BMJ Open is committed to open peer review. As part of this commitment we make the peer review history of every article we publish publicly available.

When an article is published we post the peer reviewers' comments and the authors' responses online. We also post the versions of the paper that were used during peer review. These are the versions that the peer review comments apply to.

The versions of the paper that follow are the versions that were submitted during the peer review process. They are not the versions of record or the final published versions. They should not be cited or distributed as the published version of this manuscript.

BMJ Open is an open access journal and the full, final, typeset and author-corrected version of record of the manuscript is available on our site with no access controls, subscription charges or pay-per-view fees (http://bmjopen.bmj.com).

If you have any questions on BMJ Open's open peer review process please email info.bmjopen@bmj.com

BMJ Open

Same Day Discharge Total Knee and Total Hip Arthroplasty are associated with Increased Risk of Perioperative Complications

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-031260
Article Type:	Research
Date Submitted by the Author:	24-Apr-2019
Complete List of Authors:	Liu, Jiabin; Hospital for Special Surgery, Weill Medical College of Cornell University, Department of Anesthesiology, Critical Care & Pain Management Elkassabany, Nabil; University of Pennsylvania Poeran, Jashvant; Icahn School of Medicine at Mount Sinai, Institute for Healthcare Delivery Science, Department of Population Health Science and Policy Gonzlez della Valle, Alejandro; Hospital for Special Surgery, Department of Orthopaedic Surgery Kim, David; Hospital for Special Surgery, Weill Medical College of Cornell University, Department of Anaesthesiology, Critical Care and Pain Management Maalouf, Daniel; Hospital for Special Surgery, Anesthesiology, Critical Care & Pain Management Memtsoudis, Stavros; Hospital for Special Surgery, Weill Medical College of Cornell University, Department of Anaesthesiology
Keywords:	Health & safety < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Orthopaedic & trauma surgery < SURGERY, Hip < ORTHOPAEDIC & TRAUMA SURGERY, Knee < ORTHOPAEDIC & TRAUMA SURGERY

Title: Same Day Discharge Total Knee and Total Hip Arthroplasty are associated with Increased Risk of Perioperative Complications

Jiabin Liu, MD, PhD[#*], Nabil M. Elkassabany, MD, MSCE[$], Jashvant Poeran, MD, PhD[%], Alejandro Gonzalez Della Valle, MD[&], David H. Kim, MD[#], Daniel B. Maalouf, MD, MPH[#], Stavros G. Memtsoudis, MD, PhD[#]

#: Department of Anesthesiology, Critical Care & Pain Management, Hospital for Special Surgery, Weill Cornell Medical Center, New York, NY, 10021, United States

$: Department of Anesthesiology & Critical Care, The University of Pennsylvania, Philadelphia, PA 19104, United States

%: Institute for Healthcare Delivery Science, Department of Population Health Science and Policy / Department of Orthopaedic Surgery, Icahn School of Medicine at Mount Sinai, New York, NY, 10029, United States

&: Department of Orthopaedic Surgery, Hospital for Special Surgery, Weill Cornell Medical Center, New York, NY, 10021, United States

Corresponding Author:

* Jiabin Liu, MD, PhD

Dept. of Anesthesiology, Critical Care &Pain Management, Hospital for Special Surgery,

Dept. of Anesthesiology, Weill Cornell Medical Center,

535 East 70th Street, New York, NY 10021, United States

Email: liuji@hss.edu

Funding: none

Conflict of Interest Declaration: none

Manuscript word count: 2614

Abstract word count: 267

Contributors Statement

JL and NME were involved in attaining data from NSQIP. JL, NME, AGDV, and SGM were involved in designing the study. JL analyzed data with help from JP and SGM. All authors contributed to the interpretation of the results, including JL, NME, JP, AGDV, DHM, DBM, and SGM. All authors reviewed, revised, and approved the final document. JL and SGM are the study guarantors, and take responsibility for the completeness of the data and the accuracy of the analysis.

Abstract:

Objective: To determine if same-day discharge total knee or total hip arthroplasty is not associated with increased risk of unplanned readmission and adverse outcomes within 30 days of surgery.

Design: This is a population-based observational study.

Setting: Patients who underwent primary TKA or primary total hip arthroplasty (THA) between 2011 and 2017 were divided into three groups by length of stay (LOS 0, 1, and 2-3 days). All patients with LOS > 3 days were excluded from the current study. Regression analysis and propensity score matching were performed.

Data sources: American College of Surgeons -National Surgical Quality Improvement Program database.

Main Outcomes and Measures: Primary outcomes included unplanned readmission and cardiac/pulmonary complications within 30 days of surgery.

Results: We identified 226,481 TKA (LOS 0=3,118, LOS 1=31,404, and LOS 2-3=191,959) and 140,557 THA patients (LOS 0=2,652, LOS 1=29,617, and LOS 2-3=108,288). There were no differences in 30-day mortality. After adjusting for relevant covariates, LOS 0 (compared to LOS 1) was associated with higher odds of cardiac/pulmonary complications in both TKA (OR 1.95, 95% CI 1.20~3.16; 0.67% versus 0.37%) and THA (OR 1.96, 95% CI 1.05~3.64; 0.57% versus 0.26%). There were no statistical differences in unplanned readmissions between LOS 0 and LOS 1 groups in TKA (2.41% vs 2.31%) and THA (1.62% vs 2.04%).

Conclusions: LOS 0 discharge after TKA and THA was associated with higher odds of cardiac/pulmonary complications compared to LOS 1 discharge. While the overall

burden of complications is relatively low, until future studies can confirm or challenge our findings, a measured approach is advisable when recommending discharge of patients on the same day of surgery.

Strength and limitations of this study:

- Government policy changes in USA cast significant pressure on hospitals and healthcare providers to fast track patients, and expedite a push towards performing surgery at free-standing ambulatory surgery centers. However, there are safety concerns on same-day discharge after total knee arthroplasty (TKA) and total hip arthroplasty (THA).
- After adjustment for relevant covariates, same-day discharge after TKA and THA was associated with higher odds of 30-day cardiac/pulmonary complications comparing to next day discharged patients.
- A measured approach is advisable when recommending discharge of patients on the same day of TKA or THA surgery.
- This is a population-based observational study.

Data sharing statement:

All data utilized for the current study is available via https://www.facs.org/quality-programs/acs-nsqip.

Ethics and dissemination:

The study was exempted by the institutional review board. Results will be communicated through publication in scientific journal and conference.

Introduction:

Joint arthroplasty is amongst the most commonly performed procedures in the United States with projections of continuous growth in parallel with an aging population. Total knee arthroplasty (TKA) is projected at 3.48 million procedures annually, while total hip arthroplasty (THA) at 700,000 per year by 2030 [1]. Until recently, TKA and THA were listed as Inpatient Only (IPO) procedures by the Center for Medicare and Medicaid Service (CMS), which requires greater than 24 hours of postoperative care. Financial pressures, advances in surgical techniques, improved pain management, and early physical rehabilitation have led to a continuous reduction in total hospital length of stay (LOS) after surgery [2]. This trend has made ambulatory joint arthroplasty practice feasible. In fact, CMS removed TKA from the IPO list in January 2018 with the expectation of reducing healthcare cost [3]. It is likely that CMS might remove THA from the IPO list in the near future, especially since the American Association of Orthopaedic Surgeons (AAOS) has also provided supportive statements for outpatient total hip arthroplasty [4]. Such policy decisions by CMS cast significant pressure on hospitals and healthcare providers to fast track patients, and expedite a push towards performing surgery at free-standing ambulatory surgery centers.

However, practical and logistical concerns remain regarding the safety of fast track approaches, especially the true ambulatory practice with same day discharge. While mostly focused on patient selection and optimization of peri-operative care guided under well-defined clinical pathways, actual outcome data are scarce. Several studies found no difference in short-term complications after comparing shorter inpatient stay with LOS≥

2 days [5-7]. Additional studies comparing admission status of outpatient versus inpatient, and concluded that outpatient joint arthroplasty is safe and effective [8-11]. None of these studies focused on true ambulatory population (LOS 0) and the fast track group (LOS 1). Only one previous study by Otero et al. included a small group of LOS 0 patients, and did not identify differences among TKA patients but increased complication rate in THA patients [12]. However, this earlier study was limited by the small sample size to be conclusive, and their study cohort included both emergent procedures and bilateral arthroplasties.

Given the current push towards same-say discharge after lower extremity joint arthroplasty surgery and lack of large-scale data on crucial comparisons, we therefore sought to study the safety of ambulatory surgical practice of TKA and THA with the access of several folds of more subjects to hopefully draw more convincing conclusion. For this purpose, we studied and compared complications and readmission rate and risk in patients discharged on the day of surgery (LOS 0) to those with a LOS of 1 day (LOS 1). We also included the standard practice group with LOS 2-3 days as a reference group. We hypothesized that there would be no difference in complications and readmission rates and risks among patients discharged same day of TKA or THA surgery.

Methods:

This study was exempted by the institutional review board (IRB# 2017-0716) as data accessed and analyzed were de-identified. The population-based observational study follows the STROBE statement.

Cohort description

The current study involved prospectively collected patient information without any identifiable patient specific information. None of these included study subjects would benefit from the current study. However, future patients may benefit from the knowledge highlighted in the current study once it is publicly available.

Patient and Public Involvement

We acquired the data from the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) from 2011 to 2017 (http://site.acsnsqip.org). NSQIP prospectively collects data on over 200 variables, including demographic information, comorbidities, intraoperative variables, 30-day postoperative complications, and readmission. NSQIP conducted independent follow-ups of all registered patients for 30 days even after discharged from hospital, therefore NSQIP was able to capture post-surgical events for 30 days no matter whether patients were still in hospital or were discharged to other destination. NSQIP database does not include surgical procedures performed at ambulatory surgical center as of 2017. To define our study cohort, we only included patients with the principal Current Procedural Terminology (CPT) code for primary TKA (CPT 27447) or primary THA (CPT 27130). We only included patients from 2011 to 2017, as the NSQIP dataset provides information on the readmission incidence within 30 days of surgery during this time frame. There were a total of N=232,218 and N=141,767 entries for TKA and THA with LOS from 0 to 3 calendar days, respectively. We first excluded patients categorized as "emergency" to establish a more homogenous study cohort (N=193 & 435 respectively). We then excluded patients who received bilateral arthroplasty as defined by the relevant concurrent CPT code (N= 5,544 & 775 respectively). The final cohort included 226,481 and 140,557 subjects for TKA and THA, respectively.

Study variables

Patients were separated into 3 groups based on LOS calculated based on calendar days (LOS 0 for same day discharge; LOS 1 for patients with next day discharge; and LOS 2-3 for patients with a traditional LOS of 2 to 3 days). The outcomes of interest were readmission within 30 days and six composite complication variables, including: wound infection, systemic infection, cardiac/pulmonary complications, major complications (including any cardiac, pulmonary, central nerve system, renal, or systemic infection complications), any complication (including any complications enlisted in the NSQIP database), and any complication excluding blood transfusion.

Statistical analysis

Data analysis was executed using STATA 14.2 statistical software (StataCorp LP, College Station, TX). Analysis of variance was used to analyze continuous variables.

Pearson chi-square tests were applied for categorical variables. After applying Bonferroni correction, p-value less than 0.0036 (0.05/14 variables) was used as the cutoff for statistical significance.

We next conducted single variable and multi-variable regression analysis to examine the impact of LOS on readmission and complications. The confounding variables included age, sex, race, body mass index (BMI), surgical duration, year of surgery, and ASA classification. In the regression analysis we treated the LOS 1 group as the reference. The odds ratio (OR) and 95% confidence interval (CI) were reported. We elected to report output from the multi-variable regression analysis in the result section. To further evaluate robustness of our results, we also performed a propensity score matched analysis where the same covariates were entered to calculate the propensity score to receive either same day (LOS 0) or fast track (LOS 1) surgery. We employed the Kernel matching algorithm based on the weighted average of all controls, and the weights are inversely proportional to the distance between the propensity scores.

Results:

We identified N=226,481 primary TKA (LOS 0= 3,118, LOS 1=31,404, and LOS 2-3=191,959) and 140,557 primary THA patients (LOS 0= 2,652, LOS 1=29,617, and LOS 2-3=108,288), respectively. There were no major clinically significant differences in the comorbidity burden between LOS 0 and LOS 1 groups, while LOS 2-3 group carried a higher comorbidity burden (Table 1). Between 2011 and 2017, LOS trended downwards, with an increasing number of patients being discharged on the day of surgery or the next day (TKA 1.04% in 2011, and 26.55% in 2017; THA 3.44% in 2011, and 34.91% in 2017, respectively). The discharge destination was most frequently to home amongst the various TKA groups (LOS 0 group 89.48%, LOS 1 group 97.62%, and 76.39% in LOS 2-3 group). Home discharge was the most prominent disposition in THA as well (LOS 0 group 94.72%, LOS 1 group 97.92%, and 78.37% in LOS 2-3 group). There were no differences in 30-day mortality in either TKA or THA groups (Table 2). The incidences of 30-day major complications and unplanned readmissions were low in the LOS 1 discharge group (0.53% and 2.31% in TKA; 0.43% and 2.04% in THA respectively). There were no statistically significant differences in unplanned readmission between LOS 0 and LOS 1 group in TKA patients (2.41% vs 2.31% in TKA, OR 1.10, 95% CI: 0.86~1.42), nor among THA patients (1.62% vs 2.04% in THA, OR 0.84, 95% CI: 0.60~1.16). LOS 2-3 group otherwise carried the highest incidence of unplanned readmission (Table 2).

