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Periarticular local infiltration analgesia and early recovery after primary total knee arthroplasty: a prospective observational study

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ABSTRACT

Background: Postoperative pain after total knee arthroplasty (TKA) may delay mobilization and increase opioid use. Periarticular local infiltration analgesia (LIA) is a motor-sparing technique. This study evaluated pain relief and functional recovery after a periarticular LIA protocol in primary TKA.

Methods: This prospective observational study included 40 patients aged >45 years with grade IV osteoarthritis undergoing primary TKA from May 2023 to November 2024. Deep injection before cementation contained bupivacaine 0.5% 24 ml, morphine 8 mg/ml 0.8 ml, methylprednisolone 40 mg/ml 1 ml, cefuroxime 750 mg in saline 10 ml, saline 22 ml, and epinephrine 1:1000 0.3 ml. Superficial injection before closure contained bupivacaine (0.5%) 20 ml and saline 20 ml. The primary outcome measure was postoperative pain intensity, assessed using the visual analogue scale (VAS) at 6, 12, and 24 hours.

Results: Mean age was 60.4±7.8 years; 55% were female. Mean VAS scores were 3.1±1.2, 2.4±1.1, and 1.8±0.9 at 6, 12, and 24 hours. Mean rescue opioid use was 4.2±3.3 mg intravenous morphine equivalents; 70% required ≤5 mg. Assisted ambulation within 12 hours occurred in 87.5%, unassisted straight-leg raise within 24 hours in 72.5%, mean knee flexion at 48 hours was 82°±12°, and mean hospital stay was 5.7±1 days. Knee society score improved from 45±8 to 78±7 at 6 weeks and 85±6 at 3 months.

Conclusions: A two-stage periarticular LIA protocol with a total volume of 98.1 ml was associated with low early pain scores, modest opioid use, early mobilization, and favorable recovery after primary TKA.

Keywords: Total knee arthroplasty, Periarticular injection, Local infiltration analgesia, Postoperative pain, Early mobilization, Multimodal analgesia

INTRODUCTION

Total knee arthroplasty (TKA) is one of the most successful orthopaedic procedures for relieving pain and restoring function in patients with advanced knee osteoarthritis. However, pain during the immediate postoperative period remains a major challenge and may adversely affect rehabilitation, ambulation, sleep, overall patient satisfaction, and duration of hospital stay. Inadequately controlled postoperative pain is also associated with increased opioid consumption and related adverse effects.[1] Traditional strategies for pain control after TKA have included systemic opioids, epidural analgesia, and peripheral nerve blocks. Although effective, these approaches have important limitations.

Opioids may cause nausea, vomiting, constipation, sedation, urinary retention, and respiratory depression. Continuous femoral nerve block and epidural analgesia can provide good pain control, but they may impair early mobilization because of motor weakness, hypotension, or catheter-related constraints.[2,4]

Multimodal analgesia has therefore become central to perioperative TKA care. Periarticular local infiltration analgesia has gained popularity because it delivers

analgesic agents directly to tissues involved in surgical trauma while largely preserving motor function. Systematic reviews and comparative studies have shown that periarticular infiltration can reduce pain intensity, lower opioid consumption, and facilitate functional recovery when used within an enhanced recovery pathway.[3-6] Nevertheless, substantial variability persists with respect to drug composition, dosing, and infiltration technique.[6,7]

The present prospective observational study was undertaken to evaluate the effect of a standardized two-stage periarticular local infiltration analgesia protocol on early postoperative pain and functional recovery following primary TKA in a tertiary care teaching hospital.

The primary objective was to assess postoperative pain intensity during the first 24 hours. Secondary objectives were to evaluate opioid requirement, early ambulation, recovery of knee function, short-term clinical outcome, patient satisfaction, and treatment-related complications.

METHODS

Study design and setting

This prospective observational study was conducted in the Department of Orthopaedics, Ballari Medical College and Research Center, Ballari, Karnataka, India, between May 2023 and November 2024.

Ethical approval and reporting standard

The study protocol was reviewed and approved by the Institutional Ethics Committee of Ballari Medical College and Research Center (Approval No. Prov. 80/2022-2023). Written informed consent was obtained from all participants prior to enrolment. The study was reported in accordance with the strengthening the reporting of observational studies in epidemiology (STROBE) statement.[8]

Participants

Forty consecutive patients aged more than 45 years with radiographic grade IV osteoarthritis of the knee and scheduled for primary TKA were included in the study.

Patients with inflammatory arthritis, revision TKA, active local or systemic infection, neuropathic arthropathy, severe hepatic or renal dysfunction, chronic opioid dependence, known allergy to study medications, coagulation disorders, or inability to participate in the postoperative rehabilitation protocol were excluded.

