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Original Research

# Frequency and Timing of Postoperative Complications After Outpatient Total Hip Arthroplasty

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ABSTRACT

*Background:* Although there have been several studies describing risk factors for complications after outpatient total hip arthroplasty (THA), data describing the timing of such complications is lacking.
*Methods:* Patients who underwent outpatient or inpatient primary THA were identified in the 2012-2019 National Surgical Quality Improvement Program database. For 9 different 30-day complications, the median postoperative day of diagnosis was determined. Multivariable regressions were used to compare the risk of each complication between outpatient vs inpatient groups. Multivariable Cox proportional hazards modeling was used to evaluate the differences in the timing of each adverse event between the groups.
*Results:* After outpatient THA, the median day of diagnosis for readmission was 12.5 (interquartile range 5-22), surgical site infection 15 (2-21), urinary tract infection 13.5 (6-19.5), deep vein thrombosis 13 (8-21), myocardial infarction 4.5 (1-7), pulmonary embolism 15 (8-25), sepsis 16 (9-26), stroke 2 (0-7), and pneumonia 6.5 (3-10). On multivariable regressions, outpatients had a lower relative risk (RR) of readmission (RR = 0.73), surgical site infection (RR = 0.72), and pneumonia (RR = 0.1), all $P < .05$. On multivariable cox proportional hazards modeling, there were no statistically significant differences in the timing of each complication between outpatient vs inpatient procedures ($P > .05$).
*Conclusions:* The timing of complications after outpatient THA was similar to inpatient procedures. Consideration should be given to lowering thresholds for diagnostic testing after outpatient THA for each complication during the at-risk time periods identified here. Although extremely rare, this is especially important for catastrophic adverse events, which tend to occur early after discharge.


## Introduction

As the volume of total hip arthroplasty (THA) continues to rise in the United States, recent efforts have focused on delivering high-quality and cost-effective care to meet this growth [1,2]. One such solution is outpatient THA, which has been made possible due to improvements in surgical techniques, perioperative anesthesia and pain management, and rapid rehabilitation protocols [3,4]. Economic modeling analyses have shown that cost savings may amount to $300 million in billing charges and $87 million in reimbursement if outpatient THA is performed for 30% of total hip arthroplasties [5]. Further, the Coronavirus Disease of 2019 pandemic has provided another incentive to perform arthroplasty on an outpatient basis as providers seek strategies to decrease the risk of nosocomial infection [6].

Recent studies have examined the safety of outpatient THA, demonstrating a low rate of complication and readmission rate in appropriately selected patients [3,7–14]. Courtney et al. [7] determined that patients undergoing outpatient hip and knee arthroplasty had a lower rate of complications (8%) than patients undergoing inpatient procedures (16%). Further, they highlighted

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risk factors for complications after outpatient THA, which include older age, malnutrition, and cardiac history. Similarly, Bovonratwet et al. [3] determined the reasons and risk factors for 30-day readmission following outpatient THA, which has become an outcome of interest as readmissions would potentially negate any cost-savings provided by outpatient surgery and diminish the amount of Medicare reimbursement to hospitals [3,15]. Notably, these risk factors included older age and the presence of a bleeding disorder.

Despite these recent studies, there is limited evidence surrounding the timing of complications and readmissions following outpatient THA. Ultimately, this knowledge is critical for (1) developing appropriate patient surveillance protocols and diagnostic thresholds for patients after outpatient THA and (2) providing patient counseling and education regarding concerning signs or symptoms at particular postoperative time points, especially for potentially catastrophic complications. Therefore, the aims of the present study were to: 1) compare the rate of complications between outpatient and inpatient THA; 2) determine the timing of complications and readmission following outpatient THA; and 3) compare the timing of complications and readmissions between outpatient and inpatient THA. We hypothesize that the overall rate and timing of complications are similar between patients who underwent outpatient vs inpatient THA.

