Arthroplasty Today 5 (2019) 497–509

Contents lists available at ScienceDirect

Arthroplasty Today

journal homepage: http://www.arthroplastytoday.org/

Original research

Patient-optimizing enhanced recovery pathways for total knee and hip arthroplasty in Medicare patients: implication for transition to ambulatory surgery centers

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ARTICLE INFO

Article history:
Received 26 April 2019
Received in revised form
9 August 2019
Accepted 14 August 2019
Available online 25 September 2019

Keywords:
Local infiltration analgesia
Opioids
Outpatient surgery
Pain management
Rural medicine
Total knee arthroplasty

ABSTRACT

Background: Medicare-insured patients may be candidates for outpatient total knee and hip arthroplasty (TKA/THA) because postsurgical complications are often age unrelated. We evaluated an opioid-minimizing enhanced recovery after surgery (ERAS) pathway in an inpatient setting designed to presurgically optimize and prepare patients to reduce risk of avoidable postsurgical complications and maximize feasibility of same-day discharge.

Methods: This single-center retrospective chart review included 601 unique consecutive Medicare-insured patients who underwent TKA (n = 337) or THA (n = 308) between June 1, 2015 and November 16, 2017. The ERAS pathway included presurgical nonarthroplasty treatment of osteoarthritis; physical, medical, and social optimization; and medication trials to individualize perioperative analgesia. All patients were discharged directly home without home services. Adverse events, satisfaction, and opioid use were analyzed descriptively.

Results: Mean (range) age was 72 (32-92) years; 56.7% of patients were women; 84.0% were discharged the same day, 13.8% in 1 day, and 2.2% in >1 day. Rates of minor and severe adverse events within 30 days were 0.5% and 1.1%, respectively. There were no intubations, sepsis, or deaths. Twelve patients (1.9%) had unplanned readmissions within 30 days. Patient-reported satisfaction with facility, analgesia, and communication were high. Most patients (84.2%) did not require >1 seven-day opioid prescription from the surgeon within 8 weeks postsurgery.

Conclusions: Using a patient-optimizing, opioid-minimizing ERAS pathway without home services, Medicare-insured patients undergoing TKA/THA experienced low complication rates and high satisfaction. Exploratory analysis suggests limited postsurgical opioid use. This presurgical patient-engagement approach may aid transition to freestanding ambulatory surgery centers.

Introduction

Outpatient total knee arthroplasty (TKA) and total hip arthroplasty (THA) are growing rapidly in volume. It is estimated that by 2026, 51% will be performed as outpatient procedures [1]. Concerns remain over elevated risk of complications in older patients. Even with the removal of TKA from the Centers for Medicare and Medicaid Services (CMS) inpatient-only list, TKA cannot be performed in a freestanding ambulatory surgery center (ASC).

A recent retrospective study showed that 70% of patients undergoing TKA/THA at an academic medical center would theoretically have been eligible for the procedure at an ASC [2]. The most common reasons for ineligibility were not age related but rather medical in nature (ie, body mass index, severity of comorbidities, and untreated obstructive sleep apnea). This suggests that Medicare status alone may not be a relevant exclusion criterion for ambulatory TKA/THA; therefore, expansion to freestanding ASCs for Medicare-insured patients warrants CMS consideration.

Uncontrolled pain and opioid-related nausea are common factors delaying discharge [3]. Use of opioid medication increases risk for chronic opioid use [4], and opioid-related adverse events (AEs)

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to https://doi.org/10.1016/j.artd.2019.08.008.

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https://doi.org/10.1016/j.artd.2019.08.008

are associated with prolonged hospital stays, readmission, mortality [5], and increased costs [6]. Controlling pain while minimizing opioid use has been a major focus of many TKA/THA programs [7]. Enhanced recovery after surgery (ERAS) pathways incorporating multimodal, opioid-sparing protocols have been shown to improve clinical and economic outcomes after TKA [7]. ERAS pathways incorporating presurgical physical, social, and medical optimization may be especially critical in elderly patients who experience barriers to healthcare owing to lack of transportation, social isolation, and cost. ERAS pathways offer Medicare patients quality care that meets the "Triple Aim" of healthcare: improving patient experience, improving population health, and reducing healthcare costs.

The objective of this study is to assess outcomes and feasibility of same-day discharge using a presurgical patient-optimizing, opioid-sparing ERAS pathway in Medicare-insured patients undergoing TKA/THA without home healthcare services. The pathway focused on expanding the eligible patient population, improving patient satisfaction, reducing postsurgical complications and cost, and minimizing the duration of postsurgical opioid use.

Material and methods

This is a retrospective chart review of 601 consecutive unique Medicare-insured patients who underwent primary inpatient TKA or THA between June 1, 2015 and November 16, 2017, performed by 1 surgeon at a rural hospital inpatient facility. Two Institutional Review Boards approved the study. Patient data were deidentified, and the Institutional Review Boards granted a waiver of written informed consent.

The comprehensive outpatient ERAS pathway was developed over >10 years by the senior author of this report based on patient needs and outcomes. It encompassed the entire period from the initiation of conservative/nonsurgical care of arthritis to the decision to undergo TKA/THA to at-home recovery (Appendix A). The key elements of the pathway included patient engagement, creation of realistic expectations, and presurgical development of an individualized, opioid-sparing, multimodal pain control program. There were no inclusion or exclusion criteria for entry into the ERAS pathway. Patients were required to participate in their own care and preparation for surgery.

