Pain Management Strategies To Reduce Opioid Use Following Total Knee Arthroplasty

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ABSTRACT

Introduction: Due to the rising concern regarding excessive opioid use, several alternative pain control options have been developed for total knee arthroplasty (TKA). Therefore, the purpose of this article was to review non-narcotic treatments to manage pain after TKA. Specifically, we evaluated: 1) acetaminophen; 2) cyclooxygenase-2 (cox-2) inhibitors; 3) gabapentinoids; 4) dexmedetomidine, 5) nerve blocks; 6) local analgesic infiltration; 7) transcutaneous electrical nerve stimulation (TENS); and 8) perioperative bracing.

Materials and Methods: A literature search was conducted using the PubMed and EBSCO host electronic databases. All available studies between 1998 and 2018 were evaluated. Searches were performed using the following terms: total knee arthroplasty (title), acetaminophen (title), cyclooxygenase-2 inhibitors (title), gabapentinoids (title), nerve blocks (title), local analgesic infiltration (title), transcutaneous electrical nerve stimulation (title), knee (title), postoperative outcome (title), opioids (title), analgesics (title), alternative (title), heroin (title), chronic pain (title), opioid overdose (title), and cost (title). After full-text analysis of 273 reports that satisfied the search criteria, 58 studies were included in this review.
Results: There is conflicting evidence on acetaminophen and gabapentinoids, with some studies reporting opioid use reduction with their use; whereas, others found no difference. Cox-2 inhibitors can potentially reduce opioid requirements and improve pain scores following TKA; however, they are associated with several side effects. Dexmedetomidine has been associated with reduced postoperative opioid consumption, but it has limited applications as it is associated with several major side effects. Neuraxial anesthesia can potentially help control postoperative pain; however, there is a limited effective window and identifying the specific nerve can be challenging. Local infiltrating analgesia have been found to help relieve pain in the early postoperative period. Multiple studies have identified substantial reductions in pain with knee braces. The non-invasive and non-pharmacologic nature of this treatment option makes it very safe and effective for the generalized TKA population.

Conclusion: The optimal solution for postoperative TKA pain management has yet to be determined. Although several options exist, many of them have been associated with adverse effects limiting their generalizability. Knee braces, however, have been identified as one potentially successful option. Importantly, knee braces are safe for the majority of patients and should be widely recommended for patient use.

INTRODUCTION

Inadequate postoperative pain control following total knee arthroplasty (TKA) can lead to limited participation in physical therapy, knee stiffness, lower patient satisfaction rates, increased lengths of stay, increased healthcare costs, and chronic pain. Poor pain control can also place specific populations of patients at risk for myocardial infarction, hypostatic pneumonia, anxiety, and depression. There is increasing evidence that chronic pain leads to chronic opioid use and addiction. Misuse of opioids is responsible for a $78.5 billion deficit with $28.9 billion used for an increased need for healthcare and drug rehabilitation. In 2018, the United States Congress passed the Substance Use Disorder Prevention That Promotes Opioid Recovery and Treatment for Patients and Communities (SUPPORT) bill. This bill allocates more research funding to study the effectiveness of non-opioid analgesics in pain management, to promote the use of telemedicine to treat opioid addiction in rural areas, and to provide early intervention for children who are at high risk for chronic opioid use, such as trauma.

More than 350,000 opioid overdoses occurred between 1999 and 2016, with an estimated 115 overdoses occurring daily in the United States. Some data suggests that 80% of the world’s opioid prescriptions are filled in the United States. The positive effects of mu-opioid receptors agonists, including pain relief and euphoria, must be considered alongside the many adverse effects of these drugs, including decreased gastric motility, respiratory depression, cough suppression, nausea, and vomiting. Chronic opioid use can also result in dependence and manifest in withdrawal symptoms if not regularly consumed. Similarly, short-acting mu-receptor agonists are associated with higher risks of addiction due to the rapid onset of euphoria followed by withdrawal symptoms. Largely due to their euphoric properties, prescription opioids have been associated with a 21 to 29% misuse rate and an 8 to 12% addiction rate. Misuse of prescription opioids have also been associated with a 4 to 6% risk for transitioning to heroin use. Chronic opioid use presents a major problem for the ultimate success of TKAs in terms of patient outcomes, complications, and financial burdens. Additionally, preoperative opioid use has been considered the strongest risk factor for chronic postoperative opioid use. A potential approach to address this postoperative problem is to provide adequate pain relief in the perioperative period while minimizing the use of opioids and adopting a multimodal approach of non-opioid analgesics. However, these alternative pain management options have not been well-identified and consolidated. Therefore, the purpose of this article was to review the alternative non-narcotic treatments to manage pain after TKA. Specifically, we evaluated: 1) acetaminophen; 2) cox-2 inhibitors; 3) gabapentinoids; 4) dexmedetomidine, 5) nerve blocks; 6) local analgesic infiltration; 7) transcutaneous electrical nerve stimulation; and 8) perioperative bracing.

