Arthroplasty Today 23 (2023) 101207

Contents lists available at ScienceDirect

Arthroplasty Today

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

Original Research

# Are Patient Outcomes Affected by Surgeon Experience With Total Hip Arthroplasty in Morbidly Obese Patients?

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ARTICLE INFO

*Article history:*
Received 15 December 2022
Received in revised form
8 July 2023
Accepted 26 July 2023
Available online xxx

*Keywords:*
THA
Morbid obesity
Surgeon volume
Complications

ABSTRACT

*Background:* Surgeons with high volume (HV) of total hip arthroplasty (THA) have seen better outcomes than low volume (LV) surgeons. However, literature regarding surgeon volume and outcomes in morbidly obese THA patients is scarce. This study examines the association between surgeon volume with THA in morbidly obese patients (body mass index ≥40) and their clinical outcomes.
*Methods:* We retrospectively reviewed all morbidly obese patients who underwent primary THA at our institution between March 2012 and July 2020 with 2 years of follow-up. Clinical outcomes were compared between the HV (HVa, top quartile of surgeons with the highest overall yearly THA volume) and LV (LVa) surgeons. Similar analysis was run comparing HV of morbidly obese THA (HVo, top quartile of surgeons with the highest yearly morbidly obese THA volume) and LV of morbidly obese THA (LVo) surgeons.
*Results:* Six hundred and forty-three patients and 33 surgeons were included. HVa surgeons had significantly shorter length of stay and increased home discharge. HVa and HVo surgeons had significantly shorter operative times. There were no significant differences in overall 90-day major and minor complications or clinical differences in patient-reported outcomes. Revision rates and freedom from revisions did not differ between groups at 2-year follow-up.
*Conclusions:* HVa surgeons had significantly lower length of stay and operative times and increased discharge to home. There was no significant decrease in complications or revisions in either comparison model. Complications, revision rates, and patient satisfaction in morbidly obese patients who undergo THA may be independent of surgeon volume.


## Introduction

Patients with morbid obesity (body mass index [BMI] ≥ 40 kg/m$^2$) increasingly present for total hip arthroplasty (THA). This is partly due to the rising rates of morbid obesity. According to 2017-2018 data from the National Health and Nutrition Examination Survey, 9.2% of adults in the United States fall into the morbidly obese category, up from 5.7% 10 years earlier [1]. Compounding this rise in prevalence is the greater risk of developing hip osteoarthritis severe enough to warrant surgical intervention with increasing BMI [2,3]. THA can provide enormous improvements in function and quality of life and the opportunity for weight loss by improving patients' ability to ambulate [4].

Simultaneously, there is hesitancy within hospital systems to provide THA to morbidly obese patients due to increased morbidity and costs [5]. Several studies have demonstrated that patients with morbid obesity have increased risk for postoperative wound dehiscence, periprosthetic joint infection (PJI), dislocation, early loosening of prostheses, periprosthetic fracture, thromboembolic complications, and revision surgery after THA [6,7]. Furthermore, obese patients experience longer operative times and an increased length of hospital stay (LOS) compared to the general population [8,9].

The increased risk of postsurgical complications in morbidly obese patients can be associated with higher rates of comorbidities

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https://doi.org/10.1016/j.artd.2023.101207

like type 2 diabetes [10], but another important factor is the technical difficulty of performing surgery on a large body habitus. These technical challenges (eg, retractor placement, adequate exposure) may be mitigated by increased surgical volume. Various studies have demonstrated that increased surgeon THA volume is associated with decreased revision rates, dislocations, postoperative infections, and LOS for the general population [11,12]. However, literature reporting on the relationship between surgeon THA volume and outcomes in morbidly obese patients is scarce. This study aims to examine the association between total annual THA surgeon volume vs morbidly obese-specific THA surgeon volume and surgical outcomes in these patients. We hypothesize that morbidly obese patients who receive THA from surgeons who have higher overall THA volume and higher THA volume with morbidly obese patients will have better outcomes than morbidly obese patients who have surgeons with less volume.

## Material and methods

### *Patient inclusion and stratification*

This retrospective study examined all morbidly obese patients (BMI $\geq$40 kg/m$^2$) who underwent primary unilateral THA between March 2012 and July 2020 at an urban tertiary academic health system with a minimum of 2 years of clinical follow-up. After obtaining institutional review board approval, 643 morbidly obese primary THA patients were included in this study. Thirty-three orthopaedic surgeons performed these surgical procedures; 25 were adult reconstruction (AR) fellowship-trained and 8 were non-AR fellowship-trained (all had other fellowship training such as sports medicine and trauma).

