Comparison of Selected Outcomes Associated with Two Postoperative Analgesic Approaches in Patients Undergoing Total Knee Arthroplasty

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Femoral nerve blocks (FNBs) and periarticular injections (PAIs) are often used for analgesia following bone and joint surgery. The purpose of this retrospective analysis was to investigate the association of analgesic technique with outcomes. All patients receiving total knee arthroplasty (TKA) at a regional medical center in 2014 were analyzed. Patients were grouped by whether they received an FNB or PAI of bupivacaine liposome injectable suspension (Exparel) for postoperative analgesia. Outcome variables of pain perception, morphine equivalents administered, length of stay, and total cost of care were compared using 2-tailed t tests. Readmission rate was examined using a 2-sample z test for proportions. One hundred forty-four patients were included in the study. This analysis demonstrated an association between receiving an FNB and less pain perception (P = .0497). Results also demonstrated a possible relationship between less opioid consumption in patients receiving a PAI of liposomal bupivacaine (P = .037). No statistical differences were found for the other variables. Receiving a FNB was preferable regarding patients' pain perception. Patients received less opioid analgesic when they received a PAI, possibly relating to the particular surgeon performing the primary TKA. Patients were 5 times likelier to require hospital readmission in the PAI group.

Keywords: Analgesia, anesthesia, arthroplasty, opioid, regional.

For more than 40 years, elective surgical inventions for osteoarthritis have been performed seeking a better option than opioid analgesics for patients.[1] Today, total knee arthroplasty (TKA) has become the standard of care for end-stage osteoarthritis of the knee (Figure 1). More than 80% of patients receiving TKA have substantial pain relief and functional improvement.[2] The number of TKA procedures has more than doubled over the last decade.[3] In 2013, approximately 4 million adults in the United States were living with TKA devices,[4] and projections are that the demand for TKA will rise to 3.48 million procedures annually by 2030, an increase of 673%.[4-6] Providing effective postoperative analgesia for TKA will be essential in successfully meeting the goals of cost reduction and high-quality care.[7-11]

In our facility, along with many other centers, spinal anesthesia represents the primary anesthetic for the total joint recipient because it has been associated with improved outcomes[12,13] over general anesthesia. Following return of motor and sensory pathways after spinal anesthesia, pain occurs. Both femoral nerve block (FNB) and periarticular injection (PAI) are advocated to reduce the pain (Figure 2). Failure of either modality to relieve pain results in an increased use of opioids. Inadequate pain relief and dependence on opioids within 24 to 36 hours are threats to early discharge criteria such as transfer out of bed to chair, ambulation, quadricep strength, and nausea and vomiting. Postoperative analgesia is vitally important for patients to meet the goals of discharge criteria.[14] Prolonged hospital stays are often associated with opioid use for pain because of associated respiratory depression, nausea/vomiting, falls, lack of mobility, and readmissions.[15,16]

Findings of several studies support the benefits of peripheral nerve blocks[17-25] (Figure 3). The benefits of using bupivacaine liposome injectable suspension (Exparel) for PAI have also shown similar benefits for patients[26-30] (Figure 4). At the time of this study, few comparisons were published examining FNB and PAI in the presence of a primary spinal anesthetic. The aim of this study was to analyze the differences in outcome variables comparing 2 postoperative analgesic approaches: FNB and PAI.

Methods

Following institutional review board approval, a retrospective analysis was conducted in all patients undergoing TKA during 2014 and receiving orthopedic surgical care at a regional medical center in the southeastern United States. Patients received a subarachnoid block as their primary anesthetic followed by either FNB or

Figure 1. Right Total Knee Replacement, Before (right) and After (left)
(Courtesy of colleague)

