



# An integrative review of multimodal pain management on patient recovery after total hip and knee arthroplasty

Julia Zhao<sup>a,\*</sup>, Suja P. Davis<sup>b</sup>

<sup>a</sup> School of Nursing, University of North Carolina at Chapel Hill, United states

<sup>b</sup> Assistant Professor, School of Nursing, University of North Carolina at Chapel Hill, United States

## ARTICLE INFO

### Article history:

Received 2 February 2019

Received in revised form 21 May 2019

Accepted 21 June 2019

### Keywords:

Literature review

Non-opioid pain management

Total hip arthroplasty analgesia

Total knee arthroplasty analgesia

## ABSTRACT

**Background:** Pain management after total knee arthroplasty and total hip arthroplasty is pivotal, as it determines the outcome of the recovery process after surgery. Ineffective pain control results in many postoperative complications and hinders successful recovery. In recent years, the transition from opioids to a multimodal pain management approach after total knee and total hip arthroplasty has increasingly become an alternative. This is due to the multitude of adverse effects associated with opioids. As a result, the use of non-opioid interventions such as acetaminophen, nonsteroidal anti-inflammatory drugs, cyclooxygenase-2 inhibitors, gabapentinoids, and ketamine, and techniques such as peripheral nerve block and local infiltration analgesia have become more favorable.

**Objectives:** This paper aims to summarize literature around the effectiveness of non-opioid interventions as part of a multimodal pain management after total knee and total hip arthroplasty.

**Methods:** A literature review was conducted to provide evidence-based information with respect to pain management during the postoperative period in order to enhance the pain recovery process. The literature chosen was extracted through the electronic databases PubMed, CINAHL, and Embase. Twenty-seven eligible articles were identified that met the inclusion and exclusion criteria.

**Results:** Literary evidence shows that non-opioid interventions such as acetaminophen, nonsteroidal anti-inflammatory drugs, cyclooxygenase-2 inhibitors, gabapentinoids, ketamine, peripheral nerve blocks, and local infiltration analgesia benefit patients after total knee and total hip arthroplasty for pain management. However, further quality research trials are necessary for more conclusive evidence-based information.

**Conclusion:** Selective literature supports the use of non-opioid interventions as part of a multimodal analgesics regimen for effective pain management after total knee and total hip arthroplasty.

Published by Elsevier Ltd.

## What is already known about the topic?

- Multimodal analgesia can be successful for pain management regimen with minimal adverse effects.
- Patient education enhances the process of pain management.

- This paper highlights the literature base for teaching strategies on non-opioid multimodal pain management for practicing nurses.
- The paper suggests how optimal analgesic strategy related to multimodal pain management remains a topic to be researched further.

## What this paper adds

- This paper presents the evidence base for non-opioid multimodal pain management regimen specifically for total knee arthroplasty and total hip arthroplasty.

## 1. Introduction

Total knee arthroplasty (TKA) and total hip arthroplasty (THA) are among two of the most common surgeries performed today. A core concern regarding total knee arthroplasty and total hip arthroplasty is that they are both associated with significant postoperative pain. This pain, if uncontrolled, can hinder the recovery process by setting in motion detrimental pathophysiologic processes that increase the risk of postoperative complications. Ineffective pain control can result in immobility, which can result in several medical morbidities

\* Corresponding author.

E-mail addresses: [jzhao126@gmail.com](mailto:jzhao126@gmail.com) (J. Zhao), [davissp@email.unc.edu](mailto:davissp@email.unc.edu) (S.P. Davis).

such as venous thrombosis, coronary ischemia, myocardial infarction, and pneumonia (Gaffney et al., 2017). Inefficient pain control can also hinder mobilization and rehabilitation, disrupt sleep, cause cognitive dysfunction, and increase patient anxiety. Therefore, focus on effective pain control among total knee arthroplasty and total hip arthroplasty patients is crucial as it influences recovery time, cost of healthcare, and overall patient satisfaction. Total knee arthroplasty and total hip arthroplasty procedures have increased over the last 2–3 decades and are projected to increase even further due to population aging and longevity (Singh, 2011). In the U.S., primary total knee arthroplasty has increased by 170% and revision total knee arthroplasty has increased by 270%. Concurrently, primary total hip arthroplasty has increased by 50% and revision total hip arthroplasty has increased by 60%. In Sweden, the rates of primary total knee arthroplasty have increased by 5-fold within a 20-year period. In Iceland, primary total hip arthroplasty has increased by approximately 3-fold and revision total hip arthroplasty has increased by 10-fold within the span of 14 years. In Denmark, the rates of primary and revision total hip arthroplasty have increased by 30% within a 6-year period (Singh, 2011). It is evident that the growth of total knee arthroplasty and total hip arthroplasty is a global trend. Consequently, successful postoperative pain management methods among total knee arthroplasty and total hip arthroplasty patients is significant.

Traditionally, opioids have been at the forefront of postoperative pain control for total knee arthroplasty and total hip arthroplasty. Among the most commonly used opioids are morphine, hydromorphone, oxycodone, hydrocodone, and fentanyl (Gaffney et al., 2017). However, the use of opioids has been associated with an array of negative side effects. Gaffney et al. (2017) highlighted that early complications of opioid usage can include nausea, vomiting, sedation, and constipation, while later complications may consist of ileus, respiratory depression, and pruritus (Russo et al., 2017). Additionally, opioid users indicated higher visual analog pain scores throughout hospitalization, were more likely to be discharged to a rehabilitation facility, and had more complications within 90 days of surgery (Gaffney et al., 2017). Recently, the transition to a multimodal pain management approach has increasingly become the standard of care due to its reduction in opioid use and success in recovery. According to Savarese and Tabler (2017), multimodal pain management includes the “administration of two or more drugs that act by different mechanisms for providing analgesia. These drugs may be administered via the same route or by different routes”. In 2015, a Clarification to Standard was issued by the Joint Commission for hospitals, which now expressly includes non-opioid analgesics as the recommended pharmacologic standard considering the risks of opioids (Savarese and Tabler, 2017). This study will focus specifically on the success of postoperative, non-opioid interventions on pain management and recovery.

## 2. Statement of the problem

Pain management is critically important due to its impact on the recovery process. Uncontrolled postoperative pain for orthopedic patients can result in multitude of undesirable consequences including delayed mobilization, poor surgical outcomes, and prolonged hospitalization (Goyal et al., 2008). Long-term consequences can also result, such as limited range of motion and chronic pain syndrome (Lachiewicz, 2013). Effective pain management, especially the utilization of a multimodal pain management method, can enhance better outcomes for total knee arthroplasty and total hip arthroplasty patients. Multimodal pain management can target different pain pathways. This can minimize the adverse effects of opioid treatment while improving pain management effectiveness, leading to better patient outcomes (Gallipani et al.,

2017). Examination of current evidence on non-opioid interventions for multimodal pain management is essential in informing patients before and after total knee arthroplasty and total hip arthroplasty, that their pain will be managed.