Table 3 provides results from the univariable regression, multivariable regression, and the propensity score matching analysis comparing the LOS 0 to the LOS 1 groups. The LOS

0 group was associated with higher odds of cardiac/pulmonary complications in both TKA (OR 1.95, 95% CI 1.20~3.16; unadjusted prevalence 0.67% versus 0.37%) and THA (OR 1.96, 95% CI 1.05~3.64; unadjusted prevalence 0.57% versus 0.26%) when compared to the LOS 1 group. Propensity score matching analysis confirmed such increased incidence of cardiac/pulmonary complications in LOS 0 group (Table 2). The incidence was even higher when compared to the LOS 2-3 group (Table 2).

LOS 0 group was associated higher odds of major complications in TKA recipients (OR 1.94, 95% CI: 1.29~2.92), but not in THA patients (OR 1.55, 95% CI: 0.90~2.67) compared to LOS 1 patients (Table 3 & 4). Similar patterns of differences were also observed in the outcomes for any complications, and any complications excluding transfusion. These differences were statistically significant only in TKA but not in THA (Table 3 & 4). Propensity score matching analysis further confirmed all significances (Table 2). There were no differences in wound infection and systemic infection between LOS 0 and LOS 1 groups in either TKA or THA.

Discussion:

In this analysis of data collected by NSQIP, we present data using population data that challenge the assumed safety of same day discharge after TKA or THA surgery. Our analysis showed somewhat surprising results that LOS 0 group had higher risks of cardiac/pulmonary complications within 30 days after surgery in both TKA and THA, compared to patients in the LOS 1 group. Our study also identified significantly increased odds for major complications with LOS 0 discharge status compared to LOS 1 group amongst TKA recipients.

The average LOS after TKA decreased from 3.42 days in 2011 to 2.38 days in 2017, and from 3.54 days in 2011 to 2.31 days in 2017 after THA surgery (NSQIP data). Accordingly, more patients received fast-track care in more recent years. Previous studies have not shown a difference in readmission rates and complications among fast-track TKA and THA patients [13-18]. Definition of fast-track practice has also been evolving, from previously LOS 2-3 days to as short as LOS 1 day. It is foreseeable that fast-track practice will gear towards LOS 0 day status in the future. Otero et al. studied patients from 2011 and 2013, which they concluded that there were no differences in readmission and 30-day complication in TKA between LOS 0 and LOS 1 status, while THA patients with LOS 0 status were associated with a higher 30-day complication rate [12]. However, this study is limited by the small number of patients in the LOS 0 and LOS 1 groups. In addition, the authors did not exclude patients with emergent admission status and patients who received bilateral arthroplasty procedures. Other researchers have attempted to study the difference in complications in arthroplasty based on the admission status either as outpatient or inpatient [19]. However, such categorization among arthroplasty recipients was arbitrary which was most likely influenced by the type of patients' insurance. Nonetheless, concerns remained amongst clinicians regarding the balance of safe clinical practice and fast-track efficiency.

In order to achieve these goals, clinicians have attempted to identify patients at risk of readmission or complications, and thus triage them accordingly. Many independent risk factors have been identified, including advanced age, gender, high body mass index, increased ASA classification, the presence of chronic obstructive pulmonary disease, congestive heart failure, coronary artery disease, cirrhosis, and chronic kidney disease [5 12 20-24]. In addition, poor living conditions, use of mobility aids, and social economic factors are also likely to influence LOS and outcomes [6 21 25]. Clinicians further developed prediction models to determine a patient's candidacy for fast-track surgical care with moderate success [5 6 26]. It should be mentioned, however, that some data suggest that the majority of patients suffering from a complication after joint arthroplasty may not have any identifiable risk factors[20], thus putting strategies currently being used to identify patients at risk into question.

The majority of major complications, such as cardiac/pulmonary complications, likely occur past 24 hours [5]. This timeframe may therefore fall outside the in-hospital observation period as it relates to fast-track patients. It also has been shown that over 50% of patients with major complications do not carry any of these predisposing risk factors [20]. Therefore, identifying risk factors and risk stratification of patient populations may be of limited use in predicting successful fast-track patients without risk of readmission or complications. The current approach seeks to identify higher risk patients and subsequently exclude them from the fast track pathway. This is supported by our findings that patients in the LOS2-3 group have higher comorbidity burden and are older than those in the LOS0 and LOS1 groups.

Many institutions have established enhanced recovery after surgery (ERAS) pathways for TKA and THA. These pathways seek to improve outcomes by standardizing the routine use of potentially beneficial interventions that improve outcomes and by employing patient selection strategies. Consequently they include younger and healthier patients with sufficient social support to facilitate early discharge. However, such approaches may not be sufficient to reconcile them with unaltered or lower level of complications while gearing towards true ambulatory surgical model.

We conducted this NSQIP data analysis with the hypothesis that ambulatory patients were not at increased risk comparing to other fast track surgical patients after TKA or THA. It is reasonable to assume that these fast-tracked patients were carefully selected without major comorbidity concerns. Further, it is reasonable to assume that these patients met the discharge criteria established across various institutions. Assuming such safe practice model were established and applied, our finding raise concern regarding the safety of same day discharge after TKA or THA surgery. This is especially problematic if the increased risk of complications among this group is related to gaps in continuity of care and lack of necessary early intervention when indicated. However, despite this possibility, our data is not able to establish this causal relationship at this time, and future studies are needed to identify the etiology and mechanism by which complications may develop.

Our study has several limitations. First, this is a retrospective cohort study and related limitations in respect to establishing causality apply. Although NSQIP has rigorous quality measures to ensure high quality data collection, there was still missing information on several interesting pre-existing comorbidity variables, such as stroke and myocardial infarction. Our study is therefore limited by the inclusion of available variables and recorded information only. Second, patients were categorized retrospectively based on their actual LOS determined by calendar days. Future research is indicated to prospectively assign clinical pathways and compare readmission and complications. Third, NSQIP only contains outcome information within 30 days, thus outcomes beyond this point but still related to the index procedure remain elusive. Fourth, NSQIP prohibits identifying hospital and surgeon, while studying surgical volume, inpatient hospital versus free-standing surgical center, and other practice pattern might be insightful. Last, readmission indicator in NSQIP database only included inpatient readmission. Information on emergency department visit would also be important. However, it is beyond the scope of our analysis.

Conclusion

Our study is the first comprehensive study to focus on LOS 0 TKA and THA patients. Although same day discharge after TKA and THA surgery is not associated with increased risk of unplanned readmission, these patients carry increased risk of complications. Therefore, the current trend towards increasing discharges on the same day of surgery after TKA and THA should be approached with caution and requires reconsideration. Future prospective studies are needed to confirm our finding and identify if ambulatory joint arthroplasty is associated with acceptable risk for complications and readmissions, as well as its financial impact on our healthcare system.

Acknowledge:

The authors would like to thank Haoyan Zhong, BS, MPH, for her expert support in statistical issues. The authors also would like to thank Dr. Christopher L. Wu for his insightful review of the manuscript.

Reference:

1. Kurtz S, Ong K, Lau E, et al. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. The Journal of bone and joint surgery American volume 2007;**89**(4):780-5.

2. Sloan M, Sheth NP. Length of stay and inpatient mortality trends in primary and revision total joint arthroplasty in the United States, 2000-2014. Journal of orthopaedics 2018;**15**(2):645-49.

3. CMS. January 2018 Update of the Hospital Outpatient Prospective Payment System (OPPS). In: CMS, ed., 2017.

4. AAOS. Medicare Program; Hospital Outpatient Prospective Payment and Ambulatory Surgical Center Payment Systems and Quality Reporting Program, 2017.

5. Courtney PM, Rozell JC, Melnic CM, et al. Who Should Not Undergo Short Stay Hip and Knee Arthroplasty? Risk Factors Associated With Major Medical Complications Following Primary Total Joint Arthroplasty. The Journal of arthroplasty 2015;**30**(9 Suppl):1-4.

6. Gronbeck CJ, Cote MP, Halawi MJ. Predicting Inpatient Status After Total Hip Arthroplasty in Medicare-Aged Patients. The Journal of arthroplasty 2019;**34**(2):249-54.

7. Duchman KR, Gao Y, Pugely AJ, et al. Differences in short-term complications between unicompartmental and total knee arthroplasty: a propensity score matched analysis. The Journal of bone and joint surgery American volume 2014;**96**(16):1387-94.

8. Lovecchio F, Alvi H, Sahota S, et al. Is Outpatient Arthroplasty as Safe as Fast-Track Inpatient Arthroplasty? A Propensity Score Matched Analysis. The Journal of arthroplasty 2016;**31**(9 Suppl):197-201.

9. Hoffmann JD, Kusnezov NA, Dunn JC, et al. The Shift to Same-Day Outpatient Joint Arthroplasty: A Systematic Review. The Journal of arthroplasty 2018;**33**(4):1265-74.

10. Courtney PM, Froimson MI, Meneghini RM, et al. Can Total Knee Arthroplasty Be Performed Safely as an Outpatient in the Medicare Population? The Journal of arthroplasty 2018;**33**(7S):S28-S31.

11. Courtney PM, Boniello AJ, Berger RA. Complications Following Outpatient Total Joint Arthroplasty: An Analysis of a National Database. The Journal of arthroplasty 2017;**32**(5):1426-30.

12. Otero JE, Gholson JJ, Pugely AJ, et al. Length of Hospitalization After Joint Arthroplasty: Does Early Discharge Affect Complications and Readmission Rates? The Journal of arthroplasty 2016;**31**(12):2714-25.

13. Kehlet H, Wilmore DW. Evidence-based surgical care and the evolution of fast-track surgery. Annals of surgery 2008;**248**(2):189-98.

14. Klingenstein GG, Schoifet SD, Jain RK, et al. Rapid Discharge to Home After Total Knee Arthroplasty Is Safe in Eligible Medicare Patients. The Journal of arthroplasty 2017;**32**(11):3308-13.

15. Glassou EN, Pedersen AB, Hansen TB. Risk of re-admission, reoperation, and mortality within 90 days of total hip and knee arthroplasty in fast-track

departments in Denmark from 2005 to 2011. Acta orthopaedica 2014;**85**(5):493-500.

16. Kiskaddon EM, Lee JH, Meeks BD, et al. Hospital Discharge Within 1 Day After Total Joint Arthroplasty From a Veterans Affairs Hospital Does Not Increase Complication and Readmission Rates. The Journal of arthroplasty 2018;**33**(5):1337-42.
17. Sutton JC, 3rd, Antoniou J, Epure LM, et al. Hospital Discharge within 2 Days Following Total Hip or Knee Arthroplasty Does Not Increase Major-Complication and Readmission Rates. The Journal of bone and joint surgery American volume 2016;**98**(17):1419-28.
18. Yang G, Chen W, Chen W, et al. Feasibility and Safety of 2-Day Discharge After Fast-Track Total Hip Arthroplasty: A Chinese Experience. The Journal of arthroplasty 2016;**31**(8):1686-92 e1.
19. Arshi A, Leong NL, D'Oro A, et al. Outpatient Total Knee Arthroplasty Is Associated with Higher Risk of Perioperative Complications. The Journal of bone and joint surgery American volume 2017;**99**(23):1978-86.
20. Parvizi J, Mui A, Purtill JJ, et al. Total joint arthroplasty: When do fatal or near-fatal complications occur? The Journal of bone and joint surgery American volume 2007;**89**(1):27-32.
21. Jorgensen CC, Kehlet H, Lundbeck Foundation Centre for Fast-track H, et al. Role of patient characteristics for fast-track hip and knee arthroplasty. British journal of anaesthesia 2013;**110**(6):972-80.

22. Rozell JC, Courtney PM, Dattilo JR, et al. Late Complications Following Elective Primary Total Hip and Knee Arthroplasty: Who, When, and How? The Journal of arthroplasty 2017;**32**(3):719-23.

23. Lovald ST, Ong KL, Lau EC, et al. Patient Selection in Short Stay Total Hip Arthroplasty for Medicare Patients. The Journal of arthroplasty 2015;**30**(12):2086-91.

24. Sikora-Klak J, Gupta A, Bergum C, et al. The Evaluation of Comorbidities Relative to Length of Stay for Total Joint Arthroplasty Patients. The Journal of arthroplasty 2017;**32**(4):1085-88.

25. Inneh IA, Iorio R, Slover JD, et al. Role of Sociodemographic, Co-morbid and Intraoperative Factors in Length of Stay Following Primary Total Hip Arthroplasty. The Journal of arthroplasty 2015;**30**(12):2092-7.

26. Schilling PL, Bozic KJ. Development and Validation of Perioperative Risk-Adjustment Models for Hip Fracture Repair, Total Hip Arthroplasty, and Total Knee Arthroplasty. The Journal of bone and joint surgery American volume 2016;**98**(1):e2.