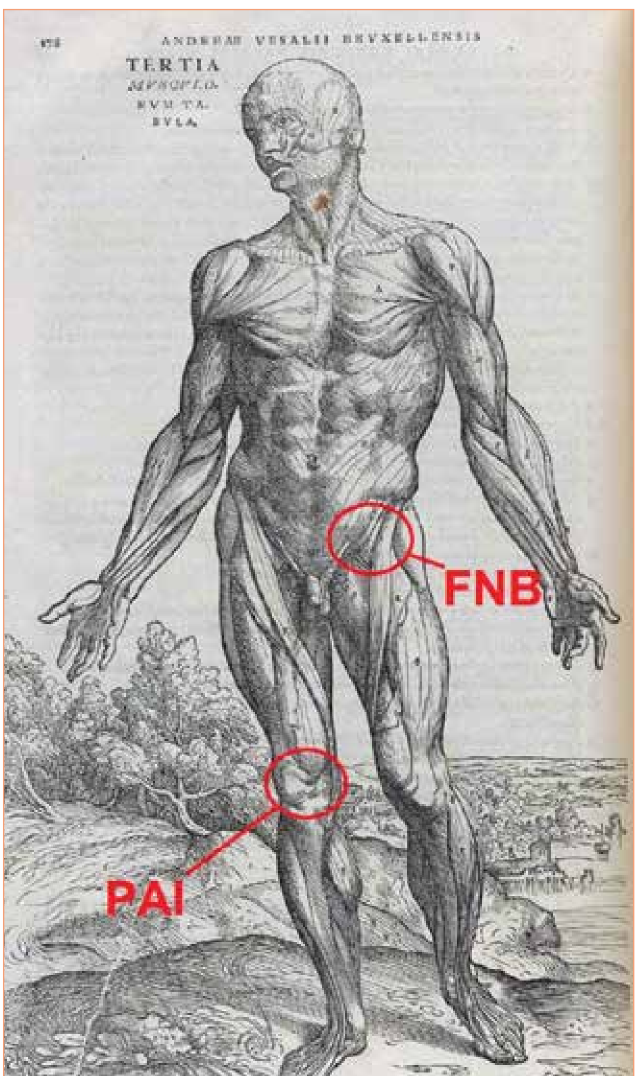

Figure 2. Vesalius' *Fabrica*[43]
Abbreviations: FNB, femoral nerve block; PAI, periarticular injection.

Figure 3. Ultrasound-Guided Femoral Nerve Block[24]

PAI. The choice of FNB or PAI was at the discretion of the surgeon. Femoral nerve blocks were placed in the postanesthesia care unit (PACU) by 1 of 14 anesthesia providers experienced in ultrasound-guided regional anesthesia (anesthesiologist or Certified Registered Nurse Anesthetist). Periarticular injections were placed in the operating room by 1 of 4 attending orthopedic surgeons. Patient data were obtained from the hospital electronic database. Patients were excluded from the study if they were receiving long-term opioid therapy that met or exceeded 3 continual months' duration immediately before their primary joint replacement. Variables examined from the hospital record were patient pain perception, opiate use (morphine equivalents [MEs]), length of stay (LOS) in the hospital, total cost of care in the hospital, and readmission rate.

Patient pain perception was defined using a 0 to 10 numeric pain rating scale value and recorded by a registered nurse chronologically throughout the period beginning with patient admission to the PACU until discharge to home. These pain score values were captured and recorded in the electronic medical record at multiple intervals throughout the hospital stay during nursing assessments (independent of opioid administration) as well as before and after opioid administration. Total pain score data ranged from only a few entries per patient to several dozen entries depending on length of stay. These averages were compared between the FNB and PAI groups using a 2-tailed *t* test.