Two separate analyses were conducted. Patients were first separated into 2 cohorts based on surgeons' annual THA volume, as seen in previous similar studies [12,13]. The first cohort included 272 (42.3%) patients with high overall volume (HVa) surgeons, defined as the 8 surgeons in the top quartile of average yearly THA volume (150.5 cases/year). The second cohort included the 371 (57.7%) patients who had a low overall volume (LVa) surgeon in the remaining 3 quartiles with 25 surgeons (38.5 cases/year). Patients were also separated into 2 cohorts in the second analysis based on surgeons' annual volume of morbidly obese-specific THAs. The first cohort included 353 (54.9%) patients with high morbidly obese THA volume (HVo) surgeons, defined as the 8 surgeons in the top quartile of average yearly morbidly obese THA volume (6.4 cases/year). The second cohort included the 290 (45.1%) patients who had one of the remaining 25 low-morbidly obese THA volume (LVo) surgeons (2.3 cases/year) in the other 3 quartiles.

### *Data collection*

Demographic data was collected including age, gender, BMI, race, American Society of Anesthesiology (ASA) classification, smoking status, Charlson Comorbidity Index, and insurance type. Patient-reported outcome measures (PROMs) including the Hip Disability and Osteoarthritis Outcome Score, Joint Replacement (HOOS, JR) and Forgotten Joint Score (FJS), and hospital clinical data including laterality, surgical approach, operative time (minutes), hospital length of stay (days), discharge disposition, 90-day readmissions, and major (dislocation, venous thromboembolism, PJI, sepsis) and minor (seroma, superficial surgical site infection/wound drainage) complications were collected [14,15]. Revision THA was defined as a procedure where the patient was required to return to the operating room for an exchange of implants in the ipsilateral hip, and indications were collected from Epic (Epic Caboodle, version 15; Verona, WI), our electronic patient medical record system, using Microsoft SQL Server Management Studio 2017 (Redmond, WA).

Operative time was calculated as the time between initial skin incision and closure. LOS was defined as the number of days spent in the hospital after surgery. Discharge disposition included discharge to home, an acute rehab facility, or a skilled nursing facility. Patients were followed postoperatively for 90-day readmissions and revisions for 2 years.

### *Outcome measures*

Primary outcomes included freedom from all-cause and septic revisions between cohorts in both analyses. Secondary outcomes included PROMs and perioperative data encompassing operative time, LOS, discharge disposition, 90-day readmissions, and major and minor complications.

### *Statistical analysis*

All data was collected and organized on Microsoft Excel software (Microsoft Corporation, Redmond, WA). Demographics and baseline characteristics of patients were represented as frequencies with percentages for categorical variables and means with standard deviations for continuous variables. Statistical differences in categorical variables and continuous variables were detected using chi-squared ($\chi$2) tests and independent sample t-tests, respectively.

Survivorship was analyzed using the Kaplan-Meier method [16]. Survivorship data was calculated using time of latest follow-up; only patients with at least 2 years of follow-up were included. Differences between the 2 cohorts in each analysis was determined using the log-rank test. *P*-values less than .05 were significant. All statistical analyses were performed using SPSS v25 (IBM Corporation, Armonk, New York).

## Results

### *Total annual THA volume analysis*

A total of 643 morbidly obese patients who underwent THA (high volume [HV]: 272 [42.3%], low volume [LV]: 371 [57.7%]) were identified. The average annual volume of primary THA for HVa and LVa surgeons was 150.5 and 38.5 cases/year, respectively. Surgeon THA volume ranged from 91.0 to 347.5 cases/year and from 3.6 to 76.5 cases/year in the HVa and LVa cohorts, respectively. Both cohorts were similar in age (59.2 $\pm$ 98.8 vs 59.7 $\pm$ 10.6 years, $P = .573$) and BMI (43.3 $\pm$ 3.2 vs 43.7 $\pm$ 3.4 kg/m$^2$, $P = .087$). The patients with LVa surgeons were more likely to be Black (26.1% vs 16.5%, $P = .015$). More patients with LVa surgeons had government insurance than those with HVa surgeons ($P = .002$). There were no significant differences regarding gender, ASA score, smoking status, and Charlson Comorbidity Index between cohorts (Table 1).

A greater proportion of procedures in the LVa cohort were conducted through posterior approach ($P < .001$). Significantly lower operative times (108.9 $\pm$ 35.8 vs 120.0 $\pm$ 33.2 minutes, $P < .001$) and hospital length of stay (2.7 $\pm$ 1.5 vs 3.3 $\pm$ 2.3 days, $P < .001$) were seen with the HVa cohort. Patients in the HVa cohort were more likely to be discharged home (83.8% vs 72.8%, $P = .004$). The incidence of overall 90-day major complications did not differ significantly between the HVa and LVa groups. The HVa cohort was more likely to develop a superficial surgical site infection/wound drainage (1.1% vs 0.0%, $P = .043$). Further complication rates can be seen in Table 2.