Table 1. Patient demographic information and comorbidity

	Total Knee Arthroplasty								Total Hip Arthroplasty							
	LOS 0		LOS 1			LOS 2-3			LOS 0		LOS 1			LOS 2-3		
	Mean/N	Std/%	Mean/N	Std/%	P value*	Mean/N	Std/%	P value**	Mean/N	Std/%	Mean/N	Std/%	P value*	Mean/N	Std/%	P value**
Age (year)	65.18	9.67	65.40	8.98	0.194	66.61	9.49	<0.001	61.46	10.67	62.13	10.68	0.002	65.07	11.33	<0.001
Sex																
Female	1682	53.94	16363	52.10	0.050	120447	62.77	<0.001	1214	45.78	13254	44.75	0.309	61006	56.37	<0.001
Male	1436	46.06	15041	47.90		71427	37.23		1438	54.22	16363	55.25		47225	43.63	
Race																
White	2512	88.98	26698	89.60	0.354	148875	88.45	<0.001	2213	90.40	25540	90.76	0.217	83651	89.17	<0.001
Black	200	7.08	2080	6.98		14103	8.38		162	6.62	1920	6.82		8108	8.64	
Others	111	3.93	1020	3.42		5330	3.17		73	2.98	681	2.42		2054	2.19	
BMI	32.09	6.39	32.18	6.17	0.419	33.06	6.91	<0.001	29.16	5.39	29.69	5.73	<0.001	30.33	6.41	<0.001
OR time (mins)	84.58	33.48	86.24	29.24	0.003	90.23	34.88	<0.001	82.60	33.49	87.67	32.02	0.002	91.43	38.26	<0.001
ASA classification																
I/II	1882	60.42	17957	57.21	0.001	99497	51.87	<0.001	1958	73.83	20148	68.07	<0.001	62496	57.76	<0.001
>=III	1233	39.58	13432	42.79		92336	48.13		694	26.17	9451	31.93		45696	42.24	
Diabetes																
Type II	367	11.77	3699	11.78	0.983	25932	13.51	<0.001	182	6.86	2152	7.27	0.127	9967	9.20	<0.001
Type I	93	2.98	955	3.04		7901	4.12		46	1.73	537	1.81		2892	2.67	
Smoker	234	7.50	2565	8.17	0.196	16263	8.47	0.036	294	11.09	3696	12.48	0.037	14317	13.22	<0.001
Function status	11	0.35	139	0.45	0.647	1932	1.01	<0.001	14	0.53	211	0.71	0.454	1885	1.75	<0.001
CHF	4	0.13	43	0.14	0.901	483	0.25	<0.001	2	0.08	25	0.08	0.878	272	0.25	<0.001

HTN	1811	58.08	19187	61.10	0.001	124958	65.10	<0.001	1185	44.68	14516	49.01	<0.001	61084	56.41	<0.001
COPD	82	2.63	732	2.33	0.294	6404	3.34	<0.001	67	2.53	660	2.23	[illegible]	4108	3.79	<0.001
Liver disease	0		4	0.01	0.529	27	0.01	0.792	1	0.04	2	0.01	0.113	22	0.02	0.222
Renal insufficiency	3	0.10	28	0.09	0.900	242	0.13	0.201	3	0.11	22	0.07	[illegible]	191	0.18	<0.001
Cancer	1	0.03	21	0.07	0.463	190	0.10	0.119	3	0.11	41	0.14	[illegible]	254	0.23	0.003
Bleeding disorder	49	1.57	445	1.42	0.488	3987	2.08	<0.001	19	0.72	354	1.20	0.027	2168	2.00	<0.001

LOS: length of stay (days); BMI: Body Mass Index; OR: Operating Room; ASA: American Society of Anesthesiologists Classification; CHF: congestive heart failure; HTN: hypertension; COPD: Chronic obstructive pulmonary disease

* p value analysis between LOS 0 and LOS 1 groups

** p value analysis among LOS 0, LOS 1, and LOS 2-3 groups

Table 2. Incidence of complications with various length of stay (LOS, Per 100 patients)

	TKA					THA				
	LOS 0	LOS 1	P value*	LOS 2-3	P value**	LOS 0	LOS 1	P value*	LOS 2-3	P value**
Mortality	0.16	0.08	0.123	0.1	0.253	0.11	0.11	0.939	0.11	0.978
Unplanned readmission	2.41	2.31	0.749	2.89	<0.001	1.62	2.04	0.144	3.26	<0.001
Major complication	0.96	0.53	0.003	0.64	0.006	0.72	0.43	0.034	0.65	<0.001
Any complication excluding transfusion	2.98	1.99	<0.001	2.74	<0.001	1.73	1.68	0.849	2.67	<0.001
Any complication	4.49	2.16	<0.001	6.95	<0.001	3.13	2.86	0.420	9.76	<0.001
Systemic infection	1.67	1.28	0.070	1.73	<0.001	1.06	1.26	0.372	2.03	<0.001
Wound infection	0.77	0.72	0.753	0.88	0.015	0.49	0.77	0.113	1.11	<0.001
Cardiac/pulmonary complications	0.67	0.37	0.009	0.44	0.023	0.57	0.26	0.005	0.39	0.002

TKA: Total knee arthroplasty; THA: Total hip arthroplasty

* p value from analysis between LOS 0 and LOS 1 groups

** p value from analysis among LOS 0, LOS 1, and LOS 2-3 groups

Table 3. Odds ratio (OR) analysis and propensity score matching (PM) analysis of complications in total knee arthroplasty (TKA)

	TKA/Single variable regression					TKA/Multi-variable regression					TKA/PM/Incidence (%)**			
	OR	P value	95% CI			OR	P value	95% CI			LOS 0	LOS 1	P value	
Mortality	2.10	0.132	0.80	5.51		1.78	0.295	0.60	5.27					
Unplanned readmission	1.04	0.749	0.82	1.32		1.10	0.445	0.86	1.42					
Major complication	1.81	0.003	1.22	2.67	*	1.94	0.001	1.29	2.92	*	0.96	0.32	0.003	*
Any complication excluding transfusion	1.51	<0.001	1.21	1.89	*	1.55	<0.001	1.22	1.96	*	2.92	1.53	<0.001	*
Any complication	2.13	<0.001	1.77	2.57	*	2.03	<0.001	1.66	2.47	*	4.42	1.85	<0.001	*
Systemic infection	1.31	0.071	0.98	1.75		1.30	0.098	0.95	1.79					
Wound infection	1.07	0.753	0.70	1.63		0.99	0.963	0.61	1.59					
Cardiac/pulmonary complications	1.84	0.010	1.16	2.94	*	1.95	0.007	1.20	3.16	*	0.68	0.25	0.018	*

* indicates significance; **: propensity score matched 2805 patients per group

Table 4. Odds ratio (OR) analysis and propensity score matching (PM) analysis of complications in total hip arthroplasty (THA)

	THA/Single variable regression					THA/Multi-variable regression					THA/PM/Incidence (%)**			
	OR	P value	95% CI			OR	P value	95% CI			LOS 0	LOS 1	P value	
Mortality	1.05	0.939	0.32	3.42		0.84	0.786	0.24	2.99					
Unplanned readmission	0.79	0.145	0.58	1.08		0.84	0.292	0.60	1.16					
Major complication	1.68	0.036	1.03	2.72		1.55	0.112	0.90	2.67					
Any complication excluding transfusion	1.03	0.849	0.76	1.4		1.00	0.979	0.72	1.41					
Any complication	1.1	0.420	0.87	1.38		1.12	0.363	0.87	1.44					
Systemic infection	0.84	0.373	0.57	1.23		0.77	0.259	0.49	1.20					
Wound infection	0.64	0.116	0.36	1.12		0.75	0.334	0.42	1.35					
Cardiac/pulmonary complications	2.15	0.007	1.24	3.75	*	1.96	0.034	1.05	3.64	*	0.49	0.12	0.020	*

* indicates significance; **: propensity score matched 2443 patients per group

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, explain how loss to follow-up was addressed
		(*e*) Describe any sensitivity analyses
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
		(c) Summarise follow-up time (eg, average and total amount)
Outcome data	15*	Report numbers of outcome events or summary measures over time
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period

Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

BMJ Open

Same Day Discharge Total Knee and Total Hip Arthroplasty are associated with Increased Risk of Cardiac/Pulmonary Complications but not Readmission Risk, a Population-based Observational Study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-031260.R1
Article Type:	Research
Date Submitted by the Author:	26-Sep-2019

Complete List of Authors:	Liu, Jiabin; Hospital for Special Surgery, Weill Medical College of Cornell University, Department of Anesthesiology, Critical Care & Pain Management Elkassabany, Nabil; University of Pennsylvania Poeran, Jashvant; Icahn School of Medicine at Mount Sinai, Institute for Healthcare Delivery Science, Department of Population Health Science and Policy Gonzalez Della Valle, Alejandro; Hospital for Special Surgery Kim, David; Hospital for Special Surgery, Weill Medical College of Cornell University, Department of Anaesthesiology, Critical Care and Pain Management Maalouf, Daniel; Hospital for Special Surgery, Anesthesiology, Critical Care & Pain Management Memtsoudis, Stavros; Hospital for Special Surgery, Weill Medical College of Cornell University, Department of Anaesthesiology

Primary Subject Heading:	Surgery
Secondary Subject Heading:	Health economics
Keywords:	Health & safety < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Orthopaedic & trauma surgery < SURGERY, Hip < ORTHOPAEDIC & TRAUMA SURGERY, Knee < ORTHOPAEDIC & TRAUMA SURGERY

SCHOLARONE™ Manuscripts

Title: Same Day Discharge Total Knee and Total Hip Arthroplasty are associated with Increased Risk of Cardiac/Pulmonary Complications but not Readmission Risk, a Population-based Observational Study

Jiabin Liu, MD, PhD[#*], Nabil M. Elkassabany, MD, MSCE[$], Jashvant Poeran, MD, PhD[%], Alejandro Gonzalez Della Valle, MD[&], David H. Kim, MD[#], Daniel B. Maalouf, MD, MPH[#], Stavros G. Memtsoudis, MD, PhD[#]

#: Department of Anesthesiology, Critical Care & Pain Management, Hospital for Special Surgery, Weill Cornell Medical Center, New York, NY, 10021, United States

$: Department of Anesthesiology & Critical Care, The University of Pennsylvania, Philadelphia, PA 19104, United States

%: Institute for Healthcare Delivery Science, Department of Population Health Science and Policy / Department of Orthopaedic Surgery, Icahn School of Medicine at Mount Sinai, New York, NY, 10029, United States

&: Department of Orthopaedic Surgery, Hospital for Special Surgery, Weill Cornell Medical Center, New York, NY, 10021, United States

Corresponding Author:

* Jiabin Liu, MD, PhD

Dept. of Anesthesiology, Critical Care &Pain Management, Hospital for Special Surgery,

Dept. of Anesthesiology, Weill Cornell Medical Center,

535 East 70th Street, New York, NY 10021, United States

Email: liuji@hss.edu

Funding: none

Conflict of Interest Declaration: none

Manuscript word count: 2797

Abstract word count: 271

Contributors Statement

JL and NME were involved in attaining data from NSQIP. JL, NME, AGDV, and SGM were involved in designing the study. JL analyzed data with help from JP and SGM. All authors contributed to the interpretation of the results, including JL, NME, JP, AGDV, DHK, DBM, and SGM. All authors reviewed, revised, and approved the final document. JL and SGM are the study guarantors, and take responsibility for the completeness of the data and the accuracy of the analysis.

Abstract:

Objective: To determine if same-day discharge total knee or total hip arthroplasty is not associated with increased risk of unplanned readmission and adverse outcomes within 30 days of surgery.

Design: This is a population-based observational study.

Setting: Patients from 708 participating institutions who underwent primary TKA or primary total hip arthroplasty (THA) between 2011 and 2017 were divided into three groups by length of stay (LOS 0, 1, and 2-3 days). All patients with LOS > 3 days were excluded from the current study. Regression analysis and propensity score matching were performed.

Data sources: American College of Surgeons -National Surgical Quality Improvement Program database.

Main Outcomes and Measures: Primary outcomes included unplanned readmission and cardiac/pulmonary complications within 30 days of surgery.

Results: We identified 226,481 TKA (LOS 0=3,118, LOS 1=31,404, and LOS 2-3=191,959) and 140,557 THA patients (LOS 0=2,652, LOS 1=29,617, and LOS 2-3=108,288). There were no differences in 30-day mortality. After adjusting for relevant covariates, LOS 0 (compared to LOS 1) was associated with higher odds of cardiac/pulmonary complications in both TKA (OR 1.95, 95% CI 1.20~3.16; 0.67% versus 0.37%) and THA (OR 1.96, 95% CI 1.05~3.64; 0.57% versus 0.26%). There were no statistical differences in unplanned readmissions between LOS 0 and LOS 1 groups in TKA (2.41% vs 2.31%) and THA (1.62% vs 2.04%).

Conclusions: LOS 0 discharge after TKA and THA was associated with higher odds of cardiac/pulmonary complications compared to LOS 1 discharge. While the overall burden of complications is relatively low, until future studies can confirm or challenge our findings, a measured approach is advisable when recommending discharge of patients on the same day of surgery.

Strength and limitations of this study:

- Information on safety of same-day discharge after total knee arthroplasty (TKA) and total hip arthroplasty (THA) is lacking
- This is the first comprehensive study to focus on length of stay (LOS) 0 and LOS 1 TKA and THA patients.
- This is a population-based observational study.

Data sharing statement:

All data utilized for the current study is available via https://www.facs.org/quality-programs/acs-nsqip. All data is available and free of charge for any researchers within these participating institutions of NSQIP (https://www.facs.org/quality-programs/acs-nsqip/participant-use).