MATERIALS AND METHODS

A thorough literature search was conducted using the PubMed and EBSCO Host electronic databases. All available studies between January 1, 1998 and December 31, 2018 were evaluated. Searches were performed using the following terms: total knee arthroplasty (title), acetaminophen (title), cyclooxygenase-2 inhibitors (title), gabapentinoids (title), nerve blocks (title), local analgesic infiltration (title), transcutaneous electrical nerve
stimulation (title); knee (title), postoperative outcome (title), opioids (title), analgesics (title), alternative (title), heroin (title), chronic pain (title), opioid overdose (title), and cost (title).

Reports were included if they evaluated clinical postoperative outcomes following TKA, the full text was available, and were written in the English language. Exclusion criteria were the following: basic science studies, cadaveric studies, animal studies, conference abstracts, conference reviews, editorials, letters to the editor, surveys, case reports, and case series.

An initial literature search was performed by two authors. Abstracts were screened to determine if identified articles met the inclusion and exclusion criteria. The full text of selected articles were then further evaluated. The list of search results was screened for repeat articles by a third author. The references of all included studies were reviewed and determined for eligibility. The initial search yielded 657 reports. Through a Title and Abstract review, we identified relevant manuscripts that were subsequently recovered in full and studied, yielding 273 reports that satisfied the search criteria. After full-text analysis, 58 studies were included in this review (Fig 1).

**RESULTS**

**Acetaminophen**

The role of acetaminophen in managing pain after total knee arthroplasty is unclear. A large part of this uncertainty is due to the unclear mechanism of action. It is thought that intravenous (IV) acetaminophen decreases COX in the brain rather than selectively blocking the COX binding site. With these properties, IV acetaminophen can help reduce postoperative pain.

A meta-analysis by Liang et al., including 865 patients who underwent total joint arthroplasty, showed significantly decreased pain scores at 24 (p<0.05), 48 (p<0.05) and 72 hours (p=0.034). There was also a decrease in opioid use at 24 (p<0.05), 48 (p<0.05) and 72 (p<0.05) hours after surgery when administered IV acetaminophen. A large database study by Barrington et al. compared 134,216 TKA patients who received oral acetaminophen and 56,475 TKA patients who received IV acetaminophen. The group found that compared to the oral cohort, IV acetaminophen patients had a 0.14 days shorter length of stay (LOS) (95% CI, -0.15 to -0.13; p<0.001) and 22% higher chance of being discharged home (odds ratio [OR]=1.22; 95% CI, 1.19 to 1.25; p<0.001). The IV cohort also had a 13% lower chance of being discharged to a skilled nursing facility (SNF) (OR = 0.87; 95% CI, 0.85 to 0.90; p<0.001). Another group found IV acetaminophen to have lower readmission rates (0.04 vs. 0.14%); oral acetaminophen patients following TKA (69% CI = 0.20 to 0.47; p<0.001). In contrast, Nwagbologu and colleagues retrospectively reviewed 148 patients undergoing TKA of which 86 received IV acetaminophen and 62 did not. The authors concluded that there was no difference in total opioid use at 24 (54.2 ± 35.9 mg vs. 45.4 ± 30.2 mg; p=.12) and 48 hours (99.2 ± 68.7 mg vs. 79.5 ± 49.1 mg; p=.06) (Table 1).