For patients with at least 2 years of clinical follow-up, all-cause revision rates did not significantly differ between HVa and LVa surgeons (7.0% vs 4.0%, $P = .100$). Similarly, revision due to PJI (61.1%

vs 73.3%) and indications for revision did not reach statistical significance (Table 3). Freedom from all-cause revision (HVa: 93.0% vs LVa: 96.0%, $P = .100$) and aseptic revision (HVa: 97.1% vs LVa: 98.9%, $P = .084$) did not significantly differ between both cohorts at 2 years postoperatively (Figs. 1 and 2).

HOOS, JR scores differed significantly between cohorts preoperatively (47.30 vs 39.36, $P = .001$) and at 1-year postoperatively (78.15 vs 70.38, $P = .047$). There were no significant differences between cohorts at 12 weeks postoperatively and in delta improvements (Table 4). No significant differences were found in FJS between groups at any time point. The HVa surgeon group had a significantly higher improvement in FJS from 12 weeks to 1 year (14.98 vs −4.17, $P = .026$) (Table 5).

### *Total annual morbidly obese patients volume analysis*

A total of 643 morbidly obese patients who underwent THA (HVo surgeons: 353 [54.9%], LVo surgeons: 290 [45.1%]) were identified. The average annual volume of morbidly obese primary THA cases for HVo and LVo surgeons was 6.4 and 2.3 cases/year, respectively. Surgeon morbidly obese-specific THA volume ranged from 5.0 to 8.3 cases/year and from 0.3 to 5.0 cases/year in the HVo and LVo cohorts, respectively. Both cohorts were similar in age (59.1 ± 10.5 vs 59.9 ± 10.0 years, $P = .336$) and BMI (43.7 ± 3.3 vs 43.4 ± 3.4 kg/m$^2$, $P = .394$). The HVo surgeon cohort was statistically significantly more likely to be White (71.4% vs 60.3%) and less likely to be Black (18.7% vs 26.2%) ($P = .013$). There were no other statistically significant differences between cohorts regarding gender, ASA score, smoking status, and insurance type (Table 1).

The HVo cohort had 20.4% of cases with a direct lateral approach, while none of the cases in the LVo cohort were completed through a direct lateral approach ($P < .001$). The HVo surgeon cohort had significantly shorter operative times than the LVo surgeon cohort (110.2 ± 32.6 vs 121.5 ± 36.2 minutes, $P < .001$). There was no difference between groups in length of stay or discharge disposition, 90-day major and minor complications, and 90-day readmissions. Further short-term clinical outcomes can be found in Table 2.

For patients with at least 2 years of clinical follow-up, all-cause revisions (5.1% vs 5.5%, $P = .81$) were similar between both groups. Similarly, revision due to PJI (77.8% vs 50.0%) and indication for revision procedures did not reach statistical significance (Table 3). Freedom from all-cause revisions (HVo surgeons: 94.9% vs LVo surgeons: 94.5%, $P = .814$) and aseptic revisions (HVo surgeons: 98.9% vs LVo surgeons: 97.2%, $P = .133$) at 2 years postoperatively did not significantly differ between both cohorts (Figs. 3 and 4).

There were no significant differences in HOOS JR or FJS scores between the HVo or LVo cohorts (Table 4). The LVo group did have a statistically significant higher improvement of their mean FJS score from 12 weeks to 2 years (32.82 vs 1.05, $P = .004$) (Table 5).

## Discussion

Many patients with BMI ≥40 kg/m$^2$ undergo THA as obesity may be a risk factor for osteoarthritis; they often face surgical complications and worse functional outcomes [6,9]. This study compares the effect of both total primary THA case volume and morbidly obese-specific THA case volume on surgical outcomes of morbidly