Patient engagement included conservative/nonarthroplasty management of hip and knee osteoarthritis per evidence-based clinical practice guidelines [8,9]; education; and medical, physical, and social optimization. Conservative care of osteoarthritis was initiated at the patient's first clinic visit before consideration of surgical intervention and included physical optimization via physical therapy. As part of conservative osteoarthritis care, a home program of strengthening and stretching exercises (1 h/d) and a walking or other upright weight-bearing aerobic program (6 h/wk) to reduce pain and improve function was customized to each patient [8,9]. Other elements included weight loss, nonopioid pain medication trials, appropriate intra-articular steroid/viscosupplementation injections, and medical optimization of modifiable problems.

Medical optimization included goals to correct not only the medical problems (ie, modifiable risk factors) known to increase a patient's risk of complications but also those found by the senior author to improve patient outcomes and satisfaction by increasing patient compliance and engagement. The conservative care of arthritis program was designed to not only treat arthritis symptoms, but also prepare the patient for joint replacement when the decision was made to pursue that option, thereby minimizing delays to surgery. The senior author's desire was to expand the population of patients suitable for outpatient joint replacement by preparing patients physically and medically for successful outpatient joint replacement.

Once conservative care of arthritis failed to meet the patient's expectations, patients were assisted as needed in additional presurgical physical, medical, and social optimization to meet the goals for TKA/THA with same-day discharge. Patients who decided to have surgery were not required to meet any inclusion criteria for entry into this part of the ERAS pathway; all patients were assisted with meeting the goals for surgery for as long as needed. Patient engagement in his or her care was a significant aspect of surgery preparation. Those unwilling to engage, participate, and comply with the ERAS pathway were offered continued nonsurgical care of osteoarthritis or referred elsewhere for care.

As part of their social optimization, patients were required to have a "JointCoach." The JointCoach could be a family member or friend. The JointCoach often assisted the patient during the conservative/nonsurgical care of arthritis program and was required to be present at the appointment for the patient's decision to undergo surgery so that the patient's and JointCoach's readiness could be determined and additional preparation could be provided as needed. For the JointCoach, readiness included understanding and willingness to perform their duties. If the patient or JointCoach was found to be unprepared or unwilling, surgery was delayed until both were fully prepared or a new JointCoach could be found. The JointCoach was also required to be present at the facility on the day of surgery and to stay with the patient for 3 days after surgery to ensure medication compliance and adherence to exercise and analgesia protocols, with the aim of improving outcomes and reducing complications. Early in the process, the patient and JointCoach participated in education regarding realistic expectations for pain, the dangers of opioid use, opioid tapering, sleep hygiene, exercise and walking programs, walker safety, wound care, and home preparation. Refresher education was provided on the day of surgery by the senior author and staff, including nurses, physical therapists, and mid-level providers. Patients were not discharged from the surgical facility until they met all physical criteria for discharge and were considered to be medically, physically, and socially prepared to be in their home without the aid of home health services. Therefore, before surgery, a short course of physical therapy was initiated to educate the patient on the use of adaptive/recovery aids (eg, walkers), home preparation and safety, activities of daily living, postsurgical flexibility/strengthening/exercise programs, joint precautions, and postsurgical icing and elevation for pain and edema control. This presurgical physical therapy was initiated to ensure that patients could demonstrate (both before and after surgery) that they knew how to use the postsurgical recovery aids; could perform activities of daily living and exercises; understood medications, precautions, and appropriate icing/elevating; and had a safe home environment.

The presurgical creation of customized, multimodal, opioid-sparing pain management was implemented. Presurgical 2-day opioid medication trials were employed to develop individualized pain, nausea, itching, constipation, urinary retention, and anesthesia treatment plans for each patient. Information pertaining to previous use and efficacy of opioid, antinausea, anti-itch, and anticonstipation medications was collected and combined with patient-specific information (eg, age, weight, height, history of constipation, medications, and medical history) to determine the appropriate dosages for the trial. Multiple trials were performed if needed to determine the best treatment plan. For the opioid medication trial, patients were instructed to take antinausea and anti-itch medications before eating and to take their oral opioid after eating, 4 times daily. Patients were also encouraged to be active. The goal was to reduce discomfort by 60% without significant side effects. Anticonstipation medication (polyethylene glycol and docusate sodium twice daily), along with adequate fluids to prevent dehydration, were commenced 1 day prior to the opioid

medication trial; anticonstipation rescue medication was also available if necessary. The individualized opioid pain medication program (with appropriate anticonstipation, anti-itch, and anti-nausea medication) was initiated immediately before surgery. With the exception of the 2-day presurgical opioid medication trial(s), opioids were not prescribed for use before surgery; though, no patient was refused surgery due to chronic or presurgical opioid use. Patients and their JointCoaches were directed to taper patients off the opioid medication as soon as possible after surgery.

A nonopioid pain medication program (acetaminophen, meloxicam, or celecoxib), developed at the time of conservative care, was initiated 1 week before surgery and continued for at least 6 weeks after surgery to reduce postsurgical pain and help patients rapidly taper off opioid medications. Multimodal pain control included anesthesia. Hypotensive and multimodal analgesia methods (Table 1) were used during surgery to minimize trauma, pain, blood loss, and infection risk and promote early function and mobility.

