Original Article

Triple injection peri-sartorius (TIPS) block for postoperative analgesia after total knee arthroplasty: Randomised controlled study

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ABSTRACT

Background and Aims: Motor-sparing analgesia after total knee arthroplasty (TKA) is crucial. The primary endpoint was the postoperative visual analogue scale (VAS) score after triple injection peri-sartorius (TIPS) block after TKA. Secondary endpoints were postoperative morphine consumption, 24-h postoperative ambulation distances and the degrees of active knee extension. **Methods:** After general anaesthesia or spinal anaesthesia administration and before surgical incision, 80 patients undergoing TKA were randomised into group TIPS (received ultrasound-guided TIPS block where 40 ml 0.25% bupivacaine and 4 mg dexamethasone were injected: 10 ml at the distal femoral triangle, 10 ml above the sartorius and 20 ml at the distal adductor canal) and group FNB (femoral nerve block; received ultrasound-guided FNB with 20 ml 0.25% bupivacaine mixed with 4 mg dexamethasone). Postoperative pain score was noted and compared. **Results:** Dynamic VAS scores were lower in the TIPS group than in FNB, while the resting VAS scores were not significantly different. Mean (standard deviation [SD]) postoperative morphine consumption was 5.82 (2.47) mg in the TIPS group (95% confidence interval [CI] 5.03,6.61) versus 9.87 (2.99) mg in the FNB group (95% CI 8.91,10.83). Ambulation distances and active postoperative knee extension in the TIPS group showed greater significance than in the FNB group (TIPS: 18.0 [7.37] m, 95% CI 15.64,20.35] vs. FNB: 8.95 [5.93] m, 95% CI 7.05,10.84) and (TIPS: 52.12 [16.39], 95% CI 46.88,57.33 vs. FNB: 26.05 [11.10], 95% CI 22.501,29.59). Nausea was more evident in FNB patients. **Conclusion:** TIPS block provides superior analgesia than FNB with motor sparing of the quadriceps after TKA.

Keywords: Analgesia, arthroplasty, femoral nerve block, knee replacement, nerve block, peri-sartorial block, triple injection, visual analogue scale

INTRODUCTION

Postoperative pain control after total knee arthroplasty (TKA) involving motor preservation of the quadriceps muscle is essential for successful surgical procedures.[1] Femoral nerve block (FNB) has been proven to provide adequate postoperative analgesia after TKA; however, quadricep weakness is a major drawback.[2]

Subsartorial block has been studied for its efficacy in providing analgesia following TKA while preserving quadriceps muscle power.[3] However, misnomers have been prescribed at different locations for different block approaches. Distal femoral triangle block (FTB) involves injection above the femoral triangle apex. Sonographically, the femoral triangle apex is identified when the medial borders of the sartorius muscle (SAM) and the adductor longus muscle (ALM) meet together. Injection at this point blocks the innervation of a major part of the anteromedial knee joint while sparing the intermediate femoral cutaneous nerve (IFCN). IFCN

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shares in the sensory supply of a part of the skin through which the surgical incision is carried out.[4] Local anaesthetic (LA) injected at the distal adductor canal may spread to the popliteal plexus, which supplies the posterior part of the joint capsule.[5]

Thus, we designed a double-blinded, randomised study to determine whether triple injection peri-sartorius (TIPS) block provides superior analgesia to FNB and avoids quadriceps weakness. The primary endpoint was the quality of postoperative analgesia determined by the visual analogue scale (VAS). The secondary endpoints were total postoperative morphine consumption, the summed ambulation distances of patients during the first 24 postoperative hours and the degrees of active knee extension provided by patients during the night of surgery. We hypothesised that a combination of LA injection at the distal femoral triangle above and under SAM and the distal adductor canal may provide good postoperative analgesia while preserving quadriceps strength.