## Material and methods

### *Patient population*

After obtaining approval from the institutional review board, the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database was queried for patients who underwent unilateral primary THA from 2012-2019 using Current Procedural Terminology code 27130. Only data from 2012 onwards were used in the current study since the NSQIP database began collecting reasons for 30-day readmission only starting from 2012 onwards. Cases involving fracture, trauma, infection, neoplasms, bilateralism, and revision or having missing data were excluded. Those meeting criteria were stratified into outpatient vs inpatient cohorts based on hospital length of stay (LOS): an outpatient procedure was defined as a LOS equal to 0 days (discharged on the same calendar day as the procedure), whereas inpatient procedures had LOS >1 day.

### *Preoperative and procedural variables*

For all patients included in the study, baseline demographic variables including age, sex, body mass index (BMI), functional status prior to surgery (independent vs dependent), American Society of Anesthesiologists (ASA) classification, smoking status, and history of several medical comorbidities (diabetes mellitus, hypertension, dyspnea on exertion, and chronic obstructive pulmonary disease) were collected for analysis. In addition, the type of anesthesia utilized during the procedure (regional only vs general) and operative time were also reviewed.

### *Rate and timing of complications*

The 30-day complications included in the analysis were readmission, surgical site infection (SSI), urinary tract infection (UTI), deep vein thrombosis (DVT), myocardial infarction (MI), pulmonary embolism (PE), sepsis, stroke, and pneumonia. For each of these complications, the median postoperative day of diagnosis with interquartile ranges was determined.

### *Statistical analysis*

Data were summarized using standard descriptive statistics, including means + standard deviations or medians with interquartile ranges for continuous variables and numbers with percentages for categorical variables. For continuous variables, univariate comparisons between outpatient and inpatient cohorts were performed using independent sample *t*-tests or Mann-Whitney *U* tests (depending on the normality of distribution). Chi-squared or Fischer's exact tests were utilized for univariate comparisons of categorical variables. Multivariable Poisson regressions with robust error variance were performed to compare the risk of each complication between outpatient vs inpatient groups while controlling for confounding variables (age, gender, BMI, smoking, ASA score, medical comorbidities, functional status prior to surgery, anesthesia type, and operative duration). Finally, multivariable Cox proportional hazards modeling was used to evaluate for differences between the cohorts with respect to the timing of each adverse event. All statistical analyses were performed in Stata version 13.1 (StataCorp, LP, College Station, TX).

## Results

### *Patient population*

After applying our inclusion and exclusion criteria, we identified 9416 patients who underwent outpatient primary unilateral THA and 220,128 who underwent inpatient primary unilateral THA. There were significant differences in the baseline characteristics of the outpatient vs inpatient cohorts, as summarized in Table 1. On average, patients who underwent outpatient THA were younger ($P < .001$) and more frequently male ($P < .001$). Additionally, they had a lower BMI ($P < .001$), greater functional independence ($P < .001$), a lower ASA score ($P < .001$), and fewer medical comorbidities ($P < .001$). With respect to intraoperative variables, patients undergoing outpatient surgery more frequently received regional anesthesia only ($P < .001$) and had shorter operative times ($P < .001$) (Table 1).

### *Rate and risk of postoperative complications*

On univariate comparison of 30-day adverse event rates between the cohorts, patients who underwent outpatient THA had a significantly lower rate of readmission ($P < .001$), SSI ($P < .001$), UTI ($P = .003$), DVT ($P = .013$), PE ($P = .016$), sepsis ($P = .008$), and pneumonia ($P < .001$) after primary THA (Table 2). There were no statistically significant differences in the rate of MI ($P = .120$) or stroke ($P = .097$). On multivariable regression analysis of these adverse events, patients who underwent outpatient THA had a lower risk of readmission (relative risk [RR] = 0.73; $P < .001$), SSI (RR = 0.72; $P = .014$), and pneumonia (RR = 0.13; $P = .004$) (Table 3). However, there were no significant differences in the risk of UTI ($P = .673$), DVT ($P = .188$), MI (0.831), PE (0.107), sepsis ($P = .179$), or stroke ($P = .453$).

