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Analyzing the Effects of Body Mass Index in Total Hip Arthroplasty Cases. Does it Influence Patient Characteristics, Operative Planning, and Postoperative Outcomes?

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Abstract

Background: Total hip arthroplasty (THA) is one of the most performed orthopaedic procedures commonly used for the treatment of osteoarthritis (OA). There are several underlying factors that lead to the formation of this condition. Not only is obesity one of the main contributors, but it is also a modifiable risk factor and one of the leading causes of end-stage arthrosis of the hip. Though there have been advancements in agricultural and health technologies, rates of obesity continue to rise causing similar increases in the demands for hip replacement surgeries. Therefore, we sought to investigate the effects of BMI on THA procedures and determine if it plays any influential role in patient characteristics, operative planning, and postoperative outcomes.

Methods: A prospectively collected database from a single institution was queried from January 2018 to December 2021, to identify 66 THA patients (mean age 69.5) included in this study. Patient's BMI were recorded preoperatively and separated into five classes in accordance with the World Health Organization classification of Normal (18.5-24.9), Pre-Obesity (25.0-29.9), Obesity Class I (30.0-34.9), Obesity Class II (35.0-39.9), and Obesity Class III (BMI ≥ 40). Patient attributes, operative characteristics, and postoperative outcomes were then stratified and grouped into the different BMI classes. All patients had radiograph imaging obtained preoperatively and at a minimum 9-month interval to observe for the presence of any radiolucent lines which would be plotted using the hip regions set forth by De Lee and Charnley.

Results: The mean BMI of our patient population was 30.5 which overall characterizes it as Obesity Class I. However, the classification that contained the most of our population was Pre-Obesity (n = 26, 39.4%). There were no males in our entire population that had a BMI considered normal, but 13 females did fall into this classification. There was a significant number of patients who underwent a direct anterior approach within the Pre-Obesity classification than those who underwent a posterolateral approach (21 vs 5 patients, *P* value = 0.047). However, for subjects meeting Obesity Class II and Class III criteria, a significant number of posterolateral approaches were performed than the direct anterior approach. In analyzing the radiographs, only 2 patients were discovered to have radiolucent lines, but no related symptoms or physical complications were reported.

Conclusion: Our investigation demonstrates that having a higher BMI only significantly affects the surgical approach to THA but can conclude that it is an excellent surgical option for the treatment of OA in obese patients.

Introduction

Obesity has plagued the healthcare industry and created numerous challenges for the practicing orthopaedic surgeon [1, 2]. It is estimated that the United States spends over $260 billion just on medical costs due to obesity-related issues in adults per year [3]. Though there have been advancements in agricultural and health technologies, rates of obesity continue to rise causing similar increases in the demands for hip replacement surgeries. By 2030, the demand for primary total hip arthroplasties (THA) is estimated to grow by 174% to 572,000 with revisions of these procedures also increasing by 137 % [4].

The rates of postoperative complications are significantly higher in patients with higher body mass index (BMI) who undergo THA [5]. However, the survivorship of THA in obese patients has shown to have no significant difference compared to nonobese patients [6,7]. Additionally, there remains mixed information on whether BMI can predict outcomes in THA. Therefore, the purpose of our study is to investigate the effects of BMI on THA procedures and determine if it plays any influential role in patient characteristics, operative planning, and postoperative outcomes.

Methods

Study Selection

This IRB-approved investigation utilized a prospectively collected database that was queried from a three-year period spanning January 2018 to December 2021 from a single institution. The total number of THA procedures was gathered and uncovered complete data for 141 eligible subjects that were treated by a single surgeon. The inclusion criteria consisted of patients who underwent a THA at our institution within the set time period. Exclusion criteria consisted of patients who had incomplete data, had bilateral THA, and who were lost at follow-up without undergoing a minimum 9-month radiograph of the operated hip.

Measures

We recorded and analyzed patient’s BMI preoperatively and categorized them into five classes in accordance with the World Health Organization classification of a Normal BMI range of 18.5-24.9, Pre-Obesity range of 25.0-29.9, Obesity Class I range of 30.0-34.9, Obesity Class II range of 35.0-39.9, and Obesity Class III range of 40 or greater [8]. A patient’s BMI has been well accepted as a reliable indicator used to gauge the severity of obesity [9]. Patient preoperative attributes, operative characteristics, and postoperative outcomes were then stratified according to the patient’s BMI and then categorized into one of these groups.

