WebLog Journal of Musculoskeletal Disorders

Systematic Review
Published: 01 Jan, 2026

Manual and Robotic Assisted Total Hip Arthroplasty: An Analysis of Peri-operative and Post-Operative Complications

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Abstract

Introduction: Robotic-assisted total hip arthroplasty usage has been rising among surgeons. This study aims to compare the difference between manual versus robotic-assisted total hip arthroplasty (RA-THA) short-term peri-operative and post-operative complications. Given improved acetabular component placement, we hypothesize that RA-THA is associated with the risk of lower overall complications and fewer revision surgical interventions compared to manual.

Methods: A non-randomized, single-institution, retrospective study was conducted utilizing a single electronic health record database. 404 robotic-assisted and 3,876 manual, posterior-lateral approach total hip arthroplasty cases from March 2018 to June 2022 were included. We compared complications within one year of the index procedure including dislocations, infection, intraoperative acetabular fractures, cup loosening, leg length discrepancy, pin track-related complications, reoperations, and peri-operative complications.

Results: We analyzed system based, 90-day post operative complications in both groups.Further, we specifically aimed to identifyspecific complications resulting in repeat operation within 1 year of index procedure. Overall complications between the groups were 14.1% *vs* 20.9% (p=.005), RA-THA *vs* manual THA respectively.There was no evidence of acetabular fractures or cases of cup loosening. R-THA also carried an increased OR (OR [95%] =1.696 [0.986 – 2.916], p=0.056) for requiring revision surgery but the result was not statistically significant.

Conclusions: When comparing RA-THA and M-THA, there is acomparable risk revision surgery associated with dislocation and periprosthetic joint infection within 1 year of index surgery, with a higher rate of periprosthetic fracture in the R-THA group. There was no significant difference in operating time and a higher rate of overall complications in the M-THA group. No complications were found with the pin tracts.

Keywords: Total Hip Arthroplasty (THA); Manual/Conventional THA (CTHA); Robotic-Assisted THA (RATHA); Electronic Medical Record (EMR); Peri-operative complications; Post-operative complications

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Received Date: *23 Dec 2025*
Accepted Date*: 30 Dec 2025*
Published Date*: 01 Jan 2026*

Citation:
Kloc A, Ferrante S, Ozdag Y, Patil S. Manual and Robotic Assisted Total Hip Arthroplasty: An Analysis of Peri-operative and Post-Operative Complications. WebLog J Musculoskelet Disord. wjmd.2026.a0103. https://doi.org/10.5281/zenodo.18211524

Introduction

Total hip arthroplasty (THA) is a commonly performed orthopedic procedure aimed at relieving pain, restoring function, and continues to increase in incidince [1, 2]. In contrast to manual THA that relies on the surgeon's expertise and dexterity to achieve optimal implant placement, robotic-assisted THA incorporates advanced imaging and guided instruments to enhance implant placement precision. It has been noted in literature that surgeons are pressured by both population demands and hospitals to perform THA procedures efficiently, accurately, and minimize complications [3, 4]. Further, the number of TA-THA procedures increased from 178 (0.1% of all THA) in 2005 to 10,045 (3.0% of all THA) in 2014, which represented a 30-fold increase in incidence.[6] In an effort to continue decreasing complication andrevision rates, the choice between manual and robotic-assisted approaches to THA has become a significant consideration for both surgeons and patients [3, 5].

With the consideration of performing an accurate procedure, the burden of component malposition is substantial, with Bozic et al reporting 22.5% of revision THAs being secondary to hip instability [6]. To combat and decrease implant malposition, there has been an increase in available technology to assist surgeons with better placement of components to decrease the dislocation rate, as well as leg length discrepancy [7-10]. Interestingly, Seagrave et al noted that the majority of arthroplasty literature did not identify a statistically significant difference between dislocating and non-dislocating THA in regard to mean angles of cup anteversion and inclination[8]. While robotic assisted THA ensures accurate acetabular component position, there remainsthe question as to whether the dislocation risk is increased or decreased with use of robotic assisted THA [11, 12, 19].

