Arthroplasty Today 8 (2021) 57–62

Contents lists available at ScienceDirect

Arthroplasty Today

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

Original Research

Differences in Immediate Postoperative Outcomes Between Robotic-Assisted TKA and Conventional TKA

David Alex Hamilton, MD, MS [a,*], Ucheze Ononuju, MD [a], Caden Nowak, MD [b], Chaoyang Chen, MD, PhD [a], Hussein Darwiche, MD [a]

[a] *Detroit Medical Center Department of Orthopaedic Surgery, Detroit, MI, USA*
[b] *Wayne State University School of Medicine, Detroit, MI, USA*

ARTICLE INFO

Article history:
Received 18 August 2020
Received in revised form
5 January 2021
Accepted 31 January 2021
Available online xxx

Keywords:
TKA
Robotic-assisted
Total
Knee
Arthroplasty

ABSTRACT

Background: Robotic-assisted total knee arthroplasty (TKA) is a growing technique in adult reconstruction. The variations between robotic-assisted and conventional TKA could lead to changes in immediate postoperative outcomes. We aimed to evaluate for differences in postoperative pain, discharge day, as well as post-hospital disposition (home vs subacute rehabilitation facility [SAR]) between robotic-assisted and conventional TKA.
Methods: We retrospectively identified 2 cohorts of patients who underwent either conventional or robotic-assisted TKA between January 2019 and July 2019. Their average pain scores from postoperative day 0, day 1, and day 2 were recorded. Their postoperative discharge day was recorded, as well as their disposition to either home or a SAR. Preoperatively, all patients are offered robotic-assisted TKA, and only those who want the procedure and undergo a preoperative CT scan receive the robotic-assisted surgery. Statistical analysis was conducted using SPSS.
Results: One hundred sixty-six patients were identified with 83 in each cohort. No differences between age, race, and gender were found. Despite minor variations in pain levels, the overall postoperative pain score analysis did not strongly favor one technique over the other. The robotic-assisted group had a significantly higher amount of patients discharged to home instead of a SAR and also had a shorter time to discharge than the conventional group.
Conclusions: Robotic-assisted TKA has similar postoperative pain scores compared with conventional TKA. The robotic-assisted cohort demonstrated other benefits including earlier discharge and are more likely to be discharged home instead of a SAR.

Introduction

Robotic-assisted total knee arthroplasty (TKA) is a growing technique in the orthopedic surgery community [1,2]. There are some variations in the surgical steps compared with conventional jig-based TKA, which can theoretically lead to a change in immediate postoperative outcomes, including pain. We aimed to evaluate the differences in postoperative pain, discharge to home vs a subacute rehabilitation facility (SAR), and time to discharge between the 2 surgical techniques.

Recent literature has demonstrated that robotic-assisted TKA achieves similar or even better technical outcomes than conventional TKA. Mannan et al. showed an improvement in coronal plane alignment when using robotic assistance [3]. Others have demonstrated that robotic-assisted arthroplasty can accurately restore both the joint line and the mechanical axis [4]. The improvements in technical outcomes shown in these and other studies are part of the reason why the use of robotic assistance continues to increase. Despite these and other technical outcomes, little evidence exists for differences in clinical outcomes when using robotic assistance compared with conventional TKA. One recent study has shown a difference in pain scores, with the robotic-assisted group having lower pain scores at certain time points than the conventional group [5]. We wanted to expand upon this knowledge with a larger cohort of patients who underwent a different type of surgical anesthesia.

* Corresponding author. Detroit Medical Center Department of Orthopaedic Surgery, 3990 John R Street - Harper 7 Brush, Detroit, MI 48021, USA. Tel.: +1 734 925 0880.
E-mail address: d.alex.hamilton@gmail.com

https://doi.org/10.1016/j.artd.2021.01.017

Outcomes in the immediate postoperative period are important to evaluate. Changes in pain between the 2 cohorts could allow for differences in pain control and also have implications for performing outpatient TKA. Changes in discharge disposition and time to discharge could have cost-savings as well as patient health benefits. We aimed to evaluate these clinical outcomes in our patient population. We hypothesized that robotic-assisted TKA would achieve similar postoperative pain scores, no difference in discharge disposition, and no difference in time to discharge compared with conventional TKA.

