



## ■ ARTHROPLASTY

# Association between surgical wait time and hospital length of stay in primary total knee and hip arthroplasty

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## Aims

In countries with social healthcare systems, such as Canada, patients may experience long wait times and a decline in their health status prior to their operation. The aim of this study is to explore the association between long preoperative wait times (WT) and acute hospital length of stay (LoS) for primary arthroplasty of the knee and hip.

## Methods

The study population was obtained from the provincial Patient Access Registry Nova Scotia (PARNS) and the Canadian national hospital Discharge Access Database (DAD). We included primary total knee and hip arthroplasties (TKA, THA) between 2011 and 2017. Patients waiting longer than the recommended 180 days Canadian national standard were compared to patients waiting equal or less than the standard WT. The primary outcome measure was acute LoS postoperatively. Secondly, patient demographics, comorbidities, and perioperative parameters were correlated with LoS with multivariate regression.

## Results

A total of 11,833 TKAs and 6,627 THAs were included in the study. Mean WT for TKA was 348 days (1 to 3,605) with mean LoS of 3.6 days (1 to 98). Mean WT for THA was 267 days (1 to 2,015) with mean LoS of 4.0 days (1 to 143). There was a significant increase in mean LoS for TKA waiting longer than 180 days (2.5% (SE 1.1);  $p = 0.028$ ). There was no significant association for THA. Age, sex, surgical year, admittance from home, rural residence, household income, hospital facility, the need for blood transfusion, and comorbidities were all found to influence LoS.

## Conclusion

Surgical WT longer than 180 days resulted in increased acute LoS for primary TKA. Meeting a shorter WT target may be cost-saving in a social healthcare system by having shorter LoS.

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## Introduction

Total knee (TKAs) and hip arthroplasties (THAs) are immensely successful surgical procedures<sup>1</sup> that are rationed through wait times in social health care systems such as Canada's.<sup>2,3</sup> Currently the benchmark for receiving arthroplasty in Canada, from decision to operate to time of operation, is set at 180 days as a national standard.<sup>4,5</sup> Despite inflow of healthcare resources, there are unmet demands from a greying Canadian population; in 2018 only 75% of Canadians reached the recommended benchmark for THA and 69% for TKA.<sup>6</sup> Wait times (WT) are a

growing concern for patients and healthcare providers alike. Patients identify WT as unacceptably long and contributory to further deterioration of their health while waiting for surgery.<sup>7-10</sup> Surgery performed later in the natural history of disease is shown to have significant impact on pain, function, and health-related quality of life at the time of surgery.<sup>11-14</sup> Prospective studies have linked preoperative functional limitations to worse postoperative patient-reported outcomes.<sup>15-18</sup>

In a social healthcare system, reductions in hospital length of stay (LoS) can improve

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patient flow, allow for higher turnover of surgical cases, and reduce WT. LoS has been linked to numerous factors including age, sex, comorbidities, intraoperative blood loss, postoperative blood transfusion, as well as marital and socioeconomic status.<sup>19-35</sup> Location of residence, facility of practice, surgeon and hospital volume, anaesthesia type, and preoperative patient education have also been implicated in LoS.<sup>36-43</sup> Interestingly, prudent reduction in LoS has not been associated with an increase in the rate of readmission.<sup>44</sup>

Despite a wealthy body of literature, no study has yet directly examined the association between preoperative WT and acute inpatient hospital LoS. This study aims to examine the relation between the disproportionately large preoperative TKA and THA WT and resultant acute LoS. We hypothesize that increased preoperative wait would be associated with increased LoS. Our secondary aim is to describe risk factors associated with variations in LoS.

## Methods

**Study population.** The study population was obtained by selecting primary TKA and THA procedures from provincial and national hospital databases and merging patient observations together based on unique identifiers from year 2011 to 2017. Databases used include Patient Access Registry Nova Scotia (PARNS), the Canadian inpatient hospital Discharge Access Database (DAD), and National Ambulatory Care Reporting System (NACRS). WT was calculated from PARNS data. LoS as well as patient demographic details and comorbidities for the two-year period prior to surgery were accessed from DAD and NACRS data. A total of 21,329 patient observations were identified between January 2011 and December 2017. Bilateral arthroplasty cases were included and comprised less than 1% of all observations. Only one patient observation had both TKA and THA procedures during the same admission. Observations were excluded based on missing linkage between PARNS and DAD/NACRS, and missing or negative values for WT or LoS. Patients with revision or emergency status were excluded. After exclusions, 18,460 observations were used in the final analytic database (Table I).