Ethics and dissemination:

The study was exempted by the institutional review board. Results will be communicated through publication in scientific journal and conference.

Introduction:

Joint arthroplasty is amongst the most commonly performed procedures in the United States with projections of continuous growth in parallel with an aging population. Total knee arthroplasty (TKA) is projected at 3.48 million procedures annually, while total hip arthroplasty (THA) at 700,000 per year by 2030 [1]. Until recently, TKA and THA were listed as Inpatient Only (IPO) procedures by the Center for Medicare and Medicaid Service (CMS), which requires greater than 24 hours of postoperative care. Financial necessity, advances in surgical techniques, improved pain management, and early physical rehabilitation have led to a continuous reduction in total hospital length of stay (LOS) after surgery [2]. This trend has made ambulatory joint arthroplasty practice feasible. In fact, CMS removed TKA from the IPO list in January 2018 with the expectation of reducing healthcare cost [3]. It is likely that CMS might remove THA from the IPO list in the near future, especially since the American Association of Orthopaedic Surgeons (AAOS) has also provided supportive statements for outpatient total hip arthroplasty [4]. Such policy decisions by CMS cast significant pressure on hospitals and healthcare providers to fast track patients, and expedite a push towards performing surgery at free-standing ambulatory surgery centers.

However, practical and logistical concerns remain regarding the safety of fast track approaches, especially the true ambulatory practice with same day discharge. While mostly focused on patient selection and optimization of peri-operative care guided under well-defined clinical pathways, actual outcome data are scarce. Several studies found no difference in short-term complications after comparing shorter inpatient stay with LOS≥

2 days [5-7]. Additional studies comparing admission status of outpatient versus inpatient, and concluded that outpatient joint arthroplasty is safe and effective [8-11]. None of these studies focused on true ambulatory population (LOS 0) and the fast track group (LOS 1). One previous study by Otero et al. included a small group of LOS 0 patients, and did not identify differences among TKA patients but increased complication rate in THA patients [12]. Gromov et al. studied 116 LOS 0 patients with matching cohort of 339 patients (LOS 1 to 9 days), and found no readmissions within 48 hours and comparable incidence of readmission within 90 days [13]. However, these earlier studies were limited by the small sample size to be conclusive, and study cohort included emergent procedures, bilateral arthroplasties, or mixed TKA/THA patient population.

Given the current push towards same-say discharge after lower extremity joint arthroplasty surgery and lack of large-scale data on crucial comparisons, we therefore sought to study the safety of ambulatory surgical practice of TKA and THA with the access of several folds of more subjects to hopefully draw more convincing conclusion. For this purpose, we studied and compared complications and readmission rate and risk in patients discharged on the day of surgery (LOS 0) to those with a LOS of 1 day (LOS 1). We also included the standard practice group with LOS 2-3 days as a reference group. We hypothesized that there would be no difference in complications and readmission rates and risks among patients discharged same day of TKA or THA surgery.

Methods:

This study was exempted by the institutional review board (IRB# 2017-0716) as data accessed and analyzed were de-identified. The population-based observational study follows the STROBE statement (second paragraph of "Patient and Public Involvement" section).

Cohort description

The current study involved prospectively collected patient information without any identifiable patient specific information. None of these included study subjects would benefit from the current study. However, future patients may benefit from the knowledge highlighted in the current study once it is publicly available.

Patient and Public Involvement

We acquired the data from the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) from 2011 to 2017 (http://site.acsnsqip.org). NSQIP prospectively collects data on over 200 variables, including demographic information, comorbidities, intraoperative variables, 30-day postoperative complications, and readmission. NSQIP conducted independent follow-ups of all registered patients for 30 days even after discharged from hospital, therefore NSQIP was able to capture post-surgical events for 30 days no matter whether patients were still in hospital or were discharged to other destination. NSQIP database does not include surgical procedures performed at ambulatory surgical center as of 2017. To define our study cohort, we only included patients with the principal Current Procedural Terminology (CPT) code for primary TKA (CPT 27447) or primary THA (CPT 27130). We only included patients from 2011 to 2017, as the NSQIP dataset provides information on the readmission incidence within 30 days of surgery during this time frame.

There were a total of N=232,218 and N=141,767 entries for TKA and THA with LOS from 0 to 3 calendar days, respectively. We first excluded patients categorized as "emergency" to establish a more homogenous study cohort (N=193 & 435 respectively). We then excluded patients who received bilateral arthroplasty as defined by the relevant concurrent CPT code (N= 5,544 & 775 respectively). The final cohort included 226,481 and 140,557 subjects for TKA and THA, respectively.

Study variables

Patients were separated into 3 groups based on LOS calculated based on calendar days (LOS 0 for same day discharge; LOS 1 for patients with next day discharge; and LOS 2-3 for patients with a traditional LOS of 2 to 3 days). The outcomes of interest were readmission within 30 days and six composite complication variables, including: wound infection, systemic infection, cardiac/pulmonary complications (including cardiac arrest requiring CPR, myocardial infarction, pulmonary embolism, unplanned intubation, and/or on ventilator >48 hours), major complications (including any cardiac, pulmonary, central nerve system, renal, or systemic infection complications), any complication (including any complications enlisted in the NSQIP database), and any complication excluding blood transfusion.

Statistical analysis

Data analysis was executed using STATA 14.2 statistical software (StataCorp LP, College Station, TX). Analysis of variance was used to analyze continuous variables. Pearson chi-square tests were applied for categorical variables. After applying Bonferroni correction, p-value less than 0.0036 (0.05/14 variables) was used as the cutoff for statistical significance.

We next conducted single variable and multi-variable regression analysis to examine the impact of LOS on readmission and complications. The confounding variables included age, sex, race, body mass index (BMI), surgical duration, year of surgery, and ASA classification. In the regression analysis we treated the LOS 1 group as the reference. The odds ratio (OR) and 95% confidence interval (CI) were reported. We elected to report output from the multi-variable regression analysis in the result section. To further evaluate robustness of our results, we also performed a propensity score matched analysis where the significant covariates were entered to calculate the propensity score to receive either same day (LOS 0) or fast track (LOS 1) surgery. We employed the Kernel matching algorithm based on the weighted average of all controls, and the weights are inversely proportional to the distance between the propensity scores.

Patient and Public Involvement

Patients were not involved in the design and conduct of current study. All patient related information was de-identified from the database to preserve privacy.

Results:

We identified N=226,481 primary TKA (LOS 0= 3,118, LOS 1=31,404, and LOS 2-3=191,959) and 140,557 primary THA patients (LOS 0= 2,652, LOS 1=29,617, and LOS 2-3=108,288), respectively. There were no major clinically significant differences in the comorbidity burden between LOS 0 and LOS 1 groups, while LOS 2-3 group carried a higher comorbidity burden (Table 1). Between 2011 and 2017, LOS trended downwards, with an increasing number of patients being discharged on the day of surgery or the next day (TKA 1.04% in 2011, and 26.55% in 2017; THA 3.44% in 2011, and 34.91% in 2017, respectively). The discharge destination was most frequently to home amongst the various TKA groups (LOS 0 group 89.48%, LOS 1 group 97.62%, and 76.39% in LOS 2-3 group). Home discharge was the most prominent disposition in THA as well (LOS 0 group 94.72%, LOS 1 group 97.92%, and 78.37% in LOS 2-3 group). There were no differences in 30-day mortality in either TKA (Table 2) or THA groups (Table 3). The incidences of 30-day major complications and unplanned readmissions were low in the LOS 1 discharge group (0.53% and 2.31% in TKA; 0.43% and 2.04% in THA respectively). There were no statistically significant differences in unplanned readmission between LOS 0 and LOS 1 group in TKA patients (2.41% vs 2.31% in TKA, OR 1.10, 95% CI: 0.86~1.42, Table 2), nor among THA patients (1.62% vs 2.04% in THA, OR 0.84, 95% CI: 0.60~1.16, Table 3). LOS 2-3 group otherwise carried the highest incidence of unplanned readmission (Table 2&3).

Table 2&3 also provides results from the univariable regression, multivariable regression, and the propensity score matching analysis comparing the LOS 0 to the LOS 1 groups.

The LOS 0 group was associated with higher odds of cardiac/pulmonary complications in both TKA (OR 1.95, 95% CI 1.20~3.16; unadjusted prevalence 0.67% versus 0.37%, Table 2) and THA (OR 1.96, 95% CI 1.05~3.64; unadjusted prevalence 0.57% versus 0.26%, Table 3) when compared to the LOS 1 group. Propensity score matching analysis confirmed such increased incidence of cardiac/pulmonary complications in LOS 0 group (Table 2&3). The incidence was even higher when compared to the LOS 2-3 group (Table 2&3).

LOS 0 group was associated with higher odds of major complications in TKA recipients (OR 1.94, 95% CI: 1.29~2.92, Table 2), but not in THA patients (OR 1.55, 95% CI: 0.90~2.67, Table 3) compared to LOS 1 patients. Similar patterns of differences were also observed in the outcomes for any complications, and any complications excluding transfusion. These differences were statistically significant only in TKA (Table 2) but not in THA (Table 3). Propensity score matching analysis further confirmed all significances (Table 2&3). There were no differences in wound infection and systemic infection between LOS 0 and LOS 1 groups in either TKA or THA.

Discussion:

In this analysis of data collected by NSQIP, we present data using population data that challenge the assumed safety of same day discharge after TKA or THA surgery. Our analysis showed somewhat surprising results that LOS 0 group had higher risks of cardiac/pulmonary complications within 30 days after surgery in both TKA and THA, compared to patients in the LOS 1 group. Our study also identified significantly increased odds for major complications with LOS 0 discharge status compared to LOS 1 group amongst TKA recipients.

The average LOS after TKA decreased from 3.42 days in 2011 to 2.38 days in 2017, and from 3.54 days in 2011 to 2.31 days in 2017 after THA surgery (NSQIP data). Accordingly, more patients received fast-track care in more recent years. Previous studies have not shown a difference in readmission rates and complications among fast-track TKA and THA patients [14-19]. Definition of fast-track practice has also been evolving, from previously LOS 2-3 days to as short as LOS 1 day. It is foreseeable that fast-track practice will gear towards LOS 0 day status in the future. Otero et al. studied patients from 2011 and 2013, which they concluded that there were no differences in readmission and 30-day complication in TKA between LOS 0 and LOS 1 status, while THA patients with LOS 0 status were associated with a higher 30-day complication rate [12]. However, this study is limited by the small number of patients in the LOS 0 and LOS 1 groups. In addition, the authors did not exclude patients with emergent admission status and patients who received bilateral arthroplasty procedures. Lately, Gromov et al studied LOS 0 patients with a matching cohort of controls with LOS 1 to 9 days [13]. The authors concluded that readmission rates were comparable. However, such comparison might not be fair since LOS 1-9 patients, especially patients with longer LOS usually have indications for hospitalization. The staying in hospital would decrease chances of readmission, nor with recorded diagnosis for readmission. Other researchers have attempted to study the difference in complications in arthroplasty based on the admission status either as outpatient or inpatient [20]. However, such categorization among arthroplasty recipients was arbitrary which was most likely influenced by the type of patients' insurance. Nonetheless, concerns remained amongst clinicians regarding the balance of safe clinical practice and fast-track efficiency.

In order to achieve these goals, clinicians have attempted to identify patients at risk of readmission or complications, and thus triage them accordingly. Many independent risk factors have been identified, including advanced age, gender, high body mass index, increased ASA classification, the presence of chronic obstructive pulmonary disease, congestive heart failure, coronary artery disease, cirrhosis, and chronic kidney disease [5 12 21-25]. In addition, poor living conditions, use of mobility aids, and social economic factors are also likely to influence LOS and outcomes [6 22 26]. Clinicians further developed prediction models to determine a patient's candidacy for fast-track surgical care with moderate success [5 6 27]. It should be mentioned, however, that some data suggest that the majority of patients suffering from a complication after joint arthroplasty may not have any identifiable risk factors[21], thus putting strategies currently being used to identify patients at risk into question.

The majority of major complications, such as cardiac/pulmonary complications, likely occur past 24 hours, and more likely peak on post-operative day 2 to 3. [5 28 29] This timeframe may therefore fall outside the in-hospital observation period as it relates to fast-track patients. It also has been shown that over 50% of patients with major complications do not carry any of these predisposing risk factors [21]. Therefore, identifying risk factors and risk stratification of patient populations may be of limited use in predicting successful fast-track patients without risk of readmission or complications. The current approach seeks to identify higher risk patients and subsequently exclude them from the fast track pathway. This is supported by our findings that patients in the LOS2-3 group have higher comorbidity burden and are older than those in the LOS0 and LOS1 groups.

Many institutions have established enhanced recovery after surgery (ERAS) pathways for TKA and THA. These pathways seek to improve outcomes by standardizing the routine use of potentially beneficial interventions that improve outcomes and by employing patient selection strategies. Consequently they include younger and healthier patients with sufficient social support to facilitate early discharge. However, such approaches may not be sufficient to reconcile them with unaltered or lower level of complications while gearing towards true ambulatory surgical model.

