle in a lateral-to-medial orientation and administered 20 mL of 0.25% bupivacaine after careful aspiration. While the patient remained in the frog-leg position, we performed an IPACK block as shown in Figure 2B. Using a linear probe (6–13 MHz) at the popliteal crease, we visualized the popliteal fossa and identified the condyles' hyperechoic line. With the in-plane approach, we inserted the same 22-gauge needle in the medial thigh between the popliteal artery and the femur, maintaining a safe distance from the peroneal nerve and the popliteal artery. After careful aspiration, we administered 20 mL of 0.25% bupivacaine.

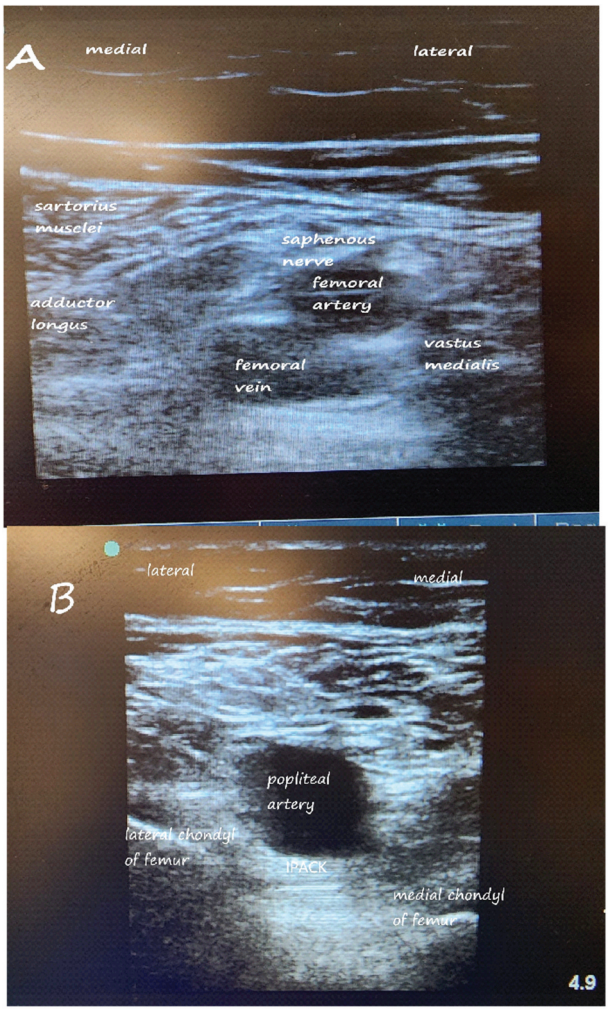

Figure 2. (A) Adductor canal block (B) I pack block.

After completion of the surgery, we reversed the residual neuromuscular block and extubated the patients. They were then transferred to the post-anaesthesia care unit (PACU), where we monitored oxygen saturation and measured blood pressure. In the PACU, we assessed the patients' pain levels using VAS and Bromage scale. The postoperative analgesic treatment for both groups started with the administration of 1 gram of IV acetaminophen and 30 mg of ketorolac. Subsequently, patients received 1 gram of IV acetaminophen every 6 hours and 30 mg of ketorolac every 12 hours in the ward. We used the VAS to measure postoperative pain at intervals of 0, 2, 4, 6, 12, 18, and 24 hours after the surgery. We delivered intravenous morphine (0.05 mg/kg) as rescue analgesia if a patient's VAS score was greater than 40. This was repeated if the patient needed further analgesia, with a daily dose limit of 20 mg.

Our primary outcome measure was the total amount of rescue analgesia required in the first 24 hours postoperatively. Secondary outcomes included the modified Bromage scale assessment for the knee joint's extensor group and the dorsiflexion and plantar flexion of the ankle joint within the first 24 hours following surgery. We also assessed pain intensity using the VAS in the first 24 hours postoperatively, intraoperative fentanyl consumption, intraoperative hemodynamic changes, block time from ultrasound scanning to the end of local anaesthetic (LA) injection for both blocks, duration of the procedure from surgical incision to surgery completion, tourniquet time from inflation to deflation, and the incidence of complications such as hematoma and adverse effects (sedation, nausea, vomiting).

