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Original Research

Peripheral Nerve Block Utilization is Associated With Decreased Postoperative Opioid Consumption and Shorter Length of Stay Following Total Knee Arthroplasty

Jennifer C. Wang, BS, Amit S. Piple, MD, Cory K. Mayfield, MD, Brian C. Chung, MD, Daniel A. Oakes, MD, Gligor Gucev, MD, Jay R. Lieberman, MD, Alexander B. Christ, MD, Nathanael D. Heckmann, MD *

Department of Orthopaedic Surgery, Keck School of Medicine of USC, Los Angeles, CA, USA

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ABSTRACT

Background: This study aims to examine differences in postoperative complications and opioid consumption associated with perioperative peripheral nerve block (PNB) utilization during primary total knee arthroplasty (TKA).

Methods: The Premier Healthcare Database was queried for adult patients who underwent primary, elective TKA from 2015 to 2020. Patients who received a femoral or adductor canal PNB were compared to patients who did not. PNB utilization was trended from 2015 to 2020. Univariate and multivariate regression analyses were performed to assess differences in the 90-day risk of postoperative complications between groups. The average inpatient opioid consumption in morphine milligram equivalents was assessed as a function of length of stay.

Results: Overall, 609,991 patients were included. PNB utilization increased from 9.29% in 2015 to 30.3% in 2020. After controlling for confounders, the PNB cohort was more likely to have same-day discharge (adjusted odds ratio [aOR] 1.88) and had a decreased risk of periprosthetic joint infection (aOR 0.87), pulmonary embolism (aOR 0.81), and respiratory failure (aOR 0.78). However, there was an increased risk of seroma (aOR 1.75) and hematoma (aOR 1.22) associated with PNB utilization. Lower average overall opioid exposure was seen in the PNB cohort vs no-PNB cohort (82.1 ± 194.7 vs 89.4 ± 214.1 morphine milligram equivalents, $P < .001$).

Conclusions: PNB utilization during primary TKA is associated with a shorter length of stay and decreased risk of multiple postoperative complications, as well as reduced postoperative opioid consumption. These data provide evidence in support of the safety and efficacy of this emerging practice. However, the clinical relevance of an increased risk of seroma and hematoma formation may warrant further investigation.

Introduction

Modern total knee arthroplasty (TKA) has represented a significant boon to patients suffering from severe knee osteoarthritis, as evidenced by the 4.7 million Americans with a TKA in 2010 [1]. Historically, perioperative pain management protocols following TKA relied significantly on the use of prescription narcotics. The numerous deleterious side effects associated with increased opioid use, such as dependence and overdose, have been well-described [2]. Recent studies have identified a potential dose-dependent relationship between early postoperative opioid use and rates of infectious, thromboembolic, and pulmonary complications following primary total joint arthroplasty (TJA) [3]. Furthermore, elderly individuals are at higher risk of complications due to increased susceptibility to the harmful side effects of opioids [4].

Consequently, there has been significant interest in the implementation of multimodal pain management strategies. Approximately 85.6% of patients undergoing TJA from 2006 to 2016

* Corresponding author. Department of Orthopaedic Surgery, Keck School of Medicine of USC, 1520 San Pablo St, Ste 2000, Los Angeles, CA 90333, USA. **Tel.:** +1 323 704 6363.
E-mail address: nate.heckmann@gmail.com

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received at least 1 additional analgesic alternative alongside opioids [5]. The use of a peripheral nerve block (PNB) as part of such an approach to pain management has been shown to lead to decreased length of stay (LOS), faster recovery, and reduced rates of postoperative complications following TJA [6]. However, prior studies in the anesthesia literature have largely failed to demonstrate a significant reduction in inpatient LOS with the use of PNB during primary TKA [7–9]. Furthermore, there remains a paucity of studies in the orthopaedic literature adequately powered to detect differences in rare outcomes after TKA in the context of this practice. Additionally, no data currently exist describing the utilization pattern and prevalence of PNBs in TKA in the United States (U.S.). Therefore, the present study aims to (1) characterize national trends in the utilization of PNB in the U.S. for primary, elective TKA from 2015 to 2020; (2) determine if perioperative PNB use was associated with decreased morphine milligram equivalents (MMEs) exposure and/or reduced LOS; and (3) examine the association between PNB use and rates of complications following TKA.

Material and methods

A retrospective cohort study was conducted on all adult patients who underwent primary, elective TKA from 2015 to 2020 using the Premier Healthcare Database (PHD), a nationally representative database containing patient-level and billing data for inpatient services. Patients were identified using International Classification of Disease, Tenth Revision, (TKA: 0SRC0- + 0SRD0-) and Current Procedural Terminology (CPT) (TKA: 27447) codes. Patients aged <18 years and who underwent TKA for nonelective indications were excluded (Supplemental Table 1). The present study was exempt from institutional review board review as the PHD does not provide protected patient health information in accordance with the Health Insurance Portability and Accountability Act.