We conducted this NSQIP data analysis with the hypothesis that ambulatory patients were not at increased risk comparing to other fast track surgical patients after TKA or THA. It is reasonable to assume that these fast-tracked patients were carefully selected without major comorbidity concerns. Further, it is reasonable to assume that these patients met the discharge criteria established across various institutions. Assuming such safe practice model were established and applied, our finding raise concern regarding the safety of same day discharge after TKA or THA surgery. This is especially problematic if the increased risk of complications among this group is related to gaps in continuity of care and lack of necessary early intervention when indicated. However, despite this possibility, our data is not able to establish this causal relationship at this time, and future studies are needed to identify the etiology and mechanism by which complications may develop.

Our study has several limitations. First, this is a retrospective cohort study and related limitations in respect to establishing causality apply. Although NSQIP has rigorous quality measures to ensure high quality data collection, there was still missing information on several interesting pre-existing comorbidity variables, such as stroke and myocardial infarction. Our study is therefore limited by the accuracy and completeness of data collection, inclusion of available variables, and recorded information only. Second, patients were categorized retrospectively based on their actual LOS determined by calendar days. Future research is indicated to prospectively assign clinical pathways and compare readmission and complications. Third, NSQIP only contains outcome information within 30 days, thus outcomes beyond this point but still related to the index procedure remain elusive. Fourth, NSQIP prohibits identifying hospital and surgeon, while studying surgical volume, inpatient hospital versus free-standing surgical center, and other practice pattern might be insightful. Last, readmission indicator in NSQIP database only included inpatient readmission. Information on emergency department visit would also be important. However, it is beyond the scope of our analysis.

Conclusion

Our study is the first comprehensive study to focus on LOS 0 TKA and THA patients. Although same day discharge after TKA and THA surgery is not associated with increased risk of unplanned readmission, these patients carry increased risk of complications. Therefore, the current trend towards increasing discharges on the same day of surgery after TKA and THA should be approached with caution and requires reconsideration. Future prospective studies are needed to confirm our finding and identify if ambulatory joint arthroplasty is associated with acceptable risk for complications and readmissions, as well as its financial impact on our healthcare system.

Acknowledge:

The authors would like to thank Haoyan Zhong, BS, MPH, for her expert support in statistical issues. The authors also would like to thank Dr. Christopher L. Wu for his insightful review of the manuscript.

Reference:

1. Kurtz S, Ong K, Lau E, et al. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. The Journal of bone and joint surgery American volume 2007;**89**(4):780-5.
2. Sloan M, Sheth NP. Length of stay and inpatient mortality trends in primary and revision total joint arthroplasty in the United States, 2000-2014. Journal of orthopaedics 2018;**15**(2):645-49.
3. CMS. January 2018 Update of the Hospital Outpatient Prospective Payment System (OPPS). In: CMS, ed., 2017.
4. AAOS. Medicare Program; Hospital Outpatient Prospective Payment and Ambulatory Surgical Center Payment Systems and Quality Reporting Program, 2017.
5. Courtney PM, Rozell JC, Melnic CM, et al. Who Should Not Undergo Short Stay Hip and Knee Arthroplasty? Risk Factors Associated With Major Medical Complications Following Primary Total Joint Arthroplasty. The Journal of arthroplasty 2015;**30**(9 Suppl):1-4.
6. Gronbeck CJ, Cote MP, Halawi MJ. Predicting Inpatient Status After Total Hip Arthroplasty in Medicare-Aged Patients. The Journal of arthroplasty 2019;**34**(2):249-54.
7. Duchman KR, Gao Y, Pugely AJ, et al. Differences in short-term complications between unicompartmental and total knee arthroplasty: a propensity score matched analysis. The Journal of bone and joint surgery American volume 2014;**96**(16):1387-94.
8. Lovecchio F, Alvi H, Sahota S, et al. Is Outpatient Arthroplasty as Safe as Fast-Track Inpatient Arthroplasty? A Propensity Score Matched Analysis. The Journal of arthroplasty 2016;**31**(9 Suppl):197-201.
9. Hoffmann JD, Kusnezov NA, Dunn JC, et al. The Shift to Same-Day Outpatient Joint Arthroplasty: A Systematic Review. The Journal of arthroplasty 2018;**33**(4):1265-74.
10. Courtney PM, Froimson MI, Meneghini RM, et al. Can Total Knee Arthroplasty Be Performed Safely as an Outpatient in the Medicare Population? The Journal of arthroplasty 2018;**33**(7S):S28-S31.
11. Courtney PM, Boniello AJ, Berger RA. Complications Following Outpatient Total Joint Arthroplasty: An Analysis of a National Database. The Journal of arthroplasty 2017;**32**(5):1426-30.
12. Otero JE, Gholson JJ, Pugely AJ, et al. Length of Hospitalization After Joint Arthroplasty: Does Early Discharge Affect Complications and Readmission Rates? The Journal of arthroplasty 2016;**31**(12):2714-25.
13. Gromov K, Jorgensen CC, Petersen PB, et al. Complications and readmissions following outpatient total hip and knee arthroplasty: a prospective 2-center study with matched controls. Acta orthopaedica 2019;**90**(3):281-85.
14. Kehlet H, Wilmore DW. Evidence-based surgical care and the evolution of fast-track surgery. Annals of surgery 2008;**248**(2):189-98.

15. Klingenstein GG, Schoifet SD, Jain RK, et al. Rapid Discharge to Home After Total Knee Arthroplasty Is Safe in Eligible Medicare Patients. The Journal of arthroplasty 2017;**32**(11):3308-13.
16. Glassou EN, Pedersen AB, Hansen TB. Risk of re-admission, reoperation, and mortality within 90 days of total hip and knee arthroplasty in fast-track departments in Denmark from 2005 to 2011. Acta orthopaedica 2014;**85**(5):493-500.
17. Kiskaddon EM, Lee JH, Meeks BD, et al. Hospital Discharge Within 1 Day After Total Joint Arthroplasty From a Veterans Affairs Hospital Does Not Increase Complication and Readmission Rates. The Journal of arthroplasty 2018;**33**(5):1337-42.
18. Sutton JC, 3rd, Antoniou J, Epure LM, et al. Hospital Discharge within 2 Days Following Total Hip or Knee Arthroplasty Does Not Increase Major-Complication and Readmission Rates. The Journal of bone and joint surgery American volume 2016;**98**(17):1419-28.
19. Yang G, Chen W, Chen W, et al. Feasibility and Safety of 2-Day Discharge After Fast-Track Total Hip Arthroplasty: A Chinese Experience. The Journal of arthroplasty 2016;**31**(8):1686-92 e1.
20. Arshi A, Leong NL, D'Oro A, et al. Outpatient Total Knee Arthroplasty Is Associated with Higher Risk of Perioperative Complications. The Journal of bone and joint surgery American volume 2017;**99**(23):1978-86.
21. Parvizi J, Mui A, Purtill JJ, et al. Total joint arthroplasty: When do fatal or near-fatal complications occur? The Journal of bone and joint surgery American volume 2007;**89**(1):27-32.
22. Jorgensen CC, Kehlet H, Lundbeck Foundation Centre for Fast-track H, et al. Role of patient characteristics for fast-track hip and knee arthroplasty. British journal of anaesthesia 2013;**110**(6):972-80.
23. Rozell JC, Courtney PM, Dattilo JR, et al. Late Complications Following Elective Primary Total Hip and Knee Arthroplasty: Who, When, and How? The Journal of arthroplasty 2017;**32**(3):719-23.
24. Lovald ST, Ong KL, Lau EC, et al. Patient Selection in Short Stay Total Hip Arthroplasty for Medicare Patients. The Journal of arthroplasty 2015;**30**(12):2086-91.
25. Sikora-Klak J, Gupta A, Bergum C, et al. The Evaluation of Comorbidities Relative to Length of Stay for Total Joint Arthroplasty Patients. The Journal of arthroplasty 2017;**32**(4):1085-88.
26. Inneh IA, Iorio R, Slover JD, et al. Role of Sociodemographic, Co-morbid and Intraoperative Factors in Length of Stay Following Primary Total Hip Arthroplasty. The Journal of arthroplasty 2015;**30**(12):2092-7.
27. Schilling PL, Bozic KJ. Development and Validation of Perioperative Risk-Adjustment Models for Hip Fracture Repair, Total Hip Arthroplasty, and Total Knee Arthroplasty. The Journal of bone and joint surgery American volume 2016;**98**(1):e2.
28. Jorgensen CC, Kehlet H, Lundbeck Foundation Centre for Fast-track H, et al. Early thromboembolic events </=1week after fast-track total hip and knee arthroplasty. Thrombosis research 2016;**138**:37-42.

29. Petersen PB, Kehlet H, Jorgensen CC, et al. Myocardial infarction following fast-track total hip and knee arthroplasty-incidence, time course, and risk factors: a prospective cohort study of 24,862 procedures. Acta orthopaedica 2018;**89**(6):603-09.

Table 1. Patient demographic information and comorbidity

	Total Knee Arthroplasty									Total Hip Arthroplasty								
	LOS 0		LOS 1			LOS 2-3				LOS 0		LOS 1			LOS 2-3		
	Mean/N	Std/%	Mean/N	Std/%	P value*	Mean/N	Std/%	P value**		Mean/N	Std/%	Mean/N	Std/%	P value*	Mean/N	Std/%	P value**
Age (year)	65.18	9.67	65.40	8.98	0.194	66.61	9.49	<0.001		61.46	10.67	62.13	10.68	0.002	65.07	11.33	<0.001
Sex																	
Female	1682	53.94	16363	52.10	0.050	120447	62.77	<0.001		1214	45.78	13254	44.75	0.[illegible]09	61006	56.37	<0.001
Male	1436	46.06	15041	47.90		71427	37.23			1438	54.22	16363	55.25		47225	43.63	
Race																	
White	2512	88.98	26698	89.60	0.354	148875	88.45	<0.001		2213	90.40	25540	90.76	0.[illegible]7	83651	89.17	<0.001
Black	200	7.08	2080	6.98		14103	8.38			162	6.62	1920	6.82		8108	8.64	
Others	111	3.93	1020	3.42		5330	3.17			73	2.98	681	2.42		2054	2.19	
BMI	32.09	6.39	32.18	6.17	0.419	33.06	6.91	<0.001		29.16	5.39	29.69	5.73	<0.001	30.33	6.41	<0.001
OR time (mins)	84.58	33.48	86.24	29.24	0.003	90.23	34.88	<0.001		82.60	33.49	87.67	32.02	0.002	91.43	38.26	<0.001
ASA classification																	
I/II	1882	60.42	17957	57.21	0.001	99497	51.87	<0.001		1958	73.83	20148	68.07	<0.001	62496	57.76	<0.001
>=III	1233	39.58	13432	42.79		92336	48.13			694	26.17	9451	31.93		45696	42.24	
Diabetes																	
Type II	367	11.77	3699	11.78	0.983	25932	13.51	<0.001		182	6.86	2152	7.27	0.[illegible]7	9967	9.20	<0.001
Type I	93	2.98	955	3.04		7901	4.12			46	1.73	537	1.81		2892	2.67	
Smoker	234	7.50	2565	8.17	0.196	16263	8.47	0.036		294	11.09	3696	12.48	0.[illegible]7	14317	13.22	<0.001
Function status	11	0.35	139	0.45	0.647	1932	1.01	<0.001		14	0.53	211	0.71	0.4[illegible]4	1885	1.75	<0.001
CHF	4	0.13	43	0.14	0.901	483	0.25	<0.001		2	0.08	25	0.08	0.[illegible]78	272	0.25	<0.001

HTN	1811	58.08	19187	61.10	0.001	124958	65.10	<0.001	1185	44.68	14516	49.01	<0.0[illegible]1	61084	56.41	<0.001
COPD	82	2.63	732	2.33	0.294	6404	3.34	<0.001	67	2.53	660	2.23	0.3[illegible]2	4108	3.79	<0.001
Liver disease	0		4	0.01	0.529	27	0.01	0.792	1	0.04	2	0.01	0.113	22	0.02	0.222
Renal insufficiency	3	0.10	28	0.09	0.900	242	0.13	0.201	3	0.11	22	0.07	0.4[illegible]1	191	0.18	<0.001
Cancer	1	0.03	21	0.07	0.463	190	0.10	0.119	3	0.11	41	0.14	0.[illegible]35	254	0.23	0.003
Bleeding disorder	49	1.57	445	1.42	0.488	3987	2.08	<0.001	19	0.72	354	1.20	0.027	2168	2.00	<0.001

LOS: length of stay (days); BMI: Body Mass Index; OR: Operating Room; ASA: American Society of Anesthesiologists Classification; CHF: congestive heart failure; HTN: hypertension; COPD: Chronic obstructive pulmonary disease

* p value analysis between LOS 0 and LOS 1 groups

** p value analysis among LOS 0, LOS 1, and LOS 2-3 groups

Table 2. Incidence of complications with various length of stay (Per 100 patients), Odds ratio (OR) analysis, and propensity score matching (PM) analysis of complications in total knee arthroplasty (TKA)

