

Comparing the Effectiveness of Ultrasound-guided Nerve Blocks vs. Opioid Use for Post Surgery Pain in Knee Replacement Patients

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Abstract. Total knee replacement (TKR) is one of the most common surgical treatments for patients with advanced knee disease when conservative management is no longer effective. Although the procedure can successfully restore joint function and improve quality of life, postoperative pain remains a major concern because it may interfere with early rehabilitation. Opioid analgesics are still widely prescribed after surgery; however, their adverse effects and the potential for prolonged use have led clinicians to consider alternative methods of pain management. This systematic review investigated the effectiveness of ultrasound-guided peripheral nerve block techniques for controlling postoperative pain after TKR. A comprehensive search of PubMed and the Cochrane Library was performed, and six randomized controlled trials satisfied the predefined inclusion criteria. Overall, the selected studies consistently showed that patients treated with ultrasound-guided nerve blocks experienced better postoperative pain control and required lower amounts of opioid medication than patients in the comparison groups. The greatest analgesic benefit was generally observed during the early postoperative period, when pain intensity is typically the highest. The findings of this review indicate that ultrasound-guided peripheral nerve block techniques can serve as an effective component of multimodal analgesia after TKR by reducing opioid requirements while providing improved postoperative pain relief and supporting recovery during the initial rehabilitation period.

Keywords: total knee arthroplasty, ultrasound-guided nerve block, postoperative pain, opioid consumption, regional anesthesia

1. Introduction

Advanced knee disease can cause persistent pain, limited mobility, and a substantial reduction in daily function. For many patients, total knee replacement (TKR) offers an opportunity to restore movement and improve quality of life [1]. Even after a successful operation, however, discomfort during the recovery period remains common. Pain that is not adequately controlled may discourage early movement, slow rehabilitation progress, and increase healthcare utilization after surgery [2, 3].

For many years, opioid medications have been a routine part of postoperative pain treatment. Although they are effective for managing moderate to severe pain, their use may be accompanied by

several unwanted effects, such as gastrointestinal symptoms, excessive drowsiness, and respiratory complications [4]. Concerns about prolonged opioid exposure have led clinicians to consider approaches that can provide pain relief while limiting reliance on these medications [5].

Regional anesthesia techniques have become increasingly important in this setting. Among them, femoral nerve block (FNB) and adductor canal block (ACB) are frequently used during TKR recovery [6]. While both approaches are designed to reduce pain transmission from the surgical area, differences exist in their influence on muscle performance. FNB may produce stronger quadriceps weakness, whereas ACB is often selected when preservation of lower-limb strength is desired [7].

Technological advances have also changed the delivery of these procedures. Ultrasound imaging enables clinicians to observe relevant anatomical structures in real time, helping guide needle placement with greater precision. This development has contributed to broader use of nerve block techniques in orthopedic surgery. Several clinical studies have described lower pain levels and decreased opioid requirements among patients treated with ultrasound-assisted nerve blocks following knee replacement surgery [8, 9].

Although encouraging results have been reported, findings remain inconsistent across published studies. Differences in study populations, intervention protocols, and outcome measurements make interpretation challenging. As a result, uncertainty remains regarding the overall clinical value of ultrasound-guided nerve block techniques after TKR. This review was therefore undertaken to examine current evidence from randomized controlled trials and to evaluate their effects on postoperative pain and opioid consumption [10, 11].

The primary objective of this review was to compare ultrasound-guided peripheral nerve block techniques with conventional opioid-centered pain management approaches in patients undergoing total knee arthroplasty.

2. Method

2.1. Search strategy

Relevant studies were identified through database screening in PubMed and the Cochrane Central Register of Controlled Trials. Publications available up to October 1, 2025, were considered. Search terms focused on topics related to knee arthroplasty, knee replacement surgery, ultrasound-assisted nerve block techniques, opioid use, and postoperative pain. Both controlled vocabulary terms and free-text keywords were applied. Different search combinations were used to maximize retrieval of potentially eligible articles.