METHODS

This randomised controlled study was conducted after obtaining ethics committee approval from Alexandria University Hospitals (IRB # 00012098). The study was carried out between April 2022 and March 2023. After all interventions were explained, patients were informed of participation in the study, and their written informed consent was obtained for participation in the study and use of the patient data for research and educational purposes. The trial was registered at ClinicalTrials.gov (NCT05289427) before patient enrolment. Guidelines of the Helsinki Declaration 2013 and the consolidated standards of trial reporting were followed throughout the study.

Eighty patients who met the American Society of Anesthesiologists (ASA) physical status I–III and were scheduled for unilateral TKA were included in the study. Patients with body mass index (BMI) >35 kg/m^2, neurological deficits or mobility-related disorders of the non-operated limb were excluded. In addition, patients who consumed regular analgesics during the previous 3 months or had any contraindication to peripheral nerve blocks were excluded. Information regarding the anaesthetic technique, the regional block and the ability of the VAS score to assess pain intensity was provided to eligible patients before surgery.

An intravenous (IV) line was secured for all patients at the preoperative anaesthesia preparation area, and IV midazolam 2 mg was administered. Patients were shifted to the operating room (OR) and a multichannel monitor was attached. The anaesthetist in charge determined the plan of anaesthesia. After induction of general anaesthesia or administration of spinal anaesthesia, computer-generated numbers in sealed opaque envelopes were used to randomise eligible patients into two groups. The anaesthesiologists performing the block were not blinded to group allocation. However, patients and the parties responsible for data collection were blinded.

Group TIPS (n = 40): Patients received a combination of suprasartorius plane block, distal FTB and distal adductor canal block (ACB). Forty ml of 0.25% bupivacaine and 4 mg of dexamethasone were prepared. Patients were placed supine with slight external rotation of the hip and slight flexion of the knee. After the injection area was disinfected, a high-frequency linear array transducer (Sonosite, Inc., Bothwell, WA, USA) was disinfected with manual multistep disinfectant wipes. Ultrasound identification of the femoral triangle apex was made by the point at which the medial borders of SAM and ALM met.[6] The injection point was identified by sliding the transducer laterally to identify the femoral vessels and then 2 cm cephalad [Figure 1]. A 22 G block needle was introduced in plane with the transducer from lateral to medial, and 10 ml of local anaesthetic (LA) mixture was injected lateral to femoral vessels under SAM. The block needle was withdrawn subcutaneously, and 10 ml of the LA mixture was injected above SAM and underneath the fascia lata (FL).[7] Femoral vessels under SAM were traced distally until they started to exit the adductor hiatus to reach the popliteal fossa. The adductor magnus muscle (AMM) is located posteromedially, the vastus medialis muscle (VMM) anterolaterally and SAM medially.[6] The block needle was introduced in plane with the probe, and 20 ml of the LA mixture was injected underneath SAM.

Group FNB (n = 40): Patients received FNB with 20 ml of 0.25% bupivacaine and 4 mg of dexamethasone. They were placed supine with slight external rotation of the hip joint. The block area was cleaned, and a high-frequency linear array transducer (Sonosite, Inc., Bothwell, WA, USA) was disinfected. The transducer was placed 2 cm below the inguinal ligament to identify femoral vessels in their own sheath and lateral to the femoral nerve under the fascia iliaca. The block needle was introduced in plane with the transducer, and the LA mixture was injected under fascia iliaca