A number of other studies have also identified conflicting results in reducing pain with intravenous acetaminophen. Additionally, IV acetaminophen has been associated with increased healthcare costs. This increased cost is of great concern, given that the expected number of TKAs performed within the next decade will increase to nearly 3.5 million cases annually. Therefore, although IV acetaminophen can potentially have benefits for certain patients, it may not be the only solution for large scale patient use.

**Cyclooxygenase-2 inhibitors**

Perioperative usage of Cyclooxygenase-2 (COX-2) inhibitors have been demonstrated to reduce opioid requirements and to improve patient outcomes following TKA. They work by blocking prostaglandin synthesis in the spinal cord and periphery, which are increased in surgical-site trauma. This drug has opioid-sparing effects and reduces postoperative nausea and vomiting. Unlike non-selective non-steroidal anti-inflammatory drugs (NSAIDs), COX-2 selective inhibitors have no effect on thromboxane or platelets, which makes them an effective form of analgesia without increased

![Figure 1. PRISMA diagram for study selection.](image-url)
bleeding risk (Table II). 34,35,37

Huang and colleagues prospectively reviewed 80 patients who underwent TKA. 34 Half of the patients received celecoxib 400mg one hour prior to surgery, followed by 200mg every 12 hours for five days postoperatively along with a morphine patient-controlled analgesia (PCA). The other half received PCA only. The authors observed a significant, 40% reduction in PCA usage (p = 0.03) in the celecoxib group and improved visual analogue scale (VAS) pain scores at 48 hours (2 ± 2 vs. 3 ± 2 points; p = 0.03) and 72 hours (2 ± 2 vs. 3 ± 2; p = 0.02).

Buvanendran and colleagues performed a prospective randomized double-blinded study of 70 patients undergoing TKA who either received a COX-2 inhibitor plus PCA or a placebo plus PCA for pain control. 35 Patients in the COX-2 group demonstrated a 20mg decrease in morphine equivalents (p < 0.05) and decreased median pain scores measured on the VAS scale during the hospital stay (2; range, 1 to 3)

### Table I

<table>
<thead>
<tr>
<th>Study</th>
<th>No. of patients, treatment, study type</th>
<th>Outcomes</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun et al. 18</td>
<td>236 (120 IV acetaminophen + multimodal anesthesia, 116 PO acetaminophen + multimodal anesthesia), meta-analysis</td>
<td>No significant difference in pain scores or opioid consumption</td>
<td>IV group: 27 nausea PO group: 25 nausea</td>
</tr>
<tr>
<td>Nwagbologu et al. 20</td>
<td>865 (534 IV acetaminophen + multimodal anesthesia, 331 multimodal anesthesia without IV acetaminophen), meta-analysis</td>
<td>Decreased pain and opioid use at 24, 48, and 72 hours postoperative with IV acetaminophen</td>
<td>None</td>
</tr>
<tr>
<td>Barrington et al. 23</td>
<td>148 (86 IV acetaminophen, 62 no acetaminophen), retrospective cohort study</td>
<td>No difference in opioid use at 24 or 48 hours</td>
<td>None</td>
</tr>
<tr>
<td>Mont et al. 24</td>
<td>134,216 oral acetaminophen 56,475 IV acetaminophen</td>
<td>IV acetaminophen associated with shorter hospital LOS (p&lt;0.001) as well as increased discharge to home (p&lt;0.001) and fewer patients to SNF (p&lt;0.001)</td>
<td>None</td>
</tr>
</tbody>
</table>