The preoperative patient characteristics consisted of their ages, mean age, sex, weight, and mean BMI. Patients categorized as ever smokers are defined as having any positive past history of smoking, regardless of current smoking status. The determination of alcohol consumption was incorporated from the National Institute on Alcohol Abuse and Alcoholism which defines a Moderate level as consumption of ≤ 2 drinks a day for men and ≤ 1 drink a day for women and defines a Heavy level as consumption of ≥ 4 drinks on any day or ≥ 14 drinks per week for men and ≥ 3 drinks on any day or ≥ 7 drinks per week for women [10].

All THA patients in our population were implanted with Stryker hardware which includes Trident® Tritanium Acetabular components, Crossfire® Polyethylene liners, and either an Accolade® C cemented or Accolade® II non-cemented femoral stem. The surgical approach (direct anterior vs posterolateral), the use of acetabular screws, and the type of femoral stem (cemented vs non-cemented) used in each THA procedure were determined at the surgeon's discretion.

The postoperative outcomes were determined by the presence or absence of periacetabular radiolucent lines. The formation of this phenomenon has been associated with aseptic loosening, implant instability, and an increased risk for revisions [11]. All patients had radiograph imaging of the acetabulum obtained preoperatively and at a minimum 6-month interval to observe for the presence of any radiolucent lines which would be plotted using the hip regions set forth by the De Lee and Charnley classification system [12].

Statistical Analysis

All data analysis was conducted using R package version 1.5.0 [13,14]. The continuous variables that pertained to the preoperative characteristics of patients, including the mean ages of groups, weight, and BMI, were reported as means with standard deviations. These values were subsequently analyzed by a One-way ANOVA test. In contrast, categorical variables such as the patient's sex, age, smoking, and alcohol use status, surgical approach, laterality, acetabular size, the use of acetabular screws, femoral stem type, femoral head size, and the presence and location of radiolucent lines were reported using counts and proportions. All data from categorical variables were analyzed using the exact chi-squared test. P values <0.05 were considered statistically significant for both continuous and categorical variables.

Results

Of the 141 eligible patients in the prospective database, 10 patients were excluded for not having complete data, 13 patients were excluded for having bilateral THA, and 52 were excluded for being lost at follow-up without sufficient radiographical data. This resulted in 66 patients who met all criteria and were included in this study (Figure 1).