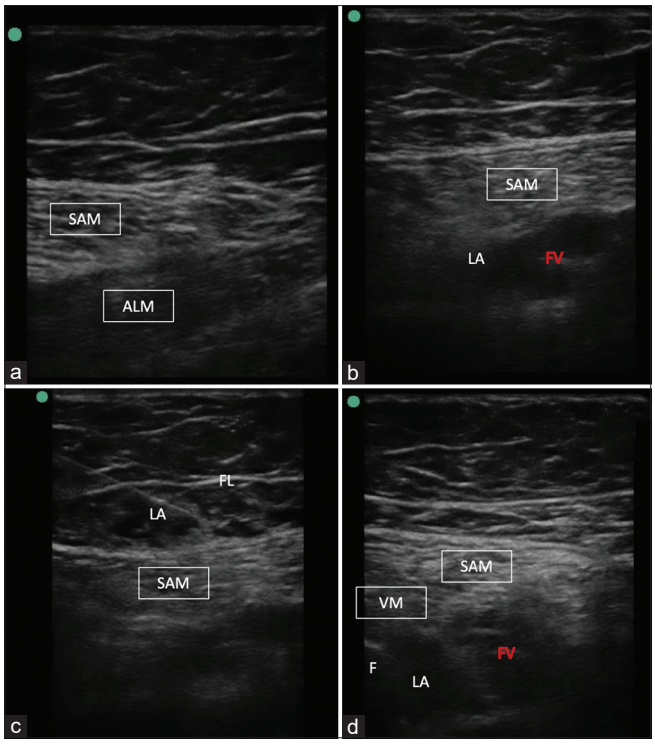

Figure 1: TIPS block. (a) Ultrasound-guided determination of the apex of the femoral triangle where the medial border of SAM meets the medial border of ALM. (b) The probe was slid cephalad 2 cm above the apex of the femoral triangle. The needle was advanced from lateral to medial, and LA was injected under SAM lateral to femoral vessels (c) The needle was withdrawn subcutaneously and advanced superficial to SAM underneath FL, and LA was injected. (d) The probe was slid distally along SAM until femoral vessels slipped posteriorly to reach the popliteal fossa. LA was injected posterior to femoral vessels. ALM = adductor longus muscle, F = femur, FL = fascia lata, FV = femoral vessels, LA = local anaesthetic, SAM = sartorius muscle, TIPS = triple injection peri-sartorius, VM = vastus medialis

just lateral to the femoral nerve.[8] One investigator did all the procedures, while another blinded investigator did the assessment.

Postoperative analgesia was based on a multimodal regimen in the form of IV paracetamol 500 mg and ketorolac 30 mg every 8 h for 24 h. Resting and dynamic VAS scores were assessed every 4 h. When the VAS score exceeded 3, a dose of 0.05 mg/kg IV morphine was given as a rescue analgesic. Total postoperative rescue analgesia measured in milligrams of morphine was calculated and recorded. Quadriceps strength was evaluated using two parameters: the ambulation distances in metres during the evening of the operation and the morning of day 1 after surgery during the rehabilitation rounds.[9] Patients were encouraged to walk assisted if they had no motor weakness or intolerable pain. Active postoperative knee extension was assessed during the evening of surgery while the patients were seated with their feet touching the ground. Patients were allowed to actively raise their legs without moving the hip joint or the trunk, and the angle of maximum knee extension was measured from 0 to 90° using a goniometer.[1] Complications related to the regional block or opioid intake were recorded.

The sample size was calculated using MedCalc software 14.12.0 (MedCalc softwareltd, Ostend, Belgium). The sample size was based on a previous study.[10] The median VAS scores in the groups were 2 and 3 at 8 h postoperatively, and the interquartile range (IQR) was 1–4 and 2-4. Based on these analyses, a minimum sample size of 80 (40 per group) was needed to achieve an effect size of 1 in the difference of the VAS score between TIPS block and FNB during the first 24 h postoperatively. This was sufficient to achieve 80% power using a two-sided independent samples *t*-test at a significance level of 0.05.

The data were collected, and Statistical Package for Social Sciences (International Business Machines SPSS Statistics for Windows, Version 24.0; IBM Corp, Armonk, NY, USA) software was used to perform the statistical analysis. Comparison between the age, VAS score, opioid consumption, ambulation distance and knee extension in the two groups was made using the unpaired *t*-test. The categorical variables (gender, ASA classification) were analysed using the Chi-square test. The data are presented as mean (standard deviation [SD]) or a number (proportion). Statistical significance between the two groups was defined at $P < 0.05$.