IV=intravenous, PO=per oral, LOS=length of stay, SNF=skilled nursing facility

### Table II

<table>
<thead>
<tr>
<th>Study</th>
<th>No. of patients, treatment, study type</th>
<th>Outcomes</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Huang et al. 34</td>
<td>80 (40 celecoxib + PCA, 40 PCA only), prospective randomized, observer-blind control study</td>
<td>40% reduced opioid consumption</td>
<td>None</td>
</tr>
<tr>
<td>Buvanendran et al. 35</td>
<td>70 (35 rofecoxib + PCA, 35 PCA only), prospective randomized double-blind study</td>
<td>20mg decrease in morphine equivalents</td>
<td>1 patient with pulmonary edema in rofecoxib group, 1 patient with foot drop in placebo group</td>
</tr>
<tr>
<td>Baharuddin et al. 36</td>
<td>34 (18 IV parecoxib, 14 IV morphine) randomized, double-blind study</td>
<td>No significant difference in numeric rating scale for pain</td>
<td>6 patients in the morphine group experienced dizziness</td>
</tr>
<tr>
<td>Bian et al. 37</td>
<td>88 (46 parecoxib + PCA, 42 placebo + PCA) prospective randomized-controlled study</td>
<td>Parecoxib group had lower VAS scores in PACU (p=0.039)</td>
<td>None</td>
</tr>
<tr>
<td>Reynolds et al. 38</td>
<td>209 (70 morphine + placebo, 70 morphine + valdecoxib 40mg, 69 morphine + valdecoxib 80 mg) multicenter, multidose, randomized-controlled trial</td>
<td>16% less morphine used in valdecoxib 40mg group and 24% less morphine use in valdecoxib 80mg</td>
<td>1 patient in morphine + valdecoxib 40mg developed acute renal failure and metabolic acidosis</td>
</tr>
</tbody>
</table>

PCA=patient-controlled analgesia, IV=intravenous, VAS=visual acuity scale, PACU=postoperative anesthesia care unit
intestinal, and cardiovascular side effects, identified concerns, such as renal, gastrointestinal. Additionally, like most pills utilized for pain management, COX-2 inhibitors are most effective when used in regular prescribed time intervals to help prevent the onset of pain. However, most patients commonly will miss a dose and have resultant pain. Therefore, while COX-2 inhibitors can provide some pain relief, typically in conjunction with other, stronger pain relief modalities, there are still concerns with their use.

**Gabapentinoids**

Pregabalin and gabapentin act on voltage-gated calcium channels at the post-synaptic dorsal horns in the spinal cord and brain and interrupt pain signal transmission. Because of their mechanism of action, this class of medication has been commonly utilized for postoperative pain management (Table III).

Buvanendran et al. performed a randomized-controlled trial of 240 TKAs in which half of the population was administered pregabalin in the immediate preoperative period followed by 14 days of postoperative use. When compared to the placebo group, the pregabalin group showed a decrease in epidural (p=0.003) and oral opioid (p=0.005) use during their hospital stay along with a 75% reduction in neuropathic pain at six months. Jain and colleagues randomized 40 TKAs into two groups: 75 mg pregabalin and a placebo group. They concluded that there was a significant difference in postoperative pain and opioid consumption with pregabalin use. In an RCT of 410 patients undergoing surgery, perioperative use of gabapentin decreased opioid cessation by 24%.

In contrast, Lunn and colleagues studied 300 opioid-naive patients undergoing TKA in a double-blind randomized controlled trial broken down into three groups: 1300 mg gabapentin, 900 mg gabapentin, and placebo. The study groups received gabapentin two hours preoperatively until postoperative day six. They found no significant difference in analgesia or opioid consumption postoperatively.

Based on the above studies, there is conflicting data on the effectiveness of gabapentinoid use in reducing postoperative opioid use after TKA. Further randomized-controlled trials with larger numbers of patients may be required to make definitive conclusions on the effectiveness of these agents in reducing postoperative narcotic consumption following TKA.

**Dexmedetomidine**

Dexmedetomidine (DEX) is a highly selective alpha 2-adrenergoreceptor agonist that can cause sedation, reduced anxiety, and analgesia without respiratory

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**Table III**

<table>
<thead>
<tr>
<th>Study</th>
<th>No. of patients, treatment, study type</th>
<th>Outcomes</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buvanendran et al.</td>
<td>240 (113 pregabalin, 115 placebo)</td>
<td>Decrease in epidural and PO opioids during hospital stay</td>
<td>Pregabalin: 1 diplopia, 4 vomiting, 14 confusion</td>
</tr>
<tr>
<td>Jain et al.</td>
<td>40 (20 75mg BID pregabalin, 20 placebo)</td>
<td>Decrease in postoperative pain and opioid consumption</td>
<td>Pregabalin: 10 Gl symptoms, 1 urinary retention</td>
</tr>
<tr>
<td>Lunn et al.</td>
<td>300 (100 1300mg gabapentin, 100 900mg gabapentin, 100 placebo)</td>
<td>No significant difference in analgesia or opioid consumption post-operatively</td>
<td>1300mg gabapentin: 2 confusion, 1 impaired balance, 3 hypotension, 3 diplopia, 3 dizziness, 1 visual disturbance</td>
</tr>
<tr>
<td>Hah et al.</td>
<td>410 (208 gabapentin 1200mg, 202 placebo), randomized, double-blind, placebo-controlled trial</td>
<td>24% increase in the rate of opioid cessation after surgery in gabapentin group, no difference in pain cessation</td>
<td>Gabapentin: 1 PE, 1 pneumothorax Placebo: 1 p/o hemodynamic instability, 1 surgical site hematoma</td>
</tr>
</tbody>
</table>