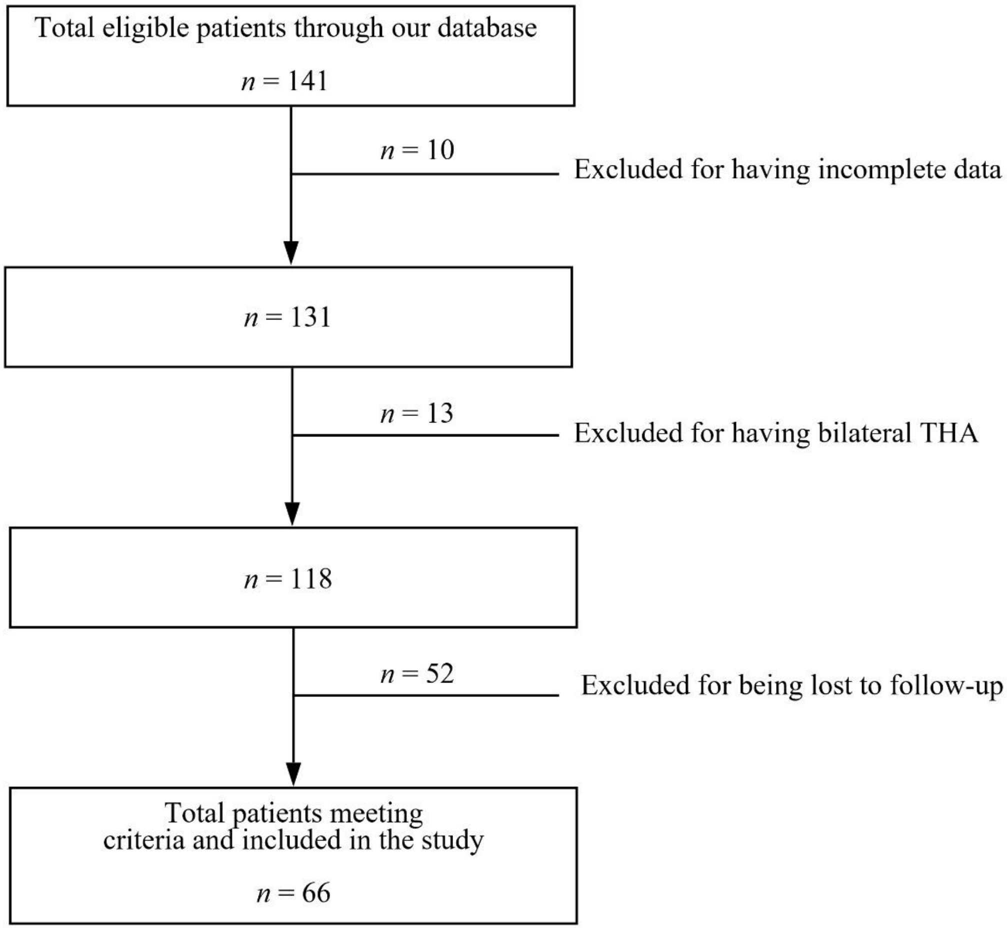

Fig. 1. Flow diagram showing study selection

Patients were stratified into five subgroups based on the World Health Organization's BMI classification for further analysis [8]. Thirteen patients (19.7%) were classified as Normal, twenty-six patients (39.4%) were classified as Pre-Obesity, eleven patients (16.7%) were classified as Obesity Class I, nine patients (13.6%) were classified as Obesity Class II, and seven patients (10.6%) were classified as Obesity Class III. The mean BMI for all our patients was calculated to be 30.5 (SD = 6.6), which identified our cohort as Obesity Class I. However, the BMI classification subgroup that composed most of our population was Pre-Obesity (n = 26, 39.4%).

Variables of patient characteristics in the five subgroups consisted of age, sex, weight, mean BMI and sex-based BMIs, and ever-smoker and alcohol consumption statuses. There was no statistically significant difference in the mean age of patients between all five groups (P = 0.054). The majority of patients in our cohort were between age 60 to 69 (n = 26, 39.4%) and 70-

79 (n = 21, 31.8%), with the overall mean age of our cohort calculated to be 69.5 (SD = 10.5). There was a total of 23 male patients (34.8%) and 43 female patients (65.2%). Overall, however, the male patients were found to have significantly higher BMIs than the female patients (33.3 vs 29.0, *P* = 0.18). There were no male patients in our cohort with a reported BMI in the Normal category, whereas thirteen female patients comprised the entirety of this subgroup. Across the end of the spectrum, five male patients (71.4%) had BMIs consistent with the Obesity Class III category whereas only two female patients (28.6%) were also found to have similar ranges. There were no statistically significant differences in ever-smoker status (*P* = 0.622) and alcohol consumption (*P* = 0.229) between the subgroups (Table 1).

Table 1. Comparison of Preoperative Patient Characteristics Stratified by BMI ^Δ^