Identification of study cohorts

After the inclusion and exclusion criteria were applied, patients who received either a femoral nerve block or an adductor canal nerve block were identified using a combination of CPT codes (ie, 64447 and 64448) and PHD-specific charge codes. Patients who received any other type of PNB were excluded from analysis. Due to a lack of specific International Classification of Disease, Tenth Revision, and CPT codes, interspace between the popliteal artery and capsule of the posterior knee blocks were not included. The cohort of patients who did not receive a PNB was used as the control group for all analyses.

Trends, patient characteristics, and hospital factors

Trends in PNB utilization and LOS were assessed during the study period. Patient demographics (ie, age, sex, race, hospital costs, and payer status) and hospital factors (ie, size, region, teaching status, and urban/rural setting) were compared between the 2 cohorts. Rates of medical comorbidities were also assessed and compared.

Study endpoints

The primary endpoint was postoperative opioid consumption, measured in MMEs, associated with PNB utilization during TKA. The PHD provides the dosage of specific opioid medications administered in the inpatient setting after the index TJA is performed. A manual calculation was then performed converting each opioid medication class into standardized MMEs. The total dosage of the medication on each postoperative day (POD) multiplied by the conversion factor resulted in the total MME for each POD. Patients were grouped into 4 cohorts on the basis of their inpatient LOS (ie, 0, 1, 2, and 3 days). Aggregate and POD-specific MME exposure was compared between patients who did and did not receive a PNB within each LOS group. The secondary endpoint was the 90-day risk of postoperative complications. The complications assessed in this study included periprosthetic joint infection (PJI), surgical site infection (SSI), sepsis, pulmonary embolism (PE), deep vein thrombosis (DVT), wound dehiscence, seroma formation, stroke, pneumonia, respiratory failure, myocardial infarction, acute kidney injury, urinary tract infection, hematoma formation, and hemarthrosis.

Statistical analyses

Trends in PNB utilization were reported as the number of TKA cases in which a PNB was included divided by the total number of TKAs performed for each calendar year. LOS trends were assessed by reporting the average LOS per calendar year in the PNB and no-PNB cohorts. Descriptive statistics were used to report all patient characteristics, hospital factors, rates of comorbidities, and opioid consumption. Chi-squared analysis, for categorical variables, and independent t-tests, for continuous variables, were used to determine significant differences in the aforementioned factors between cohorts. Univariate logistic regression was used to assess the risk of all endpoints. A multivariate model was designed to account for potential confounders, which controlled for age, sex, race, and hospital factors and comorbidities that approached a significant difference between cohorts ($P < .100$). Statistical significance was defined as $P < .05$. All statistical analyses were performed using STATA (version 16.1; StataCorp LLC, College Station, TX).

Results

Trends in PNB usage

Between 2015 and 2020, a total of 609,991 patients undergoing a primary, elective TKA were identified. Of these, 121,837 (20.0%) received a PNB. Overall, perioperative PNB utilization among TKA patients increased year-over-year, with 9.29% of patients receiving PNBs in 2015 and 30.3% in 2020 (Fig. 1).

LOS trends

From 2015 to 2020, there was a reduction in LOS following TKA, independent of PNB utilization. In 2015, the LOS was 2.41 days with the use of PNB and 2.49 without block use ($P = .045$). This decreased to 0.64 days with PNB use in 2020 compared to 1.01 days without block use ($P < .001$), which equates to a 63.4% decrease in LOS for patients receiving PNBs and 59.4% for patients who did not (Fig. 2).

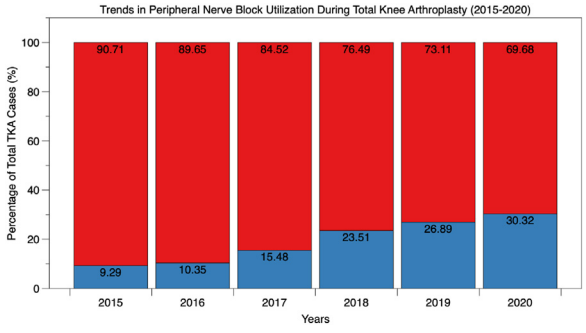

Figure 1. Trends in utilization of peripheral nerve blocks (PNBs) in total knee arthroplasty (TKA) from 2015 to 2020.