PE=pulmonary embolism, p/o=postoperative, GI=gastrointestinal
A prospective, randomized-controlled trial of 60 TKAs comparing DEX 2ug/kg with bupivacaine versus bupivacaine alone showed a decrease in postoperative mean morphine consumption (22.85 mg vs. 32.15 mg) and VAS scores in the DEX group (p < 0.05). Also, mean duration of analgesia was longer with the addition of DEX, and there was no difference in adverse effects. A meta-analysis of 28 randomized-controlled trials, with a total of 1420 patients undergoing surgery who received intravenous DEX, identified reduced opioid consumption (-17.2 mg; 95% CI: -24.4 to -10.1; p = .00001) and fewer opioid-related adverse effects (0.66; 95% CI: 0.43 to 1.02; p = .06) of DEX compared to placebo.

Based on this data, the use of DEX can potentially be a safe method to decrease opioid use following TKA. However, a key mechanism of action for this pharmaceutical is sedation, which can prevent patients from appropriately carrying out normal activities of daily living. Furthermore, a number of side effects have been noted with DEX. These include, but are not limited to: hypo/hypertension, nausea, vomiting, dry mouth, bradycardia, atrial fibrillation, as well as many others. Therefore, further randomized-controlled trials with larger numbers in the TKA population are necessary before the general use of DEX in this group can be recommended.

### Table IV

**Studies evaluating the use of dexmedetomidine for the management of pain after total knee arthroplasty**

<table>
<thead>
<tr>
<th>Study</th>
<th>No. of patients, treatment, study type</th>
<th>Outcomes</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Packiasabapathy et al.46</td>
<td>60 (20 DEX 2ug/kg + FNB, 20 DEX 1ug/kg + FNB, 20 FNB), prospective randomized-controlled trial</td>
<td>Decrease in postoperative mean morphine consumption (22.85 mg vs. 32.15 mg) and VAS scores in the DEX group</td>
<td>DEX 2ng/kg + FNB: 4 hypotension, 4 bradycardia DEX 1ug/kg + FNB: 1 hypotension, 3 bradycardia FNB: 2 hypotension</td>
</tr>
<tr>
<td>Schnabel et al.47</td>
<td>1420 (IV DEX, placebo), Meta-analysis</td>
<td>Reduced opioid consumption in DEX group</td>
<td>DEX: 38 bradycardia Placebo: 14 bradycardia</td>
</tr>
</tbody>
</table>

DEX=dexmedetomidine, FNB=femoral nerve block, VAS=visual acuity scale, IV=intravenous

### Table V

**Studies evaluating the use of neuraxial anesthesia for the management of pain after total knee arthroplasty**

<table>
<thead>
<tr>
<th>Study</th>
<th>No. of patients, treatment, study type</th>
<th>Outcomes</th>
<th>Complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memtsoudis et al.50</td>
<td>382,236 (40,036 neuraxial, 49,396 under combined neuraxial–general, and 292,804 under general anesthesia), Meta-analysis</td>
<td>Thirty-day mortality was significantly lower among neuraxial and combined neuraxial–general groups compared with those undergoing surgery under general anesthesia</td>
<td>Neuraxial: 129 PE, 28 CVA, 141 PC, 295 PNA, 1301 Infxn, 456 ARF, 102 MI Neuraxial-general: 172 PE, 58 CVA, 310 PC, 435 PNA, 1943 Infxn, 731 4935 ARF, 126 MI General: 1307 PE, 374 CVA, 2234 PC, 2669 PNA, 12507 Infxn, ARF, 787 MI</td>
</tr>
<tr>
<td>Chan et al.51</td>
<td>2710, FNB vs. PCA meta-analysis</td>
<td>FNB had lower opioid requirements at 24 hours, more knee flexion at 48 hours, and higher patient satisfaction when compared to PCA</td>
<td>None</td>
</tr>
<tr>
<td>Hanson et al.52</td>
<td>80 (40 continuous adductor canal block, 40 sham-block), randomized double-blind trial</td>
<td>Continuous adductor canal block for total knee arthroplasty reduces opioid consumption compared with that of placebo in the first 48 hours after surgery</td>
<td>None</td>
</tr>
</tbody>
</table>