Patient Variable	Normal	Pre-Obesity	Obesity Class I	Obesity Class II	Obesity Class III	Total Patients	*P* value
(*n*), patients	13	26	11	9	7	66	
Age (years) †							0.054
30-49	2 (15.4)	2 (7.7)	0 (0.0)	0 (0.0)	0 (0.0)	4 (6.1)	
50-59	0 (0.0)	2 (7.7)	0 (0.0)	0 (0.0)	2 (28.6)	4 (6.1)	
60-69	3 (23.1)	10 (38.5)	4 (36.4)	8 (88.9)	1 (14.3)	26 (39.4)	
70-79	3 (23.1)	8 (30.8)	5 (45.5)	1 (11.1)	4 (57.1)	21 (31.8)	
≥80	5 (38.5)	4 (15.4)	2 (18.2)	0 (0.0)	0 (0.0)	11 (16.7)	
Mean age (years) ‡	71.1 (14.5)	68.6 (11.3)	73.5 (6.7)	67.2 (4.2)	67.0 (8.9)	69.5 (10.5)	0.505
Sex †							0.007*
Male	0 (0.0)	9 (34.6)	5 (45.5)	4 (44.4)	5 (71.4)	23 (34.8)	
Female	13 (100.0)	17 (65.4)	6 (54.5)	5 (55.6)	2 (28.6)	43 (65.2)	
Mean BMI- Group ‡	23.3 (1.1)	27.4 (1.5)	31.6 (1.0)	37.6 (1.7)	44.1 (3.4)	30.5 (6.6)	<0.001*
Mean BMI- Sex ‡							0.018*ɣ
Male	No patients	26.9 (1.3)	31.0 (1.1)	37.6 (1.9)	43.4 (3.9)	33.3 (7.0)ɣ	<0.001*
Female	23.3 (1.1)	27.7 (1.5)	32.1 (0.8)	37.6 (1.7)	45.9 (0.0)	29.0 (6.0)ɣ	<0.001*
Weight (lbs) ‡	135.0 (20.9)	171.5 (18.0)	199.2 (18.3)	225.9 (23.3)	264.6 (22.1)	186.2 (43.4)	<0.001*
Ever Smoker †							0.622
Yes	2 (15.4)	5 (19.2)	2 (18.2)	3 (33.3)	0 (0.0)	12 (18.2)	
No	11 (84.6)	21 (80.8)	9 (81.8)	6 (66.7)	7 (100.0)	54 (81.8)	
Alcohol Consumption † ♦							0.229
None	10 (76.9)	19 (73.1)	5 (45.5)	7 (77.8)	6 (85.7)	47 (71.2)	
Moderate	3 (23.1)	6 (23.1)	6 (54.6)	2 (22.2)	1 (14.3)	18 (27.3)	
Heavy	0 (0.0)	1 (3.8)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.5)	

Δ As defined by the World Health Organization as Normal, 18.5-24.9; Pre-Obesity, 25.0-29.9; Obesity Class I, 30.0-34.9; Obesity Class II, 35.0-39.9; Obesity Class III, ≥ 40
♦ As defined by the National Institute on Alcohol Abuse and Alcoholism as Moderate, ≤ 2 drinks a day for men and ≤ 1 drink a day for women; Heavy, ≥ 4 drinks on any day or ≥ 14 drinks per week for men and ≥ 3 drinks on any day or ≥7 drinks per week for women
* Statistically Significant at *P* value < 0.05
ɣ Derived from t-Test
† Number of Patients (% of group)
‡ Mean (Standard Deviation)
BMI, Body Mass Index (kg/m^2)

Analysis of the operative characteristics of our patient population uncovered a statistically significant difference in the surgical approach used between groups (66.7% direct anterior vs 33.3% posterolateral, *P* = 0.047). Upon further investigation, it was revealed that a direct anterior approach was performed more often in patients categorized in the Normal, Pre-Obesity, and Obesity Class I subgroup than those who underwent a posterolateral approach (76.9% vs 23.1%, 80.8% vs 19.2%, and 63.6% vs 36.4% respectively). However, patients characterized in the Obesity Class II and Class III subgroups had more posterolateral approaches performed than the direct anterior approach (55.6% vs 44.4% and 71.4% vs 28.6% respectively). No significant differences were found in the laterality of patient pathology (P = 0.843), use of acetabular screws (P = 0.271), use of cementless versus cemented femoral stem type (P = 0.331), and femoral head size (P = 0.153). The top three commonly used acetabular component sizes implanted during the THA were 50 mm, 52 mm, and 54 mm (27.3%, 18.2%, and 18.2% respectively) with patients in the subgroups of Normal and Pre-obesity having the majority of these sizes (Table 2).