**Table 1**
Baseline characteristics of patients.

| Demographic variables | Overall THA volume analysis | | | Morbidly obese THA volume analysis | | |
|---|---|---|---|---|---|---|
| | Quartiles 1-3 (n = 371, average rate = 38.5 cases/y) | 4th quartile (n = 272, average rate = 150.5 cases/y) | *P*-value | Quartiles 1-3 (n = 290, average rate = 2.3 cases/y) | 4st quartile (n = 353, average rate = 6.4 cases/y) | *P*-value |
| Age (y, SD) | 59.7 (10.6) | 59.2 (9.8) | .573 | 59.9 (10.0) | 59.1 (10.5) | .336 |
| Gender | | | .136 | | | .626 |
| Female | 233 (60.1%) | 155 (57.0%) | | 178 (61.4%) | 210 (59.5%) | |
| Male | 138 (37.2%) | 117 (43.0%) | | 112 (38.6%) | 143 (40.5%) | |
| BMI (kg/m$^2$, SD) | 43.7 (3.4) | 43.3 (3.2) | .087 | 43.4 (3.4) | 43.7 (3.3) | .394 |
| Race | | | **.015**[a] | | | **.013**[a] |
| White | 234 (63.1%) | 193 (71.0%) | | 175 (60.3%) | 252 (71.4%) | |
| Black | 97 (26.1%) | 45 (16.5%) | | 76 (26.2%) | 66 (18.7%) | |
| Other | 40 (10.8%) | 34 (12.5%) | | 39 (13.4%) | 35 (9.9%) | |
| ASA classification | | | .544 | | | .736 |
| 1 | 0 (0.0%) | 0 (0.0%) | | 0 (0.0%) | 0 (0.0%) | |
| 2 | 77 (20.8%) | 65 (23.9%) | | 68 (23.5%) | 74 (21.0%) | |
| 3 | 280 (75.7%) | 200 (73.5%) | | 212 (73.4%) | 268 (75.9%) | |
| 4 | 13 (3.5%) | 7 (2.6%) | | 9 (3.1%) | 11 (3.1%) | |
| Smoking status | | | .052 | | | .800 |
| Never | 175 (58.1%) | 126 (46.5%) | | 131 (45.6%) | 170 (48.3%) | |
| Former | 146 (39.7%) | 125 (46.1%) | | 125 (43.6%) | 146 (41.5%) | |
| Current | 47 (12.8%) | 20 (7.4%) | | 331 (10.8%) | 36 (10.2%) | |
| Insurance type | | | **.002**[a] | | | .094 |
| Medicaid | 55 (14.8%) | 18 (6.6%) | | 23 (7.9%) | 50 (14.2%) | |
| Medicare | 137 (38.9%) | 90 (33.1%) | | 109 (37.6%) | 118 (33.4%) | |
| Private insurance | 174 (46.9%) | 162 (59.6%) | | 155 (53.4%) | 181 (51.3%) | |
| Workers compensation | 5 (0.8%) | 2 (0.7%) | | 3 (1.0%) | 4 (1.1%) | |
| CCI | 2.6 (2.2) | 2.4 (2.0) | .392 | 2.5 (2.0) | 2.5 (2.2) | .881 |
| THA indications | | | .384 | | | .224 |
| Primary osteoarthritis | 343 (92.5%) | 250 (91.9%) | | 272 (93.8%) | 321 (90.9%) | |
| DDH | 1 (0.3%) | 4 (1.5%) | | 2 (0.7%) | 3 (0.8%) | |
| Rheumatoid arthritis | 2 (0.5%) | 0 (0.0%) | | 2 (0.7%) | 0 (0.0%) | |
| Posttraumatic arthritis | 4 (1.1%) | 5 (1.8%) | | 3 (1.0%) | 6 (1.7%) | |
| Osteonecrosis | 10 (2.7%) | 6 (2.2%) | | 7 (2.4%) | 9 (2.5%) | |
| Other | 11 (3.0%) | 7 (2.6%) | | 4 (1.4%) | 14 (4.0%) | |

THA, total hip arthroplasty; SD, standard deviation; BMI, body mass index; kg/m$^2$, kilograms per meters squared; ASA, American Society of Anesthesiologists; DDH, developmental dysplasia of hip; CCI, Charlson Comorbidity Index.
[a] *P*-value < .05. Bold values indicate statistical significance.