To reduce the chance of missing important studies, additional records were sought from the reference sections of eligible articles and previously published reviews. No limits were applied according to publication date, language, or geographic location. All citations identified during the search process were collected in EndNote X9, where duplicate entries were removed before study screening began [12].

2.2. Eligibility criteria and data abstraction (PICOS)

The PICOS framework was used to define study selection criteria. Studies involving adults who underwent primary unilateral knee replacement surgery were considered eligible. The interventions of interest were ultrasound-guided nerve block procedures, including femoral nerve block, adductor canal block, sciatic nerve block, and combinations of these techniques with or without IPACK.

Eligible comparison groups included patients receiving placebo injections, sham interventions, standard postoperative care, or no nerve block treatment. The main outcome examined in this review was pain after surgery. Pain outcomes were commonly reported using Visual Analog Scale (VAS) or Numeric Rating Scale (NRS) measurements. Information related to opioid use and treatment-associated complications was also recorded whenever available.

Because opioid medications differed among studies, reported doses were standardized as morphine milligram equivalents (MME) whenever sufficient information was available. Only comparative clinical investigations published in peer-reviewed journals were included. Studies without an appropriate control group or without adequate outcome information were excluded from further review.

2.3. Outcome measurement and quality appraisal

Information extracted from each study included participant characteristics, study design, intervention methods, comparator groups, and reported outcomes. Pain outcomes and postoperative opioid use were collected according to the follow-up schedules reported in the original publications. Assessment times varied among studies and generally ranged from 6 to 48 hours after surgery.

To improve consistency between studies, opioid doses were expressed as morphine milligram equivalents (MME) whenever adequate information was available. Pain severity was primarily assessed using either the Visual Analog Scale (VAS) or the Numeric Rating Scale (NRS). When outcome values were not directly reported in the manuscript text, data were obtained from published graphs or estimated using established statistical procedures described in previous research.

2.4. Statistical analysis

Review Manager (RevMan) was used to organize and evaluate the available outcome data. Pain scores and opioid consumption outcomes were examined according to the reporting schedules used in the individual studies. When different opioid medications were reported, dose conversions were performed using MME values to facilitate comparison.

Substantial differences existed between studies with respect to nerve block approaches, analgesic protocols, and follow-up schedules. Because of this variability, not all outcomes were suitable for quantitative pooling. Outcomes with insufficient comparability were summarized narratively. For datasets that could be combined, forest plots were constructed to illustrate differences between treatment and comparison groups. Interpretation of the findings considered the overall pattern of results, consistency between studies, and the relative size of observed treatment effects.