### *Timing of postoperative complications*

In terms of timing for each adverse event in the outpatient cohort, there was a median time of 12.5 days (interquartile range 5-22) for readmission, 15 (2-21) for SSI, 13.5 (6-19.5) for UTI, 13 (8-21) for DVT, 4.5 (1-7) for MI, 15 (8-25) for PE, 16 (9-26) for sepsis, 2 (0-7) for stroke, and 6.5 (3-10) for pneumonia (Fig. 1). On multivariable cox proportional hazards modeling, there were no significant differences in the timing of each complication between the outpatient and inpatient cohorts (Fig. 2). The hazard ratio for outpatient readmission was 1.03 ($P = .711$), wound infection was 0.78 ($P =$

**Table 1**
Demographic and procedural variables for patients who underwent outpatient vs inpatient THA.

| Characteristic | Outpatient | | Inpatient | | *P*-value |
|---|---|---|---|---|---|
| | Number = 9416 | | Number = 220,128 | | |
| Age (y) | Average 62.5 ± 10.6 | | Average 65.3 ± 11.3 | | **<.001** |
| 18-59 | 3436 | 36.5% | 63,959 | 29.1% | |
| 60-69 | 3502 | 37.2% | 76,213 | 34.6% | |
| 70-79 | 2105 | 22.4% | 57,222 | 26.0% | |
| ≥80 | 373 | 4.0% | 22,734 | 10.3% | |
| Gender | | | | | **<.001** |
| Male | 4896 | 52.0% | 99,374 | 45.1% | |
| Female | 4520 | 48.0% | 120,754 | 54.9% | |
| Body mass index (kg/m$^2$) | Average 29.2 ± 5.3 | | Average 30.4 ± 6.3 | | **<.001** |
| 18-24 | 2043 | 21.7% | 42,281 | 19.2% | |
| 25-29 | 3593 | 38.2% | 73,000 | 33.2% | |
| 30-34 | 2493 | 26.5% | 57,832 | 26.3% | |
| ≥35 | 1287 | 13.7% | 47,015 | 21.4% | |
| Functional status prior to surgery | | | | | **<.001** |
| Independent | 9369 | 99.5% | 216,365 | 98.3% | |
| Dependent | 47 | 0.5% | 3763 | 1.7% | |
| American Society of Anesthesiologists classification (ASA) | | | | | **<.001** |
| 1-2 | 6912 | 73.4% | 123,773 | 56.2% | |
| ≥3 | 2504 | 26.6% | 96,355 | 43.8% | |
| Smoker | | | | | **<.001** |
| No | 8574 | 91.1% | 192,365 | 87.4% | |
| Yes | 842 | 8.9% | 27,763 | 12.6% | |
| Diabetes mellitus | | | | | **<.001** |
| No diabetes mellitus | 8679 | 92.2% | 193,285 | 87.8% | |
| Noninsulin-dependent diabetes mellitus | 578 | 6.1% | 20,666 | 9.4% | |
| Insulin-dependent diabetes mellitus | 159 | 1.7% | 6177 | 2.8% | |
| Hypertension | | | | | **<.001** |
| No | 5390 | 57.2% | 96,956 | 44.0% | |
| Yes | 4026 | 42.8% | 123,172 | 56.0% | |
| Dyspnea on exertion | | | | | **<.001** |
| No | 9267 | 98.4% | 210,007 | 95.4% | |
| Yes | 149 | 1.6% | 10,121 | 4.6% | |
| Chronic obstructive pulmonary disease | | | | | **<.001** |
| No | 9256 | 98.3% | 211,514 | 96.1% | |
| Yes | 160 | 1.7% | 8614 | 3.9% | |
| Anesthesia | | | | | **<.001** |
| Regional anesthesia only | 6931 | 73.6% | 114,190 | 51.9% | |
| General | 2485 | 26.4% | 105,938 | 48.1% | |
| Operative duration (min) | Average 81.3 ± 27.7 | | Average 91.0 ± 37.7 | | **<.001** |
| 0-83 min | 5603 | 59.5% | 107,022 | 48.6% | |
| 84-106 min | 2426 | 25.8% | 56,068 | 25.5% | |
| ≥107 min | 1387 | 14.7% | 57,038 | 25.9% | |

Bolded values indicate statistical significance at $P < .05$.