PCA=patient-controlled analgesia, FNB=femoral nerve block, PE=pulmonary embolism, CVA=cerebrovascular accident, PC=posterior cerebral, PNA=pneumonia, Infxn=infection, ARF=acute renal failure, MI=myocardial infarction
Neuraxial anesthesia

The role of general anesthesia in TKA has been diminished because of suboptimal outcomes when compared to neuraxial anesthesia. It can more specifically target nerve distributions responsible for pain signal transmission than systemic pain management options. Because of their concentrated, local effect, patients typically experience fewer systemic complications (Table V).

A meta-analysis of 382,236 TKAs concluded that general anesthesia has a higher risk of pulmonary compromise (p<0.00001), pneumonia (p=0.008), infections (p<0.0001), and 30-day mortality (p=0.02) when compared to neuraxial anesthesia. Chan and colleagues retrospectively reviewed 45 RCTs consisting of 2710 participants undergoing TKA with PCA or femoral nerve block (FNB). Patients who received an FNB had lower opioid requirements at 24 hours (-14.7mg, 95% CI -18.7 to -10.8 mg) and at 48 hours (-14.5mg, 95% CI -20.0 to -9.0), lower risk of nausea and vomiting, more knee flexion, and higher patient satisfaction when compared to PCA. A continuous adductor canal block for TKA is a common adjunct to reduce pain postoperatively. Adductor canal blocks avoid motor weakness as seen in PCA. A continuous adductor canal block (n =40) versus a placebo (n =40). The mean morphine consumption over 48 hours was 16.7 mg less in the adductor canal block (95% confidence interval, -29.8 to -3.6, p=0.013).

Although nerve blocks have a role in postoperative pain management, there are some limitations. Specifically, identification of the target nerve and delivery of the injection can be potentially challenging, especially in obese patients, a subpopulation of patients for which TKA is increasing. Additionally, these injections are commonly performed in the operating room after the procedure, resulting in increased operating room time and utilization. Furthermore, nerve blocks typically have a limited effective window, so are not long-term solutions. Given these drawbacks, neuraxial anesthesia might be an option for immediate postoperative pain control, but it is not a sustainable option for patients.

Local infiltrating analgesia

Intraoperative local infiltrating analgesia (LIA) has been shown to reduce morphine consumption and improve pain control without any apparent risks. Recently, a number of studies have reported on the efficacy of local infiltrating analgesic injections with liposomal bupivacaine (LB), as well as with and without dexamethasone (Table VI).

Springer found that LB, when compared to a sciatic nerve block, has a...
greater effect on the reduction of opioid use, postoperative pain, and costs of TKA. Other authors have reported on 140 TKAs using LIA with LB versus LIA with bupivacaine. LIA with LB resulted in a 66.2 mg decrease in opioid consumption 0 to 72 hours postoperatively (p=0.048) and a mean decrease in VAS pain intensity scores by 28.5 points.

The use of LIA with and without dexamethasone has also been investigated, but its following TKA is controversial due to the lack of data. The authors concluded—in a meta-analysis of eight RCTs in patients who underwent TKA with intraoperative LIA with dexamethasone—that LIA with dexamethasone resulted in reduced total opioid consumption (p=0.00001), VAS scores at 24 hours (p<0.0001) and 48 hours (p=0.0002), and postoperative nausea (p=0.00001). Another meta-analysis by Choi et al. of nine RCTs, including 727 patients who received LIA with and without corticosteroid, resulted in decreased opioid consumption (p<0.05) and VAS pain scores at 24 and 48 hours postoperatively (p<0.05), but there was no difference in pain relief at 24 hours (p>0.05).

