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Early Post-Operative Outcomes Following Robotic vs. Manual Total Knee Arthroplasty in Low- vs. High-Volume Surgeons

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Abstract

Introduction: Primary robotic total knee arthroplasty (TKA) is associated with favorable outcomes. To further understand robotic TKA learning curve, we evaluated early postoperative outcomes of robotics vs. manual TKA, based on surgeon experience. Methods: Patients (> 64 years) from the Medicare database, with primary, unilateral, elective TKA ("index") from October 2015 to December 2019 were identified and categorized based on robotic vs. manual surgery, and surgeon experience: low-count surgeons had < 40 cases in the 12-months pre-index; medium-low, medium-high and high count surgeons had 41-80, 81-120 and 121-160 cases, respectively. The low-count robotic cohort (RC) was compared to the low, medium-low, medium-high, and high count manual cohort (MC) for the length of the hospital stay (LOS), and rates of home and skilled nursing facility (SNF) discharge. Descriptive statistics (means and proportion with 95% confidence intervals) were performed. Results: 296 low-count robotic cases were compared to 209,494 low-count manual and 252,905 medium-low, medium-high and high-count manual cases. The low-count RC had an average LOS of 2.03 days (95% confidence intervals (CI): 1.86-2.20) vs. 2.20 days (95%CI: 2.20-2.21) for the low-count MC. 82.4% patients (95%CI: 78.1%-86.8%) from the low-count RC were discharged home vs. 74.2% (95%CI: 74.0%-74.4%) in the low-count MC and 83.6% (95%CI: 83.3%-84.0%) in the high-count MC. Discharge to SNF affected 15.2% (95%CI: 11.1%-19.3%) in the low-count RC vs. 21.0% (95%CI: 20.9%-21.2%) and 15.2% (95%CI: 14.9%-15.4%) in the low-count and medium-high MC, respectively. Conclusion: Patients operated with robotic surgery by surgeons with low yearly volume had a LOS and probability of home discharge similar to that of patients operated with

manual surgery by high-volume surgeons. Patients in the robotic group also had a lower rate of SNF discharge compared to the patients in the manual surgery group, with surgeons of similar experience.

1 Introduction

The use of robots for primary total knee arthroplasty (TKA) has been associated with favorable clinical and economic outcomes. (Agarwal, To, McDonnell, & Khan, 2020; Cool, Jacofsky, Seeger, Sodhi, & Mont, 2019) Studies have also demonstrated that learning curves (LC) for use of robots are short, ranging from 7 to 20 cases. (Kaper, 2020; Kayani, Konan, Huq, Tahmassebi, & Haddad, 2019; Keggi & Plaskos, 2017; Mahure et al., 2021) To further understand the impact of robotic surgery for surgeons with low-volume experience, immediate post-operative outcomes with significant impact on healthcare costs need to be evaluated. Our study was therefore designed to evaluate the length of hospital stay and the discharge disposition of patients treated with robotics vs. manual surgery, based on the experience of the treated physician.

2 Methods

2.1 Database:

The United States Centers for Medicare and Medicaid Limited Data Set Standard Analytic Files (SAF) were used for this analysis. This database includes 100% inpatient and outpatient claims of Medicare beneficiaries, which represent the majority of individuals aged 65 and above in the United States. The SAF dataset allows for longitudinal analysis of patient-level data for approximately 40 million lives each year and is available from 2000 onwards.

2.2 Population:

All patients with a primary TKA performed between October 2015 and December 2019 (pre-pandemic period) were initially included. Index was defined as the date of the TKA. All patients had elective, unilateral surgery. Exclusion criteria included: TKA or revision TKA or lower limb fractures or infections in the 12 months pre-index.

2.3 Variables:

Patient demographic (age, gender, race) and comorbidities (Elixhauser index (EI) and all 31 chronic disease states of the EI) at time of TKA were identified. For each surgery, the number of TKA surgeries performed by the surgeon in the 12-months pre-index was calculated and added as a “surgeon’s experience” variable. Additional provider variables included hospital bed size, hospital type (teaching vs. community), and hospital location (urban vs. rural).

2.4 Cohorts:

The following cohorts were created: 1) patients operated manually by surgeons with prior manual TKA experience: the “manual cohort” (MC); 2) patients operated with robotic surgery, by surgeons with exclusively robotic TKA experience: the “robotic cohort” (RC). Cases where surgeons had a mix of manual and robotic experience 12-month pre-index were not included. Patients were further categorized based on their surgeon’s experience. For the manual cohort, 4 groups were made: prior

year volume: 0-40 cases (low count MC), 41-80 cases (medium-low count MC), 81-120 cases (medium-high count MC) or 121-160 cases (high-count MC)). These four groups of patients within the MC were compared to the patients within the RC, operated by surgeons having performed 0-40 TKA in the year prior, defined herein as low-count RC cohort.

2.5 Outcomes:

The outcomes evaluated included length of hospital stay (LOS) and discharge disposition (home (which includes home health) vs. skilled nursing facility (SNF)).