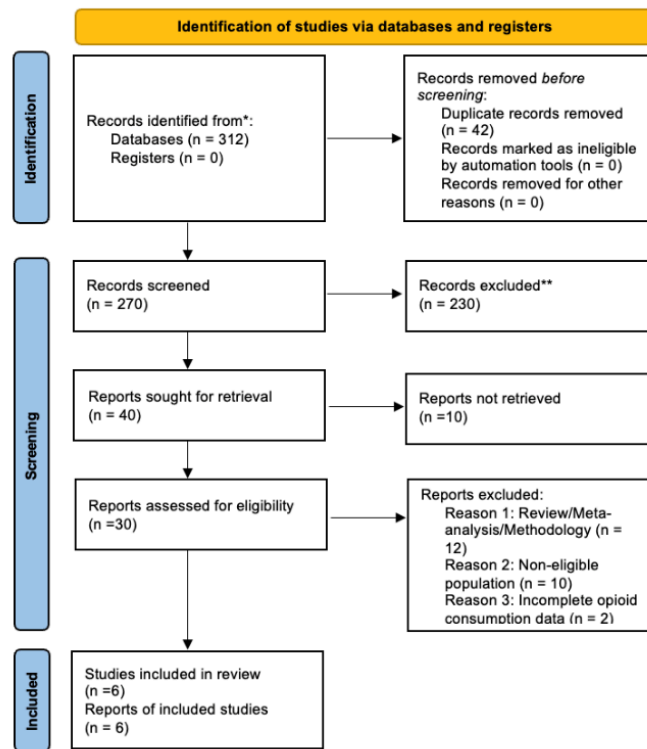
3. Results

3.1. Study selection and baseline characteristics

The study selection process is presented in Figure 1. The database search identified 312 records. After duplicate entries were removed, 270 unique records remained and proceeded to title and abstract review. Screening at this stage resulted in the exclusion of 230 records that did not meet the predefined selection criteria. Forty articles were subsequently examined in full text. Ten reports could not be obtained for detailed evaluation, leaving 30 studies for eligibility assessment. Following full-text review, 24 studies were excluded because they were review or methodological publications ($n = 12$), involved ineligible patient populations ($n = 10$), or did not provide adequate

opioid-related outcome data (n = 2). As a result, six randomized controlled trials were retained for inclusion in the systematic review and meta-analysis.

PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only



*Consider, if feasible to do so, reporting the number of records identified from each database or register searched (rather than the total number across all databases/register).

**If automation tools were used, indicate how many records were excluded by a human and how many were excluded by automation tools.

Figure 1. PRISMA flow chart describing the process used to identify and select eligible studies

The main characteristics of the included studies are summarized in Table 1. The six included randomized controlled trials evaluated different ultrasound-guided nerve block strategies following total knee arthroplasty. The interventions included femoral nerve block (FNB), adductor canal block (ACB), continuous adductor canal block (cACB), sciatic nerve block, and adductor canal block combined with infiltration between the popliteal artery and capsule of the knee (IPACK). Depending on the study protocol, participants in the comparison groups received placebo treatment, sham procedures, or standard multimodal analgesic care.

Table 1. Characteristics of included studies

Study	Year	Sample (n)	Age (mean $\pm$ SD)	Intervention	Comparator	Primary Outcome	Main Findings
Kim et al. [13]	2014	40	69 $\pm$ 6	Femoral + sciatic nerve block	No block	VAS pain, opioid use, satisfaction	Lower early postoperative pain and opioid use; higher patient satisfaction

Table 1. (continued)

Beek et al. [14]	2017	63	67 ± 8	Ropivacaine + perineural buprenorphine	Ropivacaine alone or subcutaneous buprenorphine	Time to first rescue analgesia	Lower opioid use and better first night sleep, but no significant improvement in pain or mobilization
Yin et al. [15]	2024	100	67 ± 7	ACB + IPACK with ropivacaine	ACB + OPACK with saline	Chronic postoperative pain; early pain	Lower early pain scores and opioid use; reduced chronic pain incidence
Hanson et al. [16]	2014	80	65 ± 9	Continuous adductor canal block	Sham catheter	Morphine consumption (48h)	Lower morphine consumption, better quadriceps strength and ambulation, lower pain scores
Nader et al. [17]	2016	40	64.6 ± 7.8	Adductor canal block	Saline ACB	Opioid consumption (36h)	Lower morphine-equivalent consumption and improved postoperative pain control.
Morales-Muñoz et al. [18]	2016	81	67 ± 8	Ropivacaine + perineural dexamethasone	IV dexamethasone or ropivacaine alone	Duration of analgesia	Perine dexamethasone prolonged analgesia and reduced morphine use.

A range of recovery-related outcomes was reported across the included studies. Postoperative pain was most often measured using the Visual Analog Scale (VAS) or the Numeric Rating Scale (NRS). Other reported outcomes included opioid consumption, patient recovery measures, and adverse events associated with treatment.

3.2. Quality assessment

The risk of bias assessment is presented in Figure 2. Evaluation of study methodology indicated that the included trials generally followed appropriate research procedures. Most studies reported randomization methods and incorporated blinding measures together with placebo comparison groups when applicable. Differences remained across studies with respect to nerve block techniques, anesthetic regimens, postoperative analgesic strategies, and follow-up schedules.