Perioperative protocol

All procedures were performed under standardized anaesthetic and surgical protocols by the institutional arthroplasty team. Standard perioperative antibiotic prophylaxis, thromboprophylaxis, and postoperative rehabilitation pathways were followed according to institutional practice. Postoperative systemic analgesia included paracetamol and non-steroidal anti-inflammatory drugs unless contraindicated, with rescue opioids administered for breakthrough pain.

Periarticular local infiltration analgesia technique

A surgeon-administered two-stage periarticular local infiltration analgesia protocol was used in all patients.

The deep injection was administered before cementation into the posterior capsule, collateral ligaments, periosteum, and surrounding deep soft tissues. It contained bupivacaine (0.5%) – 24 ml, morphine (8 mg/ml) – 0.8 ml, methylprednisolone (40 mg/ml) – 1 ml, Cefuroxime (750 mg prepared in saline) – 10 ml, normal saline – 22 ml and epinephrine (1:1000), 300 µg – 0.3 ml. The total deep injection volume was 58.1 ml (Table 1).

The superficial injection was administered before wound closure into the quadriceps mechanism, retinaculum, capsular margins, subcutaneous tissue, and wound edges. It contained bupivacaine (0.5%) – 20 ml and normal saline (0.9%) – 20 ml. The total superficial injection volume was 40 ml. The overall infiltrated volume was therefore 98.1 ml (Table 1).

Outcome measures

The primary outcome measure was pain intensity assessed by the visual analogue scale (VAS) at 6, 12, and 24 hours after surgery.

Secondary outcome measures included total rescue opioid consumption during the first 24 hours (expressed as intravenous morphine equivalents), proportion of patients achieving assisted ambulation within 12 hours, proportion of patients performing an unassisted straight-leg raise within 24 hours, active knee flexion at 48 hours, knee society score (KSS) at baseline, 6 weeks and 3 months, duration of hospital stay, patient satisfaction with pain management, perioperative complications.

Data collection and statistical analysis

Demographic, clinical, operative, and postoperative data were recorded in a predefined study proforma. Statistical analysis was performed using IBM statistical package for the social sciences (SPSS) statistics for Windows, version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables are presented as mean±standard deviation, and categorical variables are presented as frequency and percentage. Repeated-measures analysis of variance was used to compare VAS scores across postoperative time points. Multivariable logistic regression analysis was used to identify predictors of moderate to severe pain, defined as VAS≥4 at 6 hours. Odds ratios (ORs) were calculated. A $p<0.05$ was considered statistically significant.

Table 1: Periarticular local infiltration analgesia protocol.

Phases	Component	Concentration/amount	Volume (ml)
Deep injection	Bupivacaine	0.5%	24
	Morphine	8 mg/ml	0.8
	Methylprednisolone	40 mg/ml	1
	Cefuroxime	750 mg in saline	10
	Normal saline	Diluent/top-up	22
	Epinephrine	1:1000, 300 µg	0.3
Deep total			58.1
Superficial injection	Bupivacaine	0.5%	20
	Normal saline	0.9%	20
Superficial total			40
Overall total			98.1

RESULTS

Baseline characteristics

A total of 40 patients underwent primary TKA during the study period. The mean age was 60.4±7.8 years. Twenty-two patients (55%) were female. The mean body mass index was 32.2±4.6 kg/m², and 85% of patients were overweight or obese. Hypertension was present in 35% of patients, diabetes mellitus in 22.5%, and coexisting hypertension with diabetes mellitus in 17.5%. Mean preoperative KSS was 45±8. The mean operative duration was 92±11 minutes, and the mean estimated blood loss was 312±96 ml (Table 2).

Table 2: Baseline demographic and clinical characteristics

Characteristics	Value
Age (years)	60.4±7.8
Female sex, N (%)	22 (55)
BMI (kg/m²)	32.2±4.6
Overweight/obese, N (%)	34 (85)
Hypertension, N (%)	14 (35)
Diabetes mellitus, N (%)	9 (22.5)
Hypertension+diabetes mellitus, N (%)	7 (17.5)
Preoperative KSS	45±8
Operative time (min)	92±11
Estimated blood loss (ml)	312±96

Primary outcome: postoperative pain

Pain scores showed a progressive decline over the first 24 postoperative hours. Mean VAS pain score was 3.1±1.2 at 6 hours, 2.4±1.1 at 12 hours, and 1.8±0.9 at 24 hours. Repeated-measures analysis demonstrated a significant reduction in pain over time (Table 3).

Secondary outcomes

Mean rescue opioid requirement during the first 24 postoperative hours was 4.2±3.3 mg intravenous morphine equivalents. Twenty-eight patients (70%) required 5 mg or less of rescue opioid. Assisted ambulation within 12 hours was achieved by 35 patients (87.5%). Unassisted straight-leg raise within 24 hours was achieved by 29 patients (72.5%). Mean active knee flexion at 48 hours was 82°±12°.