2.2. Statistical analysis

The statistical analyzer analyzed the data using Statistical Package for Social Science (SPSS) version 22.0, and gave quantitative data as mean, SD, or median when appropriate (IQR). The following tests were used to convert qualitative data into frequency and percentage:

They used two independent samples in a t-test for significance to compare the two means.

They compared the proportions between two qualitative measures using the Chi-square (X2) test, which was used to determine significance.

Use the Mann-Whitney U test to compare two groups when examining non-parametric data. The confidence interval and the allowed margin of error were both set at 95%.

They took the following steps to determine whether the p-value was significant:

2.3. P-value for probability

- ♣ P-values under 0.05 are considered significant.
- ♣ An extremely noteworthy event was one that as a P-value of less than 0.001.
- ♣ 0.05 or above is considered a non-significant P-value.

3. Results

Figure 3 illustrates the CONSORT trial flowchart. We initially contacted 65 individuals, but 2 patients did not meet the enrollment requirements, and 3 patients declined to participate in the study. This left us with a total of 60 TKA patients, who were equally divided into two groups: the F-S group (30 patients) and the A-I group (30 patients). The study flowchart is illustrated in Figure 3.

Both groups showed comparable patient characteristics, surgery duration, and tourniquet time, as shown in Table 1. However, the A-I group had a longer procedure time compared to the F-S group.

Postoperative VAS scores at rest and during mobility were measured at various time points (0, 2, 4, 6, 12, 18, and 24 hours postoperatively). The results, depicted in Figures 4 and 5 respectively, showed non-significant differences with p-values >0.05.

However, the total dose of rescue analgesia was higher in the A-I group (p-value <0.001), while intraoperative fentanyl consumption did not show significant differences (p-value >0.05), as non of our patients required a booster dose of fentanyl intraoperative, as indicated in Table 2.

The modified Bromage scale, presented in Table 3, demonstrated significantly higher values in the A-I group (p-value <0.001).

Intraoperative hemodynamic changes did not reach statistical significance, with a p-value >0.05, as shown in Figures 6 and 7 respectively.'

Complications such as postoperative nausea and vomiting (PONV) and sedation, assessed using the

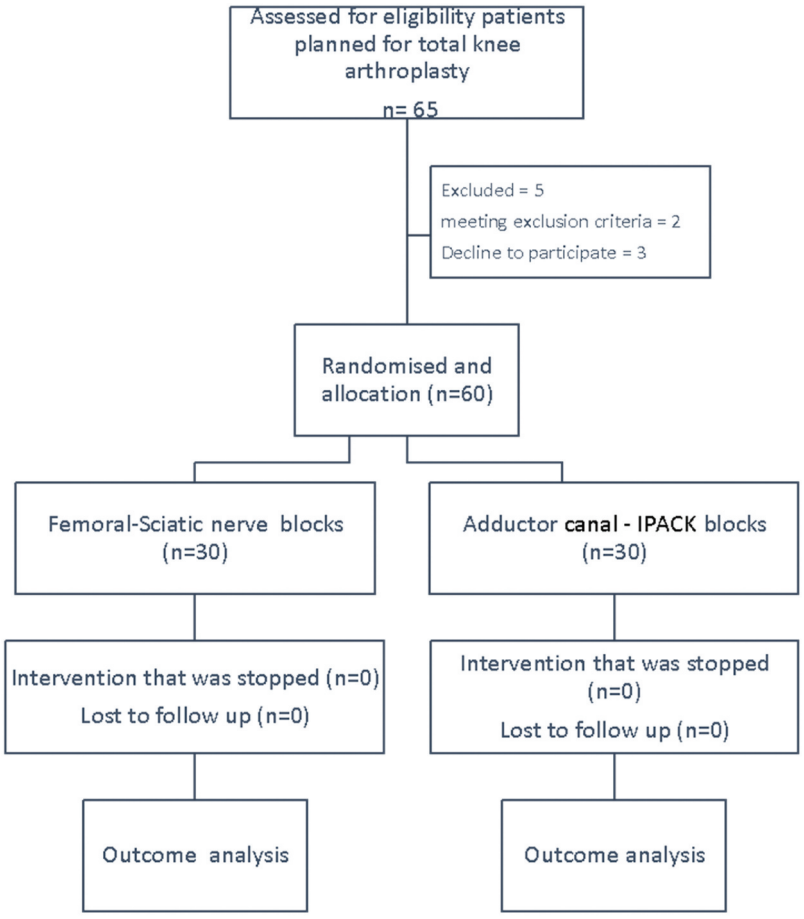

Figure 3. CONSORT flow diagram illustrating the progress of patients through the study.