Table 2. Comparison of Operative Characteristics Stratified by BMI Δ

Operative Variable	Normal	Pre-Obesity	Obesity Class I	Obesity Class II	Obesity Class III	Total Patients	*P* value
(*n*), patients	13	26	11	9	7	66	
Surgical approach †							0.047*
Direct anterior	10 (76.9)	21 (80.8)	7 (63.6)	4 (44.4)	2 (28.6)	44 (66.7)	
Posterolateral	3 (23.1)	5 (19.2)	4 (36.4)	5 (55.6)	5 (71.4)	22 (33.3)	
Laterality †							0.843
Right	6 (46.2)	15 (57.7)	7 (63.6)	5 (55.6)	5 (71.4)	38 (57.6)	
Left	7 (53.8)	11 (42.3)	4 (36.4)	4 (44.4)	2 (28.6)	28 (42.4)	
Acetabular Size (mm) †							0.014*
44	5 (38.5)	0 (0.0)	0 (0.0)	3 (33.3)	0 (0.0)	8 (12.1)	
46	0 (0.0)	3 (11.5)	1 (9.1)	0 (0.0)	0 (0.0)	4 (6.1)	
48	1 (7.7)	3 (11.5)	2 (18.2)	1 (11.1)	2 (28.6)	9 (13.6)	
50	1 (7.7)	10 (38.5)	4 (36.4)	2 (22.2)	1 (14.3)	18 (27.3)	
52	5 (38.5)	3 (11.5)	2 (18.2)	1 (11.1)	1 (14.3)	12 (18.2)	
54	1 (7.7)	6 (23.1)	2 (18.2)	0 (0.0)	3 (42.9)	12 (18.2)	
≥ 56	0 (0.0)	1 (3.8)	0 (0.0)	2 (22.2)	0 (0.0)	3 (4.5)	
Use of Acetabular Screws †							0.271
Yes	1 (7.7)	7 (26.9)	0 (0.0)	2 (22.2)	1 (14.3)	11 (16.7)	
No	12 (92.3)	19 (73.1)	11 (100.0)	7 (77.8)	6 (85.7)	55 (83.3)	
Femoral Stem Type †							0.331
Cementless	8 (61.5)	18 (69.2)	8 (72.7)	8 (88.9)	7 (100.0)	49 (74.2)	
Cemented	5 (38.5)	8 (30.8)	3 (27.3)	1 (11.1)	0 (0.0)	17 (25.8)	
Femoral Head Size (mm) †							0.153
32	5 (38.5)	2 (7.7)	1 (9.1)	3 (33.3)	0 (0.0)	11 (16.7)	
36	8 (61.5)	23 (88.5)	9 (81.8)	6 (66.7)	7 (100.0)	53 (80.3)	
40	0 (0.0)	1 (3.8)	1 (9.1)	0 (0.0)	0 (0.0)	2 (3.0)	

Δ As defined by the World Health Organization as Normal, 18.5-24.9; Pre-Obesity, 25.0-29.9; Obesity Class I, 30.0-34.9; Obesity Class II, 35.0-39.9; Obesity Class III, ≥ 40
* Statistically Significant at *P* value < 0.05
† Number of Patients (% of group)
BMI, Body Mass Index (kg/m²)

Evaluation of the radiographs to determine the postoperative outcomes for our patient population, only 2 subjects were discovered to have radiolucent lines which were both located in Zone 2 of the DeLee and Charnley Classification System, but no related symptoms or physical complications were reported. In comparing postoperative follow-up periods, patients categorized in the Normal BMI subgroup appeared more often to their appointments than patients in the other subgroups, however, this was not statistically significant (*P* = 0.237). The longest follow-up period of 948 days occurred with a patient in the Pre-Obesity subgroup (Table 3).