Materials and methods

Institutional review board approval was obtained before study initiation. A total of 166 patients were included in the study. The patients underwent either primary robotic-assisted TKA (n = 83) or primary conventional TKA (n = 83) for treatment of osteoarthritis by the same surgeon at an urban tertiary care center between January 2019 and July 2019. Inclusion criteria included patients of any age who underwent the aforementioned procedures during the time period. We excluded 4 patients from the study. Three of the four patients underwent concomitant removal of hardware at the same time as their TKA, and one patient had severe posttraumatic arthritis as well as chronic knee dislocations. The patients were otherwise consecutively treated. The operating surgeon uses the same approach and the same surgical implant company for all patients.

Spinal epidural anesthesia or general anesthesia was used for anesthesia during surgery. Most patients (n = 110) took a pain medication regimen which included acetaminophen, gabapentin, oxycodone, morphine, and ketorolac. Some patients (n = 55) occasionally also took other pain medication including hydrocodone, hydromorphone, celecoxib, methadone, codeine, and pregabalin. Variations in pain medication regimen were based off of preoperative narcotic usage.

Patients are offered robotic-assisted TKA at the time of surgical boarding. Those patients who elect to proceed with robotic assistance, including obtaining the preoperative CT scan, are the ones who end up undergoing robotic-assisted TKA. All others undergo conventional TKA.

The electronic medical record was reviewed for each patient. Each visual analog scale pain score, as recorded by nursing staff, was collected and averaged for postoperative days (POD) 0, 1, and 2. The POD0 scores were only included after the patient was out of the operating room, and any pain scores taken in the preoperative time period were excluded from our review. We chose to collect pain scores only through POD2 because the focus of this study was to evaluate the differences between the 2 cohorts in the immediate postoperative period. Also, most patients are discharged within the first 72 hours after surgery.

In addition to recording the visual analog scale pain scores, we also recorded every dose of pain medication taken in the hospital, type of surgical anesthesia, POD of discharge, the postoperative disposition (home vs SAR), as well as demographic information for each patient (age, gender, race, and BMI). The American Society of Anesthesiologists (ASA) score was also collected to account for medical comorbidities between the 2 groups.

Statistical analysis

The primary outcome of interest in this study was the average difference in pain scores over the time points after surgery and between robotic-assisted TKA and conventional TKA. First, we compared all conventional TKA patients to all robotic-assisted TKA patients. Then, to control for differences in surgical anesthesia and postoperative pain medications taken, we performed a subgroup analysis in which only the patients who received spinal anesthesia and the same postoperative pain medication regimen were selected (n = 110, 61 robotic-assisted group, and 49 of patients in conventional TKA group). The average scores were compared between each of the PODs. The analysis of variance (ANOVA) with PostHoc LSD was used to determine significant levels of difference in pain scores between the 2 surgical techniques. GLM Univariate with PostHoc LSD was used to determine significant levels of difference in pain scores between surgery types at different postoperative time points. MANCOVA was also used to determine significant levels of difference in pain scores between surgery types at different postoperative time points with consideration of the influence of pain medication as covariables. Finally, a multiple regression analysis was performed to better understand confounding variables including BMI and ASA score. For all analyses, a *P* value smaller than 0.05 was considered statistically significant. All analyses were performed using SPSS software (version 25; IBM, Chicago, IL).

Results

Demographics

The average age of the patients surveyed was 60.01 ± 9.65 years (range, 38-87). The age of the patients who underwent conventional TKA was 60.99 ± 10.49 years, and the average age for robotic-assisted TKA was 59.04 ± 8.82 years. There was not a statistical difference between these 2 groups (t-test, $P = .196$). There was also no statistically significant difference in terms of gender, race, or type of surgical anesthesia between the 2 cohorts, as shown in Table 1.