Table 1. Patients' characteristics and times.

		F-S group (*n*=30)	A-I group (*n*=30)	p-value
Age (years)		63.80±5.9	64.87±5.1	.453
BMI(kg/m^2)		34.10±2.0	34.48±2.3	.501
ASA	I	6 (20%)21(70%)3(10%)	10(33.3%)16(53.3%)4(13.3%)	0.402
	II	21(70%)	16(53.3%)	
	III	3(10%)	4(13.3%)	
Sex	Male	15(50%)15(50%)	13(43.3%)17(56.7%)	0.607
	Female	15(50%)	17(56.7%)	
Block performance time (min)		1.63±1.4	18.20±3.5	<.001 *
duration of the procedure (min)		13.3±29	128.8±33	.93
Tourniquet time(min)		85±17	84±24	.850

The data showed as mean, standard deviation, proportion, student t-test, x2 chi-square test, F-S (for femoral-sciatic block) and A-I (for Adductor canal block- IPACK) blocks.
P value < 0.05 is significant*.

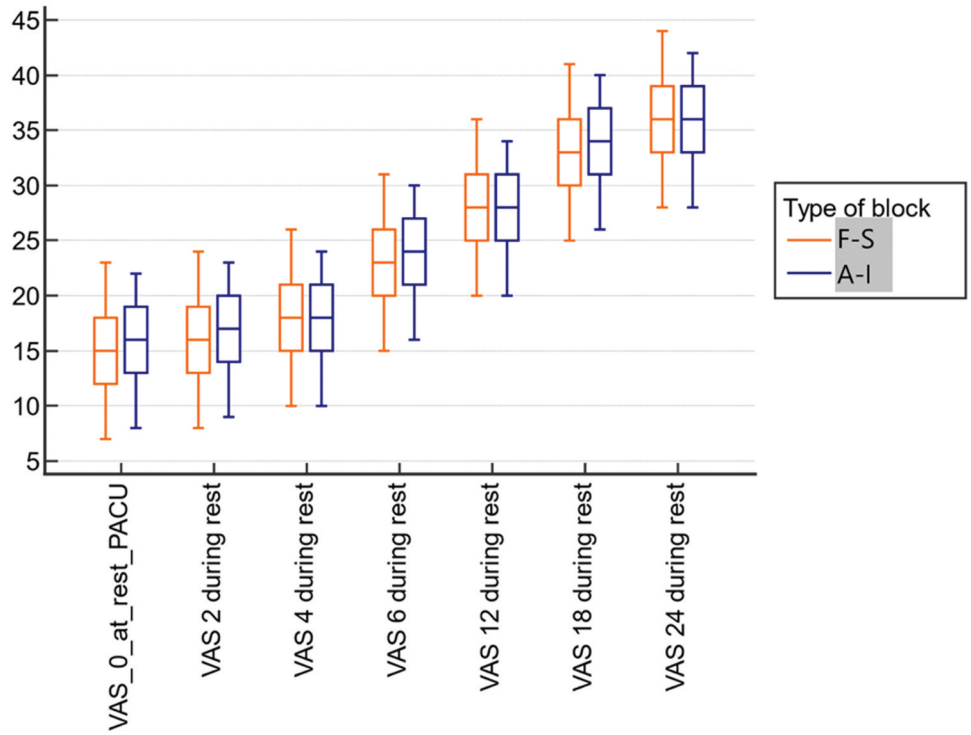

Figure 4. Box and Whisker comparison for VAS Scale at the rest.

Richmond Agitation Sedation Scale, were non-significant with p-values >0.05, as presented in Table 4.

