The Safety and Efficacy of the Anterior Approach Total Hip Arthroplasty as per Body Mass Index

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The safety and efficacy of the anterior approach total hip arthroplasty as per body mass index

Abstract

Background: Obesity is associated with component malpositioning and increased revision risk after total hip arthroplasty (THA). With anterior approaches (AA) becoming increasingly popular, the goal of this study was to assess whether clinical outcome post-AA-THA is affected by body mass index (BMI).

Methods: This multi-center, multi-surgeon, consecutive case-series used a prospective database of 1,784 AA-THAs (1,597 patients) through bikini (n=1,172) or standard (n=612) incisions. Mean age was 63 years (range, 20 to 94) and there were 57.5% women, who had a mean follow-up of 2.7 years (range, 2.0 to 4.1 years). Patients were classified into the following BMI-groups: normal (BMI <25.0; n=572); overweight (BMI: 25.0 to 29.9; n=739); obese (BMI: 30.0 to 34.9; n=330); and severely-obese (BMI ≥35.0; n=143)]. Outcomes evaluated included hip reconstruction (inclination/anteversion and leg-length), complications and revision rates), as well as patient-reported outcomes including Oxford Hip Scores (OHS).

Results: Mean post-operative leg-length difference was 2.0 mm (range, -17.5 to 39.0) with a mean cup inclination of 34.8° (range, 14.0 to 58.0°), and anteversion of 20.3° (range, 8.0 to 38.6°). **Radiographic measurements were similar between BMI-groups (p=0.1 to 0.7).** Complication and revision rates were 2.5 and 1.7%, respectively. The most common complications were fracture (0.7%), periprosthetic joint infection (PJI) (0.5%), and dislocation (0.5%). There was no difference in dislocation (p=0.885) or fracture rates (p=0.588) between BMI-groups. **There was a higher rate of wound complications (1.8%; p=0.053) and PJIs (2.1%; p=0.029) among obese and severely obese patients. Wound complications were less common among obese patients with the 'bikini' incision (odds ratio 2.7).** Pre-operative

OHS was worse among the severely obese ($p<0.001$), which showed similar improvements (Change in OHS; $p=0.144$).

Conclusion: **Anterior approach THA** is a credible option for obese patients, with low dislocation or fracture risk, and excellent ability to reconstruct the hip, leading to comparable functional improvements among BMI-groups. **Obese patients have a higher risk of PJIs. Bikini incision for AA-THA can help minimize the risk of wound-complications. How do you know this???data above→data clarified and highlighted in red**

Key words:

Total Hip Arthroplasty, Anterior Approach, Outcome, Complications, Body Mass Index, Obesity

Introduction

Obesity is a growing challenge facing the Western healthcare systems, including arthroplasty surgeons. It is estimated that, by the 2030, 20% of the world's adult population will be obese, and this proportion is predicted to continuously increase[1, 2]. Obesity is associated with younger age at the time of primary total hip arthroplasty (THA)[2, 3]. Although obese patients can expect clinical improvement following THA with a similar survival rate[4], they are at an elevated risk for complications such as infection and dislocation[5, 6]. In most studies on the results of THA among patients who have obesity, an antero-lateral[7-9] or posterior approach[7, 10] have been used.

The anterior approach (AA) is becoming increasingly popular for a primary THA, with presumed advantages such as enhanced recovery and low dislocation rates[11, 12]. However, there is literature reporting increased complication risk[13, 14]. AA is associated with technical difficulties, both on the femoral and on the acetabular side[15], as soft tissues might impede access, increasing risk of component malpositioning, contributing to instability, early loosening or periprosthetic fractures[16]. In addition, obesity has been described as a risk factor for wound complications in AA, due to immune dysfunction and the proximity of the adjacent waist crease, exacerbated in obese patients[17-20].

This study aimed to assess the impact of BMI on the clinical outcome (component position, complication- and revision rate, and patient-reported outcome) and to identify factors associated with outcome for patients who have higher BMIs. We hypothesized that the AA can be utilized safely regardless of BMI, leading to good outcomes, equivalent to those seen in non-obese patients.

Methods

Study design

This is a retrospective, consecutive case series of prospectively recorded data of patients who underwent primary THA through AA in one of two high-volume, tertiary referral institutions (Center 1: The Ottawa Hospital, Ottawa, Canada; and Center 2: Ziekenhuis Oost-Limburg, Genk, Belgium). All six participating surgeons had a minimum of 3 years' experience with, and predominantly use AA for primary THA[21]. The study was approved by the ethical committee and all participants signed an informed consent.