The average BMI in the conventional group was 39.7 ± 10.1, and the average BMI in the robotic-assisted group was 34.7 ± 6.1 (mean ± standard deviation [SD]; t-test, $P = .003$). The average ASA score in the conventional group was 2.6 ± 0.5, and the average ASA in the robotic-assisted group was 2.5 ± 0.5 (Mean ± SD; t-test, $P = .195$).

Postoperative pain

For all patients (n = 166), the overall mean 3-day pain score was 5.52 ± 1.52 (mean ± SD). For all 3 PODs combined, there was not a significant difference in pain scores between the 2 surgical techniques (Univariate GLM, PostHoc LSD, $P = .083$) (Fig. 1). However, there was a difference in pain on POD0. The robotic-assisted group averaged 5.8 ± 1.9 on the day of surgery, and the conventional group averaged 5.2 ± 1.7 (t-test, $P = .041$). There was no difference on POD1 and 2.

Table 1
Demographics.

Demographics	Conventional	Robotic-assisted	*P* value
Gender			
Male	20 (24.0%)	26 (31.3%)	.298
Female	63 (76.0%)	57 (68.7%)	
Race			
White	15 (18.1%)	13 (15.7%)	.435
Black	44 (53.0%)	52 (62.6%)	
Other	24 (28.9%)	18 (21.7%)	
Anesthesia			
Spinal	73 (89.0%)	79 (95.2%)	.142
General	9 (11.0%)	4 (4.8%)	
BMI	39.7 ± 10.1	34.7 ± 6.1	**.003**
ASA score	2.6 ± 0.5	2.5 ± 0.5	.195

“Other” race category includes Asian, American Indian, and unknown. Bold indicates statistically significant difference ($P < .05$).

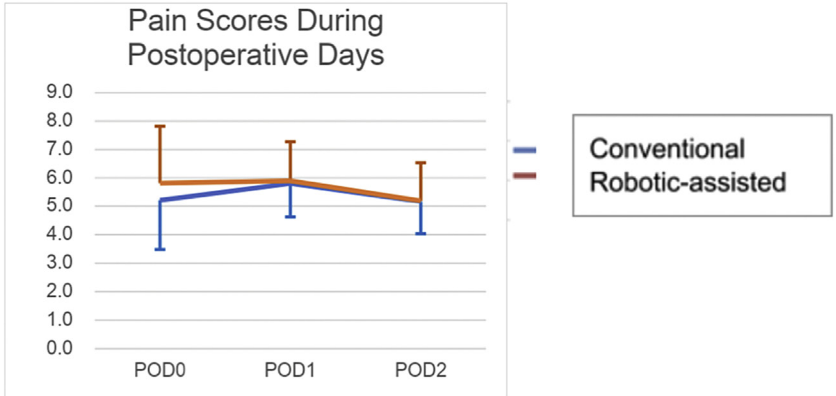

Figure 1. Pain scores for both groups on POD0, 1, and 2. There was a slightly higher pain score in the robotic-assisted group on POD0.

We also analyzed the subgroup of patients who received only spinal epidural anesthesia and the same postoperative pain medication regimen. When these patients were compared, pain scores remained the same in the robotic-assisted group (one-way ANOVA PostHoc LSD, $P = .170$) but increased in the conventional group (one-way ANOVA PostHoc LSD, $P = .000$) over the postoperative period (Fig. 2). Percent change was compared to normalize the data to avoid individual variability. The conventional group had a significantly higher percent change over the postoperative period than the robotic-assisted group (MANCOVA PostHoc LSD, $P = .003$) (Fig. 3).

Controlled by ASA score and BMI, the multiple regression analysis showed that postoperative pain score was affected by surgery type ($P = .028$) and BMI ($P = .036$).

Regarding surgical anesthesia, there was no statistical difference in pain scores between general and spinal anesthesia in either the robotic-assisted group (Univariate PostHoc LSD, $P = .926$) or the conventional group (Univariate PostHoc LSD, $P = .602$).