.070), UTI was 0.88 ($P = .361$), DVT was 0.99 ($P = .979$), MI was 0.83 ($P = .553$), PE was 0.76 ($P = .370$), sepsis was 0.86 ($P = .661$), stroke was 1.32 ($P = .725$), and pneumonia was 2.00 ($P = .337$).

**Table 2**
Demographic and procedural variables for patients who underwent outpatient vs inpatient THA.

| Complication | Outpatient | | Inpatient | | *P*-value |
|---|---|---|---|---|---|
| | Number = 9416 | | Number = 220,128 | | |
| Readmission | 166 | 1.76% | 7351 | 3.34% | **<.001** |
| Surgical site infection | 58 | 0.62% | 2542 | 1.15% | **<.001** |
| Urinary tract infection | 52 | 0.55% | 1831 | 0.83% | **.003** |
| Deep vein thrombosis | 19 | 0.20% | 784 | 0.36% | **.013** |
| Myocardial infarction | 14 | 0.15% | 497 | 0.23% | .120 |
| Pulmonary embolism | 11 | 0.12% | 527 | 0.24% | **.016** |
| Sepsis | 9 | 0.10% | 498 | 0.23% | **.008** |
| Stroke | 3 | 0.03% | 189 | 0.09% | .097 |
| Pneumonia | 2 | 0.02% | 620 | 0.28% | **<.001** |

Bolded values indicate statistical significance at $P < .05$.

## Discussion

Due to increasing healthcare expenditures and the focus on value-based healthcare in the United States, outpatient total hip arthroplasty (THA) has gained increasing popularity as an alternative to traditional, inpatient THA. Although recent studies have demonstrated that the rate of complications and readmissions after outpatient THA is comparable to inpatient THA, limited evidence exists about the timing of complications and readmissions following outpatient THA. The present study examined 9416 outpatient THA cases and determined that the incidence and timing of complications following outpatient THA were overall similar to inpatient THA.

The results of the current study determined that patients undergoing outpatient THA were at a significantly lower risk of 30-day readmission, SSI, and pneumonia compared to inpatient THA, even after controlling for age, sex, BMI, smoking, ASA score, and medical comorbidities. Currently, there is conflicting evidence in the literature about complication and readmission rates following outpatient THA compared to inpatient THA [7,16–19]. While some previous studies comparing complication rate have found a

**Table 3**
Multivariable regressions comparing risk for 30-day complications.

| Characteristic | RR | 95% CI | *P*-value |
|---|---|---|---|
| Readmission | | | **<.001** |
| Inpatient | Ref | - | |
| Outpatient | 0.73 | 0.63-0.85 | |
| Surgical site infection | | | **.014** |
| Inpatient | Ref | - | |
| Outpatient | 0.72 | 0.56-0.94 | |
| Urinary tract infection | | | .673 |
| Inpatient | Ref | - | |
| Outpatient | 0.94 | 0.71-1.24 | |
| Deep vein thrombosis | | | .188 |
| Inpatient | Ref | - | |
| Outpatient | 0.74 | 0.47-1.16 | |
| Myocardial infarction | | | .831 |
| Inpatient | Ref | - | |
| Outpatient | 1.06 | 0.62-1.80 | |
| Pulmonary embolism | | | .107 |
| Inpatient | Ref | - | |
| Outpatient | 0.61 | 0.34-1.11 | |
| Sepsis | | | .179 |
| Inpatient | Ref | - | |
| Outpatient | 0.64 | 0.33-1.23 | |
| Stroke | | | .453 |
| Inpatient | Ref | - | |
| Outpatient | 0.64 | 0.20-2.03 | |
| Pneumonia | | | **.004** |
| Inpatient | Ref | - | |
| Outpatient | 0.13 | 0.03-0.51 | |