Patients with no previous history of deep vein thrombosis (DVT) or pulmonary embolism (PE) received aspirin 325 mg immediately before surgery and knee-high compression stockings to wear for 2 weeks; compression devices were used during surgery and while at the surgery center. To meet the surgical facility's perception of Medicare requirements for anticoagulation, a single postsurgical dose of warfarin 1.25 mg was given in the recovery area. No additional dose of warfarin was given in patients without chronic anticoagulation medication use or increased risk factors for DVT or PE, but these patients continued taking aspirin 325 mg once daily for 6 weeks. Exercises for the prevention of DVT were initiated in the recovery room, and ambulation was generally initiated within 1-2 hours after surgery. A similar process was followed for patients with a history of DVT or PE; however, these patients received aspirin 325 mg once daily for 1 week and a warfarin protocol for 6 weeks. If currently using anticoagulants, patients were given presurgical enoxaparin bridging as medically indicated and aspirin 325 mg once daily for 1 week postsurgery. If currently using warfarin, the patient's regular maintenance dose was restarted immediately after surgery. The use of any other chronic anticoagulant was reinitiated 3 days after surgery.

TKA was performed using the subvastus approach with an integrated knee system without tourniquet. In the senior author's experience, using the subvastus approach poses less risk of the patient disrupting the extensor mechanism repair during the aggressive postsurgical flexibility and self-stretching protocol. THA was performed using the anterior approach with a complete hip system, acetabular cup system, and fracture table. Patients received spinal anesthesia; awake sedation; adductor canal block with bupivacaine HCl (TKA only); periarticular infiltration with liposomal bupivacaine 266 mg (EXPAREL; bupivacaine liposome injectable suspension; Pacira BioSciences, Inc., Parsippany, NJ), bupivacaine HCl, and adjuncts; anterior lateral femoral cutaneous nerve field block by the surgeon with liposomal bupivacaine 266 mg and bupivacaine HCl (THA only); and restricted intravenous opioids. Hemostasis was obtained using hypotensive anesthesia, tranexamic acid, electrocautery, and bipolar tissue sealer without a tourniquet. After surgery, the patient and his or her JointCoach were moved to a stepdown unit where they were provided with a review of walker training, exercise, dressing care, medication management, icing and elevation, and avoidance of complications. Patients were discharged home without home health services on a multimodal pain regimen (nonopioid analgesics and a 7-day opioid supply). Staff at the surgical facility called patients the day after surgery, and patients were encouraged to call the triage line (during business hours) or the surgeon/partners (after business hours) as needed. The senior author's staff also contacted patients 2-5 business days postsurgery to evaluate progress and answer questions. Patients were encouraged to call before visiting an emergency department (ED) or urgent care (UC) but were instructed to visit an ED if they experienced a heart attack or stroke, could not breathe, or fell and could not get up. Postsurgical outpatient physical therapy was initiated within 3 business days of surgery. Therapy was ordered for 6 visits over 4 weeks and renewed at the 4-week postoperative visit for an additional 4 visits over 4 weeks if deemed medically appropriate by the physical therapist.

Table 1
Surgical protocol.

Method	TKA	THA
Implant	SIGMA	CORAIL and PINNACLE cup
Approach	Subvastus	Anterior; Hana table, C-arm
Tourniquet use	No	
Bipolar tissue sealer	Radiofrequency energy and saline hemostatic sealing device	Radiofrequency energy and saline hemostatic sealing device
Sutures	Spiral knotless tissue control device	Spiral knotless tissue control device
Skin closure system	2-octyl cyanoacrylate and self-adhering mesh	2-octyl cyanoacrylate and self-adhering mesh
Surgical dressing	Silver-impregnated occlusive dressing	Silver-impregnated occlusive dressing
Drain use	No	No

SIGMA, CORAIL, and PINNACLE are registered trademarks of DePuy Synthes (Raynham, MA). Hana is a registered trademark of Mizuho OSI (Union City, CA).

At postsurgical week 2, patients who provided e-mail addresses received Internet-based satisfaction surveys via CareSense (DePuy Synthes, Conshohocken, PA). The surveys were adapted from the Hospital Consumer Assessment of Healthcare Providers and Systems Survey, a national, standardized survey and data collection methodology for measuring patient perspectives on hospital care [10].

Visits to the ED or UC and hospital admissions within 60 days postsurgery were determined by patient report and internal medical records pertaining to care in the 8-week postsurgical period, which were further validated using medical records obtained from regional medical facilities where the patient may have obtained care. Opioid refills from the surgeon within 8 weeks postsurgery and AEs, as defined by a previous American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) study [11], were also assessed within 30 and 60 days postsurgery via patient survey, internal medical records, and regional medical facility records inquiries. Data were summarized descriptively and are presented as mean (standard deviation) for continuous variables and frequency (%) for categorical variables.