## 3. Purpose

The purpose of this project was to summarize literature on multimodal postoperative pain management for total knee arthroplasty and total hip arthroplasty, with an emphasis on non-opioid analgesics. Other postoperative non-opioid interventions such as peripheral nerve blocks and local infiltration analgesia were also included in the literature synthesis.

## 4. Methods

### 4.1. Selection of articles

An integrative literature review was conducted on postoperative pain management using non-opioid interventions for total knee arthroplasty and total hip arthroplasty patients based on current research and evidence gathered from September 26<sup>th</sup>, 2017 to March 12<sup>th</sup>, 2018. The literature chosen was extracted from the electronic databases PubMed, CINAHL, and Embase. The search terms entered into the databases included (Postoperative OR “post-operative” OR postsurgical OR “post-surgical” OR “after surgery”) AND (((“total hip” OR “total knee”) AND (arthroplast\* OR replace\*)) OR TKA OR THA) AND pain\* AND (nonopioid OR “non-opioid” OR multimodal OR “multi-modal”).

### 4.2. Inclusion and exclusion criteria

The inclusion criteria were (1) review articles, randomized controlled trials, and meta-analysis articles that addressed non-opioid pain interventions for total knee arthroplasty and total hip arthroplasty; (2) articles were limited to those in English, published between 2007 and 2017, available in full text, and peer-reviewed. Exclusion criteria were (1) articles in other languages; (2) studies limited to children and adolescents.

## 5. Results

### 5.1. Article selection

The search resulted in a total of 323 articles from PubMed, 257 articles from Embase, and 25 articles from CINAHL. Amongst these articles, those that studied the use of steroids and antidepressants were manually omitted. In addition, study-based articles were manually limited to those with sample size of at least 100 patients. F1000 Workspace, an online reference manager resource was utilized to remove duplicates. The articles were then screened based on relevance and eligibility was assessed based on quality of the study. Through this process, 25 eligible articles were identified that met the inclusion and exclusion criteria. Articles were also examined for studies that could be potentially relevant, and two more eligible articles were included. The PRISMA diagram shown in Fig. 1 illustrates the process through which the studies that were ultimately included were extracted.

### 5.2. Article characteristics

The study types of the included articles consist of meta-analyses (n = 5), randomized, double-blinded, placebo-controlled trials (n = 10), open, non-randomized trials (n = 1), retrospective studies (n = 4), and review studies (n = 7). The majority of the studies indicated that people of different sex, race, and age were included (n = 18), while

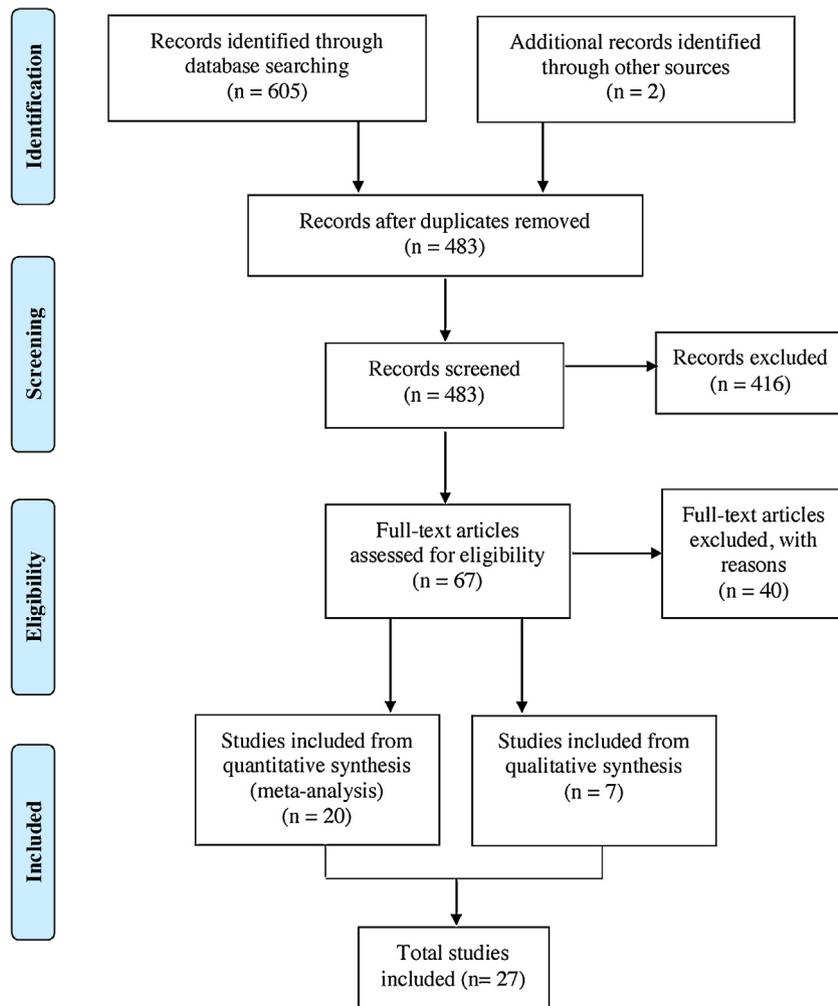


Fig. 1. PRISMA Diagram.

the remaining articles ( $n=9$ ) had exclusion criteria regarding demographics or did not mention these aspects. Some of the studies were conducted in single site settings ( $n=13$ ) while other studies were multi-centered ( $n=14$ ). Of the studies, some only addressed total knee arthroplasty ( $n=10$ ), while others addressed only total hip arthroplasty ( $n=4$ ), and there were those that addressed both total knee arthroplasty and total hip arthroplasty ( $n=13$ ).

### 5.3. Results of individual articles

Non-opioid multimodal pain management demonstrated improvement in pain and reduced opioid consumption, as well as functional outcomes after total knee arthroplasty and total hip arthroplasty. The 27 articles addressed the effectiveness of non-opioid pain interventions such as acetaminophen, nonsteroidal anti-inflammatory drugs (NSAIDs), cyclooxygenase-2 (COX-2) inhibitors, gabapentinoids, ketamine, peripheral nerve blocks, local infiltration analgesia, and multimodal interventions. Table 1 summarized the salient features, main results, and strengths and limitations of the literature review.

## 6. Literature review

### 6.1. Acetaminophen

Acetaminophen has been used as part of multimodal analgesia in total knee arthroplasty and total hip arthroplasty. It is speculated

that acetaminophen works to control pain through the inhibition of prostaglandin synthesis in the central nervous system and the blockage of pain impulse generation in the peripheral nervous system (Gallipani et al., 2017). Acetaminophen is often preferred over nonsteroidal anti-inflammatory drugs due to its lack of association with side effects such as upper gastrointestinal bleeding, renal toxicity, and potential negative effects on bone healing that nonsteroidal anti-inflammatory drugs have (Singla et al., 2015). Intravenous acetaminophen is commonly considered the best route of administration due to its rapid onset and higher bioavailability (O'Neal et al., 2017). Intravenous acetaminophen is presumed to have less hepatotoxicity than the oral formulation due to its reduced first-pass effect and may benefit those with postoperative nausea and vomiting (Gallipani et al., 2017). The recommended dose of acetaminophen is 4 g per 24 h, for both oral and intravenous administration, as indicated on the regulatory approval of the product. It is recommended that 650 mg of oral acetaminophen should be administered every 6 h, or 1000 mg of intravenous acetaminophen should be administered every 6 h postoperatively (Golladay et al., 2017). Although there are few absolute contraindications with acetaminophen use, caution should be taken in patients with hepatic impairment (McCartney and Nelligan, 2014).