This single institution adopted utilization of the Stryker Mako™ for robotic assisted THA. With the new abundance of literature comparing robotic and manual THA outcomes, we are seeking to investigate the peri-operative and post-operative complications within this institution. The purpose of this study was to compare the perioperative and post-operative complications of manual and robotic THA. Additionally, we aimed to identify dislocations, intraoperative acetabular fractures, cup loosening, leg length discrepancy, pin track related complications, and reoperations between the two groups. We hypothesize that robotic THA is associated with lower overall complications and less revision surgical interventions given an improved acetabular component placement.

Materials and Methods

Institutional Review Board approval was obtained for this retrospective study. All elective THA procedures performed between March 2018 and June 2022 at our institution which is a large, integrated healthcare system within a rural setting were identified. Cases were identified using Current Procedural Terminology (CPT®) codes 27130, 701-27130 and 705-27130. Inclusion criteria were (1) patients ≥ 18 years of age, (2) undergoing elective THA for primary hip osteoarthritis. Patients who were undergoing revision THA, THA indicated under acute reasons (such as trauma), post-traumatic arthritis, avascular necrosis (AVN), or patients who had a history of oncologic diseases were excluded from this investigation.

Two cohorts were generated after the application of the inclusion/exclusion criteria: Robotic-THA (R-THA) and manual THA (M-THA). Baseline demographic information such as – but not limited to – age and BMI at time of THA, gender, race, employment & marital status and Charleson Co-morbidity Index (CCI) were obtained and recorded. These data were collected via an automated web-service that our institution utilizes based on the available data on the patient electronic medical record (EMR).

An additional data pull was then performed to identify procedure duration, patient discharge disposition (Home *vs*. Skilled NursingFacility (SNF)/Rehab), revision surgery (performed within and beyond 90-days of the index procedure), all-cause post-operative complications resulting in repeat operation within 1 year of index surgery, and mortality. These variables comprised the outcomes of interest for this study and were identified using the previously mentioned electronic data capture system. For identifying post-operative complications, we utilized a previously published list of International Classification of Diseases 10th Revision (ICD-10) codes by our team (MUN) [24].

Another subset of our original data was extracted for patients who returned to the OR within one year of index procedure. Reasons for return were analyzed and trends observed were prosthetic joint infection (PJI), prosthetic femur fracture, and femoral head dislocation. These events were then separated, and rates were compared between manual *vs* RA-THA.

Statistical Analysis

Demographic and case data were evaluated using descriptive statistical methods. Data resulting from continuous variables were reported through mean values and standard deviations, while categorical variables were evaluated using counts and percentages. To compare categorical variables between groups, statistical analyses, including Fisher's exact test and Chi-square, where appropriate were used. For comparison of continuous data, Wilcoxon two-sample test and a Mann-Whitney test were utilized to explore differences between groups.

Additional statistical analyses were performed with a multivariate regression analysis (MRA) to determine risk factors for developing any complication, getting discharged to a SNF/Rehab and developing any post-operative complications. The results of the MRA yielded Odds Ratios (OR) which were reported as a coefficient and a 95% confidence interval. For the purposes of this investigation, and OR > 1 was deemed to increase risk whereas and OR < 1 was noted to be protective. An alpha value of 0.05 was used to designate statistical significance.

Results

We identified a total of 4,180 THA procedures performed during the investigation period. When categorized by surgical technique there were 404 cases of R-THA and 3,876 cases of M-THA. The choice for R-THA or M-THA for each patient was chosen by the individual surgeon preference. Results of the bivariate analysis revealed significant differences for some baseline demographic variables between the two cohorts. These differences included: the M-THA cohort was older (62.4 *vs* 64.3, p=0.011), had an average lower BMI (31.6 *vs* 30.7, p= 0.015), had a slightly different racial demographic distribution (94.7% *vs* 97.3% White, p=0.012), had a lower rate of current smokers (22.7% *vs* 17.6%, p=0.026) and had an overall higher percentage of patients that were retired (48.4% *vs* 59.9%, p<0.001) (Table 1).