**Statistical analysis.** WT in days was calculated as the number of days between the decision to treat date and the date of surgery. The key analysis variable was a binary indicator of WT set at 180 days as per Canadian national standard. Associations between WT, risk factors, and LoS were measured with multivariate regression analysis. Variables included in the model were age, sex, rural patient residence, neighborhood median income, admission from home, hospital, anaesthesia type, admission type, and comorbidities. All variables were used to control for primary and secondary outcomes. Multivariate log-linear Poisson regression model was used to account

**Table I.** Distribution of demographic details and comorbidities in total knee arthroplasty and total hip arthroplasty patients

Variable	TKA	THA
Total, n	11,833	6,627
Mean WT, days (range)	348 (1 to 3,605)	267 (1 to 2,015)
Mean LoS, days (range)	3.6 (1 to 98)	4.0 (1 to 143)
Mean age, yrs (range)	66.6 (17 to 98)	66.0 (13 to 99)
Female, n (%)	59.1	55.0
Admit from home, n (%)	99.3	98.3
Rural residence, n (%)	35.9	35.2
Mean MHI <sup>1</sup> per thousand CAD (range)	63.9 (17.3 to 215)	65.5 (17.3 to 215)
<b>Hospital facility, %</b>		
A	13.1	14.3
B	19.4	16.6
C	12.9	7.6
D	22.2	17.8
E	32.4	43.7
<b>Anaesthesia, %</b>		
Spinal	29.1	28.7
Block	6.7	0.6
Local	1.5	0.42
Blood transfusion	3.3	6.1
<b>Comorbidities, %</b>		
HTN	17.9	15.4
DM	19.1	12.5
CHF	0.49	0.32
IHD	2.5	2.5
PVD	0.26	0.35
CVD	0.32	0.47
Dementia	0.08	0.35
CPD	2.2	1.9
PUD	0.15	0.08
CRF	0.36	0.72
Hepatic disease	0.12	0.08
Anaemia	2.0	3.8
RA	1.3	0.78
Cancer	0.77	1.1
Metastatic disease	0.14	0.32

CHF, congestive heart failure; CPD, chronic pulmonary disease; CRF, chronic renal failure; CVD, cerebrovascular disease; DM, diabetes mellitus; HTN, hypertension; IHD, ischemic heart disease; MHI, mean household income (units per \$1000 Canadian Dollars); PUD, peptic ulcer disease and upper gastrointestinal bleed; PVD, peripheral vascular disease; RA, rheumatoid arthritis; THA, total hip arthroplasty; TKA, total knee arthroplasty.

for right skew in the LoS distribution. TKA and THA cohorts were analyzed separately. Chi-squared statistics was used to test for statistical significance at a 95% confidence level and threshold set at  $p < 0.05$  for significance. All analyses were carried out using SAS 9.4 (SAS Institute, USA). Research ethics was granted by Nova Scotia Health Authority Research Ethics Board.

## Results

**Primary TKA.** There were 11,833 patients in the TKA cohort with mean age of 67 years (17 to 98) and 59% female. Mean WT for primary TKA was 348 days (1 to



Fig. 1

Trends in wait time (WT) and acute hospital length of stay (LoS). Trends are shown for a) total knee arthroplasty (TKA) and b) total hip arthroplasty (THA) from 2011 to 2017.

3,605). The patient WT distribution had a long right skew arm; the 95<sup>th</sup> percentile waited 848 days. The annual WT had increased from 333 days in 2011 to 345 days in 2017 (Figure 1a). Mean LoS for TKA was 3.6 days (1 to 98). The annual TKA LoS demonstrated a steady decline from 4.5 days in 2011 to three days in 2017.

With respect to our primary outcome, LoS for patients waiting more than the 180-day benchmark was compared to patients waiting less, while controlling for all patient and perioperative parameters presented in Table I. Patients waiting longer than 180 days for primary TKA had 2.5% longer LoS (SE 1.1%;  $p = 0.028$ , Wald chi-squared test) compared to patients waiting less (Table II). This percentage value is in reference to the mean LoS (3.6 days) and represents 2.2 hours increased LoS for a single patient.

For our secondary outcome, patient characteristics associated with longer LoS were identified with multivariate regression analysis. The relative contribution of each characteristic is presented as percentage incidence rate ratio (IRR) and standard error (SE) in Table II. For each year of age, the mean LoS increased by 0.9% annually (SE 0.06%;  $p < 0.001$ ). Female sex had 8.7% (SE 1.0%;  $p < 0.001$ ) longer LoS. Receiving blood transfusions were associated with a significantly longer LoS (58.4% (SE 1.3);  $p < 0.001$ ). With few exceptions, most comorbidities studied had longer LoS (Table II).