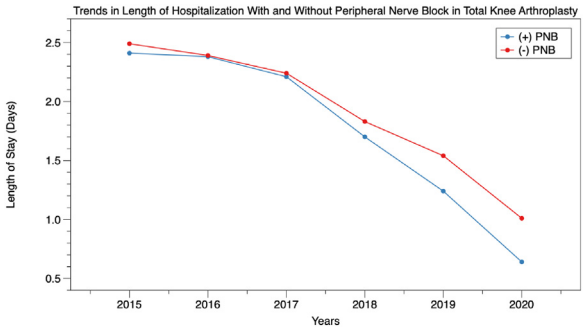

Figure 2. Trends in postoperative length of stay after total knee arthroplasty in cases performed with and without peripheral nerve blocks (PNBs) from 2015 to 2020.

Patients who received a PNB were more likely to have a same-day discharge than those who did not, even after controlling for confounders (adjusted odds ratio [aOR] 1.88, 95% confidence interval [CI] 1.83-1.93).

Differences in patient and hospital characteristics

Patients who received a PNB were similar in age to controls (67.1 ± 9.18 vs 67.2 ± 9.29 years, $P < .001$) (Table 1). Additionally, patients who received a PNB were more likely to be male (41.4% vs 40.7%, $P < .001$). Those who received a PNB had significantly shorter inpatient LOS than those who did not (1.54 ± 1.75 vs 1.95 ± 1.43, $P < .001$). Additionally, smaller hospitals (<100 beds) were more likely to utilize PNB (9.93% vs 7.56%, $P < .001$). Patients in the South and Midwest had significantly higher rates of receiving PNBs than those in the West and Northeast ($P < .001$). Finally, PNB utilization was associated with greater rates of obesity, kidney disease, blood loss anemia, congestive heart failure, chronic obstructive pulmonary disease, complicated diabetes, liver disease, and rheumatoid arthritis (Table 2).

Opioid consumption

Overall, patients who received a PNB had 8.12% lower average MME exposure than those who did not (82.1 ± 194.7 vs 89.4 ± 214.1, $P < .001$) (Table 3). Patients with an LOS <1 day who received a PNB had greater MME exposure than those who did not (53.0 ± 70.6 vs 45.9 ± 75.3, $P < .001$). In contrast, patients with an LOS of 1 day who received a PNB had lower overall (51.5 ± 59.8 vs 54.2 ± 138.5, $P < .001$) and POD0 (38.6 ± 55.3 vs 41.4 ± 125.2, $P < .001$) opioid exposure than those who did not. Patients with an LOS of 2 days who received a PNB had similar opioid exposure overall (93.7 ± 238.9 vs 93.7 ± 176.1, $P = .997$) and on POD0 (52.8 ± 221.6 vs 54.5 ± 163.2, $P = .090$). Patients who received a PNB had higher POD1 (26.5 ± 50.5 vs 25.3 ± 43.7, $P < .001$) and POD2 (14.4 ± 13.3 vs 14.0 ± 15.5, $P < .001$) opioid exposure than those who did not. Patients with an LOS of 3 days who received a PNB had lower POD0 (57.7 ± 240.6 vs 60.6 ±

Table 1
Differences in patient demographics and hospital factors.

Variable	(+) PNB n = 121,837		(−) PNB n = 488,154		*P* value
Mean age (y)	67.07 ± 9.18		67.19 ± 9.29		**<.001**
Mean LOS (d)	1.54 ± 1.75		1.95 ± 1.43		**<.001**
Total cost (USD)	15,380.96 ± 21,484.13		15,543.06 ± 8400.45		**.005**
Male (n, %)	50,464	41.42%	198,423	40.65%	**<.001**
Race (n, %)					
Asian	1327	1.09%	7524	1.54%	**<.001**
Black	11,329	9.30%	40,603	8.32%	
Other	5351	4.39%	29,924	6.13%	
Unknown	1835	1.51%	7805	1.60%	
Caucasian	101,995	83.71%	402,298	82.41%	
Hispanic (n, %)					
Yes	4005	3.29%	21,711	4.45%	**<.001**
Payer category (n, %)					
Managed care organization	27,281	22.39%	117,479	24.07%	**<.001**
Medicare	72,944	59.87%	291,823	59.78%	
Medicaid	4177	3.43%	20,126	4.12%	
Other	17,435	14.31%	58,726	12.03%	
Marital status (n, %)					
Married	79,415	65.18%	288,800	59.16%	**<.001**
Other	3518	2.89%	44,767	9.17%	
Single	38,582	31.67%	153,197	31.38%	
Bed size (n, %)					
<100	12,101	9.93%	36,904	7.56%	**<.001**
100-199	21,924	17.99%	100,803	20.65%	
200-299	26,246	21.54%	95,891	19.64%	
399-399	19,615	16.10%	78,781	16.14%	
400-499	15,952	13.09%	53,918	11.05%	
>500	25,999	21.34%	121,857	24.96%	
Urban vs rural (n, %)					
Rural	14,973	12.29%	62,327	12.77%	**<.001**
Urban	106,864	87.71%	425,827	87.23%	
Teaching status (n, %)					
No	70,364	57.75%	282,378	57.85%	**<.001**
Yes	51,473	42.25%	205,776	42.15%	
Region (n, %)					
Midwest	42,698	35.05%	110,915	22.72%	**<.001**
Northeast	12,899	10.59%	103,296	21.16%	
South	57,781	47.42%	190,850	39.10%	
West	8459	6.94%	83,093	17.02%	