Mean KSS improved from 45±8 preoperatively to 78±7 at 6 weeks and 85±6 at 3 months. The mean length of hospital stay was 5.7±1.0 days. Thirty-six patients (90%) reported satisfaction with pain management and early recovery.

Table 3: Early postoperative and short-term functional outcomes.

Outcomes	Value
VAS at 6 hours	3.1±1.2
VAS at 12 hours	2.4±1.1
VAS at 24 hours	1.8±0.9
Rescue opioid use, IV-MEQ (mg)	4.2±3.3
Rescue opioid ≤5 mg, N (%)	28 (70)
Assisted ambulation ≤12 hours, N (%)	35 (87.5)
Unassisted straight-leg raise ≤24 hours, N (%)	29 (72.5)
Active knee flexion at 48 hours	82°±12°
KSS at 6 weeks	78±7
KSS at 3 months	85±6
Length of hospital stay (days)	5.7±1.0
Satisfied with pain control, N (%)	36 (90)

Complications and predictors of early pain

Postoperative complications were infrequent and generally minor. Nausea and vomiting occurred in 6 patients (15%), transient hypotension in 3 (7.5%), superficial wound ooze in 2 (5%), and superficial surgical site infection in 1 (2.5%). No patient developed deep infection, neurovascular deficit, deep vein thrombosis, or required reoperation during the study period.

On multivariable logistic regression, body mass index ≥35 kg/m² (OR 3.9), coexistence of hypertension and diabetes mellitus (OR 3.2), and intraoperative blood loss >400 ml

(OR 2.8) was associated with increased odds of moderate-to-severe pain at 6 hours (Table 4).

Table 4: Complications and predictors of moderate-to-severe pain at 6 hours.

Variables	Value
Nausea/vomiting, N (%)	6 (15)
Transient hypotension, N (%)	3 (7.5)
Superficial wound ooze, N (%)	2 (5)
Superficial surgical site infection, N (%)	1 (2.5)
BMI ≥35 kg/m²	OR 3.9
Hypertension + diabetes mellitus	OR 3.2
Blood loss >400 ml	OR 2.8

DISCUSSION

Effective early analgesia is fundamental to enhanced recovery after total knee arthroplasty. In the present study, a standardized two-stage periarticular local infiltration analgesia protocol was associated with low early postoperative pain scores, modest rescue opioid consumption, early ambulation, and favorable short-term functional recovery. These findings support the role of periarticular infiltration as a useful motor-sparing component of multimodal analgesia after primary TKA.[3-6]

The reduction in VAS pain scores over time and the relatively low mean opioid requirement observed in this cohort suggest that targeted infiltration of periarticular tissues can provide clinically meaningful analgesia during the period of greatest postoperative discomfort. This is particularly relevant in TKA, where pain may inhibit quadriceps activation, delay physiotherapy, and prolong hospitalization. Similar benefits of local infiltration analgesia have been reported in comparative trials and systematic reviews.[3-6]

Functional recovery in the present study was encouraging. A large majority of patients achieved assisted ambulation within 12 hours, and nearly three-quarters were able to perform an unassisted straight-leg raise within 24 hours. Mean knee flexion at 48 hours and progressive improvement in KSS at 6 weeks and 3 months further suggest that the protocol did not compromise motor recovery and may have facilitated rehabilitation.

These findings are consistent with previous literature showing that periarticular infiltration can support early mobilization while avoiding the quadriceps weakness sometimes observed with femoral nerve block.[2,4,5]

Another notable observation was the acceptable safety profile of the protocol. Most adverse events were minor and self-limiting, and only one superficial surgical site infection was documented. No deep infection or major local anaesthetic-related complication occurred. The multivariable analysis also suggested that obesity, clustered cardiometabolic comorbidity, and higher intraoperative blood loss may predispose patients to greater early pain, which may help identify individuals who could benefit from closer postoperative monitoring or supplemental analgesic strategies.

Limitations

The present study has several limitations. It was a single-center observational study with a relatively modest sample size and no parallel control group, thereby limiting causal inference. In addition, the favorable results observed may reflect the broader multimodal perioperative care pathway rather than the infiltration protocol alone. Longer follow-up with patient-reported outcome measures would also strengthen interpretation. Nevertheless, the study reflects real-world arthroplasty practice and provides pragmatic data on a reproducible periarticular LIA regimen.

CONCLUSION

In conclusion, periarticular local infiltration analgesia using a two-stage protocol with a total infiltrated volume of 98. 1 ml was associated with favorable early pain control, low opioid requirement, prompt mobilization, and satisfactory short-term functional outcomes after primary TKA. This technique may be considered a useful adjunct within multimodal analgesia pathways in routine arthroplasty practice.

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