Total opioid use for each patient's entire hospital course

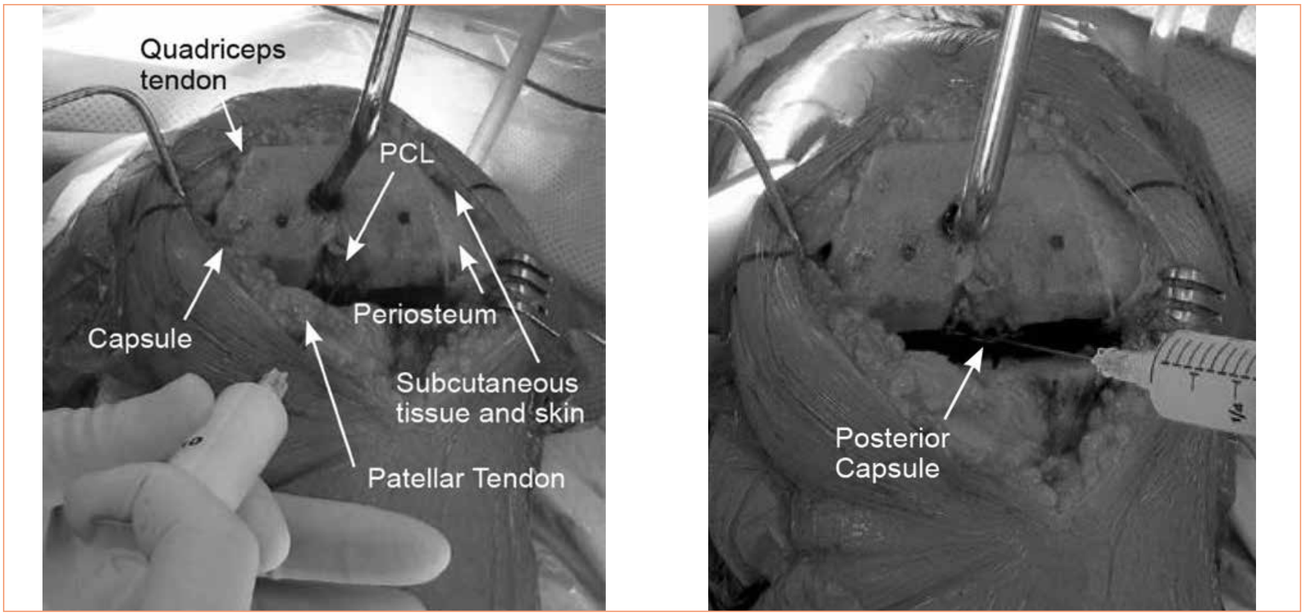

Figure 4. Periarticular Injection of Liposomal Bupivacaine (Exparel) During Total Knee Arthroplasty[30]
Abbreviation: PCL, posterior cruciate ligament.

was obtained from the nursing record for each patient. All opioid medications were ordered by the surgeon or other attending physician. There were 23 various medication combinations noted (Table 1). For standardizing use, an equianalgesic dose index was used. Criticisms exist in the proposed methods for equivalence calculations and the variability in how providers convert various opioids to a standard of measure.[31] Therefore, we attempted to standardize equivalence by using morphine, 10 mg IV, as the benchmark with an index system that took into account potencies and bioavailability between oral and parenteral routes of administration.[32] The relative potency of all opioid analgesics ordered by the various physicians was calculated as MEs. The total MEs for each patient was calculated. Differences in MEs for each group (FNB and PAI) were analyzed using a 2-tailed *t* test.

Length of stay in the hospital, calculated as whole 24-hour periods, was obtained from the patient record. Minimum stay was 1 day, and maximum was 7 days. Patient readmissions, which were fewer than 30 days from discharge, were added to the LOS calculation. Total LOS for each group, FNB and PAI, was then compared using a 2-tailed *t* test.

All hospital-associated costs related to the inpatient hospital course were compiled for each patient. This comprehensive cost database was compiled by the finance office and included the total amount that the institution billed to the third-party payers. This was represented as total cost of care. No cost related to private physician billing was included. Costs were summed for each group, FNB and PAI, and compared using a 2-tailed *t* test.

Any patient receiving TKA during the study period who was readmitted within 30 days, for any reason, was included in the readmission group and recorded in the readmission rate. This rate, expressed as a percentage, was tabulated for both groups and compared using the 2-sample *z* test for proportions.

Results

After exclusion criteria were applied, there were 144 patients in the observational group: 71 patients in the FNB group and 73 in the PAI group. Demographically, our sample was reflective of the U.S. population as a whole in regard to marital status and gender (Figures 5 and 6).[35,36] African American, Hispanic, and other ethnic affiliations represented 4.1% of the PAI group and 2.8% of the FNP group. These results support current evidence of African Americans' reluctance to choose total joint replacement compared with whites.[37] African Americans represent 22.2% of the population of the state; however, they represent only 1.8% of the county population in which this study was undertaken.[38]

Figure 7 demonstrates how, beginning in 2013, orthopedic surgeons began to use PAI. By 2015, more than 80% of the orthopedic surgeons were opting for PAI over FNB. Figure 7 demonstrates that by using only the 2014 retrospective data, we were able to represent a relatively even distribution in PAI vs FNB cases since this was the midpoint in utilization of each modality of postoperative analgesia. Table 2 summarizes the calculated mean and SD for the study variables for each group.