Based on literature review, mixed evidence was present in support of acetaminophen as part of a multimodal analgesics regimen. The intravenous route was the primary mode of medication delivery for acetaminophen in all reviewed studies.

**Table 1**  
Literature summary.

Author (S) & Year	Title	Analgesic(s) Discussed	Study Type	Sample Size	Main Results	Strengths & Limitations
Gallipani et al. (2017)	Adverse effect profile comparison of pain regimen with and without intravenous acetaminophen in total hip and knee arthroplasty patients	Acetaminophen	Retrospective, matched, cohort	609	Use of intravenous acetaminophen did not improve safety or tolerability profile or reduce opioid consumption	Strengths: <ul style="list-style-type: none"> <li>• Large sample size</li> <li>• Matched demographics</li> <li>• Includes both total knee arthroplasty and total hip arthroplasty</li> </ul> Limitations: <ul style="list-style-type: none"> <li>• Institutional limitation of intravenous acetaminophen was 3 g rather than 4 g</li> <li>• Potential under reporting of adverse effects</li> <li>• Not controlled for use of concomitant medications</li> <li>• Retrospective study</li> </ul>
Lachiewicz (2013)	The role of intravenous acetaminophen in multimodal pain protocols for perioperative orthopedic patients	Acetaminophen	Review	N/A	Intravenous acetaminophen is effective as part of a multimodal analgesic regimen in providing pain relief and reducing adverse reactions	Strengths: <ul style="list-style-type: none"> <li>• Discusses acetaminophen as an analgesic in depth</li> <li>• The author utilized intravenous acetaminophen as part of a multimodal pain regimen for the past 18 months since the article was published</li> </ul> Limitations: <ul style="list-style-type: none"> <li>• Not specific to total knee arthroplasty and total hip arthroplasty –includes other conditions</li> </ul>
O' Neal et al. (2017)	Intravenous vs oral acetaminophen as an adjunct to multimodal analgesia after total knee arthroplasty: a prospective, randomized, double-blind clinical trial	Acetaminophen	Randomized, double-blinded, placebo-controlled	174	Neither intravenous nor oral acetaminophen provide pain relief or reduce opioid consumption	Strengths: <ul style="list-style-type: none"> <li>• Compares the effectiveness of acetaminophen based on route of delivery</li> </ul> Limitations: <ul style="list-style-type: none"> <li>• Potential variability caused by anesthetic technique</li> <li>• Single site setting</li> <li>• Only studies total knee arthroplasty</li> </ul>
Singla et al. (2015)	IV acetaminophen: efficacy of a single dose for postoperative pain after hip arthroplasty: subset data analysis of 2 unpublished randomized clinical trials	Acetaminophen	Randomized, double-blind, placebo-controlled	130	Use of intravenous acetaminophen can provide pain relief and reduce rescue opioid consumption with no adverse effects	Strengths: <ul style="list-style-type: none"> <li>• Well-developed clinical trials</li> <li>• Multicenter setting</li> <li>• Specific inclusion/ exclusion criteria for patients</li> </ul> Limitations: <ul style="list-style-type: none"> <li>• Both studies were stopped prematurely</li> <li>• Limited collection of samples</li> <li>• Only pertains to total hip arthroplasty</li> </ul>
Yang et al. (2017)	Intravenous acetaminophen as an adjunct to multimodal analgesia after total knee and hip arthroplasty: a systematic review and meta-analysis	Acetaminophen	Meta-analysis	4 studies; 865	Acetaminophen can reduce pain and opioid consumption with only few adverse side effects	Strengths: <ul style="list-style-type: none"> <li>• Medline, PubMed, Embase, ScienceDirect, and the Cochrane Library were searched</li> <li>• Quality assessment was performed</li> <li>• Risk of bias was assessed</li> <li>• Large sample size</li> </ul> Limitations: <ul style="list-style-type: none"> <li>• Only 3 randomized controlled trials and 1 non- randomized controlled trial were included</li> <li>• Non- randomized controlled trials were included</li> </ul>

Table 1 (Continued)

Author (S) & Year	Title	Analgesic(s) Discussed	Study Type	Sample Size	Main Results	Strengths & Limitations
Gupta et al. (2016)	A randomized trial comparing the safety and efficacy of intravenous ibuprofen versus ibuprofen and acetaminophen in knee or hip arthroplasty	Nonsteroidal anti-inflammatory drugs –ibuprofen	Randomized, double-blinded, placebo-controlled	74	Intravenous ibuprofen combined with intravenous acetaminophen improved pain scores, decreased opioid consumption and its related adverse effects	Strengths: <ul style="list-style-type: none"> <li>Limited use of concurrent medication to one other</li> </ul> Limitations: <ul style="list-style-type: none"> <li>Not blinded</li> <li>Single site setting</li> <li>Concurrent study with acetaminophen</li> <li>Small sample size</li> </ul>
Schwinghammer et al. (2017)	Continuous infusion ketorolac for postoperative analgesia following unilateral total knee arthroplasty	Nonsteroidal anti-inflammatory drugs –ketorolac	Retrospective, open-label cohort	191	Continuous infusion ketorolac reduced pain score and opioid consumption after total knee arthroplasty	Strengths: <ul style="list-style-type: none"> <li>Largest retrospective analysis of the use of continuous infusion ketorolac for postoperative total knee arthroplasty patients</li> </ul> Limitations: <ul style="list-style-type: none"> <li>Single site setting</li> <li>Continuous infusion ketorolac group included more male patients than the opioid group</li> <li>Adjunct use of gabapentin medications wasn't captured</li> <li>Retrospective study</li> <li>Only studies total knee arthroplasty</li> </ul>
Kazerooni and Tran (2015)	Evaluation of celecoxib addition to pain protocol after total hip and knee arthroplasty stratified by opioid tolerance	Cyclooxygenase-2 inhibitor –celecoxib	Retrospective, non-randomized	142	Efficacy of celecoxib as part of a multimodal analgesics regimen depends on a patient's opioid tolerance	Strengths: <ul style="list-style-type: none"> <li>Patient population free of comorbidities that may have affected treatment</li> <li>Exclusion of confounding variables</li> </ul> Limitations: <ul style="list-style-type: none"> <li>Single site setting</li> <li>Patient population is limited to veterans</li> <li>Handful of patients received a single dose before surgery</li> <li>The threshold for opioid tolerance may be considered liberal</li> <li>Small sample size</li> </ul>
Schroer et al. (2011)	Benefits of prolonged postoperative cyclooxygenase-2 inhibitor administration on total knee arthroplasty recovery	Cyclooxygenase-2 inhibitor –celecoxib	Randomized, double-blind, placebo-controlled	107	Continued use of 400 mg celecoxib for 6 weeks has significant clinical benefits for total knee arthroplasty patients	Strengths: <ul style="list-style-type: none"> <li>Well-developed study</li> <li>Strict inclusion/ exclusion criteria</li> <li>Studies celecoxib's use after discharge</li> </ul> Limitations: <ul style="list-style-type: none"> <li>Single site setting</li> <li>Preoperative dose of 400 mg of celecoxib was also given</li> <li>Small sample size</li> <li>Only studies total knee arthroplasty</li> </ul>
Viscusi et al. (2008)	A multiple-day regimen of parecoxib sodium 20 mg twice daily provides pain relief after total hip arthroplasty	Cyclooxygenase-2 inhibitor –parecoxib	Randomized, double-blind, placebo-controlled	479	Use of 20 mg of parecoxib twice daily is more effective than placebo and somewhat effective than 20 mg of parecoxib once daily after total hip arthroplasty	Strengths: <ul style="list-style-type: none"> <li>Widespread study conducted in 53 study centers in 6 countries</li> <li>Patients were excluded if they were receiving treatments likely to confound analgesic responses</li> </ul> Limitations: <ul style="list-style-type: none"> <li>Only studies total hip arthroplasty</li> </ul>
Clarke et al. (2014)	Perioperative gabapentin reduces 24 h opioid consumption and improves in-hospital rehabilitation but not post-discharge outcomes after total knee	Gabapentinoid –gabapentin	Randomized, double-blind, placebo-controlled	179	600 mg of gabapentin preoperatively and 200 mg of gabapentin twice daily postoperatively reduced opioid consumption and	Strengths: <ul style="list-style-type: none"> <li>Re-experimentation by the same author</li> </ul> Limitations: <ul style="list-style-type: none"> <li>Single site setting</li> </ul>