	LOS 0	LOS 1	P value*	LOS 2-3	P value**	TKA/Single variable regression					TKA/Multi-variable r	
						OR	P value	95% CI			OR	P value
Mortality	0.16	0.08	0.123	0.1	0.253	2.10	0.132	0.80	5.51		1.78	0.295
Unplanned readmission	2.41	2.31	0.749	2.89	<0.001	1.04	0.749	0.82	1.32		1.10	0.445
Major complication	0.96	0.53	0.003	0.64	0.006	1.81	0.003	1.22	2.67	*	1.94	0.001
Any complication excluding transfusion	2.98	1.99	<0.001	2.74	<0.001	1.51	<0.001	1.21	1.89	*	1.55	<0.001
Any complication	4.49	2.16	<0.001	6.95	<0.001	2.13	<0.001	1.77	2.57	*	2.03	<0.001
Systemic infection	1.67	1.28	0.070	1.73	<0.001	1.31	0.071	0.98	1.75		1.30	0.098
Wound infection	0.77	0.72	0.753	0.88	0.015	1.07	0.73[illegible]	0.70	1.63		0.99	0.963
Cardiac/pulmonary complications	0.67	0.37	0.009	0.44	0.023	1.84	0.01[illegible]	1.16	2.94	*	1.95	0.007

LOS; length of stay; * indicates significance; **: propensity score matched 2796 patients per group

Table 3. Incidence of complications with various length of stay (Per 100 patients), Odds ratio (OR) analysis and propensity score matching (PM) analysis of complications in total hip arthroplasty (THA)

	LOS 0	LOS 1	P value*	LOS 2-3	P value**	THA/Single variable regression					THA/Multi-variable r	
						OR	P value	95% CI			OR	P value
Mortality	0.11	0.11	0.939	0.11	0.978	1.05	0.939	0.32	3.42		0.84	0.786
Unplanned readmission	1.62	2.04	0.144	3.26	<0.001	0.79	0.1[illegible]	0.58	1.08		0.84	0.292
Major complication	0.72	0.43	0.034	0.65	<0.001	1.68	0.036	1.03	2.72		1.55	0.112
Any complication excluding transfusion	1.73	1.68	0.849	2.67	<0.001	1.03	0.849	0.76	1.4		1.00	0.979
Any complication	3.13	2.86	0.420	9.76	<0.001	1.1	0.420	0.87	1.38		1.12	0.363
Systemic infection	1.06	1.26	0.372	2.03	<0.001	0.84	0.3[illegible]3	0.57	1.23		0.77	0.259
Wound infection	0.49	0.77	0.113	1.11	<0.001	0.64	0.116	0.36	1.12		0.75	0.334
Cardiac/pulmonary complications	0.57	0.26	0.005	0.39	0.002	2.15	0.007	1.24	3.75	*	1.96	0.034

LOS; length of stay; * indicates significance; **: propensity score matched 2423 patients per group

BMJ Open

Association between Same Day Discharge Total Knee and Total Hip Arthroplasty and Risks of Cardiac/Pulmonary Complications and Readmission: a Population-based Observational Study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-031260.R2
Article Type:	Research
Date Submitted by the Author:	28-Oct-2019
Complete List of Authors:	Liu, Jiabin; Hospital for Special Surgery, Weill Medical College of Cornell University, Department of Anesthesiology, Critical Care & Pain Management Elkassabany, Nabil; University of Pennsylvania Poeran, Jashvant; Icahn School of Medicine at Mount Sinai, Institute for Healthcare Delivery Science, Department of Population Health Science and Policy Gonzalez Della Valle, Alejandro; Hospital for Special Surgery Kim, David; Hospital for Special Surgery, Weill Medical College of Cornell University, Department of Anaesthesiology, Critical Care and Pain Management Maalouf, Daniel; Hospital for Special Surgery, Anesthesiology, Critical Care & Pain Management Memtsoudis, Stavros; Hospital for Special Surgery, Weill Medical College of Cornell University, Department of Anaesthesiology
Primary Subject Heading:	Surgery
Secondary Subject Heading:	Health economics
Keywords:	Health & safety < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, Orthopaedic & trauma surgery < SURGERY, Hip < ORTHOPAEDIC & TRAUMA SURGERY, Knee < ORTHOPAEDIC & TRAUMA SURGERY

SCHOLARONE™
Manuscripts

Association between Same Day Discharge Total Knee and Total Hip Arthroplasty and Risks of Cardiac/Pulmonary Complications and Readmission: a Population-based Observational Study

Jiabin Liu, MD, PhD[#*], Nabil M. Elkassabany, MD, MSCE[$], Jashvant Poeran, MD, PhD[%], Alejandro Gonzalez Della Valle, MD[&], David H. Kim, MD[#], Daniel B. Maalouf, MD, MPH[#], Stavros G. Memtsoudis, MD, PhD[#]

#: Department of Anesthesiology, Critical Care & Pain Management, Hospital for Special Surgery, Weill Cornell Medical Center, New York, NY, 10021, United States

$: Department of Anesthesiology & Critical Care, The University of Pennsylvania, Philadelphia, PA 19104, United States

%: Institute for Healthcare Delivery Science, Department of Population Health Science and Policy / Department of Orthopaedic Surgery, Icahn School of Medicine at Mount Sinai, New York, NY, 10029, United States

&: Department of Orthopaedic Surgery, Hospital for Special Surgery, Weill Cornell Medical Center, New York, NY, 10021, United States

Corresponding Author:

* Jiabin Liu, MD, PhD

Dept. of Anesthesiology, Critical Care &Pain Management, Hospital for Special Surgery,

Dept. of Anesthesiology, Weill Cornell Medical Center,

535 East 70th Street, New York, NY 10021, United States

Email: liuji@hss.edu

Funding: none

Conflict of Interest Declaration: None declared.

Manuscript word count: 2797

Abstract word count: 271

Contributors Statement

JL and NME were involved in attaining data from NSQIP. JL, NME, AGDV, and SGM were involved in designing the study. JL analyzed data with help from JP and SGM. All authors contributed to the interpretation of the results, including JL, NME, JP, AGDV, DHK, DBM, and SGM. All authors reviewed, revised, and approved the final document. JL and SGM are the study guarantors, and take responsibility for the completeness of the data and the accuracy of the analysis.

Abstract:

Objective: To determine if same-day discharge total knee or total hip arthroplasty is not associated with increased risk of unplanned readmission and adverse outcomes within 30 days of surgery.

Design: This is a population-based observational study.

Setting: Patients from 708 participating institutions who underwent primary TKA or primary total hip arthroplasty (THA) between 2011 and 2017 were divided into three groups by length of stay (LOS 0, 1, and 2-3 days). All patients with LOS > 3 days were excluded from the current study. Regression analysis and propensity score matching were performed.

Data sources: American College of Surgeons -National Surgical Quality Improvement Program database.

Main Outcomes and Measures: Primary outcomes included unplanned readmission and cardiac/pulmonary complications within 30 days of surgery.

Results: We identified 226,481 TKA (LOS 0=3,118, LOS 1=31,404, and LOS 2-3=191,959) and 140,557 THA patients (LOS 0=2,652, LOS 1=29,617, and LOS 2-3=108,288). There were no differences in 30-day mortality. After adjusting for relevant covariates, LOS 0 (compared to LOS 1) was associated with higher odds of cardiac/pulmonary complications in both TKA (OR 1.95, 95% CI 1.20~3.16; 0.67% versus 0.37%) and THA (OR 1.96, 95% CI 1.05~3.64; 0.57% versus 0.26%). There were no statistical differences in unplanned readmissions between LOS 0 and LOS 1 groups in TKA (2.41% vs 2.31%) and THA (1.62% vs 2.04%).

Conclusions: LOS 0 discharge after TKA and THA was associated with higher odds of cardiac/pulmonary complications compared to LOS 1 discharge. While the overall burden of complications is relatively low, until future studies can confirm or challenge our findings, a measured approach is advisable when recommending discharge of patients on the same day of surgery.

Strength and limitations of this study:

- Information on safety of same-day discharge after total knee arthroplasty (TKA) and total hip arthroplasty (THA) is lacking
- This is the first comprehensive study to focus on length of stay (LOS) 0 and LOS 1 TKA and THA patients.
- This is a population-based observational study, and cannot establish causal relationships.

Data sharing statement:

All data utilized for the current study is available via https://www.facs.org/quality-programs/acs-nsqip. All data is available and free of charge for any researchers within these participating institutions of NSQIP (https://www.facs.org/quality-programs/acs-nsqip/participant-use).

Ethics and dissemination:

The study was exempted by the institutional review board. Results will be communicated through publication in scientific journal and conference.

Introduction:

Joint arthroplasty is amongst the most commonly performed procedures in the United States with projections of continuous growth in parallel with an aging population. Total knee arthroplasty (TKA) is projected at 3.48 million procedures annually, while total hip arthroplasty (THA) at 700,000 per year by 2030 [1]. Until recently, TKA and THA were listed as Inpatient Only (IPO) procedures by the Center for Medicare and Medicaid Service (CMS), which requires greater than 24 hours of postoperative care. Financial necessity, advances in surgical techniques, improved pain management, and early physical rehabilitation have led to a continuous reduction in total hospital length of stay (LOS) after surgery [2]. This trend has made ambulatory joint arthroplasty practice feasible. In fact, CMS removed TKA from the IPO list in January 2018 with the expectation of reducing healthcare cost [3]. It is likely that CMS might remove THA from the IPO list in the near future, especially since the American Association of Orthopaedic Surgeons (AAOS) has also provided supportive statements for outpatient total hip arthroplasty [4]. Such policy decisions by CMS cast significant pressure on hospitals and healthcare providers to fast track patients, and expedite a push towards performing surgery at free-standing ambulatory surgery centers.

However, practical and logistical concerns remain regarding the safety of fast track approaches, especially the true ambulatory practice with same day discharge. While mostly focused on patient selection and optimization of peri-operative care guided under well-defined clinical pathways, actual outcome data are scarce. Several studies found no difference in short-term complications after comparing shorter inpatient stay with LOS≥

2 days [5-7]. Additional studies comparing admission status of outpatient versus inpatient, and concluded that outpatient joint arthroplasty is safe and effective [8-11]. None of these studies focused on true ambulatory population (LOS 0) and the fast track group (LOS 1). One previous study by Otero et al. included a small group of LOS 0 patients, and did not identify differences among TKA patients but increased complication rate in THA patients [12]. Gromov et al. studied 116 LOS 0 patients with matching cohort of 339 patients (LOS 1 to 9 days), and found no readmissions within 48 hours and comparable incidence of readmission within 90 days [13]. However, these earlier studies were limited by the small sample size to be conclusive, and study cohort included emergent procedures, bilateral arthroplasties, or mixed TKA/THA patient population.

Given the current push towards same-say discharge after lower extremity joint arthroplasty surgery and lack of large-scale data on crucial comparisons, we therefore sought to study the safety of ambulatory surgical practice of TKA and THA with the access of several folds of more subjects to hopefully draw more convincing conclusion. For this purpose, we studied and compared complications and readmission rate and risk in patients discharged on the day of surgery (LOS 0) to those with a LOS of 1 day (LOS 1). We also included the standard practice group with LOS 2-3 days as a reference group. We hypothesized that there would be no difference in complications and readmission rates and risks among patients discharged same day of TKA or THA surgery.

Methods:

This study was exempted by the institutional review board (IRB# 2017-0716) as data accessed and analyzed were de-identified. The population-based observational study follows the STROBE statement (second paragraph of "Patient and Public Involvement" section).

Cohort description

We acquired the data from the American College of Surgeons (ACS) National Surgical Quality Improvement Program (NSQIP) from 2011 to 2017 (http://site.acsnsqip.org). NSQIP prospectively collects data on over 200 variables, including demographic information, comorbidities, intraoperative variables, 30-day postoperative complications, and readmission. NSQIP conducted independent follow-ups of all registered patients for 30 days even after discharged from hospital, therefore NSQIP was able to capture post-surgical events for 30 days no matter whether patients were still in hospital or were discharged to other destination. NSQIP database does not include surgical procedures performed at ambulatory surgical center as of 2017. To define our study cohort, we only included patients with the principal Current Procedural Terminology (CPT) code for primary TKA (CPT 27447) or primary THA (CPT 27130). We only included patients from 2011 to 2017, as the NSQIP dataset provides information on the readmission incidence within 30 days of surgery during this time frame.

There were a total of N=232,218 and N=141,767 entries for TKA and THA with LOS from 0 to 3 calendar days, respectively. We first excluded patients categorized as "emergency" to establish a more homogenous study cohort (N=193 & 435 respectively). We then excluded patients who received bilateral arthroplasty as defined by the relevant concurrent CPT code (N= 5,544 & 775 respectively). The final cohort included 226,481 and 140,557 subjects for TKA and THA, respectively.

Study variables

Patients were separated into 3 groups based on LOS calculated based on calendar days (LOS 0 for same day discharge; LOS 1 for patients with next day discharge; and LOS 2-3 for patients with a traditional LOS of 2 to 3 days). The outcomes of interest were readmission within 30 days and six composite complication variables, including: wound infection, systemic infection, cardiac/pulmonary complications (including cardiac arrest requiring CPR, myocardial infarction, pulmonary embolism, unplanned intubation, and/or on ventilator >48 hours), major complications (including any cardiac, pulmonary, central nerve system, renal, or systemic infection complications), any complication (including any complications enlisted in the NSQIP database), and any complication excluding blood transfusion.

Statistical analysis

Data analysis was executed using STATA 14.2 statistical software (StataCorp LP, College Station, TX). Analysis of variance was used to analyze continuous variables. Pearson chi-square tests were applied for categorical variables. After applying Bonferroni correction, p-value less than 0.0036 (0.05/14 variables) was used as the cutoff for statistical significance.