Results

The analysis included 601 unique patients who underwent TKA (n = 337) or THA (n = 308) surgeries. No patient was excluded from the analyses. Overall, mean (range) age was 72 (32-92) years, 92.1% were ≥65 years old, 56.7% were women, 30.5% had heart disease, and 13.6% had diabetes. Three patients hired a JointCoach rather than using a family member or friend. There were no intubations or transfusions on the day of surgery and no directly surgery-related transfusions. Most patients (84.0%) were discharged on the same day as surgery, 13.8% in 1 day, and 2.2% in >1 day. Rates of severe and minor AEs were 1.1% and 0.5%, respectively, within 30 days postsurgery and 1.7% and 0.9% within 60 days postsurgery (Table 2). Rates of unplanned medical and surgical readmissions were 1.7% and 0.2%, respectively, within 30 days and 1.9% and 0.6% within 60 days. There were no deaths or reports of sepsis. Thirteen patients (2.0%) had an ED visit without admission. Most patients reported that they would recommend the surgical facility "very much" or "a good amount" (98.9%) and were "very much" or "a good amount" satisfied with pain management (98.3%) and education and communication (>97%; Table 3). Most patients (84.2%) did not

Table 2
Postsurgical complications.

Complication, n (%)[a]	30 d			60 d		
	TKA (n = 337)	THA (n = 308)	Total (N = 645)	TKA (n = 337)	THA (n = 308)	Total (N = 645)
Severe AE[b]	2 (0.6)	5 (1.6)	7 (1.1)	5 (1.5)	6 (1.9)	11 (1.7)
DVT/PE	2 (0.6)	1 (0.3)	3 (0.5)	2 (0.6)	2 (0.6)	4 (0.6)
Return to surgery	0	1 (0.3)	1 (0.2)	3 (0.9)	1 (0.3)	4 (0.6)
Deep wound infection	0	1 (0.3)	1 (0.2)	0	1 (0.3)	1 (0.2)
Stroke/cerebrovascular accident	0	1 (0.3)	1 (0.2)	0	1 (0.3)	1 (0.2)
Myocardial infarction	0	1 (0.3)	1 (0.2)	0	1 (0.3)	1 (0.2)
Minor AE	1 (0.3)	2 (0.6)	3 (0.5)	2 (0.6)	4 (1.3)	6 (0.9)
Urinary tract infection	0	1 (0.3)	1 (0.2)	1 (0.3)	3 (1.0)	4 (0.6)
Pneumonia	1 (0.3)	1 (0.3)	2 (0.3)	1 (0.3)	1 (0.3)	2 (0.3)
Unplanned readmission	6 (1.8)	6 (1.9)	12 (1.9)	8 (2.4)	8 (2.6)	16 (2.5)
Medical[c]	5 (1.5)	6 (1.9)	11 (1.7)	6 (1.8)	6 (1.9)	12 (1.9)
Pneumonia	1 (0.3)	1 (0.3)	2 (0.3)	1 (0.3)	1 (0.3)	2 (0.3)
Myocardial infarction or other cardiovascular event	1 (0.3)	1 (0.3)	2 (0.3)	1 (0.3)	1 (0.3)	2 (0.3)
Ulcer/gastrointestinal complication	1 (0.3)	0	1 (0.2)	1 (0.3)	0	1 (0.2)
Stroke	0	1 (0.3)	1 (0.2)	0	1 (0.3)	1 (0.2)
DVT/PE	0	0	0	1 (0.3)	0	1 (0.2)
Other medical reason[d]	2 (0.6)	3 (1.0)	5 (0.8)	2 (0.6)	3 (1.0)	5 (0.8)
Surgical[e]	1 (0.3)	0	1 (0.2)	2 (0.6)	2 (0.6)	4 (0.6)
Fracture	1 (0.3)	0	1 (0.2)	2 (0.6)	0	2 (0.3)
Infection or wound complication	0	0	0	0	1 (0.3)	1 (0.2)
Dislocation	0	0	0	0	1 (0.3)	1 (0.2)

[a] Patients with ≥1 complication.
[b] The following severe AEs were not experienced: organ or space infection, wound dehiscence, unplanned intubation, peripheral nerve injury, ventilator >48 h, renal insufficiency or failure, cardiac arrest, sepsis, septic shock, and death.
[c] The following unplanned medical readmissions were not experienced: renal insufficiency or failure, urinary tract infection, superficial infection, sepsis/septic shock, anemia, pulmonary complication, and mental disorders.
[d] Other medical reasons included syncope (n = 2) and urinary retention (n = 3).
[e] The following unplanned surgical readmissions were not experienced: hernia or hematoma, mechanical failure or complication, acute pain, hemarthrosis, sprain/contusion, and other surgical reason.

require an opioid prescription beyond the initial 7-day prescription at discharge.

Discussion

The ERAS pathway for outpatient knee and hip replacements was developed over a 10-year period, through trial and error, using the best information available at the time and the senior author's experience. The materials, approaches, medications, and anesthesia used were found to yield the most consistent results and lowest perceived complications in the senior author's outpatient total joint practice. Using an opioid-minimizing and medically, physically, and socially optimizing ERAS pathway designed to engage patients in their own care and to minimize the risk of postsurgical complications, most Medicare patients chose to participate and were discharged from the hospital on the same day, with high satisfaction and low rates of complications and opioid requirements. With the use of hypotensive anesthesia, tranexamic acid, and bipolar tissue sealer without a tourniquet, no day-of-surgery or directly surgery-related transfusions occurred.

The ERAS pathway was designed to maximize the number of Medicare patients who could successfully and safely undergo outpatient joint replacement. A novel element of the program was a short course of physical therapy that was initiated before surgery not as prehabilitation, which is not supported by American Academy of Orthopedic Surgeons guidelines [9,12], but instead as a means to teach the use of adaptive aids, home preparation and safety, activities of daily living, and postsurgical strengthening and exercise, among other elements. In our experience, shifting some of these activities to the presurgical setting is beneficial in preparing patients to be in their home without the aid of home health services.