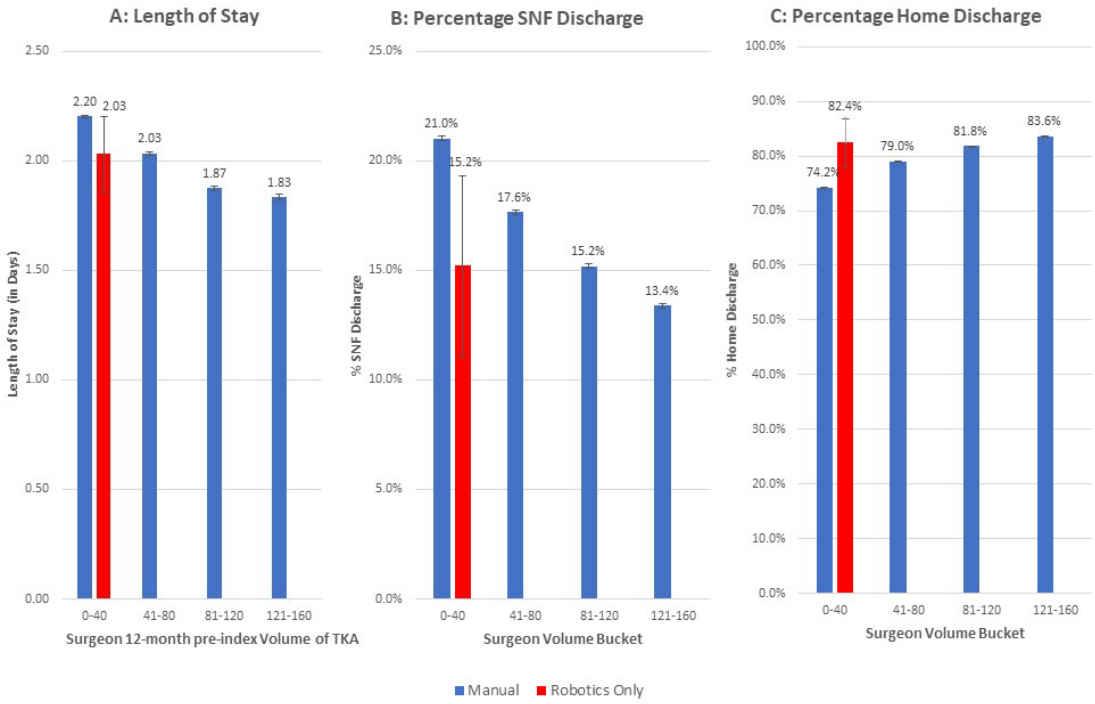
3 Results and Discussion

The number of cases and contributing surgeons is shown in Table 1. The average LOS (in days) and discharge to home or SNF are shown graphically in Figure 1.

Table 1*:* **Count of surgeons and patients in the manual cohort (MC) or robotics cohort (RC), based on surgeon prior-year experience (defined as the count of manual (for MC) or robotic (for RC) TKA cases performed in the 12 months prior to the index TKA, shown in the table below in-between brackets).**

Cohort	Number of Surgeons	Number of TKA Cases
MC with low-count surgeons (0-40)	14,400	209,494
MC with medium-low count surgeons (41-80)	3,336	144,136
MC with medium-high count surgeons (81-120)	1,216	70,360
MC with high-count surgeons (121-160)	499	38,409
RC with low-count surgeons (0-40)	156	296

Figure 1: Postoperative outcomes in patients treated with robotic vs. manual TKA, based on surgeon experience. A: Average length of hospital stay; B: Percentage SNF discharge; C: Percentage home discharge. Error bars represent 95% confidence intervals.



The LOS for the low-count RC was 2.03 (95% confidence intervals (CI): 1.86-2.20) vs. 2.20 (95%CI: 2.20-2.21) for the low-volume MC. For patients within the medium-low, medium-high and high-count MC, LOS decreased to 2.03 (95%CI: 2.02-2.04), 1.87 (95%CI: 1.87-1.88) and 1.83 (95%CI: 1.82-1.85), respectively. In the low-count RC, 82.4% patients (95%CI: 78.1%-86.8%) were discharged home. In the MC, home discharge reached 74.2% (95%CI: 74.0%-74.4%) in the low-count cohort and increased to 83.6% (95%CI: 83.3%-84.0%) in the high-count cohort. Discharge to SNF was observed for 15.2% (95%CI: 11.1%-19.3%) in the low-count RC, vs. 21.0% (95%CI: 20.9%-21.2%) in the low-count MC. In the other MCs, SNF discharge declined from 17.6% (95%CI: 17.5%-17.8%) to 15.2% (95%CI: 14.9%-15.4%) and 13.4% (95%CI: 13.1%-13.7%) in the medium-low, medium-high and high-count cohorts.

Our findings suggest that for outcomes related to surgical effectiveness (LOS, home discharge, SNF discharge), cohorts of patients treated robotically by surgeons with low-count experience achieved better outcomes compared to cohorts of patients treated manually by surgeon with low-count experience. In fact, patients in the low-count RC cohort had outcomes similar to those of the MC cohort treated by surgeons with at least 40-more cases in the prior year. This finding suggests that robotic surgery may help improve outcomes of surgeons that only perform few procedures every year. Our findings complement those of Mahure *et al*, who reported that patient-reported outcomes and adverse event rates in patients operated with robotic surgery early within a surgeon's learning curve are similar to those of patients operated with robotic surgery by experienced surgeons, suggesting that

the effectiveness and safety of robotic surgery is observable already early on, in less experienced surgeons. (Mahure et al., 2021). The safe and effective use of robotic surgery, early in the surgeon's learning curve, was also reported by other groups, using other robots, thus suggesting a consistent trend across robotic surgery.(Bell et al., 2021; Vanlommel, Neven, Anderson, Bruckers, & Truijen, 2021).

A key strength of our analysis relies in the large number of surgeries included in our assessment. However, a limitation of our current analysis is the fact that patient demographic and comorbid factors were not matched between groups.

4 Conclusions

Patients operated with robotic surgery by surgeons with low yearly volume had a LOS and probability of home discharge similar to that of patients operated with manual surgery by high-volume surgeons. Patients in the robotic group also had lower rate of SNF discharge compared to the patients in the manual surgery group, with surgeons of similar experience.

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