RR, relative risk; CI, confidence interval; Ref., reference.
Bolded values indicate statistical significance at $P < .05$, controlling for comorbidities.

decreased rate of complication in outpatients [7,10,17,19], others have shown either no differences in complication rate [16] or an increased rate of complication [18]. The present study, which demonstrated a comparable rate of readmission (1.76%) and specific complications to the previous studies, utilized a large cohort of 9416 outpatients to add additional evidence in support of the safety of outpatient THA. Notably, the outpatients included in this study tended to be younger and have fewer comorbidities than the inpatients, highlighting the importance of appropriate patient selection. However, following multivariate adjustment, the decrease in the rate of 30-day readmission, SSI, and pneumonia remained significant.

The present study also determined that the timing of complications between outpatient and inpatient THA was similar. This is an important area of investigation, as surgeons should be cognizant of when complications tend to occur after outpatient THA, especially without the additional oversight and care conferred by an inpatient stay. Furthermore, given the lack of additional inpatient monitoring, it is critical for patients and caregivers to understand the timing, signs/symptoms, and importance of early intervention for any potentially life-threatening postoperative complications. Specifically, in the present study, stroke and myocardial infarction tended to occur early within the postoperative period, suggesting that these complications may have been detected and/or intervened upon sooner during an inpatient stay. Thus, our findings support the implementation of patient/caregiver education regarding these 2 complications for patients who undergo outpatient arthroplasty.

Previous studies in traditional, inpatient THA have determined that most complications occur within 5 days of operation. Notably, Parvizi et al. [20] determined that 90% of major 30-day complications occurred within 4 days following THA. Similarly, Johnson et al. [21] noted that 60% of catastrophic events, defined as pulmonary embolism, myocardial infarction or cardiac arrest, cerebrovascular accidents, and death, occurred within 5 days following THA. In contrast to these studies examining the timing of complications following THA, Reddy et al. [22] recently compared the timing of complications with respect to inpatient and outpatient THA and noted a similar distribution of emergency department visits, readmissions, and complications between the cohorts. However, this study used data from a single healthcare system in California, thus limiting its overall generalizability. Further, similar to the study by Johnson et al. [21], the current study determined that catastrophic events, including myocardial infarction and stroke, occurred within 5 days following outpatient THA. Altogether, these findings suggest that the threshold for diagnostic testing for these