**Table 2**
Short-term clinical outcomes.

| Surgical characteristics and outcomes | Overall THA volume analysis | | | Morbidly obese THA volume analysis | | |
|---|---|---|---|---|---|---|
| | Quartiles 1-3 (n = 371, average rate = 38.5 cases/y) | 4th quartile (n = 272, average rate = 150.5 cases/y) | *P*-value | Quartiles 1-3 (n = 290, average rate = 2.3 cases/y) | 4st quartile (n = 353, average rate = 6.4 cases/y) | *P*-value |
| Laterality | | | | | | |
| Right | 197 (53.1%) | 149 (55.0%) | .637 | 161 (55.5%) | 185 (52.6%) | .454 |
| Left | 174 (46.9%) | 122 (45.0%) | | 129 (44.5%) | 167 (47.4%) | |
| Surgical approach | | | | | | |
| Posterior | 319 (86.0%) | 151 (55.5%) | **<.001**[a] | 230 (79.3%) | 240 (68.0%) | **<.001**[a] |
| Anterior | 52 (14.0%) | 49 (18.0%) | | 60 (20.7%) | 41 (11.6%) | |
| Direct lateral | 0 (0.0%) | 72 (26.5%) | | 0 (0.05) | 72 (20.4%) | |
| Operative time (min, SD) | 120.0 (33.2) | 108.9 (35.8) | **<.001**[a] | 121.5 (36.2) | 110.2 (32.6) | **<.001**[a] |
| LOS (d, SD) | 3.3 (2.3) | 2.7 (1.5) | **<.001**[a] | 3.0 (2.3) | 3.0 (1.8) | .981 |
| Discharge disposition | | | | | | |
| Home | 270 (72.8%) | 228 (83.8%) | **.004**[a] | 220 (75.9%) | 278 (78.8%) | .380 |
| Acute rehab facility | 17 (4.6%) | 7 (2.6%) | | 14 (4.8%) | 10 (2.8%) | |
| Skilled nursing facility | 84 (22.6%) | 37 (13.6%) | | 56 (19.3%) | 65 (18.4%) | |
| 90-D major complications | 15 (4.0%) | 12 (4.4%) | .818 | 10 (3.4%) | 17 (4.8%) | .390 |
| Dislocation | 2 (0.5%) | 0 (0.0%) | .225 | 1 (0.3%) | 1 (0.3%) | .889 |
| Venous thromboembolism | 1 (0.3%) | 1 (0.4%) | .825 | 1 (0.3%) | 1 (0.3%) | .889 |
| PJI | 11 (3.0%) | 10 (3.7%) | .616 | 8 (2.8%) | 13 (3.7%) | .512 |
| Sepsis | 1 (0.3%) | 1 (0.4%) | .825 | 0 (0.0%) | 2 (0.6%) | .199 |
| 90-d minor complications | 1 (0.3%) | 3 (1.1%) | .184 | 2 (0.7%) | 2 (0.6%) | .843 |
| Seroma | 1 (0.3%) | 0 (0.0%) | .391 | 0 (0.0%) | 1 (0.3%) | .364 |
| Superficial SSI/wound drainage | 0 (0.0%) | 3 (1.1%) | **.043**[a] | 2 (0.7%) | 1 (0.3%) | .452 |
| 90-d readmissions | 17 (4.6%) | 22 (8.1%) | .066 | 17 (5.9%) | 22 (6.2%) | .845 |

THA, total hip arthroplasty; SD, standard deviation; PJI, periprosthetic joint infection; SSI, surgical site infection.
[a] *P*-value < .05. Bold values indicate statistical significance.

obese patients receiving THA. The main findings of this study were: (1) the HVa group had significantly lower operative times and LOS while the HVo group had only significantly lower operative times; (2) both analyses found no significant clinical differences among cohorts in 90-day major or minor complications or readmissions; (3) all-cause and aseptic revisions did not differ significantly between groups in both analyses; and (4) there were clinically insignificant differences in PROMs between cohorts.

Operative time is an important modifiable factor of complications in THA [17,18]. In a study conducted by Duchman et al. using the American College of Surgeons National Surgical Quality Improvement Program database, longer operative time in total joint arthroplasty was associated with complications including surgical site infections, postoperative transfusion, sepsis, reoperation, and anesthesia-related risks such as renal insufficiency [19,20]. They also found that an extended operative time of 151 to 180 minutes elevated the risk of complications by 24% compared to procedures between 60 and 120 minutes [19,20]. Morbidly obese patients who undergo THA often have significantly longer operative times and are thus placed at a higher risk of all the above associated complications [4,8]. THA in heavier patients can be more technically challenging and take longer due to difficulties like hip dislocation of heavier limbs, more involved dissection, difficulty obtaining exposure, and longer wound closure time [8,21]. We found that the top quartiles of surgeons with the highest overall and morbidly obese-specific THA volumes had significantly lower operative times than the other 3 quartiles. This suggests that increased surgeon experience in THA in all patients, not just morbidly obese patients, may mitigate these challenges in achieving shorter operative times.

Previous studies have found that surgeons who perform more yearly THAs have decreased risk of complications [11,22]. Charalambous et al. conducted a similar study to determine the association between surgeon THA experience and risk of complications in obese patients [23]. They found increased surgeon experience with morbidly obese-specific THA was advantageous in decreasing

**Table 3**
Revision outcomes.

| Revision outcomes | Overall THA volume analysis | | | Morbidly obese THA volume analysis | | |
|---|---|---|---|---|---|---|
| | Quartiles 1-3 (n = 371, average rate = 38.5 cases/y) | 4th quartile (n = 272, average rate = 150.5 cases/y) | *P*-value | Quartiles 1-3 (n = 290, average rate = 2.3 cases/y) | 4th quartile (n = 353, average rate = 6.4 cases/y) | *P*-value |
| All-cause revisions | 15 (4.0%) | 19 (7.0%) | .100 | 16 (5.5%) | 18 (5.1%) | .814 |
| Revision cause | | | | | | |
| Aseptic loosening | 1 (6.7%) | 1 (5.6%) | .323 | 1 (6.3%) | 1 (5.6%) | .369 |
| Dislocation | 2 (13.3%) | 1 (5.3%) | | 2 (12.5%) | 1 (5.6%) | |
| Fracture | 1 (6.7%) | 6 (33.3%) | | 5 (31.3%) | 2 (11.1%) | |
| PJI | 11 (73.3%) | 11 (61.1%) | | 8 (50.0%) | 14 (77.8%) | |
| Type of revision procedure | | | | | | |
| DAIR | 9 (60.0%) | 9 (47.4%) | .527 | 6 (37.5%) | 12 (66.7%) | .207 |
| Two stage revision | 2 (13.3%) | 1 (5.3%) | | 2 (12.5%) | 1 (5.6%) | |
| Single stage revision | 0 (0.0%) | 1 (5.3%) | | 0 (0.0%) | 1 (5.6%) | |
| Aseptic revision | 4 (26.7%) | 8 (42.1%) | | 8 (50.0%) | 4 (22.2%) | |