Bold represents values that achieved statistical significance ($P < .05$).

Table 2
Differences in comorbidities.

Comorbidity	(+) PNB n = 121,837		(−) PNB n = 488,154		*P* value
	n	%	N	%	
AKI/CKD	8447	6.93%	32,729	6.70%	**.004**
Blood loss anemia	689	0.57%	2457	0.50%	**.007**
CHF	4616	3.79%	16,311	3.34%	**<.001**
Chronic PUD	311	0.26%	1296	0.27%	.533
Coagulopathy	1835	1.51%	10,087	2.07%	**<.001**
COPD	17,515	14.38%	68,640	14.06%	**.005**
Iron deficiency anemia	1541	0.26%	5718	1.17%	**.007**
DM w/o complications	19,052	15.64%	77,480	15.87%	**.045**
DM with complications	7887	6.47%	27,927	5.72%	**<.001**
Fluid imbalance	5744	4.71%	28,972	5.94%	**<.001**
HIV/AIDS	37	0.03%	158	0.03%	.727
Hypertension	72,972	59.89%	291,982	59.81%	.612
Hypothyroidism	20,002	16.42%	78,549	16.09%	**.006**
Liver disease	1515	1.24%	5228	1.07%	**<.001**
Lymphoma	175	0.14%	838	0.17%	**.032**
Metastatic cancer	39	0.03%	158	0.03%	.951
Obesity	38,871	31.90%	144,304	29.56%	**<.001**
Other neurologic disorders	2361	1.94%	9541	1.95%	.707
Paralysis	79	0.06%	351	0.07%	.406
Peripheral vascular disease	2845	2.34%	11,873	2.43%	**.048**
Psychosis	207	0.17%	886	0.18%	.392
Pulmonary circulation disorder	913	0.75%	4101	0.84%	**.002**
Rheumatoid arthritis	4150	3.41%	15,877	3.25%	**.007**
Valve disease	793	0.65%	3337	0.68%	.213
Weight loss	102	0.08%	672	0.14%	**<.001**

AKI, acute kidney injury; CHF, congestive heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; PUD, peptic ulcer disease; SD, standard deviation.
Bold represents values that achieved statistical significance ($P < .05$).

174.9, $P = .049$) but higher POD1 (28.6 ± 53.3 vs 27.5 ± 54.5, $P < .001$), POD2 (24.3 ± 24.4 vs 22.4 ± 23.2, $P < .001$), and POD3 (12.1 ± 14.9 vs 11.5 ± 13.9, $P < .001$) opioid exposure than those who did not.

Complications associated with PNB usage

Patients who received PNBs had a lower prevalence of most complications studied (Table 4). After controlling for confounders, patients who received PNBs remained at a lower risk of nearly all postoperative complications, including PJI (aOR 0.87, 95% CI 0.80-0.96, $P = .005$), sepsis (aOR 0.84, 95% CI 0.75-0.96, $P = .007$), PE (aOR 0.81, 95% CI 0.720-0.91, $P < .001$), and pneumonia (aOR 0.84, 95% CI 0.76-0.95, $P = .006$) (Table 4). There were no significant differences noted in the risk of postoperative SSI, DVT, wound dehiscence, stroke, or hemarthrosis between the cohorts. Patients who received PNBs were at increased risk of seroma (aOR 1.87, 95% CI 1.21-3.31, $P = .017$) and hematoma formation (aOR 1.22, 95% CI 1.05-1.41, $P = .008$).

Table 3
Differences in postoperative opioid exposure by length of stay.