4. Discussion

Our randomized prospective comparative study demonstrated that the total dose of postoperative rescue analgesia used in group A-I was significantly higher than in group F-S. However, group A-I did not affect muscle power during the first 24 hours, despite no differences between the two groups in terms of VAS scores during rest and mobility in the first 24 hours after surgery. Additionally, the block performance time was longer in the A-I group than in the F-S group, without any procedure-related or medication-related complications.

In our study, the visual analogue scale (VAS) revealed no discernible difference in pain levels at rest and during mobility, which is consistent with the findings of Thobhani and colleagues. Similarly, Joe et al. concluded that there was no considerable difference in VAS scores within the first 24 hours postoperatively [7,8].

Our results analysis demonstrated that the F-S group exhibited stronger analgesic effectiveness and required lower dosages of rescue analgesia within the first 24 hours after surgery, in agreement with the findings of Thobhani et al., who reported significantly less opioid usage compared to other groups [7].

Motor assessment using the modified Bromage scale revealed that the A-I group experienced less motor impairment in knee extension and ankle dorsiflexion, while the F-S group experienced quadriceps

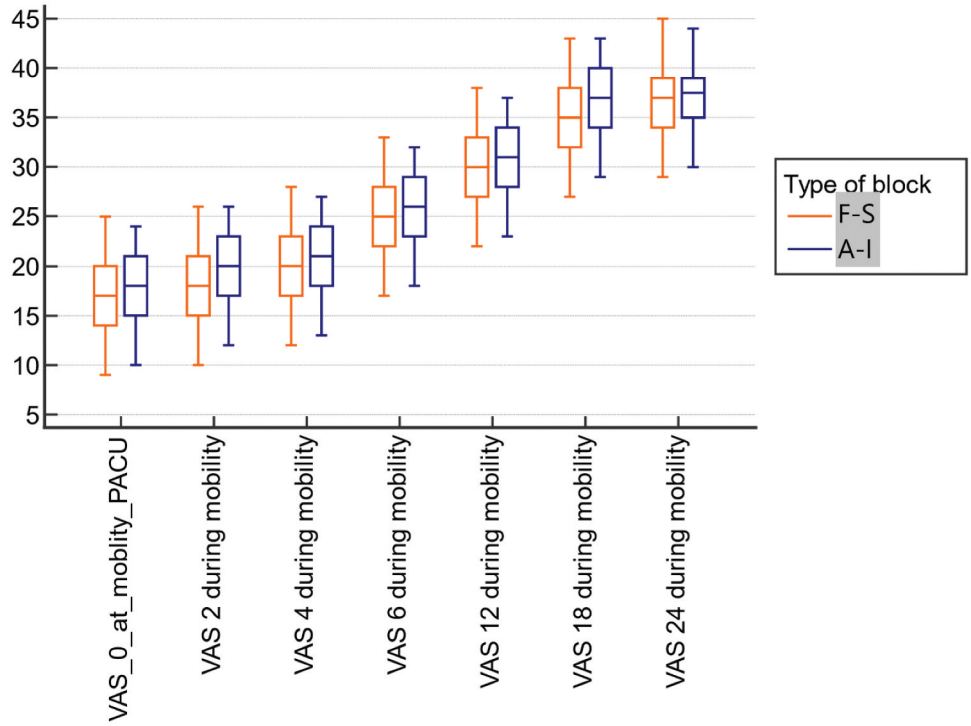

Figure 5. Box and Whisker comparison for VAS Scale during mobility.

Table 2. Total dose of postoperative rescue analgesia, Fentanyl consumption intraoperatively.

	F-S group (*n*=30) Mean±SD	A-I group (*n*=30) Mean±SD	p-value total
The total dose of rescue analgesia (mg)	6.57±1.6	8.87±2.3	<.001*
Fentanyl consumption (ug)	142.76±13.15	147.16±1.64	.160

The data presented as mean standard deviation (SD), *P* value < 0.05 is significant*.

weakness and an inability to dorsiflex, increasing the risk of falling. However, motor weakness was statistically insignificant at 24 hours postoperatively, as motor power in all muscles was regained. These findings are consistent with those of Thobhani et al., who showed that gait distance was substantially longer during physiotherapy in the A-I group, confirming no significant muscle power impairment. Et et al. also demonstrated no significant difference in time to up-go (TUG) and range of motion (ROM) between IPACK and PAI groups, as both blocks target the genicular branches of the knee and do not affect quadriceps or calf muscles. Due to a decreased incidence of foot drop, IPACK was chosen as the preferred motor-sparing option compared to sciatic nerve blocks at any level (proximal or distal) or selective tibial branch blocks [9]. A study by Chan et al. reported foot drop in 2 out of 411 patients who received IPACK block at 30 minutes and 2 hours, but muscle power at 24 and 48 hours was comparable in the ACB-SNB group (0.48%) [10]. Similarly, Joe et al. found knee extension strength, assessed using a dynamometer, to be highly significant in the quadriceps muscle [8].