Patient characteristics associated with shorter LoS are denoted with negative IRR values in Table II. Operations performed more recently had a shorter mean LoS per surgical year (-3.8 (SE 0.3);  $p < 0.001$ ). Patients who received local anaesthetic had 13.4% (SE 5.0;  $p = 0.003$ ) shorter LoS. Peripheral hospitals labelled facility A to D were compared to the central academic hospital labelled facility E. Patients receiving their operations in peripheral hospitals had 13.9% to 24.8% ( $p < 0.001$ ) shorter LoS. Admittance from home, rural residence, and higher mean household income were all associated with shorter LoS.

**Primary THA.** The THA cohort had 6,627 patients with mean age of 66 years (13 to 99) and 55% (3,645) female. THA WT distribution had a shorter mean WT of 267 days (1 to 2,015) and 95<sup>th</sup> percentile waited 742 days. The annual THA WT had increased from 247 days in 2011 to 299 days in 2017 (Figure 1b). Mean THA LoS was four days (1 to 143) and the annual THA LoS had decreased from 4.9 days in 2011 to 3.3 days in 2017. In the THA cohort, there was no significant difference in LoS for patients waiting longer than 180 days (1.3% (SE 1.3);  $p = 0.317$ , Wald chi-squared test).

Association of patient demographics and perioperative parameters followed a similar pattern to the TKA cohort with few exceptions. In the THA cohort use of local anaesthetic was not associated with shorter LoS (-6.9% (SE 10.2);  $p = 0.466$ , Wald chi-squared test). Several comorbidities differed in correlation significance compared to TKA.

## Discussion

To our knowledge, this is the first study directly examining the relationship between long WT and hospital LoS for primary TKA and THA. Our WT distributions had a broad range with patients waiting years before their elective surgery. We included all the long waiters in our final analysis. Patients waiting longer than the 180-day national benchmark to receive TKA experienced a statistically significantly longer LoS. The 2.5% increase in LoS represented a small standard effect size of 2.2 hours for a single patient. Therefore, the average waiting patient can rest assured that the absolute magnitude of their hospital LoS is not drastically affected by their longer WT. However from a public health perspective, the observed 2.5% higher LoS is equivalent to 153 days of hospital bed overuse annually in our study. Providing patients with timely TKA can liberate hospital resources for more efficient use, and in our healthcare setting would allow a maximum of 42 additional TKAs to be performed annually

**Table II.** Influence of patient characteristics on length of stay for elective primary total hip arthroplasty and total knee arthroplasty.

Variable	TKA			THA		
	IRR, %	SE	p-value	IRR, %	SE	p-value
WT > days	2.5	1.1	0.028	1.3	1.3	0.317
Age (per year)	0.9	0.06	< 0.001	1.5	0.06	< 0.001
Female	8.7	1.0	< 0.001	10.6	1.3	< 0.001
Year of surgery (per year)	-3.8	0.3	< 0.001	-4.0	0.4	< 0.001
Admit from home	-44.7	3.9	< 0.001	-33.4	3.5	< 0.001
Rural residence	-5.5	1.2	< 0.001	-8.1	1.5	< 0.001
MHI* (per thousand CAD)	-0.09	0.02	< 0.001	-0.06	0.03	0.029
<b>Hospital facility†</b>						
A	-20.4	2.3	< 0.001	-24.5	2.6	< 0.001
B	-24.6	2.2	< 0.001	-28.9	2.6	< 0.001
C	-24.8	2.0	< 0.001	-10.7	2.6	< 0.001
D	-13.9	1.6	< 0.001	-12.7	2.0	< 0.001
<b>Anaesthesia</b>						
Spinal	-1.0	1.4	0.479	-1.7	1.6	0.299
Block	0.2	2.2	0.914	10.7	7.5	0.159
Local	-13.4	5.0	0.003	-6.9	10.2	0.466
Blood transfusion	58.4	2.4	< 0.001	47.5	2.5	< 0.001
<b>Comorbidities</b>						
HTN	1.8	1.4	0.193	14.7	1.8	< 0.001
DM	6.3	1.2	< 0.001	16.6	1.8	< 0.001
CHF	53.2	4.7	< 0.001	56.3	7.2	< 0.001
IHD	10.8	2.9	< 0.001	-4.9	3.7	0.170
PVD	-9.5	10.1	0.296	7.4	9.2	0.422
CVD	56.9	6.9	< 0.001	3.6	7.8	0.637
Dementia	192.4	11.5	< 0.001	166.5	5.4	< 0.001
CPD	19.1	3.0	< 0.001	20.3	4.3	< 0.001
PUD	73.2	8.5	< 0.001	354.9	8.2	< 0.001
CRF	28.2	6.4	< 0.001	42.4	4.8	< 0.001
Hepatic disease	14.4	13.3	0.280	9.8	25.1	0.677
Anaemia	15.4	3.1	< 0.001	23.3	3.0	< 0.001
RA	3.3	4.6	0.417	-5.7	7.5	0.419
Cancer	25.5	5.4	< 0.001	14.7	5.8	0.014
Metastatic disease	-10.1	13.9	0.416	16.1	9.0	0.083

\*IRR for MHI is per \$1,000 Canadian Dollars.