	arthroplasty with peripheral nerve block				improved knee range of motion	<ul style="list-style-type: none"> <li>• Preoperative administration of 400 mg celecoxib and 600 mg gabapentin</li> <li>• Only studies total knee arthroplasty</li> </ul>
Clarke et al. (2009)	Adding gabapentin to a multimodal regimen does not reduce acute pain, opioid consumption or chronic pain after total hip arthroplasty	Gabapentinoid –gabapentin	Randomized, double-blind, controlled	126	A single dose of 600 mg gabapentin doesn't reduce pain scores or morphine consumption when combined with a robust multimodal analgesic regimen	<p>Strengths:</p> <ul style="list-style-type: none"> <li>• Detailed explanation of the procedure</li> </ul> <p>Limitations:</p> <ul style="list-style-type: none"> <li>• Single dose measure</li> <li>• Small sample size</li> <li>• Only studies total hip arthroplasty</li> </ul>
Kadic et al. (2017)	The effect of pregabalin and s-ketamine in total knee arthroplasty patients: a randomized trial	Gabapentinoid –pregabalin	Randomized, double-blind, placebo-controlled	60	150 mg of pregabalin resulted in adverse side effects of dizziness and diplopia	<p>Strengths:</p> <ul style="list-style-type: none"> <li>• Well-developed study</li> <li>• Detailed description of the study design</li> </ul> <p>Limitations:</p> <ul style="list-style-type: none"> <li>• Single center setting</li> <li>• Sample size is not within inclusion limits</li> </ul>
Li et al. (2017)	The efficacy of pregabalin for the management of postoperative pain in primary total knee and hip arthroplasty: a meta-analysis	Gabapentinoid –pregabalin	Meta-analysis	823	Pregabalin was found to reduce pain and opioid consumption and improve knee function	<p>Strengths:</p> <ul style="list-style-type: none"> <li>• PubMed, Embase, Cochrane Central Register of Controlled Trials, and Google Scholar databases were searched</li> <li>• Quality assessment was performed</li> <li>• High quality of included literature</li> </ul> <p>Limitations:</p> <ul style="list-style-type: none"> <li>• Includes randomized controlled trials with perioperative administration of pregabalin</li> <li>• Only 7 randomized controlled trials were included</li> </ul>
Peng et al. (2007)	Use of gabapentin for perioperative pain control –a meta-analysis	Gabapentinoid –gabapentin	Meta-analysis	18 studies; 1181	Gabapentin use reduces pain and opioid consumption, and decreases opioid related adverse effects	<p>Strengths:</p> <ul style="list-style-type: none"> <li>• Medline, Embase, PubMed, Cochrane Clinical Trials Register, Science Citation Index, Controlled Trials Register, TextMed, Science Direct, IngentaConnect, and Google Scholar were searched</li> <li>• Only randomized controlled trials are included</li> </ul> <p>Limitations:</p> <ul style="list-style-type: none"> <li>• Studies preoperative and intraoperative administration of gabapentin</li> <li>• Studies different doses</li> </ul>
Sawan et al. (2014)	Pregabalin reduces opioid consumption and improves outcome in chronic pain patients undergoing total knee arthroplasty	Gabapentinoid –pregabalin	Retrospective	262	Pregabalin use can reduce opioid consumption in patients who were users of chronic pain medication	<p>Strengths:</p> <ul style="list-style-type: none"> <li>• Evaluates efficacy of pregabalin in patients who are users of chronic pain medication</li> </ul> <p>Limitations:</p> <ul style="list-style-type: none"> <li>• The effect of pregabalin is compared with a historical cohort</li> <li>• Only 75 mg of pregabalin was administered</li> <li>• Only studies total knee arthroplasty</li> </ul>
Zhang et al. (2015)	Reanalysis of morphine consumption from two randomized controlled trails of gabapentin using longitudinal statistical methods	Gabapentinoid –gabapentin	Reanalysis of randomized, blinded, placebo-controlled trials using longitudinal statistical methods	203	Gabapentin does not significantly reduce opioid consumption following total knee arthroplasty and total hip arthroplasty	<p>Strengths:</p> <ul style="list-style-type: none"> <li>• Reanalysis of previous experiments</li> </ul> <p>Limitations:</p> <ul style="list-style-type: none"> <li>• Single center setting</li> <li>• There are variabilities in the studies</li> <li>• Gabapentin was administered preoperatively</li> </ul>