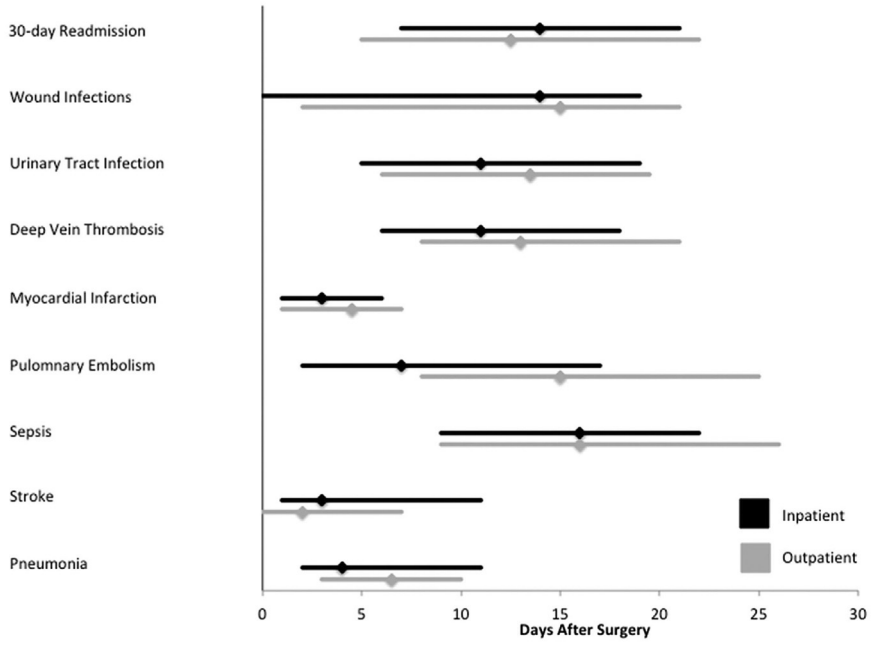


**Figure 1.** Timing of adverse events.

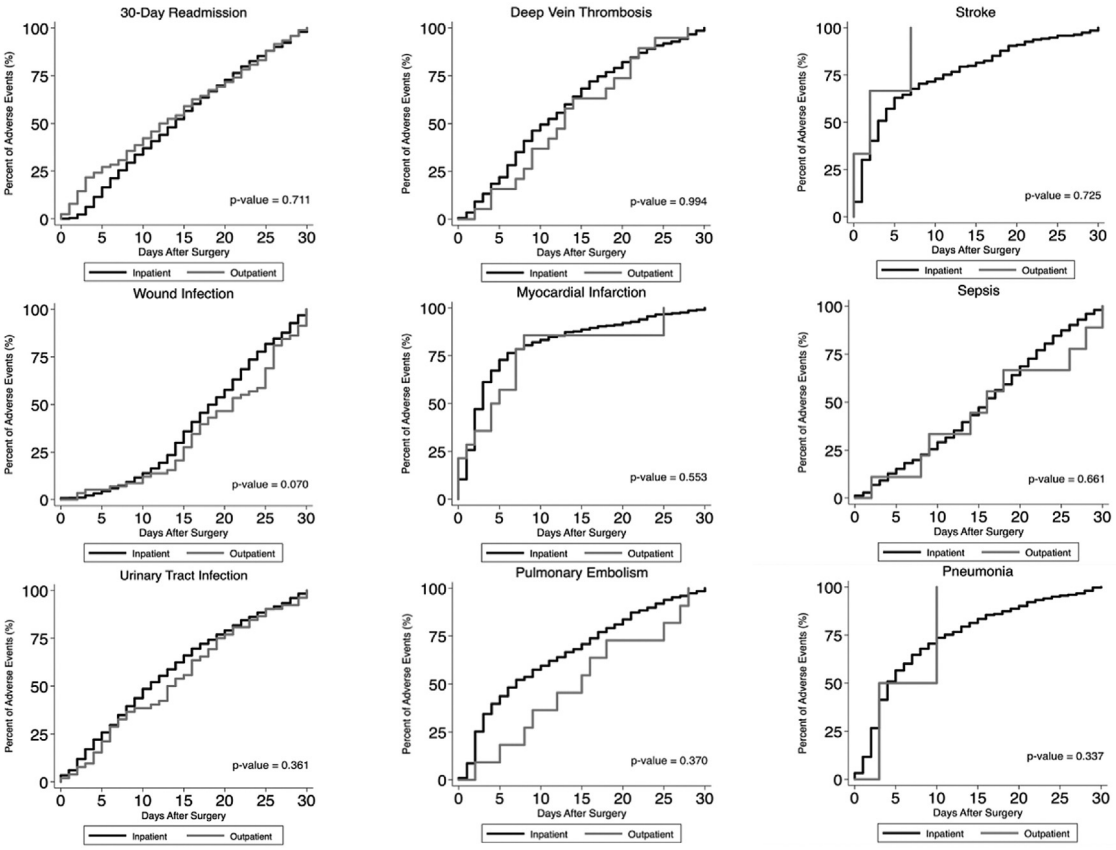


**Figure 2.** Multivariate Cox proportional hazards model of adverse events.

catastrophic complications and the other complications highlighted by this study should be lowered in their respective time frames. As THA transitions to the outpatient setting, this current study effectively provides a reference for surgeons about the timing of complications following outpatient procedures.