Our analysis demonstrated that patients who received a regional anesthetic at our facility in the form of an ultrasound-guided FNB in the PACU had lower documented pain scores throughout their hospital course (mean pain perception scores, 4.48 for FNB vs 5.02

Medication, generic (brand)	Dose and formulation
Hydrocodone/APAP	10/325 mg tablet
Hydrocodone/APAP	5/325 mg tablet
Hydromorphone	1 mg/1 mL injection
Hydromorphone	2 mg tablet
Morphine	10 mg/1 mL injectable cartridge
Morphine	4 mg/1 mL injectable cartridge
Morphine	30 mg PCA syringe
Oxycodone CR (Oxycontin)	10 mg tablet CR
Oxycodone CR (Oxycontin)	20 mg tablet CR
Oxycodone/acetaminophen	5/325 mg tablet
Oxycodone	5 mg tablet
Morphine	5 mg/1 mL vial
Hydromorphone	2 mg/1 mL injection
Hydromorphone	Low dose: 30 mg/30 mL PCA vial
Oxycodone/APAP	10/325 mg tablet
Morphine	15 mg tablet ER
Oxycodone CR (Oxycontin)	80 mg tablet CR
Meperidine hydrochloride	50 mg/1 mL
Fentanyl	250 μg/5 mL injection
Acetaminophen-codeine	5 mL syringe (12 mg codeine)
Hydrocodone-acetaminophen	7.5/500 mg, 15 mL (1 c) elixir
Acetaminophen-codeine phosphate (Tylenol #3)	300/30 mg tablet
Hydrocodone-acetaminophen	10/650 mg tablet

Table 1. Documented Opioids Administered to Patients Undergoing Total Knee Arthroplasty in 2014
Abbreviations: APAP, acetyl-para-aminophenol (acetaminophen); CR, controlled release; ER, extended release; PCA, patient-controlled analgesia.

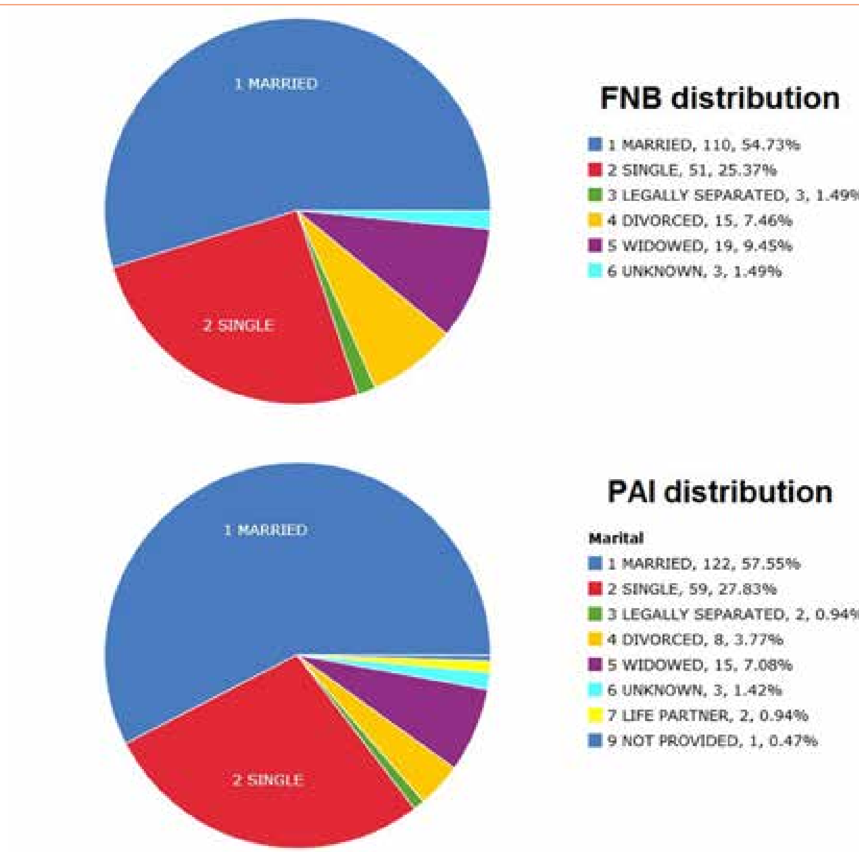

Figure 5. Marital Status
Abbreviations: FNB, femoral nerve block; PAI, periarticular injection.

for PAI, P = .0497; Figure 8). Additionally, our analysis showed that patients receiving PAIs received fewer opioids during their stays (mean MEs were 168.59 mg for FNB and 126.45 mg for PAI, P = .0370; Figure 9). Both pain perception and ME had small effect sizes (Cohen d = 0.332912 and 0.353498, respectively) owing to large,