Regarding postoperative pain medications, the doses of gabapentin, oxycodone, and morphine were not statistically different between the 2 groups (Figs. 4-6, respectively), although there was a trend toward patients requiring a higher dose of morphine on POD2 in the conventional group (Univariate PostHoc LSD, $P = .789$, .700, and .085, respectively).

Discharge

More patients were discharged home instead of a SAR in the robotic-assisted group than the conventional group. In the robotic-assisted group, 90.4% of patients were discharged home, and 9.6% were discharged to a SAR. In the conventional TKA group, 79.5% of patients were discharged home, and 20.5% of patients were discharged to a SAR (Chi-Square, Pearson test, $P = .051$; Fisher Exact test [1-side], $P = .041$) (Table 2).

Finally, the patients undergoing conventional TKA had a longer time to discharge than the robotic-assisted group, at 2.57 days vs 2.19 days, respectively (t-test, $P = .033$).

Discussion

As robotic-assisted TKA becomes more popular, it is important to evaluate the technique from all aspects. While some of the aforementioned studies show that robotic-assisted arthroplasty

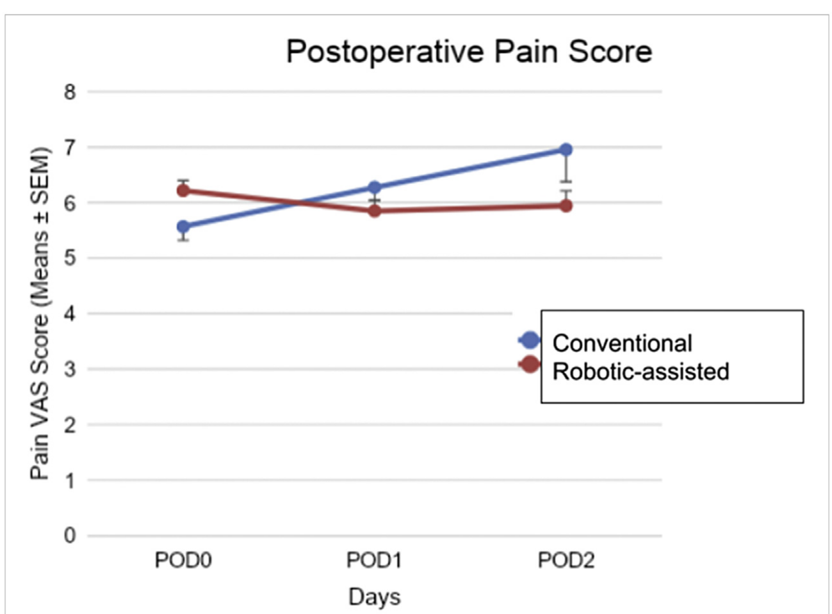

Figure 2. Subgroup analysis of those patients undergoing spinal anesthesia and the same postoperative pain medication regimen. There was a slightly higher pain score in the robotic-assisted group on POD0, then appeared to be decreased. While in the conventional TKA group, pain score increased in POD1 and POD2.