Analysis of peri-operative variables revealed that the R-THA cohort had a longer average length of stay (LOS) (2.2 *vs* 1.9 days, p=0.013). Additionally, we noted that the M-THA cohort had a lower rate of getting discharged to a SNF/Rehab (14.5% *vs* 10.7%, p=0.043) and a lower rate of revision surgery (5.6% *vs* 3.1%, p=0.021). However, we noted the M-THA group had an overall greater rate of all-cause post-operative complication development (14.1% *vs* 20.9%, p=0.005) (Table 2).

There were no complications associated with pin sites in the R-THA group. Further, from our subset of patients who returned to the operative room within one year we assessed between the two groups, the rates of prosthetic joint infection (PJI), prosthetic joint fracture, and dislocations. These rates for manual THA were 1.21% dislocation, 0.34% fracture, and 0.75% PJI. The rates for robotic THA were 0.49% dislocation, 1.73% femur fracture, and 1.23% PJI. When comparing the two groups the P values were p=0.099 for dislocation, p=0.15 for PJI, and p<0.05 for fracture.

The results of the MRA revealed several risk factors that were of interest. For developing any complication, we observed that a longer procedure duration (OR [95%] = 1.016 [1.013 – 1.018], p<0.001) and a higher average CCI (OR [95%] = 1.132 [1.083 – 1.183], p<0.001) were independent risk factors. R-THA was found to be protective

Table 1: Demographics and preoperative variables.

	Robotic THA (n=404)	Manual THA (n=3876)	p-value
Average age (SD)	62.4 (11.9)	4.3 (12.3)	**0.011**
Average BMI (SD)	31.6 (6)	30.7 (6.2)	**0.015**
Gender, n (%)			
Men	198 (49%)	1867 (48.2%)	0.776
Women	206 (51%)	2009 (51.8%)	
Laterality, n (%)			
Right	219 (54.3%)	2128 (54.9%)	0.833
Left	185 (45.7%)	1748 (45.1%)	
Race, n (%)			
White	382 (94.7%)	3770 (97.3%)	**0.012**
Black/African American	19 (4.6%)	87 (2.2%)	
Asian	-	6 (0.2%)	
Native Hawaii/ Pacific Islander	-	2 (0.1%)	
Unknown	3 (0.7%)	17 (0.4%)	
Marital status, n (%)			
Married/With Partner	231 (57.2%)	2151 (55.5%)	0.643
Single/Divorced/Widowed	173 (43.4%)	1725 (44.5%)	
Employment status, n (%)			
Full time	120 (29.9%)	881 (22.7%)	**<0.001**
Part time	12 (3%)	132 (3.4%)	
Retired	196 (48.4%)	2320 (59.9%)	
Not employed	76 (18.8%)	535 (13.8%)	
Current smoker, n (%)	69 (22.7%)	682 (17.6%)	**0.026**
Insurance status, n (%)			
Private	257 (63.5%)	2411 (62.2%)	0.806
Medicaid/Medicare	145 (35.9%)	1417 (36.6%)	
Federal/Military	2 (0.7%)	17 (0.4%)	
Workers Comp/No Fault	-	29 (0.7%)	
Self-pay	-	2 (0.1%)	
Average CCI* score (SD)	0.9 (1.8)	0.9 (1.6)	0.153

*CCI= Charleson Co-morbidity Index.

Table 2: Peri-operative variables and post-operative outcomes.