**Table 1** (Continued)

Author (S) & Year	Title	Analgesic(s) Discussed	Study Type	Sample Size	Main Results	Strengths & Limitations
Remerand et al. (2009)	The early and delayed analgesic effects of ketamine after total hip arthroplasty: a prospective, randomized, controlled, double-blind study	Ketamine	Randomized, double-blind, placebo-controlled	154	Ketamine use decreased opioid consumption and improved pain both short term and long term	Strengths: • Good description of the methodology Limitations: • Single site setting • Only studies total hip arthroplasty
Souzdalnitcki et al. (2014)	Ketamine in perioperative analgesia for knee surgeries: review of evidence from randomized controlled trials	Ketamine	Systematic review	12 studies; 594	Ketamine use reduced pain scores, reduced opioid consumption, and improved rehabilitation	Strengths: • Limits studies to randomized controlled trials • Quality assessment was performed Limitations: • No limitations on date of publication • Includes perioperative use of ketamine • Only studies total knee arthroplasty • Surgeries other than total knee arthroplasty were included
Horlocker (2010)	Pain management in total joint arthroplasty: a historical review	Peripheral nerve blocks	Review	N/A	Peripheral nerve blocks enable early mobilization, rehabilitation, and decrease hospital stay and cost	Strengths: • Good description of the indications, benefits, and side effects of peripheral nerve blocks Limitations: • Studies were only referenced in a generalized manner • Not specific to peripheral nerve blocks
Kerr and Kohan (2008)	Local infiltration analgesia: a technique for the control of acute postoperative pain following knee and hip surgery	Local infiltration analgesia	Open, non-randomized	325	Local infiltration analgesia can decrease opioid consumption and promote early mobilization	Strengths: • Specifies the analgesic components of the local infiltration analgesia • In depth description of the procedure and administration Limitations: • Non-randomized • There is no control group for comparison
Seangleulur et al. (2016)	The efficacy of local infiltration analgesia in the early postoperative period after total knee arthroplasty	Local infiltration analgesia	Meta-analysis	38 studies; 3026	Local infiltration analgesia use provides pain relief, improves range of motion, and shortens length of stay	Strengths: • Good description of local infiltration analgesia • 38 randomized controlled trials were included • Studies specifically postoperative administration • Risk of bias assessment was performed Limitations: • The analgesic components of local infiltration analgesia were not included • Only studies total knee arthroplasty
Byrne and Clark (2015)	Total knee arthroplasty –the optimal analgesic regime	Multimodal: acetaminophen –paracetamol, nonsteroidal anti-inflammatory drugs, gabapentinoids, ketamine, peripheral nerve blocks, local	Review	N/A	The optimal pain regimen should be tailored to suit each patient	Strengths: • Weighs evidence for each analgesic • Good visual illustrations • No conflict of interest Limitations: • Refers to the study as an opinion piece • Includes pre-, intra-, and postoperative methods

		infiltration analgesia				<ul style="list-style-type: none"> <li>• Only studies total knee arthroplasty</li> </ul>
Golladay et al. (2017)	Oral multimodal analgesia for total joint arthroplasty	Multimodal: acetaminophen, nonsteroidal anti-inflammatory drugs –ibuprofen, ketolorac, cyclooxygenase-2 inhibitor –celecoxib, gabapentinoids –gabapentin, pregabalin	Review	N/A	Oral multimodal analgesia is shown to reduce opioid consumption	<p>Strengths:</p> <ul style="list-style-type: none"> <li>• Suggests a dosing regimen</li> <li>• Includes randomized controlled trials</li> </ul> <p>Limitations:</p> <ul style="list-style-type: none"> <li>• Incorporates preoperative dosing regimen</li> <li>• Broad references of clinical trials</li> </ul>
Goyal et al. (2008)	Pain management after total joint arthroplasty	Multimodal: acetaminophen, nonsteroidal anti-inflammatory drugs, gabapentinoids –pregabalin, peripheral nerve blocks, local infiltration analgesia	Review	N/A	Multimodal analgesics regimen can maximize analgesia while minimizing adverse side effects	<p>Strengths:</p> <ul style="list-style-type: none"> <li>• Strong emphasis on pain management in a multimodal fashion</li> </ul> <p>Limitations:</p> <ul style="list-style-type: none"> <li>• Vague descriptions of the referenced studies</li> </ul>
McCartney and Nelligan (2014)	Postoperative pain management after total knee arthroplasty in elderly patients: treatment options	Multimodal: nonsteroidal anti-inflammatory drugs, gabapentinoids, ketamine, peripheral nerve blocks, local infiltration analgesia	Review	N/A	Multimodal analgesics regimen allows for pain relief while avoiding side effects from reliance on a single drug	<p>Strengths:</p> <ul style="list-style-type: none"> <li>• Advantages and disadvantages of analgesics is discussed</li> <li>• Touches on chronic pain after surgery</li> </ul> <p>Limitations:</p> <ul style="list-style-type: none"> <li>• Focuses only on the elderly population</li> <li>• Includes other analgesics such as antidepressants</li> <li>• Only studies total knee arthroplasty</li> </ul>
McKenzie et al. (2013)	Multimodal pain management for total hip arthroplasty	Multimodal: peripheral nerve blocks, local infiltration analgesia	Review	N/A	There are advantages and disadvantages with peripheral nerve blocks and local infiltration analgesia	<p>Strengths:</p> <ul style="list-style-type: none"> <li>• Good information on peripheral nerve blocks and local infiltration analgesia</li> <li>• Provides a comprehensive outlook on the future of multimodal analgesia</li> <li>• An authentic multimodal pain management protocol was developed</li> </ul> <p>Limitations:</p> <ul style="list-style-type: none"> <li>• Includes analgesics that are not part of the study</li> <li>• Not many analgesics are discussed</li> </ul>

Strong literature support based on a meta-analysis, an analysis of one randomized controlled trial (RCT), and a review study showed positive results for acetaminophen such as its ability to improve pain, reduce opioid consumption and its related adverse side effects after total knee arthroplasty and total hip arthroplasty (Lachiewicz, 2013; Singla et al., 2015; Yang et al., 2017). One randomized controlled trial showed that neither oral nor intravenous acetaminophen provided value in pain relief or reduction in opioid use (O'Neal et al., 2017). However, this study did not utilize the recommended doses of oral and intravenous acetaminophen and the study results were not considered statistically significant. The retrospective study results of Gallipani et al. (2017) reported side effects with intravenous acetaminophen treated patients and the study did not support the effectiveness of acetaminophen as part of a pain management regimen. However, this study did not

control for concomitant medications that may have been used by the patients at the time, which makes it hard to be certain the adverse side effects were due to the administration of acetaminophen.

## 6.2. Traditional nonsteroidal anti-inflammatory drugs

Nonsteroidal anti-inflammatory drugs reduce pain by inhibiting cyclooxygenase enzymes that synthesize prostaglandins during trauma, which causes inflammation and nociceptive pain. Traditional nonsteroidal anti-inflammatory drugs such as ibuprofen and ketorolac inhibit both cyclooxygenase-1 and cyclooxygenase-2 isoenzymes, which classifies them as nonselective. The inhibition of the cyclooxygenase-2 isoenzymes is what produces the analgesia and anti-inflammatory effects (Goyal et al., 2008).

Inhibition of both cyclooxygenase-1 and cyclooxygenase-2 isoenzymes can cause adverse effects on the gastrointestinal and hematologic systems, as the former plays a key role in gastric mucosa protection and platelet aggregation. Also, caution must be taken in patients with renal impairment or significant cardiovascular disease (McCartney and Nelligan, 2014). Traditional nonsteroidal anti-inflammatory drugs are also associated with increased postoperative bleeding, wound hematoma, and increased blood transfusion requirements after total joint arthroplasty (Schroer et al., 2011). Some studies also mention the effect of nonsteroidal anti-inflammatory drugs on bone formation and healing as a potential concern (Horlocker, 2010). Approved postoperative administration of ibuprofen should be 800 mg every 6 h and ketorolac should be 15–30 mg every 6 h (Golladay et al., 2017).