This study has several notable limitations in concordance with the NSQIP database. First, the NSQIP database only reports on adverse events that occur within 30 days of the procedure, and thus, longer term complications or readmissions are not captured by this data set. However, as shown by prior studies, most complications following THA occur shortly after procedure and are therefore included in the present analysis [20–22]. Next, while the current study controlled for over 150 preoperative, intraoperative, and postoperative variables, the database is unable to account for thromboembolic prophylaxis or arthroplasty-specific complications, including dislocation, periprosthetic fracture, or prosthetic joint infection. Furthermore, there are several important confounding variables that are not accounted for in the present analysis. Specifically, it is possible that procedures being performed on an ambulatory basis are less technically challenging with less morbidity (ie, acetabular dysplasia, complex femoral deformities, severe osteoporosis, joint ankylosis, acetabular protrusio, etc.), which potentially biases the result. Lastly, data provided in the present study depends on accurate coding practices by trained reviewers. Although the NSQIP database undergoes routine auditing and interrater disagreement has been shown to be below 2%, there is still the opportunity for error at this stage. [23]. For example, Rolston et al. in 2017 evaluated the validity of the NSQIP database in neurosurgery research and ultimately found errors in up to 100% of cases in terms of mismatched Current Procedural Terminology codes and postoperative diagnoses, underscoring that caution should be taken when evaluating and interpreting the results of such studies [24]. Despite these limitations, the present study provides a large sample of 9416 patients, robust multivariate analysis, and a complication and readmission rate comparable to previous studies, all of which lend significant power to the conclusions. It should also be noted that no author of the present study has individual ownership of an ambulatory surgery center.

## Conclusions

The overall rate of 30-day readmission, SSI, and pneumonia was lower in patients undergoing outpatient THA than in traditional, inpatient THA, even after controlling for age, sex, BMI, smoking, ASA score, and medical comorbidities. Following multivariate adjustment, the timing of specific complications and readmissions following outpatient THA was similar to inpatient THA. The present study provides a reference for the specific time that complications tend to occur after outpatient THA, and the thresholds for diagnostic testing after outpatient THA should be lowered for each complication during the time periods identified to be of greatest risk. Given that myocardial infarction and stroke tend to occur early in the postoperative period, the implementation of patient and caregiver education regarding the signs/symptoms and importance of early intervention for these potentially catastrophic complications should be considered.

## Conflicts of interest

P. Bovonratwet is an editorial board member of HSS Journal, European Spine Journal, and Arthroscopy: The Journal of Arthroscopic and Related Surgery. M. P. Ast receives royalties from OrthAlign; is a speaker bureau of BD, Convatec, OrthAlign, Smith & Nephew, and Stryker; is a paid consultant for BD, Bioventus, Conformis, OrthAlign, Smith & Nephew, and Surgical Care Affiliates; has stock options in ConveyMED, H2S, OrthAlign, Ospitek, Osso VR, and Parvizi Surgical Innovations; receives research support from Smith & Nephew; is an editorial board member of Journal of Arthroplasty, JOEI, and Orthopedics; and is a board/committee member of AAHKS, AAOS, EOA, and Foundation for Physician Advancement. E. P. Su receives royalties from Kyocera Corporation, OrthAlign, and United Orthopedic Corporation; is a paid consultant for Smith & Nephew, OrthAlign, and United Orthopedic Corporation; has stock options in OrthAlign and HS2 LLC; receives research support from Smith & Nephew and United Orthopedic Corporation; receives financial and material support from Kyocera Corporation; and is an editorial board member of Techniques in Orthopaedics. All other authors declare no potential conflicts of interest.

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## CRediT authorship contribution statement

**Scott M. LaValva:** Writing – review & editing, Writing – original draft, Visualization. **Patawut Bovonratwet:** Writing – original draft, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Aaron Z. Chen:** Resources, Data curation. **Drake G. Lebrun:** Writing – review & editing, Methodology, Conceptualization. **Ryann A. Davie:** Resources, Methodology, Investigation. **Tony S. Shen:** Writing – review & editing, Supervision, Methodology, Investigation. **Edwin P. Su:** Writing – review & editing, Supervision, Resources, Project administration. **Michael P. Ast:** Writing – review & editing, Supervision, Resources, Project administration, Conceptualization.

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