Hospitalization duration	(+) PNB	(−) PNB	*P* value
	MME (SD)	MME (SD)	
Overall	82.1 (194.7)	89.4 (214.1)	**<.001**
LOS <1	52.97 (70.62)	45.86 (75.27)	**<.001**
LOS = 1			
Overall MME	51.46 (59.8)	54.16 (138.54)	**<.001**
POD 0	38.58 (55.27)	41.39 (125.21)	**<.001**
POD 1	12.88 (19.19)	12.76 (59.08)	.689
LOS = 2			
Overall MME	93.73 (238.9)	93.74 (176.08)	.997
POD 0	52.82 (221.62)	54.51 (163.17)	.090
POD 1	26.5 (50.52)	25.27 (43.72)	**<.001**
POD 2	14.41 (13.26)	13.96 (15.50)	**<.001**
LOS = 3			
Overall MME	122.76 (266.96)	121.94 (199.95)	.617
POD 0	57.74 (240.63)	60.58 (174.9)	**.049**
POD 1	28.61 (53.33)	27.54 (54.53)	.010
POD 2	24.29 (24.43)	22.35 (23.30)	**<.001**
POD 3	12.11 (14.88)	11.47 (13.91)	**<.001**

AKI, acute kidney injury; CHF, congestive heart failure; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; PUD, peptic ulcer disease; SD, standard deviation.
Bold represents values that achieved statistical significance ($P < .05$).

Discussion

Since 2015, there has been a steady increase in the utilization of perioperative PNBs during primary, elective TKAs performed in the U.S. such that over a quarter of procedures in 2020 made use of this analgesic intervention. In this study, PNB utilization during TKA was associated with an increased likelihood of same-day discharge; lower risk of infectious, thromboembolic, and respiratory complications; and lower overall postoperative opioid consumption. These results largely support the safety and efficacy of this expanding practice in the TKA patient population. However, the clinical relevance of an increased risk of seroma and hematoma formation associated with PNBs may warrant further investigation.

Existing data on PNBs in TKA have largely come from the anesthesia literature and focus on comparing types of PNBs [8,10–15], PNBs to other analgesic strategies [7,16–19], or a combination of the two [20,21]. Three prior studies have examined the association of PNBs in TKA with opioid consumption from a broad, PNB vs no-PNB perspective [9,22,23]. Our finding of decreased opioid consumption in TKA patients who received a PNB is consistent with these prior results. Gleicher et al. found lower 24-hour oral morphine usage in patients who received perioperative adductor canal blocks than in those who did not (38 mg vs 60 mg, $P < .001$) [22]. However, this group examined perioperative PNB placement as a part of a 4-part extended recovery strategy

Table 4
Differences in 90-day postoperative complications.

Complication	(+) PNB n = 121,837	(−) PNB n = 488,154	Univariate analysis			Multivariate analysis		
			OR	*P* value	95% Confidence interval	aOR	*P* value	95% Confidence interval
PJI	563 (0.46%)	2515 (0.52%)	0.89	**.019**	0.82-0.98	0.87	**.005**	0.80-0.96
SSI	114 (0.09%)	360 (0.07%)	1.27	**.027**	1.03-1.57	1.23	.063	0.99-1.52
Sepsis	318 (0.26%)	1493 (0.31%)	0.85	**.010**	0.76-0.96	0.84	**.007**	0.75-0.96
PE	366 (0.30%)	1809 (0.37%)	0.81	**<.001**	0.72-0.91	0.81	**<.001**	0.72-0.91
DVT	749 (0.61%)	3070 (0.63%)	0.98	.576	0.90-1.06	0.99	.828	0.91-1.08
Wound dehiscence	513 (0.42%)	1836 (0.38%)	1.12	**.024**	1.02-1.24	1.07	.181	0.97-1.18
Seroma	23 (0.02%)	46 (0.01%)	2.00	**.007**	1.21-3.31	1.87	**.017**	1.12-3.11
Stroke	127 (0.10%)	531 (0.11%)	0.96	.666	0.79-1.16	0.94	.557	0.77-1.15
Pneumonia	358 (0.29%)	1575 (0.32%)	0.91	.110	0.81-1.02	0.84	**.006**	0.76-0.95
Respiratory failure	621 (0.51%)	2951 (0.60%)	0.84	**<.001**	0.77-0.92	0.78	**<.001**	0.71-0.85
MI	152 (0.12%)	741 (0.15%)	0.82	**.027**	0.69-0.98	0.82	**.032**	0.69-0.98
AKI	1804 (1.48%)	9056 (1.86%)	0.81	**.000**	0.69-0.98	0.78	**<.001**	0.73-0.82
UTI	1281 (1.05%)	5917 (1.21%)	0.87	**<.001**	0.81-0.92	0.83	**<.001**	0.78-0.89
Hematoma	244 (0.20%)	789 (0.16%)	1.24	**.003**	1.07-1.43	1.22	**.008**	1.05-1.41
Hemarthrosis	302 (0.06%)	87 (0.07%)	1.15	.238	0.91-1.47	1.15	.254	0.90-1.47