The literature evidence was strong for traditional nonsteroidal anti-inflammatory drugs as part of a multimodal analgesics regimen. A randomized, placebo-controlled clinical trial that combined intravenous ibuprofen with intravenous acetaminophen for pain management showed pain improvement, reduction in opioid consumption, and reduction in adverse effects up until postoperative day 3 (Gupta et al., 2016). A retrospective, cohort study demonstrated beneficial effects of continuous intravenous ketorolac (Schwinghammer et al., 2017). This study also showed significant decrease in respiratory depression and antiemetic use in the continuous ketorolac group compared with the opioid protocol group. However, the study was only limited among total knee arthroplasty patients.

### 6.3. Cyclooxygenase-2 inhibitors

Cyclooxygenase-2 inhibitors are a newer class of nonsteroidal anti-inflammatory drugs that selectively inhibit the cyclooxygenase-2 enzyme, relieving pain and inflammation, while sparing the cyclooxygenase-1 enzyme, which protects the lining of the gastric mucosa. Therefore, cyclooxygenase-2 inhibitors such as celecoxib and parecoxib have fewer gastrointestinal side effects than traditional nonsteroidal anti-inflammatory drugs. Furthermore, selective inhibition of the cyclooxygenase-2 enzyme does not comprise platelet function, rendering it safe to be administered postoperatively (Schroer et al., 2011). As a result, cyclooxygenase-2 inhibitors can be administered in the immediate postoperative period (Goyal et al., 2008). The approved dosage for celecoxib is 200 mg twice daily (Golladay et al., 2017).

Similar to traditional nonsteroidal anti-inflammatory drugs, the literature review showed strong support for cyclooxygenase-2 inhibitors. Two randomized, double-blind, placebo-controlled studies provided strength to the evidence for cyclooxygenase-2 inhibitors, specifically celecoxib, as part of a multimodal analgesics regimen (Schroer et al., 2011; Viscusi et al., 2008). The study by Schroer et al. (2011) demonstrated significant clinical benefit of celecoxib use for up to 6 weeks after surgery. The results of a retrospective study (Kazerooni and Tran, 2015) highlighted that effectiveness of celecoxib as a COX-2 inhibitor depends on the patient's opioid tolerance. However, the study stated that celecoxib was largely associated with reduction in pain scores, opioid consumption, length of stay, and as needed opioid use. The study by Viscusi et al. (2008) showed that 20 mg of parecoxib twice was more effective than both placebo and 20 mg once daily, with no adverse effects. This poses the question of whether or not higher dose of parecoxib can be taken to maximize its effects while maintaining its safety profile. Between these studies, Kazerooni and Tran (2015) conducted the study among both total knee arthroplasty and total hip arthroplasty population, whereas Schroer et al. (2011) conducted the study only among total knee arthroplasty patients and Viscusi et al. (2008) conducted the study only among total hip arthroplasty patients.

### 6.4. Gabapentinoids

Gabapentinoids such as gabapentin and pregabalin are anti-convulsants often used after surgeries to reduce pain and opioid consumption. Gabapentin is widely used as an adjunct for postoperative pain management, including total knee arthroplasty and total hip arthroplasty. The exact mechanism of the analgesic effect of gabapentinoids is still uncertain, however, it is assumed to inhibit voltage gated  $Ca^{2+}$  channels and release of neurotransmitter glutamate, involved in pain sensation and transmission (Chincholkar, 2018). Side effects of gabapentin are usually mild, with the most common ones being somnolence, dizziness, ataxia, and fatigue, making it a relatively safe drug to administer (Clarke et al., 2009). However, doses of gabapentinoids should be reduced in older patients with renal or hepatic impairment (McCartney and Nelligan, 2014). It is recommended that 600 mg of gabapentin should be given 3 times a day and 150 mg of pregabalin should be given twice a day after surgery (Golladay et al., 2017). For gabapentin, higher doses exhibited an analgesic ceiling effect, with more side effects without further reduction in pain (Clarke et al., 2014).

The literature review on gabapentinoids as part of a multimodal analgesics regimen concluded in some mixed results. A meta-analysis supported gabapentin and its effectiveness as an analgesic and its opioid-sparing abilities. However, the study did show that there was a significant increase in dizziness and an increase in sedation with its use (Peng et al., 2007). In a randomized, double-blind, controlled study that was conducted twice, the first of which was on total hip arthroplasty A patients, gabapentin showed no benefits of use in regards to pain relief or reduction in opioid consumption (Clarke et al., 2009). However, the second study which was conducted on total knee arthroplasty patients did show improvement in pain and reduction in opioid consumption along with some improvements in functionality (Clarke et al., 2014). An empirical analysis of two randomized, controlled trials showed no evidence that gabapentin has clinical benefits as an analgesic (Zhang et al., 2015). Both a meta-analysis and a randomized controlled trial favored pregabalin as a multimodal analgesic (Kadic et al., 2017; Li et al., 2017). The meta-analysis showed benefits of pregabalin in terms of pain control, reduction in opioid consumption, knee flexion degree, and adverse effects (Li et al., 2017). The randomized controlled trial showed decrease in opioid consumption and some degree of improvement in knee flexion (Kadic et al., 2017). A retrospective study concluded that pregabalin may even decrease opioid consumption in patients who are opioid tolerant (Sawan et al., 2014), but it was only conducted among total knee arthroplasty patients.

### 6.5. Ketamine

The drug ketamine could be a versatile addition to multimodal analgesia. Ketamine in low dosage has been shown to improve pain management after total knee arthroplasty through antagonism of the *N*-methyl-D-aspartate (NMDA) receptor, which produces anesthetic effects. Although low-doses of ketamine has been shown to improve pain management, it is not commonly used due to availability of other effective medications and its potential psychomimetic adverse effects such as hallucinations and nightmares (McCartney and Nelligan, 2014).

The literature evidence was robust for ketamine, as both a systematic review and a randomized controlled trial strongly supported the efficacy of ketamine as a multimodal analgesic. Both studies showed lower pain score, reduced opioid consumption, and improved mobilization with the use of ketamine (Souzdanitski et al., 2014; Remerand et al., 2009). The randomized controlled trial showed that ketamine is effective even in the

presence of other analgesics (Remerand et al., 2009). In addition, the study showed that ketamine improved rehabilitation up to 1 month and postoperative chronic pain up to 6 months after surgery. However, Souzdalnitski et al. (2014) included surgeries other than total knee arthroplasty while Remerand et al. (2009) only included total hip arthroplasty patients.

### 6.6. Peripheral nerve block

The use of peripheral nerve block (PNB) is a technique that specifically targets the lower-extremities as a non-opioid analgesic for pain management after total arthroplasty. It involves the percutaneous insertion of a catheter intraoperatively. The catheter infuses anesthetic medications, usually ropivacaine and epinephrine to decrease nerve stimulation in the area (McKenzie et al., 2013). Peripheral nerve blocks include femoral nerve blocks, fascia iliaca blocks, and lumbar plexus blocks. It can be in the form of a continuous infusion or a single-dose injection (Goyal et al., 2008). The femoral nerve block is a commonly used technique in total knee arthroplasty. The femoral nerve is readily accessible and there is level one evidence that targeting this nerve reduces pain and opioid consumption following total knee arthroplasty (Byrne and Clark, 2015). The limitation of femoral nerve block is anesthetic-induced quadriceps weakness, which can increase the risk for falls (Horlocker, 2010). However, the saphenous nerve block and adductor canal block may be useful adjuncts for avoiding this issue while providing pain relief (McCartney and Nelligan, 2014).