Table 3. Comparison of Postoperative Outcomes Stratified by BMI Δ

Postoperative Variable	Normal	Pre-Obesity	Obesity Class I	Obesity Class II	Obesity Class III	Total Patients	*P* value
(*n*), patients	13	26	11	9	7	66	
Patients with radiolucent lines †	1 (7.7) α	1 (3.8) α	0 (0.0)	0 (0.0)	0 (0.0)	2 (3.0%)	1
Length of follow-up (months) ƒ	25.0 (14.0 - 29.0)	18.0 (11.5 - 30.2)	13.0 (11.0 - 28.5)	21.0 (11.0 - 23.0)	16.0 (12.5 - 20.0)	19.0 (11.0 - 27.8)	0.245

Δ As defined by the World Health Organization as Normal, 18.5-24.9; Pre-Obesity, 25.0-29.9; Obesity Class I, 30.0-34.9; Obesity Class II, 35.0-39.9; Obesity Class III, ≥ 40
α Located in Zone 2 as defined by the DeLee and Charnley Classification System
ƒ Median (IQR, interquartile range, postoperative variable)
† Number of Patients (% of group)
BMI, Body Mass Index (kg/m^2)

Discussion

Obesity has become a national epidemic in the U.S. that has cost the healthcare system billions of dollars each year. Not only has it been shown to increase the risk of certain orthopaedic diseases in adults, but it contributes to the poor development of children as well. In a study conducted by Loder, 1630 children with 1993 slipped capital femoral epiphyses were analyzed and discovered that over 63% of the patients had a weight that was greater than or equal to the 90^{th} percentile of their age group [15]. Wang et al. reported that obese boys showed significantly poorer proprioception in knee flexion movements than non-obese boys [16]. This result was also confirmed by Gushue et al. who reported that overweight children showed a significantly higher peak internal knee abduction moment during early stance than non-overweight children. This suggests that heavier children may develop gait adaptation to maintain a similar knee extensor load. However, compensation for imbalances in the frontal plane may not fully occur, which may result in increased medial compartment joint loads leading to early stages of arthritic changes [17].

In the population with more mature skeletal systems, the effects of obesity after THA has been a subject of debate with reports of conflicting evidence available. In a report published by Moran et al., no significant relationship existed between patients who were morbidly obese and the development of postoperative THA complications after analyzing 800 patients [18]. Lehman et al., reported similar outcomes in that obesity did not markedly increase the risk of postoperative complications after a 2-year follow-up period [19]. However, further studies have concluded that obesity plays a significant factor in operative time, postoperative length of stay, and prosthetic component positioning [20, 21].

Our study uncovered similar outcomes that can relate to either side of the argument. While the only significant factor in BMI levels in our patient characteristics was the female sex, smoking and drinking statuses were not. In a study by Morgenstern et al., investigators reported similar outcomes claiming that smoking was completely unrelated to actual weight [22].

The most significant finding in our data was identifying that the posterolateral surgical approach was more favored in patients with an elevated BMI. Previous investigations have uncovered that patients with a BMI of 35 kg/m^2 or higher who have undergone a THA via a direct anterior approach are at an increased risk of developing periprosthetic joint infections (PJI) due to proximity and the overhanging abdominal pannus which can nest organisms such as *C. albicans* [23, 24]. However, none of our patients developed PJI or needed to undergo any revisions after a 9-month postoperative period.

Interestingly, the two patients in our population who developed radiolucent lines were both female and had BMIs under 30 kg/m^2. This may suggest that patients with lower BMIs are more favorable to have an earlier, more physically active postoperative period which may explain the early onset of the radiolucent lines. Yet, in a study conducted by Bergschmidt et al., patients with obesity were reported to achieve better improvements and increase their daily activity earlier than non-obese patients [25]. Therefore, other underlying factors may contribute to these findings, leaving additional and longer periods of study necessary in the future.

Our study has certain limitations. The total number of patients included in our population was only 35% of the 141 subjects who were eligible through our database. Over 36% of eligible patients were lost to follow-up (52/141) which may have altered our power. Furthermore, our target follow-up for radiographic imagining was set to a minimum 9-month postoperatively period, so there may be other unmeasured factors that could have developed and contributed to alternate outcomes beyond this time frame. However, our total population mean follow-up length was 19 months (range 11 to 27 months).

Conclusion

Advancements in modern medicine, both in prosthetic designs and surgical techniques, have broadened the indications for THA. Despite the sophisticated nature and complexity regarding the effects of obesity, our investigation demonstrates that having a higher BMI only significantly affects the surgical approach to THA but can conclude that it is an excellent surgical option for the treatment of OA in obese patients.

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