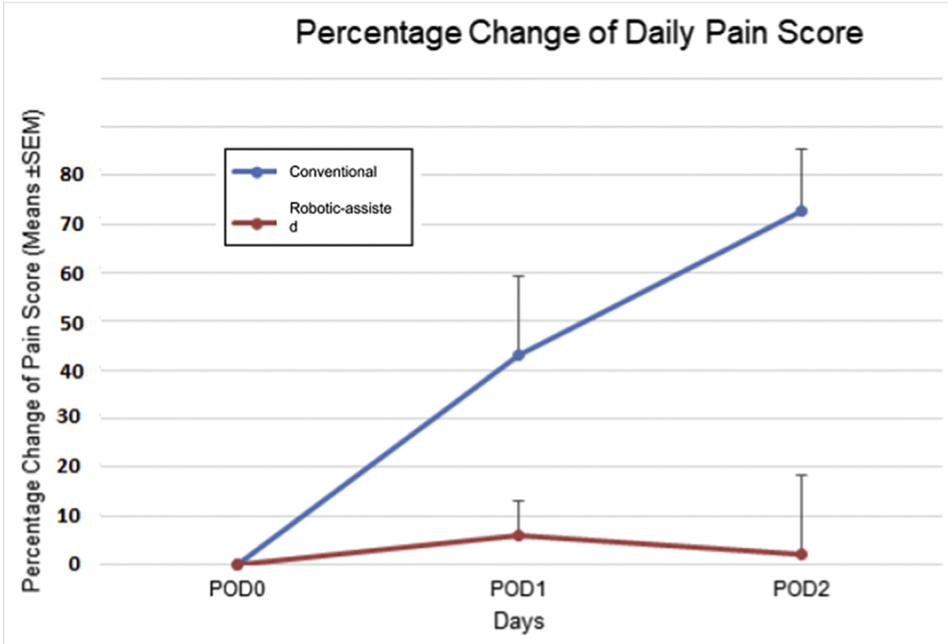

Figure 3. Subgroup analysis of those patients undergoing spinal anesthesia and the same postoperative pain medication regimen. Percent change in daily pain scores for both groups is shown. Pain scores increased in the conventional group over the 3 postoperative days. There was a statistical difference between 2 groups (MANCOVA PostHoc LSD, $P = .003$).

achieves the same or better technical outcomes, fewer studies have shown changes in clinical outcomes [6]. We aimed to evaluate for differences in 3 of the immediate postoperative outcomes between the 2 groups: pain scores on POD0, 1, and 2; discharge disposition (home vs SAR); and time to discharge.

Demographics

As this was a retrospective study, we wanted to identify all variables that could possibly confound our results. The 2 cohorts showed no differences in age, race, and gender. We used the ASA score to represent medical comorbidities, and no difference existed in the average ASA score between the 2 groups. No differences were demonstrated in terms of pain medication dosing in the postoperative period. The average BMI was slightly higher in the conventional TKA group at 39.7 vs 34.7. We will discuss how this difference in BMI may affect pain and discharge status in each appropriate subsection.

Postoperative pain

For all 3 days combined, the overall average pain scores showed no difference for the robotic-assisted and conventional procedures.

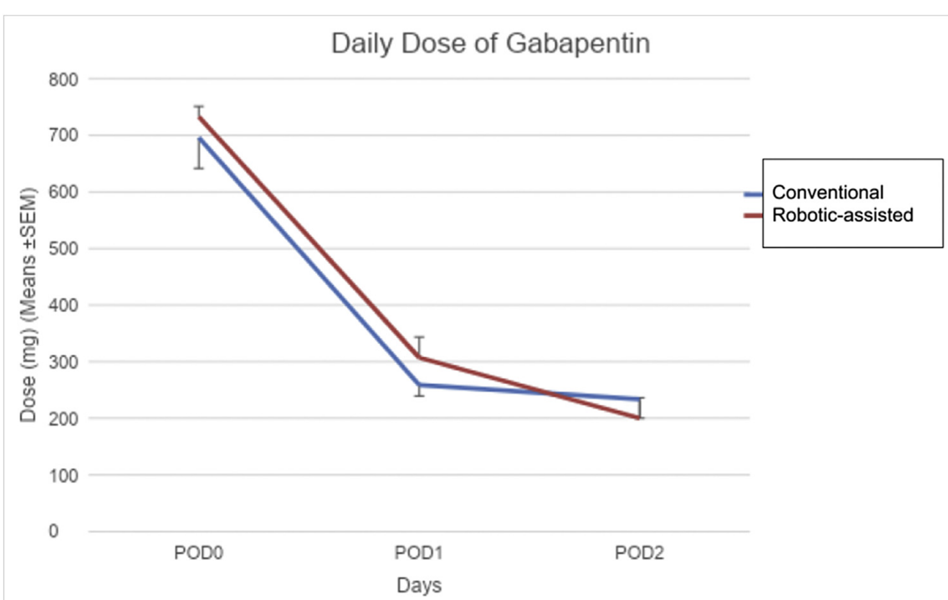

Figure 4. Gabapentin dosing on POD0, 1, and 2. The dose of gabapentin decreased each postoperative day.