The results of Seo and colleagues showed that foot drop occurred in 35% of cases in ACB in combination with a popliteal sciatic nerve block, but these findings spontaneously resolved at 24 hours when assessing dorsiflexion using manual muscle testing (MMT) [11]. These results were similar to our study, despite Seo using ropivacaine, which has a shorter duration than bupivacaine.

Our findings align with those of Zheng et al., who concluded that there was less motor power impairment in the ACB-IPACK group within the first 48 hours postoperatively. In their study, 6.6% of patients in the IPACK

Table 3. Modified Bromage scale data at measured time points.

	F-S group (*n*=30)		A-I group (*n*=30)		
modified Bromage Scale	Median	IQR	Median	IQR	P-value
modified Bromage 2hr	1	1–1	2	1–2	<0.001*
modified Bromage 4hr	1	1–2	4	4–4	<0.001*
modified Bromage 6	2	1–2	4	4–4	<0.001*
modified Bromage 12	3	2–3	4	4–4	<0.001*
modified Bromage 18	3	3–4	4	4–4	<0.001*
modified Bromage 24	4	4–4	4	4–4	1

Data presented as IQR, range, and median, *P* value < 0.05 is significant*.

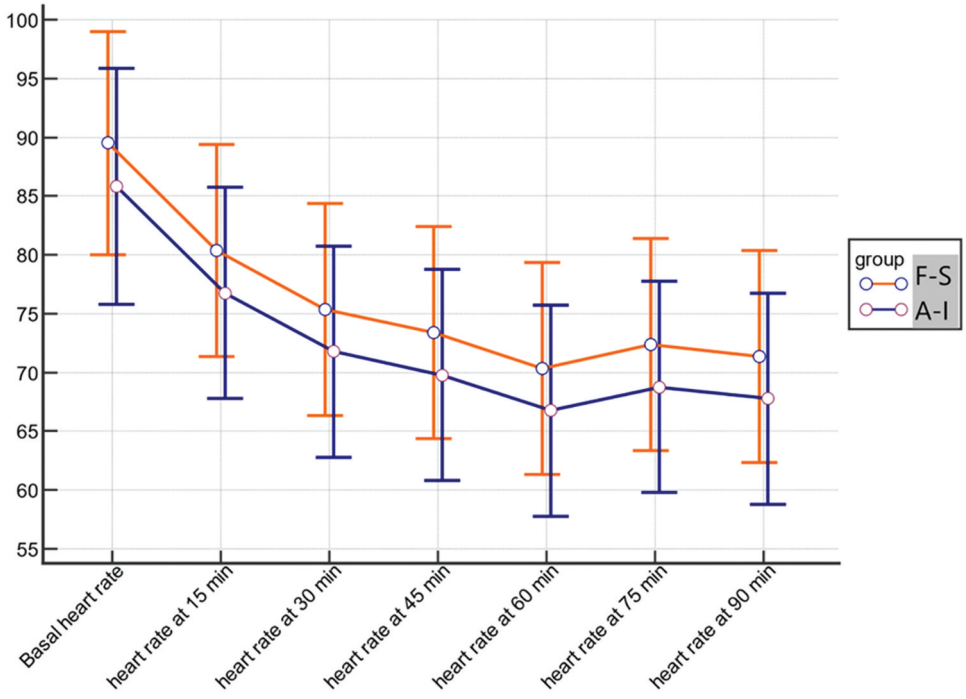

Figure 6. As regard hemodynamic changes; Heart Rate (beats/min).