Some patients required extensive assistance over many months to meet their health goals (ie, optimization of modifiable medical risk factors); however, no patients were excluded because of amount or duration of assistance required. Very few patients chose not to participate in the program or were unable to meet health goals. Likewise, very few hired a JointCoach in place of recruiting a family member or friend. JointCoaches were rarely rejected as being inadequate, although some needed remedial education. In those cases, surgery was rescheduled until the JointCoach was deemed competent and appropriate. In several cases in which the JointCoach was determined to be unprepared for the required tasks after surgery, a friend or other family member was substituted before proceeding with surgery. These findings suggest that Medicare patients may be suitable candidates for TKA/THA in freestanding ASCs and that CMS reimbursement restriction, not clinical eligibility, is the main limiting factor.

Our findings suggest that same-day discharge does not increase risk for postsurgical complications. Comparing complication rates can be difficult because of inconstancies in how they are collected and reported. To facilitate comparison, we applied the same definitions used in a previous study of patients in the ACS-NSQIP database who underwent TKA/THA in outpatient and inpatient settings [11]. Rates of complications compare favorably to those from the ACS-NSQIP database, limited to the NSQIP system (Table 4) [11]. If, as a recent analysis suggests [13], the NSQIP database underreports such complications compared with other large, national databases such as the Humana (Louisville, KY) administrative claims database (rates ~2-8 times higher than NSQIP), rates in our study may compare even more favorably with national averages. The number of patients filling a second opioid prescription (requiring opioid pain medication beyond 1-week prescription) was also lower than previously reported [4,14], suggesting that the presurgical determination of appropriate opioid medication and dose contained in the ERAS pathway provided adequate postsurgical analgesia during recovery. It also indicates that the Centers for Disease Control and Prevention guideline of a 3-day to 7-day opioid prescription for most patients with acute pain is not an

Table 3
Patient satisfaction.

Composite score	Responses, n (%)[a]
Recommendation of the facility[b]	n = 436
Yes, very much	366 (83.9)
Yes, a good amount	65 (14.9)
Yes, slightly	4 (0.9)
No, not at all	1 (0.2)
Pain management[c]	n = 1309
Yes, very much	1080 (82.5)
Yes, a good amount	207 (15.8)
Yes, slightly	19 (1.5)
No, not at all	3 (0.2)
Education about surgery, medication, and recovery[d]	n = 872
Yes, very much	786 (90.1)
Yes, a good amount	80 (9.2)
Yes, slightly	6 (0.7)
No	0
Discharge education[e]	n = 876
Yes, very much	685 (78.2)
Yes, a good amount	172 (19.6)
Yes, slightly	16 (1.8)
No	3 (0.3)
Communication with nurses[f]	n = 874
Yes, very much	757 (86.6)
Yes, a good amount	110 (12.6)
Yes, slightly	6 (0.7)
No	1 (0.1)
Communication with physician[g]	n = 873
Yes, very much	831 (95.2)
Yes, a good amount	39 (4.5)
Yes, slightly	3 (0.3)
No	0

[a] Sample size based on the number of responses, which in some cases exceeded the number of patients because some categories involved multiple questions.
[b] Would you recommend this surgical facility to others undergoing surgery?
[c] Composite score of 3 questions: (1) During your surgical facility stay, was your pain controlled most of the time? (2) During your surgical stay, were the nurses able to control your pain at a level where you were comfortable? (3) During the course of your joint replacement, was the pain control program effective in keeping your pain at a manageable level?
[d] Composite score of 3 questions: (1) Did you receive adequate educational materials about what to expect during the joint replacement process? (2) Did the educational materials give you a good understanding of the things you were accountable for doing in recovering from your joint replacement surgery? (3) Did the educational materials you received give you a clear understanding of why you need to take each of your medications?
[e] Composite score of 2 questions: (1) When you left the surgical facility, did you fully comprehend items that you were accountable for doing in recovering from your joint replacement surgery? (2) When you were discharged from the surgical facility, were you fully aware of the reasons for taking each of your medications?
[f] Composite score of 2 questions: (1) During your surgical facility stay, were the nurses and staff polite and did they treat you kindly? (2) During your surgical facility stay, did the nurses and staff explain items in a way that you could easily comprehend?
[g] Composite score of 2 questions: (1) During your stay at the surgical facility, was the surgeon polite and did he treat you kindly? (2) During your time at the surgical facility, did the surgeon explain important procedural items in a thorough manner?

Table 4
Comparison of complications with published ACS-NSQIP data.