	Robotic Total Hip Arthroplasty (n=404)	Manual Total Hip Arthroplasty (n=3876)	p-value
Average operative time (SD)*	96.1 (31.8)	97.6 (36.6)	0.466
Average length of stay (SD)[a]	2.2 (1.4)	1.9 (1.5)	**0.013**
Discharge Disposition			
Home	345 (85.5%)	3459 (89.3%)	**0.043**
Home – Self care	170	1922	
Home with services	175	1537	
Rehab	39 (9.6%)	415 (10.7%)	
Revision surgery, n (%)	23 (5.6%)	121 (3.1%)	**0.021**†
Revision <90 days	-	16	
Revision >90 days	23	105	
Complications, n (%)	57 (14.1%)	810 (20.9%)	**0.005**‡
Central nervous system		1	
Cardiac		1	
Vascular		5	
Respiratory		1	
Gastrointestinal	1	5	
Urinary	-	12	
Hematoma	2	27	
Dehiscence	1	7	
Abscess	2	21	
Deep vein thrombosis	-	33	
Pulmonary Embolism	1	15	
Anemia	27	649	
Periprosthetic joint infection	16	120	
Mortality, n (%)	1 (0.3%)	19 (0.5%)	0.704

*= Average time is expressed in minutes, a=length of stay is expressed in days †: p-value expressed for revision *vs* no revision, ‡:p-value expressed for complication *vs* no complication.

(OR [95%] = 0.565 [0.397 – 0.803], p<0.001) against complication development. Similarly, older age (OR [95%] = 1.056 [1.044 – 1.068], p<0.001), higher CCI (OR [95%] = 1.125 [1.070 – 1.184], p<0.001) and R-THA (OR [95%] = 1.548 [1.085 – 2.209], P=0.016) were observed to increase the risk of getting discharged to a SNF/Rehab. For having to undergo any revision surgery after the index THA, the results of the MRA showed older age (OR [95%] = 1.018 [1.001 – 1.037], p=0.043), being a non-smoker (OR [95%] = 1.712 [1.098 – 2.671], p=0.018) and a higher CCI (OR [95%] = 1.124 [1.033 – 1.222], p=0.006) to be independent risk factors. R-THA also carried an increased OR for

Table 3: Multivariate binary logistic regression results for post-operative outomces.

Variable(s)	Odds Ratio [95% Confidence Interval]	p-value
DEVELOPING ANY COMPLICATION		
BMI	1.009 [0.997 – 1.022]	0.155
Age	1.001 [0.994 – 1.008]	0.797
Procedure Duration	1.016 [1.013 – 1.018]	**<0.001**
Male gender	0.806 [0.684 – 0.950]	**0.009**
White race	0.589 [0.380 – 0.914]	**0.018**
Private insurance	0.796 [0.664 – 0.995]	**0.014**
Non-smoker	1.121 [0.900 – 1.397]	0.306
CCI	1.132 [1.083 – 1.183]	**<0.001**
Robotic THA	0.565 [0.397 – 0.803]	**<0.001**
DISCHARGE TO REHABILITATION FACILITY		
BMI	0.991 [0.973 – 1.009]	0.323
Age	1.056 [1.044 – 1.068]	**<0.001**
Procedure Duration	1.003 [1.000 – 1.006]	0.075
Male gender	0.928 [0.750 – 1.147]	0.488
White race	1.320 [0.598 – 2.913]	0.492
Private insurance	1.152 [0.925 -1.453]	0.206
Non-smoker	1.109 [0.808 -1.522]	0.523
CCI	1.125 [1.070 – 1.184]	**<0.001**
Robotic THA	1.548 [1.085 – 2.209]	**0.016**
	ANY REVISION SURGERY	
BMI	1.016 [0.987 – 1.045]	0.287
Age	1.018 [1.001 – 1.037]	**0.043**
Procedure Duration	1.003 [0.998 – 1.007]	0.231
Male gender	0.835 [0.583 -1.194]	0.322
White race	1.313 [0.404 - 4.262]	0.651
Private insurance	0.865 [0.587 -1.276]	0.465
Non-smoker	1.712 [1.098 – 2.671]	**0.018**
CCI	1.124 [1.033 – 1.222]	**0.006**
Robotic THA	1.696 [0.986 – 2.916]	0.056

Abbreviation Reference: comprehensive complication index (CCI), total hip arthroplasty (THA), body mass index (BMI), standard deviation (SD).

any reason including dislocation (OR [95%] =1.696 [0.986 – 2.916], p=0.056) but the result was not statistically significant. (Table 3).