Only one review article (Horlocker, 2010) addressed the benefits of peripheral nerve block after total joint arthroplasty and the article highlighted the benefits of early mobilization, faster rehabilitation, and reduced length of stay with its usage. The study mentioned potential side effects associated with the presence of a lower-extremity block such as motor blockade that can make ambulation difficult, nerve injury, bleeding, and infection (Horlocker, 2010). Quality articles that studied the use of peripheral nerve block were limited and were not evaluated in this study.

### 6.7. Local infiltration analgesia

The analgesic technique of local infiltration analgesia (LIA), also known as peri or intra-articular injection, involves the systematic infiltration of analgesics into the tissues around the structures that were subjected to surgical trauma. It can also be followed by top-ups and extensive re-injection through a catheter that has been placed during surgery. The analgesics can consist of a mixture of pharmacological agents such as morphine sulfate, nonsteroidal anti-inflammatory drugs, epinephrine, methylprednisolone, and local anesthetics such as bupivacaine or ropivacaine (McKenzie et al., 2013). The optimal mixture of local infiltration analgesia is still a subject that requires further research. The technique was developed to avoid sedation and facilitate rapid physiological recovery in an effort to enable early mobilization and rehabilitation (Kerr and Kohan, 2008). Administration of local infiltration analgesia has gained popularity due to its ability to spare motor blockade and risk of falling in patients (Kadic et al., 2017), which are potential side effects of peripheral nerve blocks, as mentioned previously. However, its limitation is that it has a short duration of action as it is in the form of a single-injection (McCartney and Nelligan, 2014).

Both the reviewed studies (Kerr and Kohan, 2008; Seangleulur et al., 2016) supported the use of local infiltration analgesia for effective pain management after knee and hip surgery. In an open, non-randomized study by Kerr and Kohan (2008), the results showed satisfactory pain control, reduction in opioid consumption, and improved rehabilitation. Side effects such as orthostatic

hypotension and nausea/ vomiting were occasionally associated with initial standing. The local infiltration analgesia used in this study comprised of a mixture of ropivacaine, ketorolac, and adrenaline. In the meta-analysis by Seangleulur et al. (2016), local infiltration analgesia use was associated with lower pain score, reduction in opioid consumption, higher range of motion, and shorter length of stay. The study results showed that its use was relatively safe, with no association of serious effects or complications. However, the study did not include the common medications that comprised the local infiltration analgesia.

### 6.8. Multimodal pain management

The pain associated with total knee arthroplasty and total hip arthroplasty is mediated by multiple pathways. As a result, a comprehensive postoperative pain management is necessary, such as a multimodal analgesics regimen that uses at least 2 agents with different mechanisms to control pain (Schwinghammer et al., 2017). It utilizes a multidisciplinary approach with the purpose of maximizing the positive aspects of the treatment while minimizing the potential side effects (Horlocker, 2010). The World Health Organization (WHO) and the American society of Anesthesiologists (ASA) have recommended that multimodal pain management should be implemented whenever possible (Gallipani et al., 2017).

Several studies combined several non-opioid analgesics and studied its effect on postoperative pain management and recovery after total knee arthroplasty and total hip arthroplasty, which resulted in favorable results (Byrne and Clark, 2015; Golladay et al., 2017; Goyal et al., 2008; McCartney and Nelligan, 2014; McKenzie et al., 2013). The review by Golladay et al. (2017) showed that multimodal analgesia had positive effect on both early and long-term outcomes for total knee arthroplasty and total hip arthroplasty patients. In the review by McKenzie et al. (2013), an authentic multimodal pain management protocol was developed for total knee arthroplasty and total hip arthroplasty patients, which resulted in significant reduction in pain and decrease in opioid consumption. This study utilized acetaminophen, celecoxib, and pregabalin as part of their non-opioid analgesics. McCartney and Nelligan (2014) stated in their study that administration of non-opioid analgesics should be given with caution or reduced in the elderly population who have physiological impairments.

## 7. Discussion

The goal of this integrative review was to synthesize literary evidence on the effects of non-opioid interventions as part of multimodal pain management for total knee arthroplasty and total hip arthroplasty. The summary of the postoperative outcomes related to the non-opioid interventions are reported in Table 2.

Of the 27 reviewed articles, a majority ( $n = 23$ ) supported non-opioid interventions as part of multimodal pain management after total knee arthroplasty and total hip arthroplasty, while the rest of the articles did not show clinical significance of non-opioid analgesics as part of a pain management regimen ( $n = 4$ ). Among the articles that supported non-opioid analgesics, the evaluation of non-opioid interventions resulted in improvement in pain as well as other postoperative outcomes after total knee arthroplasty and total hip arthroplasty (Byrne and Clark, 2015; Clarke et al., 2014; Golladay et al., 2017; Kadic et al., 2017; Kerr and Kohan, 2008; Li et al., 2017; McCartney and Nelligan, 2014; McKenzie et al., 2013; Remerand et al., 2009; Seangleulur et al., 2016; Schroer et al., 2011; Souzdalnitski et al., 2014). Among the non-opioid interventions that were reviewed, the superior ones were cyclooxygenase-2 inhibitors, traditional nonsteroidal anti-inflammatory drugs, ketamine, and local infiltration analgesia due to the highly promising results with postoperative outcomes after total knee