Complication, n (%)	ACS-NSQIP	Current study	
	30 d (N = 121,669) [11]	30 d (N = 645)	60 d (N = 645)
Severe AE	2171 (1.78)[a]	7 (1.1)	11 (1.7)
Return to surgery	1046 (0.86)	1 (0.2)	4 (0.6)
Thrombolic event (DVT/PE)	790 (0.65)	3 (0.5)	4 (0.6)
Deep wound infection	209 (0.17)	1 (0.2)	1 (0.2)
Organ/space infection	163 (0.13)	0	0
Sepsis	152 (0.12)	0	0
Wound dehiscence	130 (0.11)	0	0
Myocardial infarction	74 (0.06)	1 (0.2)	1 (0.2)
Death	59 (0.05)	0	0
Unplanned intubation	38 (0.03)	0	0
Renal insufficiency	31 (0.03)	0	0
Septic shock	27 (0.02)	0	0
Stroke/CVA	25 (0.02)	1 (0.2)	1 (0.2)
Cardiac arrest requiring CPR	19 (0.02)	0	0
Ventilator >48 h	18 (0.01)	0	0
Renal failure	13 (0.01)	0	0
Minor AE	450 (0.37)[a]	3 (0.5)	6 (0.9)
Superficial infection	240 (0.20)	0	0
Urinary tract infection	131 (0.11)	1 (0.2)	4 (0.6)
Pneumonia	88 (0.07)	2 (0.3)	2 (0.3)
Unplanned readmission	3336 (2.74)[a]	12 (1.9)	16 (2.5)
Medical	1445 (1.19)	11 (1.7)	12 (1.9)
Thrombolic event (DVT/PE)	241 (0.20)	0	1 (0.2)
Ulcer/gastrointestinal complication	109 (0.09)	1 (0.2)	1 (0.2)
Pneumonia	65 (0.05)	2 (0.3)	2 (0.3)
MI, CHF, or other cardiovascular complications	56 (0.05)	2 (0.3)	2 (0.3)
Sepsis/septic shock	50 (0.04)	0	0
Pulmonary complications	35 (0.03)	0	0
Anemia	31 (0.03)	0	0
Renal insufficiency or failure	31 (0.03)	0	0
Urinary tract infection	29 (0.02)	0	0
Mental disorders	12 (0.01)	0	0
Stroke	12 (0.01)	1 (0.2)	1 (0.2)
Other undefined medical reason	774 (0.64)	5 (0.8)	5 (0.8)
Surgical	1886 (1.55)[a]	1 (0.2)	4 (0.6)
Infection or wound complication	721 (0.59)	0	1 (0.2)
Hernia or hematoma	95 (0.08)	0	0
Acute pain	94 (0.08)	0	0
Dislocation	92 (0.08)	0	1 (0.2)
Fracture	87 (0.07)	1 (0.2)	2 (0.3)
Mechanical failure or complication	67 (0.06)	0	0
Hemarthrosis	16 (0.01)	0	0
Sprain or contusion	16 (0.01)	0	0
Other surgical reason	698 (0.57)	0	0

CHF, congestive heart failure; CPR, cardiopulmonary resuscitation; CVA, cerebrovascular accident; MI, myocardial infarction.
[a] Number of unique patients with ≥1 event.

unreasonable goal. However, our analysis should be considered exploratory, as we did not assess whether patients received additional opioid prescriptions from other providers. Moreover, we did not have data on use of prescribed opioid medication (ie, number of pills taken) or presurgical opioid use (no patients were excluded for chronic or presurgical opioid use). Conclusions regarding the pathway's effects on opioid use should not be drawn until more robust analyses are conducted.

Opioid-related AEs can extend hospital stay and increase rates of hospital readmission and costs [5], limiting transition to ambulatory procedures. Using our patient-optimizing, opioid-minimizing ERAS pathway, with no home medical services, total spending for TKA at our center was 25% below the state average for Medicare-insured patients according to the Bundled Payments for Care Improvement Initiative scorecard. However, costs for surgery were not analyzed as part of the current study. This outcome requires further study with consideration of the many different cost contributors for TJA such as physical therapy and patient optimization, anesthesia, hospital stay, and ED and UC visits. We have successfully implemented the same ERAS pathway at a freestanding ASC, where nearly all commercially insured patients were able to receive TKA/THA. Together, these results are promising with regard to feasibility of TKA/THA at a freestanding ASC for Medicare-insured patients.

Study limitations include the retrospective design, with potential for uncontrolled confounding factors, lack of a control group, and the moderate sample size. Although all surgeries were performed at a single center by 1 surgeon, which may limit generalizability, this provided consistency with regard to nursing care, physical therapy instruction, anesthesia, surgical protocols, and infiltration techniques for liposomal bupivacaine. We did not

track how many patients declined to participate in the patient-optimizing ERAS pathway in favor of other care, and patients may self-select against participating in a program where they must take responsibility for their own care. Considering the volume of patients seen and number of surgeries performed, the ERAS pathway and its results are very popular in the rural area where the senior author practices. The vast majority of patients were referred by word of mouth or from primary care physicians who are pleased with the program results. The program was developed to be inclusive of any patient who wanted to participate while being mindful of those for whom this pathway would be unsafe, who should therefore be referred to a larger and more comprehensive facility.

Our findings suggest that this ERAS pathway offering presurgical patient engagement, presurgical optimization of modifiable risk factors, and individually customized opioid-minimizing pain management may yield low rates of complications and high patient satisfaction. Opioid use findings suggest that this approach has the potential to help meet Centers for Disease Control and Prevention guidelines for postsurgical opioid use but were exploratory in nature and require more thorough and robust assessment. The individual elements contained within the protocol also need to be validated through comparative studies, but the protocol as a whole was highly successful in a Medicare population that was willing to engage and participate in their care. The findings also suggest that Medicare patients may undergo same-day TKA/THA with low rates of complications and that the potential exists for safe and successful TKA/THA at freestanding ASCs.