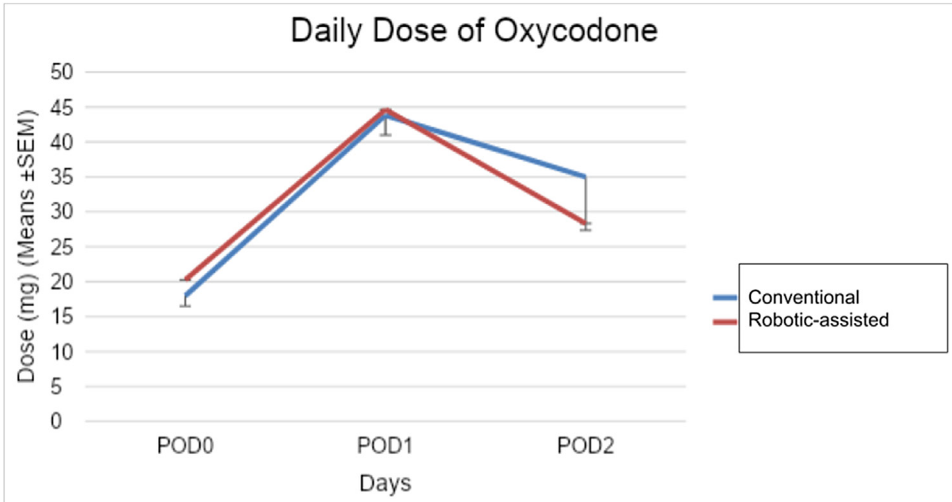

Figure 5. Oxycodone dosing on POD0, 1, and 2. The dose of oxycodone went up on POD1 and down by POD2 in both groups.

When the days were split up, we found that the robotic-assisted arthroplasty cohort had higher average pain scores on POD0 than the conventional group, at 5.8 vs 5.2. Differences in surgical technique, such as the extra drill holes for the array clamp constructs in the robotic-assisted procedure, might account for the marginally higher pain scores. This may be an important difference to recognize, such as in the setting of outpatient TKA. A recent systematic review showed that 22% of failed same-day discharges for outpatient arthroplasty were for inadequate pain control [7]. Our slightly higher pain on POD0 in the robotic-assisted group may confer an adjustment in pain modalities when performing outpatient robotic-assisted arthroplasty. Importantly, these differences disappear on POD1 and 2.

When controlling for the same type of surgical anesthesia and postoperative pain regimen, the conventional group had slightly higher pain scores each day while the robotic-assisted group scores remained the same. We also reported the percent change in pain scores each day, to normalize the values. There was a significantly higher percent change in pain score for the conventional group.

While these overall cohort and the subgroup analyses show some differences in pain scores at different time points, our study results do not strongly favor one technique over the other. The differences in BMI between the 2 groups likely do not affect this overall conclusion on postoperative pain.

Discharge

Our study demonstrates an advantage for the robotic-assisted group in terms of discharge disposition and time to discharge. The robotic-assisted cohort had a higher percentage of patients discharged home vs SAR and a shorter length of stay. This is an important difference to appreciate. Cost of total joint arthroplasty and postprocedural costs are key areas of recent orthopedic research. One study found that discharge to a SAR accounted for 45% of postprocedural costs after total joint arthroplasty [8]. In another study, Bini et al. demonstrated that after TKA, a patient who is discharged to a rehabilitation facility is twice as likely to be readmitted for medical complications compared with a patient who is discharged home and that was after selecting only patients with an ASA score of 2 or less in each group [9]. We also know that discharging to home is associated with significantly lower