THA, total hip arthroplasty; PJI, periprosthetic joint infection; DAIR, debridement, antibiotics, and implant retention.

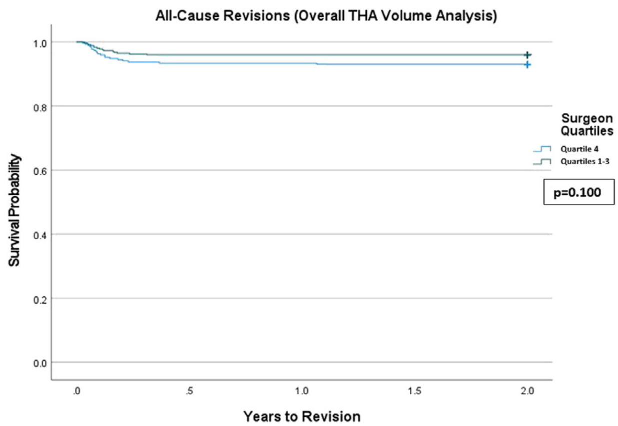


**Figure 1.** Kaplan-Meier curve showing freedom from all-cause revision over 2 years for high and low overall THA volume surgeon quartiles.

risk of serious complications within 1 year postoperatively by approximately 35% for every 10 additional morbidly obese THA procedures performed in the year prior to index surgery [23]. However, no protective association was found between overall THA surgeon experience and outcomes in obese patients [23]. Our study corroborates their finding that overall THA surgeon experience had no effect on risk of complications in obese patients; we did not identify a significant difference in 90-day readmissions and major complications between the HVa and LVa cohorts. Contrary to their results, we found no significant differences in 90-day readmissions and major or minor complications between HVo and LVo cohorts. Though we expected increased surgeon experience with morbidly obese patients would be associated with decreased complications, this effect was not seen. Perhaps this is due to utilization of a single institution with 3 of our top quartile of HVa surgeons also in the top quartile of HVo surgeons.

Previous studies have reported higher rates of revision surgeries among morbidly obese THA patients [6,24]. Onggo et al. conducted a meta-analysis comparing outcomes of THA in obese vs nonobese patients; they found morbidly obese patients had over double the odds of requiring a revision or suffering a dislocation after THA [25]. Given that low surgeon/hospital volume has been associated with higher odds of all-cause revisions, we initially hypothesized that morbidly obese patients who receive THA from low overall and morbidly obese-specific volume surgeons would have increased complications and revisions [26]. Charalambous et al. studied complications including revisions among morbidly obese THA recipients with respect to surgeon overall and morbidly obese-specific THA volume; they found heightened probability of revisions as surgeon THA volume increased substantially [23]. They also found that probability of revisions initially decreased as morbidly obese-specific THA volume surgeons increased from zero to 10 cases a year; however, higher volumes had increased probability of revision [23]. While there was no significant increased risk of revision between cohorts, we did find that neither increased surgeon volume with overall or morbidly obese-specific THA resulted in significant differences in all-cause or aseptic revisions between cohorts.

HOOS, JR and FJS scores are PROMs utilized in THA patients to evaluate the effectiveness of the procedure from the patient's perspective. Lyman et al. studied the minimal clinically important difference, defined as the minimum change in PROMs that is perceived as a change in health, in HOOS, JR scores in Medicare THA patients; they associated substantial clinical benefit with an improvement of 22 points [27]. In our study, delta improvements from preoperative to 12 weeks and 1 year were similar between cohorts in both models; however, all delta improvements for each time point were over 22 points. This may be because morbidly obese patients often notice substantial functional gain given their poor baseline state compared to patients who are not obese and report clinically significant improvements in HOOS, JR scores [28]. Though there are statistically significant differences between HVa and LVa cohorts in preoperative and 1-year HOOS, JR scores, these differences of less than 22 points are not clinically significant. Additionally, the HVa group had a higher preoperative score, which is likely the reason their 1-year HOOS JR score was higher than the LVa group. Similarly, there were no clinically significant differences in FJS scores between cohorts in both models. This may be because it is difficult to detect significant differences in PROMs between groups since THA has historically been an extremely successful operation [29].