We next conducted single variable and multi-variable regression analysis to examine the impact of LOS on readmission and complications. The confounding variables included age, sex, race, body mass index (BMI), surgical duration, year of surgery, and ASA classification. In the regression analysis we treated the LOS 1 group as the reference. The odds ratio (OR) and 95% confidence interval (CI) were reported. We elected to report output from the multi-variable regression analysis in the result section. To further evaluate robustness of our results, we also performed a propensity score matched analysis where the significant covariates were entered to calculate the propensity score to receive either same day (LOS 0) or fast track (LOS 1) surgery. We employed the Kernel matching algorithm based on the weighted average of all controls, and the weights are inversely proportional to the distance between the propensity scores.

Patient and Public Involvement

The current study involved prospectively collected patient information without any identifiable patient specific information. None of these included study subjects would benefit from the current study. However, future patients may benefit from the knowledge highlighted in the current study once it is publicly available. Patients were not involved in the design and conduct of current study. All patient related information was de-identified from the database to preserve privacy.

Results:

We identified N=226,481 primary TKA (LOS 0= 3,118, LOS 1=31,404, and LOS 2-3=191,959) and 140,557 primary THA patients (LOS 0= 2,652, LOS 1=29,617, and LOS 2-3=108,288), respectively. There were no major clinically significant differences in the comorbidity burden between LOS 0 and LOS 1 groups, while LOS 2-3 group carried a higher comorbidity burden (Table 1). Between 2011 and 2017, LOS trended downwards, with an increasing number of patients being discharged on the day of surgery or the next day (TKA 1.04% in 2011, and 26.55% in 2017; THA 3.44% in 2011, and 34.91% in 2017, respectively). The discharge destination was most frequently to home amongst the various TKA groups (LOS 0 group 89.48%, LOS 1 group 97.62%, and 76.39% in LOS 2-3 group). Home discharge was the most prominent disposition in THA as well (LOS 0 group 94.72%, LOS 1 group 97.92%, and 78.37% in LOS 2-3 group). There were no differences in 30-day mortality in either TKA (Table 2) or THA groups (Table 3). The incidences of 30-day major complications and unplanned readmissions were low in the LOS 1 discharge group (0.53% and 2.31% in TKA; 0.43% and 2.04% in THA respectively). There were no statistically significant differences in unplanned readmission between LOS 0 and LOS 1 group in TKA patients (2.41% vs 2.31% in TKA, OR 1.10, 95% CI: 0.86~1.42, Table 2), nor among THA patients (1.62% vs 2.04% in THA, OR 0.84, 95% CI: 0.60~1.16, Table 3). LOS 2-3 group otherwise carried the highest incidence of unplanned readmission (Table 2&3).

Table 2&3 also provides results from the univariable regression, multivariable regression, and the propensity score matching analysis comparing the LOS 0 to the LOS 1 groups.

The LOS 0 group was associated with higher odds of cardiac/pulmonary complications in both TKA (OR 1.95, 95% CI 1.20~3.16; unadjusted prevalence 0.67% versus 0.37%, Table 2) and THA (OR 1.96, 95% CI 1.05~3.64; unadjusted prevalence 0.57% versus 0.26%, Table 3) when compared to the LOS 1 group. Propensity score matching analysis confirmed such increased incidence of cardiac/pulmonary complications in LOS 0 group (Table 2&3). The incidence was even higher when compared to the LOS 2-3 group (Table 2&3).

LOS 0 group was associated with higher odds of major complications in TKA recipients (OR 1.94, 95% CI: 1.29~2.92, Table 2), but not in THA patients (OR 1.55, 95% CI: 0.90~2.67, Table 3) compared to LOS 1 patients. Similar patterns of differences were also observed in the outcomes for any complications, and any complications excluding transfusion. These differences were statistically significant only in TKA (Table 2) but not in THA (Table 3). Propensity score matching analysis further confirmed all significances (Table 2&3). There were no differences in wound infection and systemic infection between LOS 0 and LOS 1 groups in either TKA or THA.

Discussion:

In this analysis of data collected by NSQIP, we present data using population data that challenge the assumed safety of same day discharge after TKA or THA surgery. Our analysis showed somewhat surprising results that LOS 0 group had higher risks of cardiac/pulmonary complications within 30 days after surgery in both TKA and THA, compared to patients in the LOS 1 group. Our study also identified significantly increased odds for major complications with LOS 0 discharge status compared to LOS 1 group amongst TKA recipients.

The average LOS after TKA decreased from 3.42 days in 2011 to 2.38 days in 2017, and from 3.54 days in 2011 to 2.31 days in 2017 after THA surgery (NSQIP data). Accordingly, more patients received fast-track care in more recent years. Previous studies have not shown a difference in readmission rates and complications among fast-track TKA and THA patients [14-19]. Definition of fast-track practice has also been evolving, from previously LOS 2-3 days to as short as LOS 1 day. It is foreseeable that fast-track practice will gear towards LOS 0 day status in the future. Otero et al. studied patients from 2011 and 2013, which they concluded that there were no differences in readmission and 30-day complication in TKA between LOS 0 and LOS 1 status, while THA patients with LOS 0 status were associated with a higher 30-day complication rate [12]. However, this study is limited by the small number of patients in the LOS 0 and LOS 1 groups. In addition, the authors did not exclude patients with emergent admission status and patients who received bilateral arthroplasty procedures. Lately, Gromov et al studied LOS 0 patients with a matching cohort of controls with LOS 1 to 9 days [13]. The authors concluded that readmission rates were comparable. However, such comparison might not be fair since LOS 1-9 patients, especially patients with longer LOS usually have indications for hospitalization. The staying in hospital would decrease chances of readmission, nor with recorded diagnosis for readmission. Other researchers have attempted to study the difference in complications in arthroplasty based on the admission status either as outpatient or inpatient [20]. However, such categorization among arthroplasty recipients was arbitrary which was most likely influenced by the type of patients' insurance. Nonetheless, concerns remained amongst clinicians regarding the balance of safe clinical practice and fast-track efficiency.

In order to achieve these goals, clinicians have attempted to identify patients at risk of readmission or complications, and thus triage them accordingly. Many independent risk factors have been identified, including advanced age, gender, high body mass index, increased ASA classification, the presence of chronic obstructive pulmonary disease, congestive heart failure, coronary artery disease, cirrhosis, and chronic kidney disease [5 12 21-25]. In addition, poor living conditions, use of mobility aids, and social economic factors are also likely to influence LOS and outcomes [6 22 26]. Clinicians further developed prediction models to determine a patient's candidacy for fast-track surgical care with moderate success [5 6 27]. It should be mentioned, however, that some data suggest that the majority of patients suffering from a complication after joint arthroplasty may not have any identifiable risk factors[21], thus putting strategies currently being used to identify patients at risk into question.

The majority of major complications, such as cardiac/pulmonary complications, likely occur past 24 hours, and more likely peak on post-operative day 2 to 3. [5 28 29] This timeframe may therefore fall outside the in-hospital observation period as it relates to fast-track patients. It also has been shown that over 50% of patients with major complications do not carry any of these predisposing risk factors [21]. Therefore, identifying risk factors and risk stratification of patient populations may be of limited use in predicting successful fast-track patients without risk of readmission or complications. The current approach seeks to identify higher risk patients and subsequently exclude them from the fast track pathway. This is supported by our findings that patients in the LOS2-3 group have higher comorbidity burden and are older than those in the LOS0 and LOS1 groups.

Many institutions have established enhanced recovery after surgery (ERAS) pathways for TKA and THA. These pathways seek to improve outcomes by standardizing the routine use of potentially beneficial interventions that improve outcomes and by employing patient selection strategies. Consequently they include younger and healthier patients with sufficient social support to facilitate early discharge. However, such approaches may not be sufficient to reconcile them with unaltered or lower level of complications while gearing towards true ambulatory surgical model.

We conducted this NSQIP data analysis with the hypothesis that ambulatory patients were not at increased risk comparing to other fast track surgical patients after TKA or THA. It is reasonable to assume that these fast-tracked patients were carefully selected without major comorbidity concerns. Further, it is reasonable to assume that these patients met the discharge criteria established across various institutions. Assuming such safe practice model were established and applied, our finding raise concern regarding the safety of same day discharge after TKA or THA surgery. This is especially problematic if the increased risk of complications among this group is related to gaps in continuity of care and lack of necessary early intervention when indicated. However, despite this possibility, our data is not able to establish this causal relationship at this time, and future studies are needed to identify the etiology and mechanism by which complications may develop.

Our study has several limitations. First, this is a retrospective cohort study and related limitations in respect to establishing causality apply. Although NSQIP has rigorous quality measures to ensure high quality data collection, there was still missing information on several interesting pre-existing comorbidity variables, such as stroke and myocardial infarction. Our study is therefore limited by the accuracy and completeness of data collection, inclusion of available variables, and recorded information only. Second, patients were categorized retrospectively based on their actual LOS determined by calendar days. Future research is indicated to prospectively assign clinical pathways and compare readmission and complications. Third, NSQIP only contains outcome information within 30 days, thus outcomes beyond this point but still related to the index procedure remain elusive. Fourth, NSQIP prohibits identifying hospital and surgeon, while studying surgical volume, inpatient hospital versus free-standing surgical center, and other practice pattern might be insightful. Last, readmission indicator in NSQIP database only included inpatient readmission. Information on emergency department visit would also be important. However, it is beyond the scope of our analysis.

Conclusion

Our study is the first comprehensive study to focus on LOS 0 TKA and THA patients. Although same day discharge after TKA and THA surgery is not associated with increased risk of unplanned readmission, these patients carry increased risk of complications. Therefore, the current trend towards increasing discharges on the same day of surgery after TKA and THA should be approached with caution and requires reconsideration. Future prospective studies are needed to confirm our finding and identify if ambulatory joint arthroplasty is associated with acceptable risk for complications and readmissions, as well as its financial impact on our healthcare system.

Acknowledge:

The authors would like to thank Haoyan Zhong, BS, MPH, for her expert support in statistical issues. The authors also would like to thank Dr. Christopher L. Wu for his insightful review of the manuscript.

Reference:

1. Kurtz S, Ong K, Lau E, et al. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. The Journal of bone and joint surgery American volume 2007;**89**(4):780-5.
2. Sloan M, Sheth NP. Length of stay and inpatient mortality trends in primary and revision total joint arthroplasty in the United States, 2000-2014. Journal of orthopaedics 2018;**15**(2):645-49.
3. CMS. January 2018 Update of the Hospital Outpatient Prospective Payment System (OPPS). In: CMS, ed., 2017.
4. AAOS. Medicare Program; Hospital Outpatient Prospective Payment and Ambulatory Surgical Center Payment Systems and Quality Reporting Program, 2017.
5. Courtney PM, Rozell JC, Melnic CM, et al. Who Should Not Undergo Short Stay Hip and Knee Arthroplasty? Risk Factors Associated With Major Medical Complications Following Primary Total Joint Arthroplasty. The Journal of arthroplasty 2015;**30**(9 Suppl):1-4.
6. Gronbeck CJ, Cote MP, Halawi MJ. Predicting Inpatient Status After Total Hip Arthroplasty in Medicare-Aged Patients. The Journal of arthroplasty 2019;**34**(2):249-54.
7. Duchman KR, Gao Y, Pugely AJ, et al. Differences in short-term complications between unicompartmental and total knee arthroplasty: a propensity score matched analysis. The Journal of bone and joint surgery American volume 2014;**96**(16):1387-94.
8. Lovecchio F, Alvi H, Sahota S, et al. Is Outpatient Arthroplasty as Safe as Fast-Track Inpatient Arthroplasty? A Propensity Score Matched Analysis. The Journal of arthroplasty 2016;**31**(9 Suppl):197-201.
9. Hoffmann JD, Kusnezov NA, Dunn JC, et al. The Shift to Same-Day Outpatient Joint Arthroplasty: A Systematic Review. The Journal of arthroplasty 2018;**33**(4):1265-74.
10. Courtney PM, Froimson MI, Meneghini RM, et al. Can Total Knee Arthroplasty Be Performed Safely as an Outpatient in the Medicare Population? The Journal of arthroplasty 2018;**33**(7S):S28-S31.
11. Courtney PM, Boniello AJ, Berger RA. Complications Following Outpatient Total Joint Arthroplasty: An Analysis of a National Database. The Journal of arthroplasty 2017;**32**(5):1426-30.
12. Otero JE, Gholson JJ, Pugely AJ, et al. Length of Hospitalization After Joint Arthroplasty: Does Early Discharge Affect Complications and Readmission Rates? The Journal of arthroplasty 2016;**31**(12):2714-25.
13. Gromov K, Jorgensen CC, Petersen PB, et al. Complications and readmissions following outpatient total hip and knee arthroplasty: a prospective 2-center study with matched controls. Acta orthopaedica 2019;**90**(3):281-85.
14. Kehlet H, Wilmore DW. Evidence-based surgical care and the evolution of fast-track surgery. Annals of surgery 2008;**248**(2):189-98.