†Reference is academic hospital facility E.

CHF, congestive heart failure; CPD, chronic pulmonary disease; CRF, chronic renal failure; CVD, cerebrovascular disease; DM, diabetes mellitus; HTN, hypertension; IHD, ischemic heart disease; IRR, incidence rate ratio; MHI, mean household income; PUD, peptic ulcer disease and upper gastrointestinal bleed; PVD, peripheral vascular disease; RA, rheumatoid arthritis; SE, standard error; THA, total hip arthroplasty; TKA, total knee arthroplasty; WT, wait time.

owing to bed availability. At the individual patient level, longer LoS does not seem clinically relevant, however at the population level it may represent a cost saving target for future policies and interventions.

WT longer than 180 days for THA was not associated with longer LoS in our study despite similar patient demographic data and controlled parameters to TKA cohort. We speculate the local pattern of practice may be responsible for this discrepancy. Patients with concurrent hip and knee osteoarthritis with comparable levels of pain and disability from both joints are usually scheduled for a THA procedure first; aTKA procedure may be delayed until after initial patient recovery. Therefore, deleterious effects of waiting and deconditioning may have been

less extensive in THA cohort and consequently resulted in no appreciable effect on postoperative LoS. Alternatively, it may be that the anatomy and biomechanics of the arthritic knee are less tolerant to longer WT and result in slower postoperative recovery.

We have identified several demographic and health characteristics associated with longer LoS. Age and female sex are well established risk factors for longer LoS,<sup>19-21,24-26</sup> and their association was confirmed again. Likewise, we found that pre-existing anaemia and requirement for postoperative blood transfusion were linked to longer LoS, and they have been reported so in literature.<sup>27-29,45</sup> Interestingly, regional blocks did not affect LoS in either the TKA or THA groups, however administration of local anaesthetic in the TKA cohort significantly reduced LoS

( $p = 0.003$ ). A prior systematic review had identified local anaesthesia as an effective means for acute pain management and reduction of LoS,<sup>46</sup> however did not demonstrate clear benefits as an adjunct to regional blocks. Many previous publications have reported on increased LoS based on composite scores such as the Charlson Comorbidity Index, American Society of Anesthesiologists (ASA) grade,<sup>47</sup> or number of comorbidities.<sup>20,23,24,30-34</sup> Few authors have studied separate comorbidities in the same patient population in order to compare their relative contribution to LoS. Our study is able to provide the relative significance of each comorbidity towards increased LoS and provide a basis for their comparison. Seeing our results confirming previously identified risk factors in increased LoS affirms the external validity of our findings. We can be more confident that our results can be generalized to the greater Canadian population and other social healthcare systems.

Several limitations to our study have been considered. Firstly, other confounders outside of the variables already identified may contribute to the significance of increased LoS in the TKA cohort. In fact, the deterioration in patient health while waiting can only be hypothesized, but not proven, by our methodology. Secondly, use of administrative data is prone to information misclassification and reporting biases, particularly with regards to comorbidities. Comorbidities are extracted from hospital DAD for patient admissions from two years prior to their primary arthroplasty; diagnosis of comorbidities is based on clinician reporting and lacks a pre-specified diagnostic threshold or standard diagnostic test. As such, bias may arise from our inability to verify each patient comorbidity against a pre-specified reference. Furthermore, if a patient did not have a hospital admission in the two years prior to their operation, their comorbidities would not be included in our analysis. Additionally, removal of incomplete records from the dataset based on missing linkages and missing values may introduce selection bias. Perioperative care has evolved over the studied years including perioperative patient education, postoperative patient analgesia, rehabilitation protocol, and discharge criteria. Some of the aforementioned factors account for the decreasing trends in LoS, however they are not captured within our data and may bias our findings.

In conclusion, patients waiting more than 180 days for TKA have longer acute care LoS. Longer LoS may be due to deteriorating health status while placed on a surgical waitlist and may represent an indirect cost to the patient and the healthcare system. Optimization of modifiable risk factors during the waiting period may lead to reduced LoS and reduced WT downstream. Furthermore, the identified risk factors may play a role in managing patient expectation regarding LoS during surgical consent.



### Take home message

- Patients waiting longer than 180 days for total knee arthroplasty have statistically longer acute care length of stay, albeit with less clinical significance.

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