AKI, acute kidney injury; MI, myocardial infarction; UTI, urinary tract infection.
Bold represents values that achieved statistical significance ($P < .05$).

after the surgical intervention implemented simultaneously. Memtsoudis et al. examined over 700,000 TKAs from 2006 to 2013 and reported 12.7% lower oral morphine equivalent utilization in the PNB vs the no-PNB cohort ($P < .001$) [9]. The authors did not specify the postoperative timeframe the data were collected, which is important given the confounding effect imparted by variations in hospitalization length. Interestingly, we observed higher average opioid consumption in patients with an LOS <1 day who received a PNB than in those who did not. Given that this was only observed for the same-day discharge cohort, it is likely a reflection of modern multimodal pain strategies that incorporate early, aggressive pain control to preemptively prevent pain sensitization and encourage same-day discharge. As such, it is probable these data reflect differences in institutional practice rather than true differences in patient-guided analgesic needs.

The lower risk of both infectious and noninfectious complications associated with PNB utilization during TKA is promising. Only 2 prior studies have examined postoperative surgical and medical complications in this context. Memtsoudis et al. reported lower odds of pulmonary complications in patients who received a PNB than in those who did not in a 2016 study and lower odds of respiratory failure in a 2021 meta-analysis, findings similar to those reported presently [9,24]. The 2016 study also reported a lower risk of thromboembolism among patients who received a PNB but did not delineate the risk of PE or DVT specifically. These outcomes may be modulated by the positive association of PNBs with postoperative pain and, consequently, decreased time to mobilization and hospitalization duration.

PNB utilization is not without some risk, as suggested by the increased risk of seroma and hematoma formation observed among patients who received PNBs in this study. Seromas are a relatively benign complication following TKA but may impede wound healing and serve as a nidus for infection [25]. Although higher rates of SSI and wound dehiscence were observed in the PNB cohort presently, the decreased risk of PJI suggests the relationship between seroma and postoperative wound complications in this patient population may be less concerning. Hematomas, when unable to self-resolve, can be problematic for similar reasons. The incidence of postoperative hematoma after TKA requiring surgical evacuation was estimated to be 0.24% in a single-institution study of over 17,000 primary TKAs [26]. In that study, those who required surgical evacuation for postoperative hematomas had significantly higher 5-year rates of a subsequent major reoperation (12.3% vs 0.9%, $P < .001$) and deep periprosthetic infection (13.6% vs 1.4%, $P < .001$) than those who did not. The results were limited by an inconsistent method for confirming the absence of deep infection at the time of evacuation and a failure to account for confounders when calculating the 5-year estimates. The location of hematomas and seromas in the present study was not specified and, therefore, may be associated with either the block or surgical site. As such, further investigation into these risks with respect to PNB utilization in TKA may be warranted.

This study has a number of limitations. First, the utilization of PNBs was examined as a binary variable rather than at the level of PNB type and number of blocks. Differentiating between adductor canal and femoral nerve blocks was not possible using the PHD. We do not believe this diminishes the importance of our findings that describe contemporary national arthroplasty practice patterns and identified a decreased LOS, average opioid utilization, and risk of a number of infectious and noninfectious complications associated with this practice. Second, the rationale and indications for PNB were unavailable, which may affect the results from institutions that selectively use these interventions in patients at risk of increased postoperative pain. To minimize a confounding effect, patients with a history of substance use disorder were excluded, and all significantly different comorbidities and demographic factors between the 2 cohorts were controlled for in the multivariate model. Third, we were unable to determine when the PNB was discontinued for patients with an LOS >1 day. Fourth, intra-articular injections could not be accounted for given the lack of a corresponding procedural code. Lastly, although we observed decreased overall opioid consumption in patients who received a PNB compared to those who did not, whether this statistically significant difference is also clinically relevant remains unclear as no gold standard for the minimal clinically important difference in postoperative opioid use currently exists. Prospective studies on PNBs with controlled populations examining this question may be warranted.

The strengths of this study merit acknowledgment. First, few studies have described differences in TKA outcomes related to PNB use in aggregate. The growing trend towards incorporating this analgesic practice into primary, elective TKA procedures underscores the timeliness and relevance of this study. Second, the data used for analysis are the most contemporary data available through a national database and, therefore, are reflective of modern practice patterns. Third, over 600,000 patients were included in the

present analysis, providing adequate power to detect significant differences in otherwise rare outcomes. Finally, the effect of PNB utilization during primary, elective TKAs was examined from the arthroplasty perspective, resulting in a focus on postoperative complications and the associated postoperative timeframe relevant to orthopaedic surgeons.