RESULTS

A total of 88 patients were eligible for the study. Four patients in each group were excluded; thus, 80 patients were enroled in the study [Figure 2]. Patient demographics were comparable between the two groups [Table 1].

There were no significant differences in the VAS scores between the TIPS and FNB groups at 4, 8, 12, 16, 20 and 24 h postoperatively ($P = 0.079$, 0.281, 0.081, 0.069, 0.064 and 0.083, respectively). Patients in the TIPS group had significantly lower dynamic VAS scores than those in the FNB group at 4, 8, 12, 16, 20 and 24 h postoperatively ($P = 0.021$, 0.036, 0.041, 0.023, 0.041 and 0.021, respectively) [Table 2]. Patients in the TIPS group needed less postoperative rescue analgesia than patients in the FNB group did. The mean (SD) (95% confidence interval [CI]) postoperative morphine

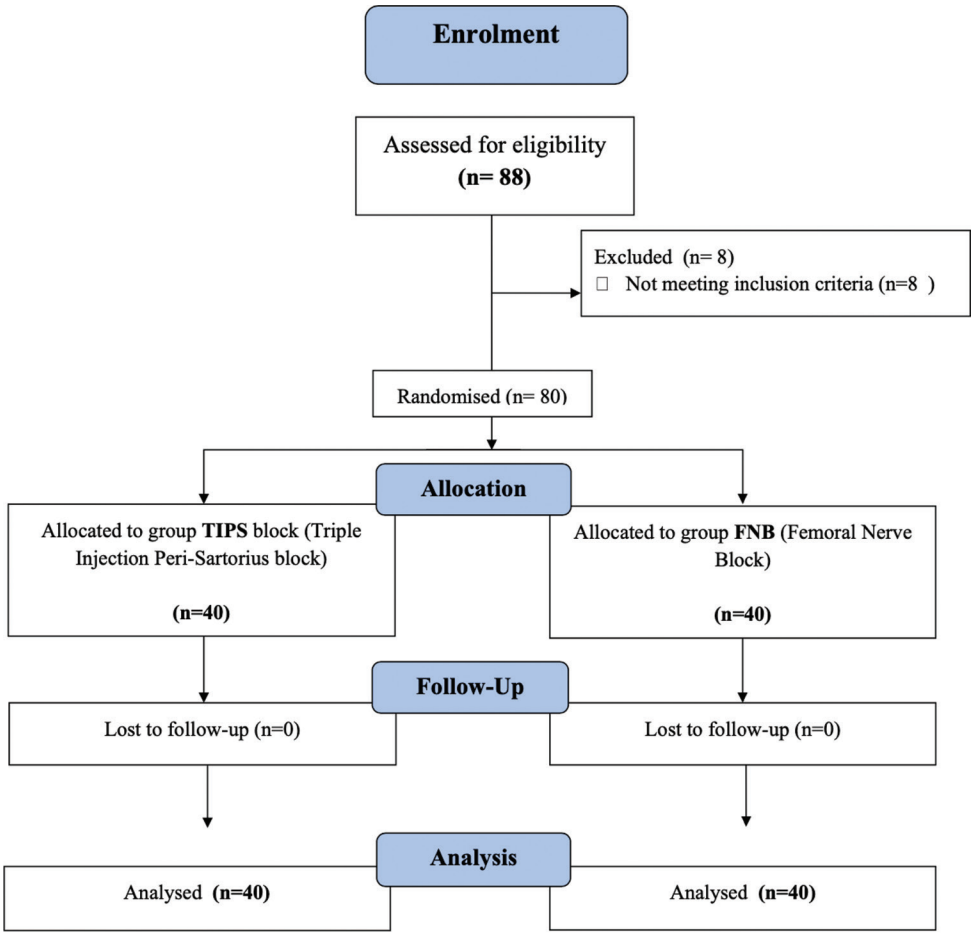

Figure 2: Consolidated standards of reporting trials (CONSORT) flow chart

Table 1: Patient demographics

	Group TIPS (*n*=40)	Group FNB (*n*=40)
Age (years)	62.27 (7.77)	64.75 (6.81)
Gender:male/female	17/23	16/24
ASA Physical status I/II/II	14/11/15	10/13/17