15. Klingenstein GG, Schoifet SD, Jain RK, et al. Rapid Discharge to Home After Total Knee Arthroplasty Is Safe in Eligible Medicare Patients. The Journal of arthroplasty 2017;**32**(11):3308-13.
16. Glassou EN, Pedersen AB, Hansen TB. Risk of re-admission, reoperation, and mortality within 90 days of total hip and knee arthroplasty in fast-track departments in Denmark from 2005 to 2011. Acta orthopaedica 2014;**85**(5):493-500.
17. Kiskaddon EM, Lee JH, Meeks BD, et al. Hospital Discharge Within 1 Day After Total Joint Arthroplasty From a Veterans Affairs Hospital Does Not Increase Complication and Readmission Rates. The Journal of arthroplasty 2018;**33**(5):1337-42.
18. Sutton JC, 3rd, Antoniou J, Epure LM, et al. Hospital Discharge within 2 Days Following Total Hip or Knee Arthroplasty Does Not Increase Major-Complication and Readmission Rates. The Journal of bone and joint surgery American volume 2016;**98**(17):1419-28.
19. Yang G, Chen W, Chen W, et al. Feasibility and Safety of 2-Day Discharge After Fast-Track Total Hip Arthroplasty: A Chinese Experience. The Journal of arthroplasty 2016;**31**(8):1686-92 e1.
20. Arshi A, Leong NL, D'Oro A, et al. Outpatient Total Knee Arthroplasty Is Associated with Higher Risk of Perioperative Complications. The Journal of bone and joint surgery American volume 2017;**99**(23):1978-86.
21. Parvizi J, Mui A, Purtill JJ, et al. Total joint arthroplasty: When do fatal or near-fatal complications occur? The Journal of bone and joint surgery American volume 2007;**89**(1):27-32.
22. Jorgensen CC, Kehlet H, Lundbeck Foundation Centre for Fast-track H, et al. Role of patient characteristics for fast-track hip and knee arthroplasty. British journal of anaesthesia 2013;**110**(6):972-80.
23. Rozell JC, Courtney PM, Dattilo JR, et al. Late Complications Following Elective Primary Total Hip and Knee Arthroplasty: Who, When, and How? The Journal of arthroplasty 2017;**32**(3):719-23.
24. Lovald ST, Ong KL, Lau EC, et al. Patient Selection in Short Stay Total Hip Arthroplasty for Medicare Patients. The Journal of arthroplasty 2015;**30**(12):2086-91.
25. Sikora-Klak J, Gupta A, Bergum C, et al. The Evaluation of Comorbidities Relative to Length of Stay for Total Joint Arthroplasty Patients. The Journal of arthroplasty 2017;**32**(4):1085-88.
26. Inneh IA, Iorio R, Slover JD, et al. Role of Sociodemographic, Co-morbid and Intraoperative Factors in Length of Stay Following Primary Total Hip Arthroplasty. The Journal of arthroplasty 2015;**30**(12):2092-7.
27. Schilling PL, Bozic KJ. Development and Validation of Perioperative Risk-Adjustment Models for Hip Fracture Repair, Total Hip Arthroplasty, and Total Knee Arthroplasty. The Journal of bone and joint surgery American volume 2016;**98**(1):e2.
28. Jorgensen CC, Kehlet H, Lundbeck Foundation Centre for Fast-track H, et al. Early thromboembolic events </=1week after fast-track total hip and knee arthroplasty. Thrombosis research 2016;**138**:37-42.

29. Petersen PB, Kehlet H, Jorgensen CC, et al. Myocardial infarction following fast-track total hip and knee arthroplasty-incidence, time course, and risk factors: a prospective cohort study of 24,862 procedures. Acta orthopaedica 2018;**89**(6):603-09.

Table 1. Patient demographic information and comorbidity

	Total Knee Arthroplasty								Total Hip Arthroplasty							
	LOS 0		LOS 1			LOS 2-3			LOS 0		LOS 1			LOS 2-3		
	Mean/N	Std/%	Mean/N	Std/%	P value*	Mean/N	Std/%	P value**	Mean/N	Std/%	Mean/N	Std/%	P value*	Mean/N	Std/%	P value**
Age (year)	65.18	9.67	65.40	8.98	0.194	66.61	9.49	<0.001	61.46	10.67	62.13	10.68	0.002	65.07	11.33	<0.001
Sex																
Female	1682	53.94	16363	52.10	0.050	120447	62.77	<0.001	1214	45.78	13254	44.75	0.[illegible]09	61006	56.37	<0.001
Male	1436	46.06	15041	47.90		71427	37.23		1438	54.22	16363	55.25		47225	43.63	
Race																
White	2512	88.98	26698	89.60	0.354	148875	88.45	<0.001	2213	90.40	25540	90.76	0.[illegible]7	83651	89.17	<0.001
Black	200	7.08	2080	6.98		14103	8.38		162	6.62	1920	6.82		8108	8.64	
Others	111	3.93	1020	3.42		5330	3.17		73	2.98	681	2.42		2054	2.19	
BMI	32.09	6.39	32.18	6.17	0.419	33.06	6.91	<0.001	29.16	5.39	29.69	5.73	<0.001	30.33	6.41	<0.001
OR time (mins)	84.58	33.48	86.24	29.24	0.003	90.23	34.88	<0.001	82.60	33.49	87.67	32.02	0.002	91.43	38.26	<0.001
ASA classification																
I/II	1882	60.42	17957	57.21	0.001	99497	51.87	<0.001	1958	73.83	20148	68.07	<0.001	62496	57.76	<0.001
>=III	1233	39.58	13432	42.79		92336	48.13		694	26.17	9451	31.93		45696	42.24	
Diabetes																
Type II	367	11.77	3699	11.78	0.983	25932	13.51	<0.001	182	6.86	2152	7.27	0.[illegible]7	9967	9.20	<0.001
Type I	93	2.98	955	3.04		7901	4.12		46	1.73	537	1.81		2892	2.67	
Smoker	234	7.50	2565	8.17	0.196	16263	8.47	0.036	294	11.09	3696	12.48	0.0[illegible]7	14317	13.22	<0.001
Function status	11	0.35	139	0.45	0.647	1932	1.01	<0.001	14	0.53	211	0.71	0.4[illegible]4	1885	1.75	<0.001
CHF	4	0.13	43	0.14	0.901	483	0.25	<0.001	2	0.08	25	0.08	0.[illegible]78	272	0.25	<0.001

HTN	1811	58.08	19187	61.10	0.001	124958	65.10	<0.001	1185	44.68	14516	49.01	<0.001	61084	56.41	<0.001
COPD	82	2.63	732	2.33	0.294	6404	3.34	<0.001	67	2.53	660	2.23	0.322	4108	3.79	<0.001
Liver disease	0		4	0.01	0.529	27	0.01	0.792	1	0.04	2	0.01	0.113	22	0.02	0.222
Renal insufficiency	3	0.10	28	0.09	0.900	242	0.13	0.201	3	0.11	22	0.07	0.401	191	0.18	<0.001
Cancer	1	0.03	21	0.07	0.463	190	0.10	0.119	3	0.11	41	0.14	0.735	254	0.23	0.003
Bleeding disorder	49	1.57	445	1.42	0.488	3987	2.08	<0.001	19	0.72	354	1.20	0.027	2168	2.00	<0.001

LOS: length of stay (days); BMI: Body Mass Index; OR: Operating Room; ASA: American Society of Anesthesiologists Classification; CHF: congestive heart failure; HTN: hypertension; COPD: Chronic obstructive pulmonary disease

* p value analysis between LOS 0 and LOS 1 groups

** p value analysis among LOS 0, LOS 1, and LOS 2-3 groups

Table 2. Incidence of complications with various length of stay (Per 100 patients), Odds ratio (OR) analysis, and propensity score matching (PM) analysis of complications in total knee arthroplasty (TKA)

						TKA/Single variable regression					TKA/Multi-variable r	
	LOS 0	LOS 1	P value*	LOS 2-3	P value**	OR	P value	95% CI			OR	P value
Mortality	0.16	0.08	0.123	0.1	0.253	2.10	0.132	0.80	5.51		1.78	0.295
Unplanned readmission	2.41	2.31	0.749	2.89	<0.001	1.04	0.749	0.82	1.32		1.10	0.445
Major complication	0.96	0.53	0.003	0.64	0.006	1.81	0.003	1.22	2.67	*	1.94	0.001
Any complication excluding transfusion	2.98	1.99	<0.001	2.74	<0.001	1.51	<0.001	1.21	1.89	*	1.55	<0.001
Any complication	4.49	2.16	<0.001	6.95	<0.001	2.13	<0.001	1.77	2.57	*	2.03	<0.001
Systemic infection	1.67	1.28	0.070	1.73	<0.001	1.31	0.071	0.98	1.75		1.30	0.098
Wound infection	0.77	0.72	0.753	0.88	0.015	1.07	0.753	0.70	1.63		0.99	0.963
Cardiac/pulmonary complications	0.67	0.37	0.009	0.44	0.023	1.84	0.011	1.16	2.94	*	1.95	0.007

LOS; length of stay; * indicates significance; **: propensity score matched 2796 patients per group

Table 3. Incidence of complications with various length of stay (Per 100 patients), Odds ratio (OR) analysis and propensity score matching (PM) analysis of complications in total hip arthroplasty (THA)

	LOS 0	LOS 1	P value*	LOS 2-3	P value**	THA/Single variable regression					THA/Multi-variable r	
						OR	P value	95% CI			OR	P value
Mortality	0.11	0.11	0.939	0.11	0.978	1.05	0.939	0.32	3.42		0.84	0.786
Unplanned readmission	1.62	2.04	0.144	3.26	<0.001	0.79	0.145	0.58	1.08		0.84	0.292
Major complication	0.72	0.43	0.034	0.65	<0.001	1.68	0.036	1.03	2.72		1.55	0.112
Any complication excluding transfusion	1.73	1.68	0.849	2.67	<0.001	1.03	0.849	0.76	1.4		1.00	0.979
Any complication	3.13	2.86	0.420	9.76	<0.001	1.1	0.420	0.87	1.38		1.12	0.363
Systemic infection	1.06	1.26	0.372	2.03	<0.001	0.84	[illegible]	0.57	1.23		0.77	0.259
Wound infection	0.49	0.77	0.113	1.11	<0.001	0.64	0.116	0.36	1.12		0.75	0.334
Cardiac/pulmonary complications	0.57	0.26	0.005	0.39	0.002	2.15	0.007	1.24	3.75	*	1.96	0.034

LOS; length of stay; * indicates significance; **: propensity score matched 2423 patients per group

STROBE Statement

	Item No	Recommendation	Yes/No	Location in manuscript
Title and Abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	Yes	page 1/title; page 3/abstract
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	yes	page 3/abstract
Introduction				
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	yes	page 5 & 6/Introduction
Objectives	3	State specific objectives, including any prespecified hypotheses	yes	page 6/introduction/second paragraph
Methods				
Study design	4	Present key elements of study design early in the paper	yes	page 7-9/methods
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	yes	page 7-8/methods
Participants	6	(a)		
		Cohort study—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	yes	page 7/method/last paragraph - page8
		Case-control study—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls	n/a	
		Cross-sectional study—Give the eligibility criteria, and the sources and methods of selection of participants	n/a	
		(b) Cohort study—For matched studies, give matching criteria and number of exposed and unexposed Case-control study—For matched studies, give matching criteria and the number of controls per case	yes	page 9/methods/ second paragraph
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	yes	page 8/methods/third paragraph
		For each variable of interest, give sources of data and details of methods of assessment (measurement).	yes	page 7/methods/last paragraph
Data sources/measurement	8	Describe comparability of assessment methods if there is more than one group	yes	page 8/methods/second paragraph
Bias	9	Describe any efforts to address potential sources of bias	yes	page 9/methods/statistical analysis
Study size	10	Explain how the study size was arrived at	n/a	
Quantitative variable	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	yes	page 9/methods/statistical analysis
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	yes	page 9/methods/statistical analysis
		(b) Describe any methods used to examine subgroups and interactions	yes	page 9/methods/second paragraph
		(c) Explain how missing data were addressed	n/a	
		(d) Cohort study—If applicable, explain how loss to follow-up was addressed Case-control study—If applicable, explain how matching of cases and controls was addressed Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	n/a	
		(e)Describe any sensitivity analyses	n/a	
Results				
Participants	13	(a) Report the numbers of individuals at each stage of the study—e.g., numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	n/a	
		(b) Give reasons for non-participation at each stage	n/a	
		(c)Consider use of a flow diagram	n/a	
Descriptive data	14	(a) Give characteristics of study participants (e.g., demographic, clinical, social) and information on exposures and potential confounders	yes	page 10/result/first paragraph & table 1
		(b) Indicate the number of participants with missing data for each variable of interest	n/a	
		(c)		
		Cohort study—Summarise follow-up time (e.g., average and total amount)	yes	page 7/method/patient and public involvement
		Cohort study—Report numbers of outcome events or summary measures over time	yes	page 8/method/study variables
		Case-control study—Report numbers in each exposure category, or summary measures of exposure		
		Cross-sectional study—Report numbers of outcome events or summary measures		
Outcome data	15	Report numbers of outcome events or summary measures over time	yes	page 10/results, tables 2&3
		(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included	yes	page 10&11/results, tables 2&3
		(b)Report numbers of outcome events or summary measures over time	n/a	
Main results	16	(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a	
Other analysis	17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses		
Discussion				
Key results	18	Summarise key results with reference to study objectives	yes	page 12/discussion/first paragraph
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	yes	page 15/discussion/second paragraph
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	yes	page 12-15/discussion
Generalisability	21	Discuss the generalisability (external validity) of the study results	yes	page 12/discussion/second paragraph, page 13/discussion/first paragraph
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	n/a	