Discussion

The overall aim of our study was to compare the peri-operative complication risk within our institution and to contribute our data to the growing body of literature comapring RA-THA and manual THA. There is much discordance between complication risks in the literature, so increasing the data pool may assist with creating better trends with individual complications. Many studies have assessed dislocation rates between RA-THA and manual THA. Honl et al demonstrated dislocation was more frequent in the group treated with robotic implantation, occurring in eleven of the sixty-one patients in that group compared with three of eighty in the other group (p< 0.001). Comparing this to our data, we noted RA-THA having a 0.49% dislocation rate and the manual THA having 1.21%, although this was not statistically significant in our study. This difference in our rates compared to Honl et al could be in part to our manual group having a significantly larger sample size. However, it also could be due to higher precision of acetabular cup position with the RA-THA [11, 12, 19].

Other complications that could result in returning to the operating room are periprosthetic femur fracture and periprosthetic joint infection (PJI). These two complications are highly devastating and may require multiple returns to the OR, with possible revision of the arthroplasty. Though it was not statistically significant, our results demonstrated a higher rate of PJI among the RA-THA (0.75% *vs* 1.23%), which is in concordance with a meta-analysis that analyzed multiple parameters between manual and RA-THA [22]. Onggo et al suggested this difference in rate could be in part to increased equipment for the RA-THA leading to more opportunities for pathogens.

Regardingperiprosthetic femur fracture, our results demonstrated higher rates in the RA-THA (1.73% *vs* 0.34%, p<0.05). These results were concordant with results from Singh et al that demonstrated a higher rate among the RA-THA cohort (1.1% *vs* 0.7%) [23]. They attributed this rate could possibly be in part to the tracking pins. However, they also stated their short follow-up times may skew this data, and longer follow-up durations may demonstrate different rates.

Length of operation between RA-THA and manual THA was also of interest in current literature with Singh et al, Simcox et al, Chen et al all noted longer operating times for RA-THA. However, our study demonstrated no significant difference in operating times between the two groups (p=0.466). The discordance between studies could be in part to the learning curve with using the robot. Additionally, the additional steps of setting up the robot, registering the robot, and placing the iliac crest pins takes time which could be why operative times for the RA-THA were longer.

A limitation to our study was that it was conducted at a single institution. This fact brings into question the diversity of the patient population, which was predominately white (>90% in both cohorts.) However, while our patient population was similar, multiple attending orthopaedic surgeons, with differing levels of expertise, were performing these surgeries. It should also be noted that our cohort groups were significantly different in size and non-randomized. This may be in part to RA-THA being relatively newer, but it strengthens the argument that this method has lower complication rates despite attending surgeons performing less of these cases. Sherman et al. discussed that most American Association of Hip and Knee Surgeons members felt that 20-40 surgical cases were needed to become competent with RA-THA. With that said, allowing for more time for more surgeons to increase reps with RA-THA may change complication trends in the future. However, our current data may still be important as it works to help guide surgeons when deciding between surgical approaches. Just as there were learning curves to the different surgical approaches for hip arthroplasty, this novel way of performing this surgery will take time to develop and learn.

Conclusion

There is a growing body of literature comapring RA-THA and manual THA. There is acomparable risk revision surgery associated with dislocation and periprosthetic joint infection within 1 year of index surgery, with a higher rate of periprosthetic fracture in the R-THA group. There was no significant difference in operating time and a higher rate of overall complications in the M-THA group. No complications were found with the pin tracts. Further studies among multiple institutions are needed to further strengthen these findings.

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