Although local infiltrating analgesic injections can provide pain control, their effects have been most noted during the immediate postoperative window. Additionally, these injection formulations are relatively newer, so additional studies evaluating long-term effects need to be performed before universal use is instated.

**Transcutaneous electrical nerve stimulation (TENS)**

Transcutaneous electrical nerve stimulation (TENS) also has some benefits as adjunctive therapy to standard therapies. A recent prospective, randomized, single-blinded trial was performed on 23 patients who received either TENS or standard of care. Patients who received TENS had significant improvements in timed-up-and-go tests and objective Knee Society Scores as compared to the controls. The TENS patients also had significant improvements in subjective functional and quality-of-life outcomes. Furthermore, TENS patients had more significantly improved the quadriceps strength than the standard cohort. Based on these results, patients who receive TENS therapy can potentially achieve better improvements in pain, function, and quality-of-life than those who undergo standard therapy alone.

**Bracing**

Knee braces are a well-established pain management modality that has been widely used by patients. Because of their track-record, the American Academy of Orthopaedic Surgeons recommends bracing for biomechanical joint pain or instability secondary to osteoarthritis. Similarly, the National Institute for Health and Care Excellence (NICE) guidelines also recommend knee bracing for osteoarthritis.

Conservative treatment with braces may reduce pain and improve gait and leg strength, which may lead to a decrease in opioid consumption prior to surgery, translating to a decrease in chronic opioid use.

A randomized prospective study by Chughtai and colleagues studied patients who had Kellgren-Lawrence grades 3 to 4 osteoarthritis treated with a pneumatic unloader brace versus conventional treatment at minimum follow-up of one year. Patients treated with a brace received fewer injections (56 vs. 83%, p=0.026) and had lower rates of subsequent TKA (18 vs. 36%). Katsuragawa et al. concluded that valgus knee bracing increased bone mineral density in the lateral compartment by transferring forces across the knee from medial to lateral. Johnson and colleagues reported on 10 patients who received bracing and 15 patients without bracing for knee osteoarthritis that failed nonoperative treatment. Patients reported improved range of motion (ROM), knee angle at heel strike, and walking speed. Kolisek et al. evaluated 60 patients who were managed with bracing alone, exercise alone, or bracing with exercise. The authors found significant reductions in pain for the brace-only group as compared to the exercises-only group (p=0.027). Another study evaluated 167,751 patients who received bracing, though not limited to the knee, and found substantial reductions in pain, stiffness, and swelling. The group also noted marked improvements in patient-reported range of motion.

Postoperatively knee bracing may be used to improve ROM in a contracted TKA. Herpburn and colleagues reviewed four patients with loss of extension and one patient with loss of flexion following TKA. They found a 49% increase in extension and an 80% increase in flexion with the use of dynamic splinting. Finger and Willis reported a case of a 61-year-old male who presented with a -20 degree loss of extension. After two months of rehabilitation, ROM improved to 12 degrees extension and then full extension with dynamic splinting for two additional months. According to the few studies in the literature, dynamic splinting seems to be an effective way to treat knee contraction after TKA.

Based on the above data, braces are potential treatment options for knee osteoarthritis. Given the advantages braces have preoperatively at improving range of motion and reducing pain, it would be expected that similar findings would occur postoperatively. A non-pharmacological pain reduction option that can potentially limit the use of opioids or other pain medications is an unmet need for patients. Knee braces are one possible option to meet this need.

**CONCLUSION**

Postoperative pain management following total knee arthroplasty remains a challenge for many patients and physicians. Poor pain control and overuse of opioids can result in inferior outcomes in terms of patient satisfaction scores, rehabilitation efforts, and complications. The use of multimodal analgesics, including perioperative use of COX-2 inhibitors, anesthesia with DEX and peripheral nerve blocks, and intraoperative liposomal bupivacaine, have all been shown to be beneficial for postoperative pain control. However, each of these options has also been associated with conflicting evidence and/or side effects that cannot be overlooked. Perioperative knee bracing, however, has been shown to be safe and effective. Additionally, as a non-pharmacological option, there is no risk of addiction or overdose, as is the case with the majority of currently available pain control options. Therefore, based on the available data, knee braces are viable options that can substantially help reduce postoperative pain following total knee arthroplasty.
 AUTHORS' DISCLOSURES

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