Conclusions

From 2015 to 2020, there was a 21.0% increase in the proportion of primary, elective TKAs performed in the U.S. utilizing PNBs, with nearly 1 in 3 cases utilizing this intervention in 2020. This trend was found to be associated with shorter hospitalizations; lower risk of infectious, thromboembolic, and respiratory complications; and lower total postoperative opioid consumption than TKAs without PNBs. In this contemporary analysis of the effect of PNBs on outcomes in TKA patients, the results provide evidence in support of the safety of this promising, emerging practice.

Conflicts of interest

A. B. Christ is a paid consultant for Intellijoint Surgical and Smith & Nephew and a member of American Academy of Orthopaedic Surgeons (AAOS), Musculoskeletal Tumor Society, and Orthopaedic Research Society. D. A. Oakes receives royalties from and is a paid consultant for LimaCorporate. J. R. Lieberman receives royalties from DePuy, a Johnson & Johnson company; is a paid consultant for DePuy, a Johnson & Johnson company; has stock or stock options in BD Surgiphor and Hip Innovation Technology; receives financial or material support from Saunders/Mosby-Elsevier; and is a member of AAOS, Hip Society, Musculoskeletal Transplant Foundation, and Western Orthopaedic Association. N. D. Heckmann is a paid consultant for Intellijoint Surgical and MicroPort Orthopedics; has stock or stock options in Intellijoint Surgical; and is a member of AAOS, AJRR, and AAHKS. All other authors declare no potential conflicts of interest.