Study quality was examined using the Cochrane Risk of Bias 2 (RoB 2) framework [19]. Two trials demonstrated a low overall likelihood of bias, whereas the remaining four raised some methodological concerns. These concerns were primarily associated with protocol adherence and outcome reporting practices. No study was categorized as having a high level of bias.

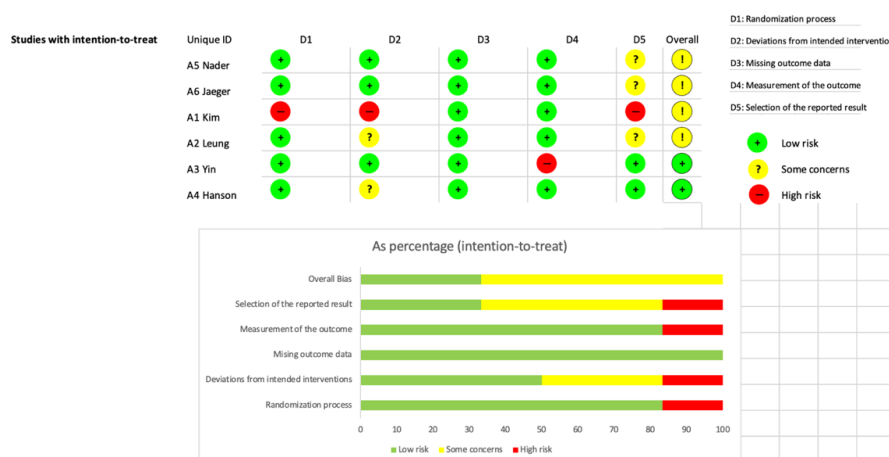


Figure 2. Traffic light plot summarizing the risk-of-bias assessment of the included randomized controlled trials

Outcome assessment schedules differed between studies. While most investigators reported pain outcomes within the first 48 hours after surgery, several studies collected data at less common intervals, including 18, 20, and 36 hours. Because assessment schedules were not uniform, direct comparison of some outcomes was not possible and narrative description was used instead.

Additional variability was observed in the opioid medications administered and in the way opioid use was reported. To improve consistency across studies, reported opioid doses were standardized as morphine milligram equivalents (MME) whenever the necessary information was available.

3.3. Primary outcomes

3.3.1. Early postoperative pain (0-12 hours)

In Figure 3, the forest plot presents the forest plot comparing early postoperative pain scores (≤ 12 hours) between the ultrasound-guided peripheral nerve block and opioid-based analgesia groups. Across the included studies, the clearest differences between intervention and control groups were observed during the earliest stage of recovery after surgery. In general, patients who received ultrasound-guided nerve block techniques reported lower pain levels and required fewer additional analgesic medications than those managed with control treatments.

Jaeger et al. [13] reported reduced pain during knee flexion within the first 1 to 6 hours after surgery among patients treated with adductor canal block compared with placebo. A similar pattern was observed by Kim et al. [20] who found lower VAS scores during the first 18 postoperative hours in patients receiving combined femoral and sciatic nerve blocks. These findings indicate that nerve block interventions may provide meaningful analgesic benefit during the period when postoperative discomfort is often greatest.

Yin et al. [15] investigated whether adding infiltration between the popliteal artery and capsule of the knee (IPACK) to an adductor canal block could improve pain control. Patients who received ACB combined with IPACK reported lower NRS pain scores at 4, 8, and 16 hours after surgery and required less rescue analgesia than those in the placebo group. They also reported better comfort during the early recovery period. These findings support the use of ACB combined with IPACK as a potential strategy for improving postoperative analgesia while preserving motor function.