Conclusions

Using a patient-optimizing, opioid-minimizing ERAS pathway without home services, Medicare-insured patients undergoing TKA/THA experienced low rates of complications and high satisfaction. This approach of presurgical patient engagement may provide avenues for transition to freestanding ASCs.

Acknowledgments

Editorial support for development of this manuscript was provided by Krystina Neuman, PhD, at C4 MedSolutions, LLC (Yardley, PA), a CHC Group company, and was funded by Pacira BioSciences, Inc. Pacira BioSciences, Inc. participated in the review of the manuscript. The authors were independently responsible for the study design and collection, analysis, and interpretation of data, as well as the final approval to submit for publication.

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Engagement and medical/social optimization

- Each patient is required to have a "JointCoach" (family, friend, or employed professional) who participates in presurgical education, preparation, and counseling. The JointCoach must be present at the ASC on the day of surgery and stay with the patient for 3 days after surgery. In cases in which the JointCoach needs additional education and preparation, surgery is rescheduled until the JointCoach is deemed competent and appropriate.
- The JointCoach duties include
  - Dispensing all postsurgical medications for 4 days after surgery.
  - Guaranteeing patient adherence to exercise, stretching, walking, and edema-control regimens.
- Patients' engagement in their own care begins at first contact with the surgeon's staff and includes agreement to be an active participant, to receive education, and to set realistic expectations. Usually patients undergo a program of conservative arthritis care before surgery. Because the surgeon practices in an area with limited primary care physicians, the program includes weight loss, exercise, physical therapy, non-opioid pain medication trials, and medical optimization.
- Patients receive assistance in the following areas:
  - Stabilization of medical issues (eg, cardiology, BMI, diabetes, smoking, hypertension, depression, opioid minimization, urinary retention, chronic edema, dental health, integument continuity, infection risk, DVT/PE history, bacterial colonization, open wound, skin lesions, fistulas, use of biologics/immunosuppressive medications,

Appendix A. Enhanced recovery after surgery pathway. AJRR, American Joint Replacement Registry; ASA, American Society of Anesthesiologists; ASC, ambulatory surgery center; BID, twice daily; BMI, body mass index; DVT, deep vein thrombosis; ER, extended release; IV, intravenous; NSAID, nonsteroidal anti-inflammatory drug; PACU, postanesthesia care unit; PE, pulmonary embolism; QD, once daily; QID, 4 times daily; SBP, systolic blood pressure; THA, total hip arthroplasty; TKA, total knee arthroplasty. [a]Patients with risk of mortality based on AJRR score and/or with ASA score >3 were prepared for surgery with the ERAS pathway as with all other patients. If they participated in the ERAS pathway and met the goals, they were referred to surgical facilities with a higher acuity level of care than the surgeon's rural facility.

dementia/memory loss) o Meeting standard inclusion criteria for inpatient TKA/THA: BMI <36 kg/m^2, hemoglobin A1c <7%, SBP <140 mm Hg, AJRR mortality risk score <5%, low to moderate cardiac risk, smoking cessation, albumin >3.5, hemoglobin within laboratory normal limits, controlled depression/anxiety[a] o Social optimization: creation of a social support network, including JointCoach, and a safe postsurgical at-home environment o Home preparation • Stop chronic anticoagulation; bridge with enoxaparin if necessary (last dose 24 h before surgery) • At ≤2 months before surgery, a nasal swab for culture is obtained. If colonized with an organism resistant to standard prophylactic surgical antibiotic treatment (ie, methicillin-resistant staphylococcus aureus or other), the antibiotic regimens are modified to treat the organism while still maintaining recommended antibiotic coverage. Antibiotics are not initiated before surgery.
Education • Education is founded on delivery of patient-centered care and initiated upon decision to undergo the surgery. o Includes realistic expectations for pain, dangers of opioid use, opioid tapering, presurgical and postsurgical exercise, sleep hygiene, and wound care • The patient and JointCoach receive written handouts on preparation for joint replacement and must demonstrate they have read them and have prepared for the decision for surgery appointment and scheduling.

Appendix A. (*continued*).

- The decision for surgery appointment is a one-on-one session with the surgeon to set expectations regarding pain, responsibilities, recovery timeline, benefits of the procedure, wound care, and reasons for limited success, and to discuss the dangers of opioid use and appropriate opioid tapering.
- Patients are counseled that they will have discomfort and to take additional opioid doses only if discomfort would limit their ambulation or exercise.
- The day of surgery, refresher education is provided on medications, exercises, walker use, home safety, wound care, and tapering of opioid medication.

Physical optimization

- All patients complete a conservative/non-arthroplasty care of osteoarthritis program using presurgical physical therapy (6 visits during 4 weeks) to customize an at-home strengthening and stretching program to improve function and reduce pain.
    - Physical therapy includes an individualized exercise program comprising strengthening and stretching (1–2 h/d) and upright walking (6 h/wk outside of daily activities).
- A short course of physical therapy (3 presurgical visits) is initiated after the decision to undergo surgery to educate patients on use of adaptive aids (eg, walker and shoe aids), home preparation and safety, activities of daily living, joint precautions, postoperative home exercise, icing, and elevation.
- The postsurgical rehabilitation program includes
    - Icing and elevation (90-degree hip/knee flexion position).
    - Sleep hygiene education
    - Self-rehabilitation: stretching 15 min QID, strengthening 15 min QID, walking (4–6

Appendix A. (*continued*).