**Table 2**  
Postoperative outcomes after total knee arthroplasty and total hip arthroplasty.

Author (s) & Year	Non-opioid interventions	Improvement in pain	Functional outcomes	Side effects of medication	Reduced opioid consumption & related adverse effects
Byrne and Clark (2015)	Multimodal pain management	Yes	Yes	N/A	Yes
Clarke et al. (2009)	Gabapentin	No	N/A	No adverse side effect noted	No
Clarke et al. (2014)	Gabapentin	Yes	Yes; better active assisted knee range of motion	No adverse side effect noted	Yes
Gallipani et al. (2017)	Acetaminophen	No	N/A	Yes; anemia and increased alanine aminotransferase (ALT)	No
Golladay et al. (2017)	Multimodal pain management	Yes	Yes	N/A	Yes
Goyal et al. (2008)	Multimodal Analgesia	Yes	N/A	N/A	Yes
Gupta et al. (2016)	Nonsteroidal anti-inflammatory drugs -ibuprofen	Yes	N/A	N/A	Yes
Horlocker (2010)	Peripheral nerve block	N/A	Yes; early mobilization, rehabilitation and reduced hospital stay	Yes; potential nerve injury, bleeding, and infection	N/A
Kazerooni and Tran (2015)	Cyclooxygenase-2 inhibitor -celecoxib	Yes	N/A	N/A	Yes
Kadic et al. (2017)	Gabapentinoid -pregabalin	Yes	Yes; some improvement in knee flexion degree	Yes; diplopia and dizziness	Yes
Kerr and Kohan (2008)	Local infiltration analgesia	Yes	Yes; improved mobilization	Yes; orthostatic hypotension and nausea/vomiting	Yes
Lachiewicz (2013)	Acetaminophen	Yes	N/A	No adverse side effects noted	Yes
Li et al. (2017)	Gabapentinoid -pregabalin	Yes	Yes; improved knee flexion degree	No adverse side effect noted	Yes
McCartney and Nelligan (2014)	Multimodal pain management	Yes	Yes	N/A	Yes
McKenzie et al. (2013)	Multimodal pain management	Yes	Yes	N/A	Yes
O' Neal et al. (2017)	Acetaminophen	No	N/A	N/A	No
Peng et al. (2007)	Gabapentinoid -gabapentin	Yes	N/A	Yes; dizziness and sedation	Yes
Remerand et al. (2009)	Ketamine	Yes	Yes; improved mobilization	No adverse side effect noted	Yes
Sawan et al. (2014)	Gabapentinoid -pregabalin	N/A	N/A	No adverse side effect noted	Yes
Schroer et al. (2011)	Cyclooxygenase -2 inhibitor -celecoxib	Yes	Yes; faster return of knee range of motion and function	Yes; cardiovascular events	Yes
Schwinghammer et al. (2017)	Nonsteroidal anti-inflammatory drugs -ketorolac	Yes	N/A	No adverse side effect noted	Yes
Seangleulur et al. (2016)	Local infiltration analgesia	Yes	Yes; improved range of motion	N/A	Yes
Singla et al. (2015)	Acetaminophen	Yes	N/A	No adverse side effect noted	Yes
Souzdalnitcki et al. (2014)	Ketamine	Yes	Yes; improved mobilization	N/A	Yes
Viscusi et al. (2008)	Cyclooxygenase -2 inhibitor -parecoxib	Yes	N/A	No adverse side effects noted	Yes
Yang et al. (2017)	Acetaminophen	Yes	N/A	N/A	Yes
Zhang et al. (2015)	Gabapentinoid -gabapentin	No	N/A	N/A	No

arthroplasty and total hip arthroplasty. Additionally, the gabapentinoid pregabalin is a notable non-opioid intervention that received strong support, as well.

With regard to side effects, there were only few reported remarkable side effects for the non-opioid interventions (n = 6). Of the reported side effects, they were only minor incidents such as anemia and increase alanine aminotransferase (ALT) related to acetaminophen (Gallipani et al., 2017), diplopia, dizziness, and sedation related to gabapentinoids (Peng et al., 2007; Kadic et al., 2017), orthostatic hypotension and nausea/ vomiting related to local infiltration analgesia (Kerr and Kohan, 2008), and cardiovascular events related to cyclooxygenase-2 inhibitor celecoxib (Viscusi et al., 2008). Reduction in opioid related adverse effects with the use of non-opioid interventions were reported in majority of the articles (n = 21). The opioid related adverse events that were commonly reduced were respiratory depression, nausea/vomiting, pruritus, and impaired concentration.

The evidence from the articles illustrated the ability of non-opioid interventions to improve functional outcomes after total knee arthroplasty and total hip arthroplasty, as the majority of

non-opioid interventions led to improvement in functional outcomes (n = 13). The commonly reported functional outcomes included improvement in range of motion (Clarke et al., 2009; Kadic et al., 2017; Li et al., 2017; Seangleulur et al., 2016; Schroer et al., 2011) and early mobilization (Horlocker, 2010; Kerr and Kohan, 2008; Remerand et al., 2009; Souzdalnitcki et al., 2014). One particularly noteworthy study is the review study conducted by Horlocker (2010), where the use of a non-opioid intervention resulted in functional outcomes of early mobilization, rehabilitation, and reduced length of stay.

Overall, our review presented favorable results with different non-opioid interventions as part of multimodal pain management for patients after total knee arthroplasty and total hip arthroplasty. The reviewed articles included study settings in the United States, Spain, Australia, New Zealand, and Scotland. Many of the studies in the article were multi-centered or synthesized studies that were conducted in multiple different institutions and settings, as well. This demonstrates the feasibility and acceptability of different non-opioid interventions across diverse healthcare settings in the world.

As the pain management paradigm is focusing on a shift from heavy dependency on opioids to other non-opioid measures, the synthesis of results in this review are promising, as exhibited by the magnitude of literature in support of non-opioid interventions. However, future quality research trials are necessary at this time, as there does exist confounding evidence in the support of non-opioid interventions. This is essential for grounded evidence-based information, so that we as a healthcare community are able to establish a common understanding of what constitutes as best practice when it comes to pain management after total knee arthroplasty and total hip arthroplasty.

## 8. Nursing implications

The result of this review will help practicing nurses to advocate for different non-opioid interventions for patients after total knee arthroplasty and total hip arthroplasty and to develop a teaching tool for educating patients regarding different non-opioid interventions that are available in practice.

Discussion of pain management and other educational strategies has been shown to reduce hospital length of stay and may help improve postoperative pain management and rehabilitation (McCartney and Nelligan, 2014). Nurses spend a significant amount of time with patients in the hospital, more than any of the other health care team professionals. Therefore, it is pivotal for nurses to make sure that patients receive high quality and effective education. The development of effective patient education interventions has been described as one of the many ways to ensure the future of quality nursing (Ingadottir et al., 2016).

Increased knowledge of analgesic effects improves adherences to pain management, and consequently reduces pain (Bjornness et al., 2017). Postoperative patients are one of the growing groups of patients who need comprehensive and timely education, as they have a larger role in postoperative self-care due to shorter hospitalization times (Ingadottir et al., 2016).

## 9. Limitations

There are several limitations to this study. There is limitation to the literature review, as only one person extracted the literature and performed the inclusion/exclusion process. This can result in human error and potential bias can exist, such as for the study to produce positive outcomes for multimodal pain management. Another limitation is that although this study focuses on postoperative pain management, the literature was not screened for incorporation of preoperative and intraoperative pain management. Many of the literature have preoperative and intraoperative pain management as part of their trial process. This makes it hard to establish if the efficacy of the analgesics is based on its postoperative use.

## 10. Conclusion

Total knee arthroplasty and total hip arthroplasty are two of the most prevalent surgeries performed, and they are expected to increase due to aging population and longevity. Inefficient pain control may lead to slower recovery period, increased healthcare costs, and decline in overall patient satisfaction. In this manner, successful pain control becomes a pertinent issue in the field of healthcare. Opioids have traditionally been used to control postoperative pain. However, opioids have a multitude of adverse effects with its use. Hence, the transition to a multimodal pain management approach has recently been advocated. Information gathered from this review will help to inform practicing nurses on non-opioid interventions after total knee arthroplasty and total hip arthroplasty, which they can utilize to advocate for their patients.

## Declaration of Competing Interest

There are no conflict of interest that exist.

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