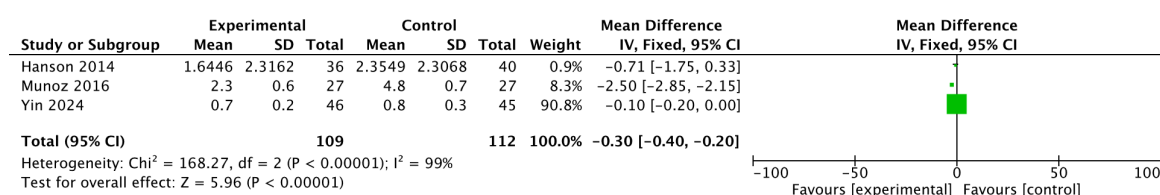


Figure 3. Forest plot comparing early postoperative pain scores (≤ 12 hours) between ultrasound-guided peripheral nerve block and opioid-based analgesia groups

3.3.2. Intermediate postoperative pain (12-24 hours)

Pain outcomes during the 12–24 hour period continued to favor nerve block interventions, although the magnitude of benefit differed among studies. Evidence from several trials suggested that continuous catheter techniques and adjuvant-enhanced nerve blocks produced effects that lasted longer than those observed with single-injection approaches.

Leung et al. [21] observed lower opioid use and smaller VAS area-under-the-curve values during the first 20 postoperative hours among patients treated with continuous adductor canal block. Hanson et al. (2014) reported a similar pattern, with reduced cumulative morphine consumption in the continuous adductor canal block group compared with placebo controls.

Morales-Muñoz et al. [18] evaluated dexamethasone as an adjunct to femoral nerve block. Perineural administration resulted in a longer analgesic duration than either intravenous dexamethasone or placebo. Participants receiving perineural dexamethasone also demonstrated prolonged sensory blockade, lower pain ratings after surgery, and fewer reported adverse events.

Taken together, the available studies suggest that techniques designed to prolong nerve block duration, including continuous catheter administration and adjuvant use, may contribute to improved pain control beyond the earliest postoperative hours.

3.3.3. Late postoperative pain (24-48 hours)

In Figure 4, the forest plot shows the forest plot comparing late postoperative pain scores (24–48 hours) between the intervention and control groups. During the 24–48 hour period after surgery, differences between treatment and comparison groups became less consistent than those observed earlier in recovery. Although several studies continued to report favorable outcomes in patients receiving nerve block interventions, the magnitude of improvement was generally smaller than that seen during the first postoperative day.

Hanson et al. [16] reported continued reductions in opioid requirements between 24 and 48 hours after surgery among patients treated with continuous adductor canal block. In contrast, studies evaluating single-injection nerve block techniques reported fewer differences between intervention and control groups during the same follow-up period.

Evidence from the included studies suggests that some analgesic effects may continue into the later stages of recovery, particularly when continuous catheter techniques are used. However, results were not uniform across studies. Differences in intervention protocols, local anesthetic regimens, and postoperative pain management strategies may have contributed to the variation in reported outcomes.

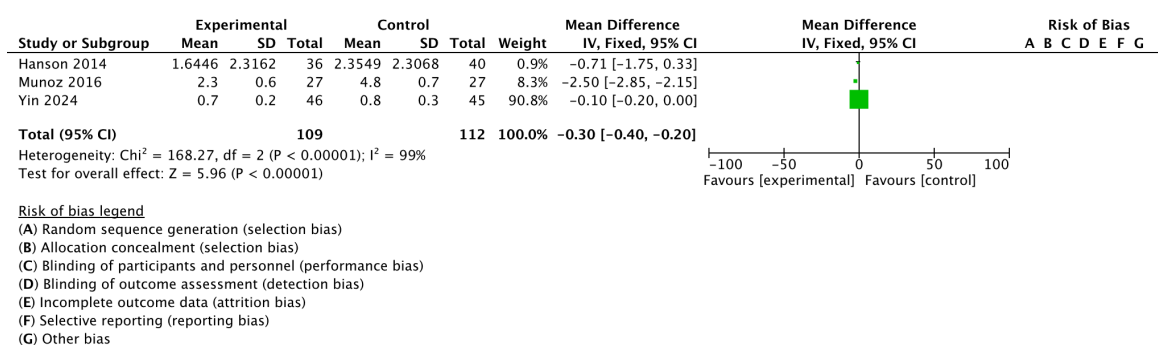


Figure 4. Forest plot comparing pain outcomes measured between 24 and 48 hours after surgery in intervention and comparison groups

3.3.4. Opioid consumption

Opioid use was reported in all included studies. Across the available evidence, patients who received ultrasound-guided nerve block interventions generally required smaller amounts of opioid medication following surgery than participants assigned to control treatments. This pattern indicates that nerve block interventions may reduce the need for postoperative opioid analgesics. The pooled analysis of postoperative opioid consumption, expressed as morphine milligram equivalents (MME), is presented in Figure 5.