Data expressed as mean (SD) or number. ASA=American Society of Anesthesiologists, FNB=Femoral nerve block, TIPS=Triple injection peri-sartorius, *n*=Number of patients

consumption was 5.825 (2.47) (5.035, 6.614) mg in the TIPS group and 9.875 (2.99) (8.919, 10.830) mg in the FNB group ($P = 0.001$).

The mean ambulation distances during the evening and morning rounds carried out by patients in the TIPS group were greater than those carried out by patients in the FNB group. The mean (SD) in the TIPS group was 18 (7.37) m versus 8.95 (5.93) m in the FNB group ($P = 0.001$) [Table 3]. Moreover, the mean (SD) degree of active postoperative knee extension measured during the evening of surgery was better among TIPS patients [52.125 (16.39)°] than among FNB patients [26.05 (11.10)°] ($P = 0.001$) [Table 3]. Nausea was significantly more evident in FNB patients (37%) than in TIPS patients (20%). Other postoperative complications were not significantly different between patients of the two groups.

DISCUSSION

The current study demonstrated that TIPS injection of LA is superior to FNB for postoperative pain relief after TKA. The lower postoperative dynamic VAS scores and morphine consumption showed this. Moreover, the TIPS technique spares the motor power of the quadriceps muscle and helps patients rehabilitate earlier in the postoperative period than FNB. Motor sparing in the TIPS group was manifested by a better range of ambulation distances and a greater degree of active knee extension than in the FNB group.

ACB provided equivalent analgesia to FNB after knee surgery in several studies.[11,12] Moreover, ACB may preserve the quadriceps' muscle motor power, help early mobilisation and decrease the risk of falls during postoperative rehabilitation.[11,12] However, other studies revealed different outcomes regarding

Table 2: Pain assessment during the postoperative period

Postoperative	Resting VAS			Dynamic VAS		
	Group TIPS (*n*=40)	Group FNB (*n*=40)	*P*	Group TIPS (*n*=40)	Group FNB (*n*=40)	*P*
4 h	0.97 (1.23) (0.58, 1.36)	1.38 (1.27) (0.96, 1.78)	0.079	1.63 (1.17) (1.25, 1.99)	2.50 (0.75) (2.25, 2.74)	0.021
8 h	1.50 (1.40) (1.05, 1.94)	1.68 (1.29) (1.26, 2.08)	0.281	2.00 (1.24) (1.60, 2.39)	2.80 (0.94) (2.49, 3.10)	0.036
12 h	1.60 (1.24) (1.20, 1.99)	1.97 (1.14) (1.68, 2.41)	0.081	2.23 (1.10) (1.87, 2.57)	2.95 (0.81) (2.68, 3.21)	0.041
16 h	1.93 (1.31) (1.50, 2.34)	2.33 (1.07) (1.98, 2.66)	0.069	2.60 (1.10) (2.24, 2.95)	3.03 (0.73) (2.79, 3.25)	0.023
20 h	2.30 (1.07) (1.95, 2.64)	2.63 (0.81) (2.36, 2.88)	0.064	2.98 (0.86) (2.69, 3.25)	3.27 (0.64) (2.92, 3.37)	0.041
24 h	2.48 (0.85) (2.20, 2.74)	2.72 (0.75) (2.65, 3.09)	0.083	3.03 (0.53) (2.85, 3.19)	3.50 (0.78) (3.24, 3.75)	0.021

Data expressed as mean (SD) (95% CI). CI=Confidence interval, FNB=Femoral nerve block, SD=Standard deviation, TIPS=Triple injection peri-sartorius, VAS=Visual analogue scale, *n*=Number of patients