sessions for total of 60 min/d), icing, and elevation o Six physical therapy visits over 4 weeks
Multimodal postsurgical pain management • Tailored pain management regimens are developed for each patient to meet individual postoperative analgesic needs while reducing the risks of complications during the postoperative course (eg, sedation, nausea, vomiting, confusion, inadequate pain control, sleep disturbance, urinary retention, and constipation). • At least 1 week before surgery, patients are initiated on a non-opioid pain medication program targeting a 50% reduction in degenerative joint disease symptoms with activity. The choice of NSAID is determined by patient preference and experience with the non-surgical care of their arthritis. o Vitamin C 1000 mg BID o Platelet-function–sparing NSAID (celecoxib 400 mg/meloxicam 15 mg QD) o Acetaminophen ER 650 mg QID • If symptoms of urinary retention are identified or occur during the opioid trial, tamsulosin or similar medication is initiated 7 days before surgery. • A series of 2-day presurgery trials is used to predetermine the optimum opioid, antinausea/anti-itch medication, and anticonstipation program for each patient and to identify patients with constipation problems or opioid-related urinary retention. o Opioid (eg, oxycodone, codeine, tramadol, hydromorphone, or morphine) QID, combined antinausea/anti-itch medication QID, and anticonstipation program targeting 60% reduction in degenerative joint disease symptoms/pain with activity without sedation or confusion and with tolerable nausea, vomiting, itching, and urinary retention

Appendix A. (*continued*).

- Three days before surgery, patients are initiated on their individualized constipation prevention program.
- Immediately before surgery in the PACU, patients receive their first dose of oral opioid and antinausea medication (as determined from their presurgery medication trial), non-opioid pain medications, IV ketorolac 15 mg, and IV dexamethasone.
- Patients continue to receive IV ketorolac 15 mg, immediately postoperatively and every 6 hours as needed while in the surgical facility.
- Intraoperatively, patients receive
    - IV tranexamic acid (dosed based on body weight, 2 g if <100 kg; 2.5 g if 101–120 kg; 3 g if >120 kg)
    - Limited IV fluids (500–1000 mL)
    - No IV opioids or benzodiazepines unless absolutely necessary
    - Short-acting spinal anesthesia (chloroprocaine 30–60 mg); general anesthesia if spinal fails
    - Awake sedation (propofol)
    - Hypotensive agent
    - Adductor canal block (TKA only) with bupivacaine HCl
    - Anterior lateral femoral cutaneous nerve field block (THA only) with liposomal bupivacaine 266 mg (EXPAREL®; bupivacaine liposome injectable suspension; Pacira BioSciences, Inc., Parsippany, NJ) and bupivacaine HCl
    - Local infiltration analgesia, TKA:
        - 80 mL total (liposomal bupivacaine, 266 mg/20 mL; bupivacaine HCl 0.5%, 30 mL;

Appendix A. (*continued*).

ketorolac, 15 mg; epinephrine; normal saline, 30 mL)
    - 30 mL (2.5-mL aliquots) injected in skin (22-gauge spinal needles)
    - 35 mL (2.5-mL aliquots) injected in periosteum/soft tissue of the medial, lateral and anterior femur 6–8 cm proximal to joint surface
    - 15 mL injected in posterior femur soft tissue/periosteum 5 cm proximal to joint capsule
  - Local infiltration analgesia, THA:
    - 70 mL total (liposomal bupivacaine, 266 mg/20 mL; bupivacaine HCl 0.5%, 30 mL; ketorolac, 15 mg; epinephrine; normal saline, 20 mL)
    - 30 mL (2.5-mL aliquots) injected in skin
    - 20 mL injected as anterior lateral femoral cutaneous nerve block
    - 20 mL (2.5-mL aliquots) injected in periosteum/soft tissue of the lateral troch bursa and lateral femur
- Postoperatively, patients receive non-opioid, opioid, and antinausea medications as determined by the preoperative trial. Oral opioids are used as needed if the patient's pain level exceeds his or her comfort during mobilization and exercise.
- After surgery, patients continue on the scheduled non-opioid pain medication for ≥6 weeks.
- Patients are discharged with a 7-day supply of scheduled opioids with instruction to follow the scheduled opioid dosing and antinausea program until the local anesthetic wears off (2–3 days), taking opioid medication up to 4 times daily as needed. They are instructed to taper off the scheduled opioid doses and as-needed doses as rapidly as possible.

Surgical protocol and techniques (also see **Table 1**)

- No eating or drinking non-clear liquids after midnight before surgery

Appendix A. (*continued*).

• Clear liquids up to 2 hours before check-in at surgical facility • Homeostasis via hypotensive anesthesia, tranexamic acid, electrocautery, and a bipolar tissue sealer • Advanced suture and wound closure systems to reduce wound complications and infection risks • Subvastus approach and an integrated knee system without tourniquet for TKA; anterior approach and complete hip system, acetabular cup system, and fracture table for THA • All knees are cemented without antibiotic. • Postoperatively in the ASC, patients receive IV tranexamic acid (1 g if limited bleeding; 2 g if field is not completely dry before closure)
Discharge criteria • Good pain control, patient and JointCoach satisfaction with education, and ASC staff determination of safety for home environment • Ability to walk ≥350 feet with a walker, navigate stairs, and perform postoperative exercise program • JointCoach and patient demonstrate understanding of medications and rehabilitation protocols

Appendix A. (*continued*).