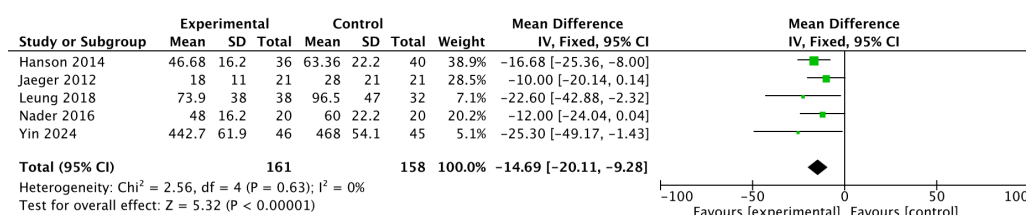


Figure 5. Forest plot comparing postoperative opioid consumption expressed as morphine milligram equivalents (MME)

Nader et al. [17] reported lower morphine-equivalent requirements among patients treated with adductor canal block compared with saline controls. Hanson et al. [16] observed reduced cumulative morphine use during the first 48 postoperative hours in patients receiving continuous adductor canal block. Similar findings were reported by Kim et al. [20], who documented lower oxycodone consumption during the first three days after surgery among patients treated with combined femoral and sciatic nerve blocks.

To improve comparability, opioid doses were standardized as morphine milligram equivalents whenever sufficient information was available. Interpretation of these outcomes should be approached with caution because studies differed in the opioid medications used, dose conversion procedures, reporting formats, and postoperative analgesic protocols.

Taken together, the included studies showed a consistent trend toward lower opioid use among patients receiving ultrasound-guided nerve block techniques following total knee arthroplasty.

3.4. Secondary outcomes

Information regarding adverse events was available in several of the included studies. Reported events mainly involved postoperative nausea and vomiting (PONV), temporary sensory

disturbances, and minor discomfort at the injection site. None of the reviewed studies described permanent nerve injury, serious infection, or other major complications that were clearly linked to the nerve block procedures

Morales-Muñoz et al. [18] reported fewer adverse events among patients receiving perineural dexamethasone than among those treated with placebo or intravenous dexamethasone. Yin et al. [15] likewise reported an absence of nerve block-related complications during follow-up. In the remaining studies, adverse events were uncommon and, when reported, were generally mild in nature.

Table 2 summarizes the adverse events reported in the included studies. Available safety data suggest that serious complications associated with ultrasound-guided nerve block techniques were uncommon in patients undergoing total knee arthroplasty. However, interpretation of these findings should remain cautious because methods used to collect and report adverse event data differed across

Table 2. Reported adverse events across included studies

Study	Reported adverse events
Jaeger et al. [13]	No major adverse events or permanent omplications were reported.
Hanson et al. [16]	No serious complications related to continuous adductor canal block were observed.
Kim et al. [20]	No permanent neurologic injury or major block-related complications were reported.
Leung et al. [21]	The serious adverse events associated with continuous adductor canal block were reported.
Morales-Muñoz et al. [18]	The perineural dexamethasone group demonstrated fewer postoperative side effects and complications compared with placebo and intravenous dexamethasone groups.
Nader et al. [17]	No serious treatement-ralted adverse events were reported.
Yin et al. [15]	No nerve block-related complications were reported during the follow-up period.

4. Discussion

This review examined evidence from randomized controlled trials investigating ultrasound-guided peripheral nerve block techniques in patients undergoing total knee arthroplasty. Across the included studies, patients receiving nerve block interventions generally experienced lower postoperative pain levels and reduced opioid use compared with control groups. These findings suggest that regional anesthesia techniques may contribute to postoperative pain management as part of a multimodal analgesic approach.