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References

[1] Maradit Kremers H, Larson DR, Crowson CS, Kremers WK, Washington RE, Steiner CA, et al. Prevalence of total hip and knee replacement in the United States. J Bone Joint Surg Am 2015;97:1386–97.
[2] CDC, National Center for Health Statistics. Wide-ranging online data for epidemiologic research (WONDER). http://wonder.cdc.gov; 2020 [accessed 30.10.22].
[3] Chung BC, Bouz GJ, Mayfield CK, Nakata H, Christ AB, Oakes DA, et al. Dose-dependent early postoperative opioid use is associated with periprosthetic joint infection and other complications in primary TJA. J Bone Joint Surg Am 2021;103:1531–42.
[4] Petre BM, Roxbury CR, McCallum JR, DeFontes KW, Belkoff SM, Mears SC. Pain reporting, opiate dosing, and the adverse effects of opiates after hip or knee replacement in patients 60 years old or older. Geriatr Orthop Surg Rehabil 2012;3:3–7.
[5] Memtsoudis SG, Poeran J, Zubizarreta N, Cozowicz C, Mörwald EE, Mariano ER, et al. Association of multimodal pain management strategies with perioperative outcomes and resource utilization: a population-based study. Anesthesiology 2018;128:891–902.
[6] Halawi MJ, Grant SA, Bolognesi MP. Multimodal analgesia for total joint arthroplasty. Orthopedics 2015;38:e616–25.
[7] Xing Q, Dai W, Zhao D, Wu J, Huang C, Zhao Y. Adductor canal block with local infiltrative analgesia compared with local infiltrate analgesia for pain control after total knee arthroplasty: a meta-analysis of randomized controlled trials. Medicine 2017;96:e8103.
[8] Paul JE, Arya A, Hurlburt L, Cheng J, Thabane L, Tidy A, et al. Femoral nerve block improves analgesia outcomes after total knee arthroplasty: a meta-analysis of randomized controlled trials. Anesthesiology 2010;113:1144–62.
[9] Memtsoudis SG, Poeran J, Cozowicz C, Zubizarreta N, Ozbek U, Mazumdar M. The impact of peripheral nerve blocks on perioperative outcome in hip and knee arthroplasty-a population-based study. Pain 2016;157:2341–9.
[10] Zhang L-K, Zhang B-Y, Quan R-F, Xu H, Sun Y-J, Zhou J-H. Single shot versus continuous technique adductor canal block for analgesia following total knee arthroplasty: a PRISMA-compliant meta-analysis. Medicine 2019;98:e15539.
[11] Wang C, Chen Z, Ma X. Continuous adductor canal block is a better choice compared to single shot after primary total knee arthroplasty: a meta-analysis of randomized controlled trials. Int J Surg 2019;72:16–24.
[12] Terkawi AS, Mavridis D, Sessler DI, Nunemaker MS, Doais KS, Terkawi RS, et al. Pain management modalities after total knee arthroplasty: a network meta-analysis of 170 randomized controlled trials. Anesthesiology 2017;126:923–37.
[13] Yu R, Wang H, Zhuo Y, Liu D, Wu C, Zhang Y. Continuous adductor canal block provides better performance after total knee arthroplasty compared with the single-shot adductor canal block?: an updated meta-analysis of randomized controlled trials. Medicine 2020;99:e22762.
[14] Zorrilla-Vaca A, Li J. The role of sciatic nerve block to complement femoral nerve block in total knee arthroplasty: a meta-analysis of randomized controlled trials. J Anesth 2018;32:341–50.
[15] Patterson ME, Bland KS, Thomas LC, Elliott CE, Soberon Jr JR, Nossaman BD, et al. The adductor canal block provides effective analgesia similar to a femoral nerve block in patients undergoing total knee arthroplasty–a retrospective study. J Clin Anesth 2015;27:39–44.
[16] Sardana V, Burzynski JM, Scuderi GR. Adductor canal block or local infiltrate analgesia for pain control after total knee arthroplasty? A systematic review and meta-analysis of randomized controlled trials. J Arthroplasty 2019;34:183–9.
[17] Fan L, Zhu C, Zan P, Yu X, Liu J, Sun Q, et al. The comparison of local infiltration analgesia with peripheral nerve block following total knee arthroplasty (TKA): a systematic review with meta-analysis. J Arthroplasty 2015;30:1664–71.
[18] Tian Y, Tang S, Sun S, Zhang Y, Chen L, Xia D, et al. Comparison between local infiltration analgesia with combined femoral and sciatic nerve block for pain management after total knee arthroplasty. J Orthop Surg Res 2020;15:41.
[19] Chaubey D, Mahajan HK, Chauhan PR, Govind PS, Singh P, Dhanevar R, et al. Comparison of continuous femoral nerve block versus local infiltration analgesia as a postoperative analgesia in unilateral total knee arthroplasty. J Clin Diagn Res 2017;11:UC13–6.
[20] Wang Q, Hu J, Zeng Y, Li D, Yang J, Kang P. Efficacy of two unique combinations of nerve blocks on postoperative pain and functional outcome after total knee arthroplasty: a prospective, double-blind, randomized controlled study. J Arthroplasty 2021;36:3421–31.
[21] Kampitak W, Tanavalee A, Ngarmukos S, Amarase C. Opioid-sparing analgesia and enhanced recovery after total knee arthroplasty using combined triple nerve blocks with local infiltration analgesia. J Arthroplasty 2019;34:295–302.
[22] Gleicher Y, Siddiqui N, Mazda Y, Matelski J, Backstein DJ, Wolfstadt JI. Reducing acute hospitalization length of stay after total knee arthroplasty: a quality improvement study. J Arthroplasty 2021;36:837–44.
[23] Liu Q, Chelly JE, Williams JP, Gold MS. Impact of peripheral nerve block with low dose local anesthetics on analgesia and functional outcomes following total knee arthroplasty: a retrospective study. Pain Med 2015;16:998–1006.
[24] Memtsoudis SG, Cozowicz C, Bekeris J, Bekere D, Liu J, Soffin EM, et al. Peripheral nerve block anesthesia/analgesia for patients undergoing primary hip and knee arthroplasty: recommendations from the International Consensus on Anesthesia-Related Outcomes after Surgery (ICAROS) group based on a systematic review and meta-analysis of current literature. Reg Anesth Pain Med 2021;46:971–85.
[25] Bullocks J, Bob Basu C, Hsu P, Singer R. Prevention of hematomas and seromas. Semin Plast Surg 2006;20:233–40.
[26] Galat DD, McGovern SC, Hanssen AD, Larson DR, Harrington JR, Clarke HD. Early return to surgery for evacuation of a postoperative hematoma after primary total knee arthroplasty. J Bone Joint Surg Am 2008;90:2331–6.

Appendix

Supplemental Table 1
ICD-10 codes for exclusion.

ICD-10 Description	ICD-10 Codes
Neoplasm	C40.2%, C40.8%, C40.9%, C41.9%, C76.5%, C79.5%, C80.0%
Trauma	M80.05%, M80.06%, M80.85%, M80.86%, M84.351%, M84.352%, M84.36%, M84.451%, M84.452%, M84.453%, M84.46%, M84.651%, M84.652%, M84.653%, M84.66%, M84.75%, S72%, S79.0%, S79.1%, S82.0%, S82.1%, S82.2%, S82.3%, S82.4%, S82.8%, S82.9%, S89.0%, S89.1%, S89.2%, S89.3%, M96.66%, M96.67%, M96.69%
Periprosthetic fracture	M97.0%, M97.1%
Complications of orthopedic implants	T84.0%, T84.116%, T85.117%, T84.124%, T84.125%, T84.126%, T84.127%, T84.194%, T84.195%, T84.196%, T84.197%, T84.218%, T84.228%, T84.3%, T84.4%, T84.8%, T84.9%

ICD-10, International Classification of Diseases, Tenth Revision.