This study has several limitations. As this study was retrospective, we cannot control for the introduction of inherent bias and possibility of errors of recorded data. There were several known confounders in this study that we did not measure, such as bone cement type and technique and implant type. Patients received THA for a variety of diagnoses including primary osteoarthritis, osteonecrosis, rheumatoid arthritis, and developmental dysplasia of the hip. As patient expectations postoperatively may have differed among different diagnoses and affected PROM scores, we will consider controlling for diagnoses in the future. Additionally, we did not propensity match cohorts for baseline characteristics. These demographic characteristics, such as race, are social determinants of health and may impact patients' postoperative function and recovery. Quartiles had a mix of AR fellowship and non-AR fellowship-trained surgeons; differences in outcomes may have been more apparent when comparing cohorts with exclusively AR fellowship or non-AR fellowship-trained HV and LV surgeons. Furthermore, there were some surgeons who had similar annual THA volumes that were included in either the HV or LV cohorts; future larger cohort analyses can compare surgeons in just quartiles 1 and 4 to achieve a larger difference in average annual THA volumes. Patients were followed for 2 years postoperatively for freedom from revisions; however, longer follow-up and an increased sample size are suggested to fully demonstrate the differences in outcomes in morbidly obese patients who undergo surgery by HV vs LV surgeons. Additionally, PROMs were unavailable for many included patients as collection was only enforced beginning in 2018. Future studies may consider comparing

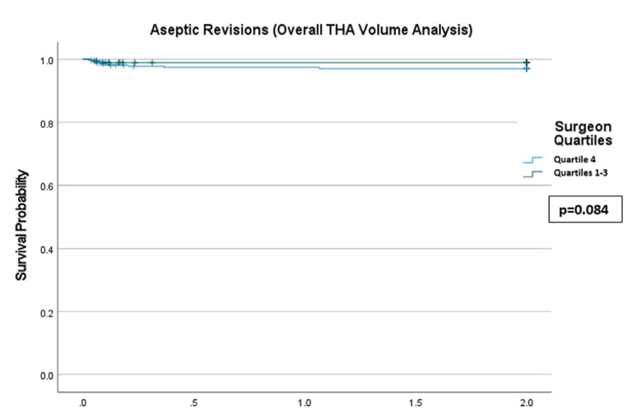


**Figure 2.** Kaplan-Meier curve showing freedom from aseptic revision over 2 years for high and low overall THA volume surgeon quartiles.

**Table 4**
HOOS, JR score (score, SD).

| High overall THA volume vs Low overall THA volume surgeons | | | |
|---|---|---|---|
| HOOS, JR score | Quartiles 1-3 (average rate = 38.5 surgeries/y) | 4th quartile (average rate = 150.5 surgeries/y) | *P*-value |
| Preoperative | 39.36 (14.11) | 47.30 (14.70) | **.009**[a] |
| 12 wk | 68.54 (17.54) | 68.69 (17.07) | .961 |
| 1 y | 70.38 (16.73) | 78.15 (18.12) | **.047**[a] |
| Delta improvements | | | |
| Preoperative to 12 wk | 29.63 (20.34) | 24.67 (16.36) | .218 |
| Preoperative to 1 y | 31.50 (18.65) | 34.05 (15.07) | .524 |
| High morbidly obese THA volume vs low morbidly obese THA volume surgeons | | | |
| | Quartiles 1-3 (average rate = 2.3 surgeries/y) | 4th Quartile (average rate = 6.4 surgeries/y) | *P*-value |
| Preoperative | 48.21 (13.59) | 42.77 (15.42) | .063 |
| 12 wk | 71.25 (17.58) | 66.76 (16.68) | .130 |
| 1 y | 76.05 (19.36) | 76.00 (17.07) | .989 |
| Delta improvements | | | |
| Preoperative to 12 wk | 23.00 (19.91) | 28.05 (16.16) | .188 |
| Preoperative to 1 y | 30.70 (15.42) | 34.78 (16.58) | .284 |

HOOS, JR, Hip Disability and Osteoarthritis Outcome Score, Joint Replacement; SD, standard deviation; THA, total hip arthroplasty.
[a] *P*-value < .05. Bold values indicate statistical significance.

the top quartile of surgeons to each quartile individually to determine if results remain similar between each comparison.

## Conclusions

Morbidly obese THA patients with HVa or high morbidly obese patient-specific volume surgeons have similar 90-day complication rates and freedom from revisions to LVa or low morbidly obese patient-specific volume surgeons. HVa and HVo cohorts had lower operative times, suggesting increased surgeon volume in all THA cases is useful in preparing surgeons for THA in patients with BMI ≥40. PROMs were clinically similar between groups in both analyses, indicating patient satisfaction with their THA may be independent of surgeon volume. Morbidly obese patients need not prioritize surgeon volume when choosing a surgeon; however, additional research with longer follow-up and more patients may provide further insight.