Variable	FNB (n = 71)	PAI (n = 73)	*P*
Pain perception score	4.48 (1.89)	5.02 (1.30)	.0497
ME, mg	168.59 (130.45)	126.45 (106.79)	.0370
LOS, d	2.97 (1.08)	2.63 (0.86)	.422
Cost of care, $	18,572.65 (3,716.11)	19,505.48 (4,4769.16)	.422
Readmission rate, %	1.4	6.8	.3678

Table 2. Statistical Analysis, Mean (SD)
Abbreviations: FNB, femoral nerve block; LOS, length of stay; PAI, periarticular injection; ME, morphine equivalent.

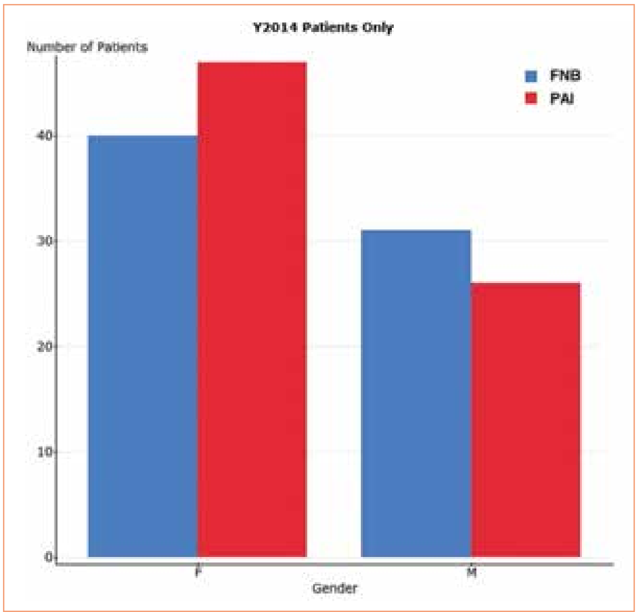

Figure 6. Gender Distribution
Abbreviations: FNB, femoral nerve block; PAI, periarticular injection; Y, year.

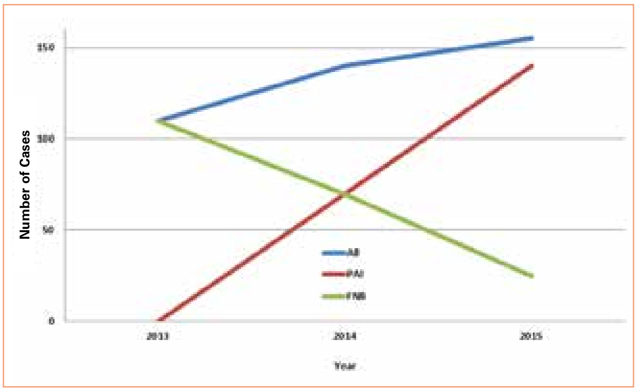

Figure 7. Number of PAI Versus FNB Cases per Year
Abbreviations: All, total number of total knee replacements; FNB, femoral nerve block; PAI, periarticular injection.

within-group variability. The remaining variables analyzed, length of stay, cost of care and readmission rate, were not significant. However, the PAI group did have a readmission rate that was 5 times larger than that of the FNP group, although the difference was statistically insignificant (P = .3678). This difference could represent a clinically significant finding in this exploratory study. Primary reasons for readmission were wound integrity (PAI, n = 3), pain management (PAI, n = 1), and pneumonia (FNB, n = 1).

Discussion

Our study sought to gain understanding in the relationship between 2 analgesic modalities and associated outcome variables. The reported decrease in pain in the group receiving FNB could be due to the increased pain medications ordered by the surgeons, or it could be due to less activity related to decreased quadriceps motor function frequently associated with this form of proximal regional analgesia. This was not examined in the retrospective data. Postoperative pain medications were ordered by the surgeon. Use of patient-controlled analgesia (PCA) and/or oral opioid medications given on a scheduled order set could be a factor or factors in the increase of pain medications in this group and account for the reported decrease in pain.