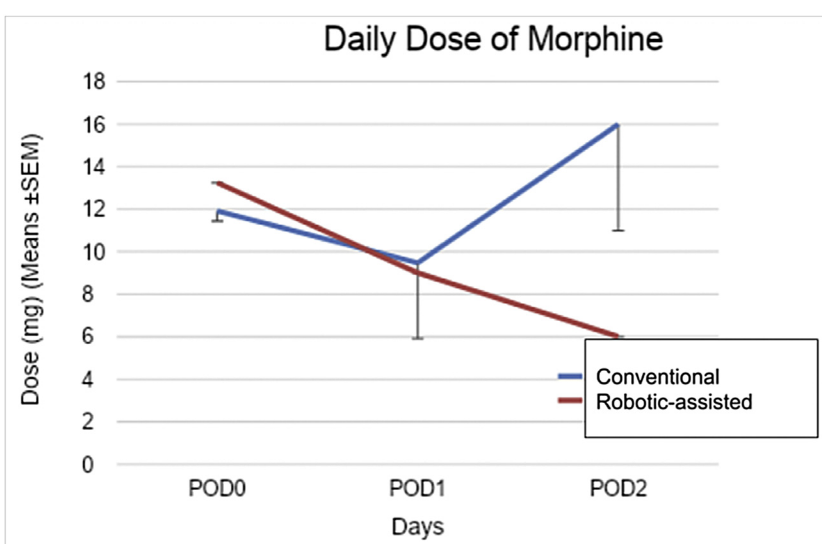

Figure 6. Dose of morphine on POD0, 1, and 2. There was a trend toward a higher dose of morphine in the conventional group, however not a statistical difference.

Table 2
Discharge disposition and surgery type.

Discharge destination	Conventional	Robotic-assisted
Home	66 (79.5%)	75 (90.4%)
SAR	17 (20.5%)	8 (9.6%)

Chi-Square, Pearson test, $P = .051$; Fisher Exact test (1-side), $P = .041$.

postoperative costs than discharging to a SAR [10]. Robotic-assisted TKA costs more than conventional TKA for the surgery itself [11]. However, increased rates of discharge home and decreased time to discharge are potential benefits both from a cost-savings and a medical complication standpoint.

We may ask ourselves if the slightly higher BMI of 39.7 in the conventional vs 34.7 in the robotic-assisted group may affect the discharge destination. Multiple studies have recently been published on factors that influence discharge destination after arthroplasty. One study showed that age was a predictor of discharge to home vs SAR; however, BMI was not a predictor of discharge destination after TKA [12]. Another recent publication evaluated a preoperative risk assessment tool for predicting discharge disposition after revision hip and knee arthroplasty. They performed both univariable and multivariable analyses on BMI as a predictor of discharge destination and found that BMI did not predict discharge disposition in either analysis [13]. While it is possible that the small difference in BMI may contribute to our discharge findings, these studies show that it is unlikely.

This study has some limitations. This is a retrospective study and not a randomized, prospective study. We were careful to evaluate for differences in surgical anesthesia as well as pain medications taken postoperatively. For pain score analysis, we did look at the subgroup of patients who received the same surgical anesthesia and the same postoperative pain regimen to help control for those variables. Second, as all patients are initially offered robotic-assisted arthroplasty, those who are most motivated to obtain their preoperative CT scan are the patients who end up undergoing the robotic-assisted procedure. These more motivated patients may be more likely to discharge home instead of SAR. Third, this study does not correlate the immediate postoperative outcomes with long-term outcomes between robotic-assisted and conventional TKA. Despite these limitations, this is the largest cohort available comparing immediate postoperative outcomes between these 2 surgical techniques.

An interesting follow-up study could be a cost-effectiveness analysis between the 2 cohorts. We have identified some potential for cost savings in the robotic-assisted group, despite it being a more expensive surgery. A long-term cost savings analysis would provide a more detailed look at true cost differences between the surgical techniques. Another beneficial study would be a prospective, randomized trial to remove any aspect of selection bias between the cohorts.

Conclusions

Robotic-assisted TKA has some variations in immediate postoperative outcomes compared with conventional TKA. Despite some minor variations in postoperative pain levels, the overall pain scores did not strongly favor one technique over the other. The robotic-assisted group has a higher percentage of patients discharged to home instead of SAR and also a shorter time to discharge. Further analysis is required to definitively know which technique is best for which patient.

Conflict of interests

The authors declare there are no conflicts of interest.

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