**Table 5**
FJS score (score, SD).

| High overall THA volume vs low overall THA volume surgeons | | | |
|---|---|---|---|
| FJS score | Quartiles 1-3 (average rate = 38.5 surgeries/y) | 4th quartile (average rate = 150.5 surgeries/y) | *P*-value |
| 12 wk | 46.30 (34.65) | 44.35 (30.03) | .862 |
| 1 y | 54.73 (27.32) | 56.42 (31.50) | .851 |
| 2 y | 70.99 (24.90) | 63.99 (33.10) | .485 |
| Delta improvements | | | |
| 12 wk to 1 y | −4.17 (24.53) | 14.98 (21.08) | **.026**[a] |
| 12 wk to 2 y | 9.03 (9.41) | 12.51 (23.45) | .812 |
| High morbidly obese THA volume vs low morbidly obese THA volume surgeons | | | |
| | Quartiles 1-3 (average rate = 2.3 surgeries/y) | 4th Quartile (average rate = 6.4 surgeries/y) | *P*-value |
| 12 wk | 44.36 (29.59) | 44.99 (31.97) | .940 |
| 1 y | 61.68 (27.50) | 51.34 (32.26) | .171 |
| 2 y | 78.65 (26.32) | 61.63 (31.24) | .100 |
| Delta improvements | | | |
| 12 wk to 1 y | 16.16 (24.58) | 7.67 (19.90) | .186 |
| 12 wk to 2 y | 1.05 (12.40) | 32.82 (16.70) | **.004**[a] |

FJS, Forgotten Joint Score; SD, standard deviation; THA, total hip arthroplasty.
[a] *P*-value < .05. Bold values indicate statistical significance.

## Conflicts of interest

J. Rozell reports being a board or committee member of the New York State Society of Orthopaedic Surgeons. M. Meftah reports having stock or stock options in CAIRA Surgical and Constance, being a paid consultant for Conformis and Intellijoint, having IP royalties at Innomed, being a board or committee member at International Society for Technology in Arthroplasty (ISTA), and being on the editorial or governing board at Orthopedics. R. Schwarzkopf reports being a board or committee member at American Association of Hip and Knee Surgeons (AAOS) and American Academy of Orthopaedic Surgeons (AAHKS), being on the editorial or governing board at Arthroplasty Today and The Journal of Arthroplasty (JOA), having stock or stock options at Gauss Surgical, Intellijoint, and Patient Specific Instrumentation (PSI), being a paid consultant at Intellijoint, Zimmer, and Smith & Nephew, and receiving IP royalties and research support from Smith & Nephew. V. Rajahraman, I. Shichman, and E. Berzolla have no disclosures.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2023.101207.

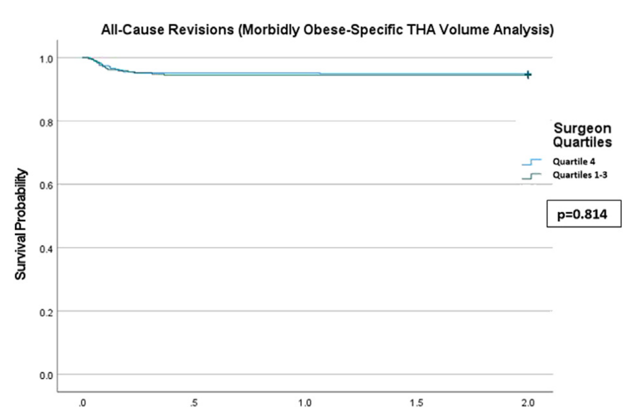


**Figure 3.** Kaplan-Meier curve showing freedom from all-cause revision over 2 years for high and low morbidly obese-specific THA volume surgeon quartiles.

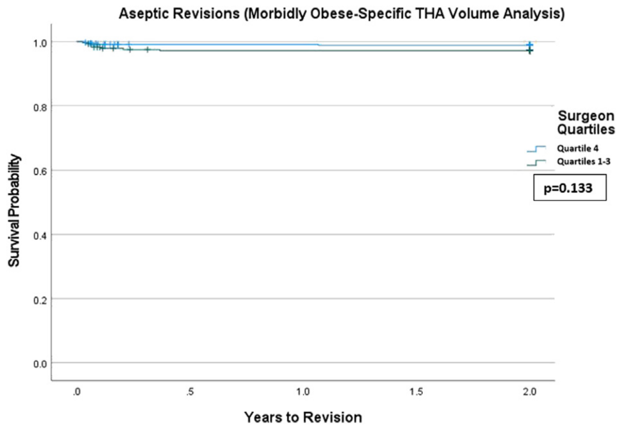


**Figure 4.** Kaplan-Meier curve showing freedom from aseptic revision over 2 years for high and low morbidly obese-specific THA volume surgeon quartiles.

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