The readmission rate was statistically the same for both groups in this retrospective analysis. However, the PAI group had 5 times more patients readmitted. The degree of clinical significance pertaining to the observed readmissions in the PAI group strongly supports further study of this topic. The effect this had on costs and length of stay may be significant. In a future study, reasons for readmission should be examined further as well as differences in costs and length of stay. Changing opinions by orthopedic surgeons and modifications in surgical technique during 2014 may have affected the efficacy of analgesic approaches and the resultant outcome variables.

The primary limitation of this research relates to the design as a retrospective data analysis conducted at a relatively small regional medical center. This study examined 2 *groups* of patients and was therefore limited in ability to describe the observed phenomena on an individual level or measure the degree of meaning that analgesic technique had on each patient's surgical/anesthetic experience.[39] Factors such as multiple surgeons performing TKAs with or without PAIs, multiple anesthesia providers performing FNBs (the level of ultrasonography expertise possessed by anesthesiologists and Certified Registered Nurse Anesthetists), and nursing perceptions of as-needed opioid order sets may affect the data analysis to unknown degrees and may have contributed to the statis-

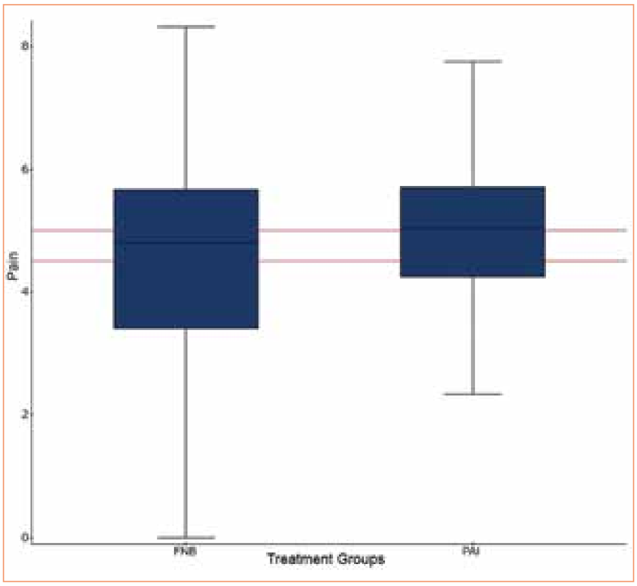

Figure 8. Distribution of Pain, Year 2014 Patients Only, Means Significantly Different ($P = .0497$)
Abbreviations: FNB, femoral nerve block; PAI, periarticular injection

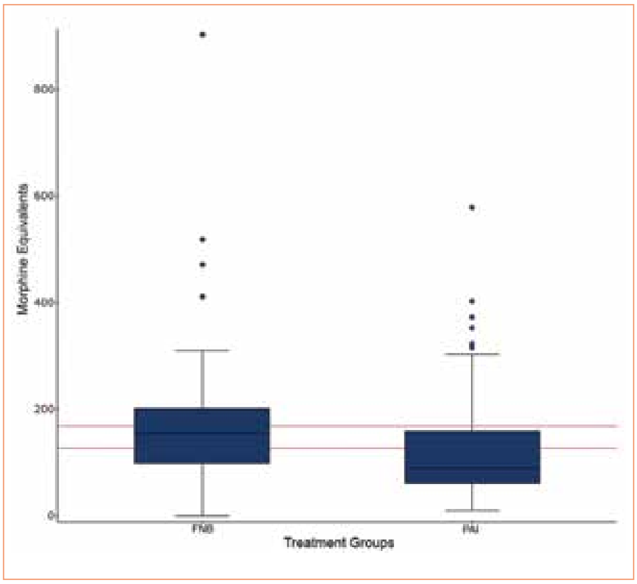

Figure 9. Distribution of Total Morphine Equivalents Received, Year 2014 Patients Only, Means Significantly Different ($P = .0370$)
Abbreviations: FNB, femoral nerve block; PAI, periarticular injection.

tical evidence found in this research. This retrospective analysis provides possible associations among variables but fails to demonstrate cause and effect relationships. Examining the role of regional analgesia techniques as they relate to improved pain control and lower incidences of opioid-related adverse effects[40-42] continues to build credibility. However, the exact causes of lower pain scores and higher opioid consumption were not clarified in the retrospective review of the electronic medical records. Future prospective studies are encouraged to develop deeper understanding of potential causal relationships in analgesic modalities and improved outcomes in patients undergoing TKA.

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DISCLOSURES

The authors have declared no financial relationships with any commercial entity related to the content of this article. The authors did not discuss off-label use within the article.