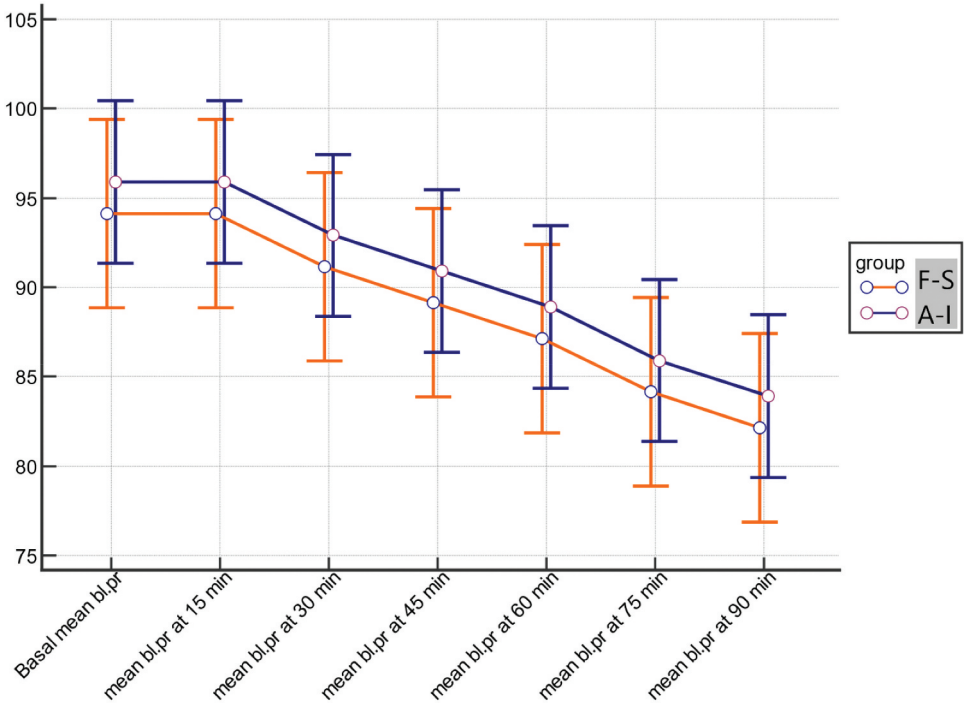

Figure 7. As regard hemodynamic changes (Mean blood pressure) (mmHg).

Table 4. Complication.

		F-S group (n=30)	A-I group (n=30)	Overall p-value
PONV		6(20%)	3(10%)	0.282
Sedation by Richmond Agitation Sedation scale	−2	2(6.7%)	2(6.7%)	0.826
	−1	10(33.3%)	9(30%)	
	0	9(30%)	11(36.7)	
	1	9(30%)	7(23.3%)	
	2	0(0%)	1(3.3%)	

Data expressed as proportion, x2 (Chi-square test).

group developed foot drop, contrasting with our results where no difference was observed between the two groups after 24 hours. This indicates that IPACK treatment facilitated the early recovery of joint motor function [12]. Kampitak et al. also confirmed that common peroneal nerve (CPN) affection led to foot drop and an increased incidence of falling [13].

Regarding procedure time, the A-I group had a longer duration compared to the F-S group. This may be attributed to the experience and knowledge gained along the learning curve, as IPACK is a relatively new block that has only been used in practice for the past four years. This supports the findings of Joe et al., who found no distinction between the two groups.

Postoperative complications were comparable between both groups, which is consistent with the findings of Seo et al. and Zheng et al. [11,12].

Regarding sedation scores, Mahmoud et al., using the Ramsay sedation score, found no change in the level of sedation during the first postoperative day. This is similar to our results, as we used the Richmond Agitation Sedation scale, which showed no significant changes on the first postoperative day [14].

Limitations: Our study is based on a single institution and needs to be replicated in other institutes with a larger sample size to validate our findings.

5. In conclusion

We found that F-S blocks required a lower dose of rescue analgesia, despite no significant difference in VAS scores. Furthermore, the A-I group exhibited less muscle power impairment postoperatively.

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The authors report no conflict of interest

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Research Ethics Committee at Faculty of Medicine, Ain Shams University Hospital, Cairo, Egypt (FAMSU MD 54a/2021/2022).

Trial registration

Pan African Clinical Trial Registry PACTR202204592395672. Registered on 8 April 2022

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