Table 3: Motor power assessment of the operated limb

	Group TIPS (*n*=40)	Group FNB (*n*=40)	*P*
Ambulation distances (m)	18 (7.37) (15.64, 20.35)	8.95 (5.93) (7.05, 10.86)	0.001
Active postoperative knee extension (in degrees)	52.125 (16.39) (46.88, 57.36)	26.05 (11.10) (22.50, 29.59)	0.001

Data expressed as mean (SD) (95% CI). CI=Confidence interval, FNB=Femoral nerve block, SD=Standard deviation, TIPS=Triple injection peri-sartorius, *n*=Number of patients

better pain relief achieved by FNB and non-significant differences in the motor strength of the quadriceps or the risk of falls.[13-16] Such discrepancies may be related to the dissimilar approaches used for ACB, the misnomers of ACB and FTB and the use of anatomical versus ultrasound-guided landmarks to determine the actual boundaries of the adductor canal or the femoral triangle.[17-19] The spread of different volumes of LAs injected at variable levels of the adductor canal may also play a role in determining the precise profile of analgesia and the motor-sparing effects of the block.[20]

TIPS block targets motor-sparing analgesia through injection at three planes. In the present study, distal FTB was performed similar to the method described by Sonawane *et al*.[6] The injection was performed approximately 2 cm above the apex of the femoral triangle. Such injection targets the saphenous nerve and the nerve to the vastus medialis. Also, LA spread under SAM may reach the subsartorial plexus, which comprises the saphenous nerve's infrapatellar branch, the obturator nerve's anterior division and the thigh's medial cutaneous nerve (MFCN). MFCN provides sensory supply to the skin and subcutaneous tissues of the medial thigh and the anteromedial part of the knee.[6] The small volume used for injection at this level may prevent LA from reaching the femoral nerve motor branches. However, subsartorial injection at this level spares IFCN, which is responsible for the sensory supply in the distribution of the surgical incision.[4] Suprasartorial LA injection blocks IFCN. Combining with FTB may relieve the whole incisional pain during TKA. The distal ACB is intended to provide sensory blockade of the popliteal plexus supplying the posterior compartment of the knee.[6]

Bjørn *et al*.[4] suggested that sparing the anterior femoral cutaneous nerves (AFCNs) after FTB may lead to less-potent analgesia after TKA than after FNB. They developed a volunteer study and documented that IFCN block is important for analgesia of the surgical incision following TKA. AFCNs branch from the anterior division of the femoral nerve. They give rise to MFCN and IFCN supplying the proximal part of the medial parapatellar incision. Pascarella *et al*.[21] recently published a clinical article describing an approach combining FTB with IFCN blockade. The technique involves three planes for injection: inside the femoral triangle, just underneath the sartorius outside the canal and superficial to the sartorius. The authors suggested that this technique may achieve complete anaesthesia of the surgical incision used in TKA through blockade of the saphenous nerve, MFCN and IFCN. The technique by Pascarella *et al*. ignored pain arising from the posterior compartment of the knee and recommended further investigations of their work.

The present study has several limitations. The block technique was carried out after anaesthesia; hence, the sensory and motor distributions of the blocks could not be studied. The postoperative assessment was performed based on pain relief, the ambulation distances documented during the physiotherapy rounds and the angles of knee extension. Surgical factors and the preoperative physical status of the patients may influence these data. We preferred to perform the regional block after anaesthesia since the TIPS technique involves two punctures and three needle manipulations. The use of suprasartorial plane injection could not be assessed. The study evaluated

a combination of motor-sparing plane injections compared to the well-studied FNB. An ongoing study is designed to evaluate the addition of suprasartorial injection to dual subsartorial block after TKA.

CONCLUSION

After TKA, the triple injection peri-sartorial block provides superior analgesia to FNB, with motor sparing of the quadriceps.

Study data availability

De-identified data shall be provided with reasonable justification via email to the corresponding author upon request.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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