The most noticeable differences between intervention and control groups occurred during the first postoperative hours. Several studies reported lower pain scores during this period among patients receiving peripheral nerve blocks. This observation is clinically relevant because pain is often most intense immediately after surgery and may affect mobility, participation in rehabilitation, and overall recovery. Improved pain control during this stage may therefore support earlier functional recovery [22].

Results reported during the 12–48 hour period were less uniform. One possible explanation is that the effects of single-injection nerve blocks gradually decrease as local anesthetics wear off. By comparison, studies evaluating continuous catheter techniques or adjuvant-enhanced blocks reported benefits that extended beyond the immediate postoperative phase. Hanson et al. [16] and Leung et al. [21] observed continued reductions in opioid use with continuous adductor canal block, while

Morales-Muñoz et al. [18] reported prolonged analgesia and sensory blockade following the use of perineural dexamethasone [23].

The observations from this review generally align with findings reported in previous studies of regional anesthesia for total knee arthroplasty [24]. Earlier reviews have also described reductions in postoperative pain and opioid use among patients receiving peripheral nerve block interventions [25]. In addition, the current review highlights the potential role of continuous adductor canal block and adjunctive dexamethasone in extending analgesic duration beyond the earliest stage of recovery [26].

A reduction in opioid use was one of the most consistent findings across the included studies. This may be clinically meaningful because opioid medications are associated with adverse effects such as nausea, vomiting, constipation, sedation, and respiratory complications. Lower opioid exposure may therefore reduce the likelihood of medication-related side effects during recovery.

Several nerve block techniques were represented in the included studies, including femoral nerve block, adductor canal block, sciatic nerve block, and adductor canal block combined with IPACK [27]. Although femoral nerve block has been widely used for postoperative analgesia after total knee arthroplasty, its effect on quadriceps strength may influence early ambulation [28]. Adductor canal block has attracted increasing interest because it can provide analgesia while preserving motor function to a greater extent [29]. This characteristic may be particularly relevant in Enhanced Recovery After Surgery (ERAS) pathways, where early mobilization is encouraged as part of postoperative recovery [30].

Several factors should be considered when interpreting these findings [31]. Considerable variation existed between studies in nerve block techniques, anesthetic regimens, postoperative analgesic protocols, opioid conversion methods, and outcome assessment schedules. Pain outcomes were also reported at different postoperative time points, including 18, 20, and 36 hours after surgery, which limited direct comparison. In some studies, numerical values were estimated from published figures or converted into morphine milligram equivalents, introducing potential measurement uncertainty. In addition, the relatively small number of eligible trials limited opportunities for subgroup analysis.

Future studies would benefit from greater consistency in outcome reporting and postoperative assessment schedules. Additional direct comparisons between adductor canal block, femoral nerve block, and adductor canal block combined with IPACK may help clarify which approach provides the most favorable balance between pain relief and functional recovery following total knee arthroplasty.

Across the included studies, patients who received ultrasound-guided nerve block interventions generally experienced lower pain levels and required less opioid medication after surgery. Although differences existed between studies, the overall pattern of results favored the use of these techniques during postoperative recovery after total knee arthroplasty.

5. Conclusion

The studies included in this review generally reported lower postoperative pain scores and reduced opioid requirements in patients receiving ultrasound-guided nerve block interventions after total knee arthroplasty. The most noticeable differences between intervention and control groups were observed during the early stage of recovery, although some approaches appeared to provide benefits that extended beyond the first postoperative hours.

Among the evaluated techniques, adductor canal block demonstrated a favorable balance between analgesia and preservation of quadriceps function. Findings from several studies also indicated that

continuous adductor canal block and the addition of perineural dexamethasone may prolong the duration of postoperative pain relief.

The findings reviewed in this study support the continued use of ultrasound-guided nerve block techniques as part of postoperative pain management following total knee arthroplasty. Their use may help limit opioid exposure while supporting recovery during the postoperative period.

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