Study population

Between January 1st, 2018 and June 1st, 2020, 901 total hip arthroplasties were performed in 832 patients in Center 1 by 4 surgeons, and 1,461 hip arthroplasties in 1,267 patients in Center 2 by 2 surgeons. The inclusion process has been outlined in a flowchart (See Figure 1). Exclusion criteria were age less than 18 years old (n=2), patients deceased during the follow-up from causes unrelated to THA (n=19), THA through lateral (n=3) or posterior approach (n=133), secondary osteoarthritis to childhood diseases (n=22), femoral neck fracture (n=29), osteonecrosis (n=38), post-traumatic arthritis (n=11), conversion of an intramedullary nail (n=10) or hip fusion (n=1) to THA, rheumatoid arthritis (n=2), metastasis (n=1), absent BMI data (n=179), and follow-up less than 2 years (n=128). This left 1,784 procedures (1,597 patients) for inclusion (726 THA in 674 patients from Center 1; and 1,058 THA in 923 patients from Center 2).

Patients were classified into sub-groups based on their BMI at the time of surgery. The groups were: BMI <25.0 (not overweight); BMI 25.0 to 29.9 (overweight); BMI 30.0 to 34.9 (obesity); and BMI ≥35.0 (severe obesity)[22].

Among all included AA THA, 572 had a normal weight (32.1%), 739 were overweight (41.4%), 330 had obesity (18.5%), and 143 severe obesity (8.0%). There were 1,025 men (43.4%) and 1,337 women (56.6%), who had a mean BMI of 27.6 kg/m^2 (range, 15.8 to 50.8 kg/m^2). The mean age of the cohort was 63 years (range, 20 to 94). Patients who had severe obesity were much younger (61 years, range 28 to 86) in comparison to non-overweight (64 years, range, 21 to 94; p=0.005), and overweight (62 years, range 25 to 91 years; p=0.009) patients. The mean follow-up was 2.7 years (range, 2.0 to 4.1 years), with no difference among the obesity groups (p=0.134) (See Table 1).

Surgery and implant characteristics were prospectively collected in the database. All THAs were performed through an AA with the patient in supine position on a standard operating table[23] (n=1,388) or using a positioning table[24] (n=396), through a 'bikini' incision (n=1,172) or a longitudinal incision (n=612). Three surgeons used the 'bikini' incision, these surgeons also performed a capsular repair, while the others perform a capsulectomy. A fourth surgeon uses the 'bikini' incision for patients who had a BMI ≥35 kg/m^2. The Pinnacle® acetabular cup (DePuy-Synthes, Warsaw, Indiana, United States) was used in 934 cases (52.4%), the G7 acetabular cup (Zimmer-Biomet, Warsaw, Indiana, United States) in 725 cases (40.6%), and the Trilogy® cup (Zimmer-Biomet) in 123 cases (6.9%). A total of 1,712 (96.0%) stems were uncemented and 72 stems (4.0%) were cemented, in cases of high fracture risk due to osteopenia (Dorr C femur). The decision to use a cemented stem was made during pre-operative templating or intra-operatively, based on the surgeons' judgement. The most commonly used stems were Corail® (DePuy-Synthes) (n=932), Microplasty® (Zimmer-Biomet) (n=656), Avenir® (Zimmer-Biomet) (n=104), and Taperlock® (Zimmer-Biomet) (n=44). An intraoperative radiograph prior to implantation of final implants was used systematically in most cases in Center 1 (3/4 surgeons); no intra-operative fluoroscopy was used in Center 2 (2 surgeons). Patients allowed weight-bearing as tolerated post-operatively without any anterior/posterior hip precautions (n=1,670) (5 surgeons), or protected weight bearing during the first 2 post-operative weeks (n=114) (1 surgeon), as per surgeons' preference.

Radiographic analyses

Standing antero-posterior (AP) pelvic radiographs were analyzed and a calibration marker was used to correct for magnification error. The longitudinal rotation of the pelvis was verified as correct when the tip of the coccyx was in line with pubic symphysis[25, 26]. If the coccyx deviated ≥1 centimeter from the symphyseal line the X-ray was considered unacceptable for measurement purposes.

A power analysis was performed to determine the minimum number of subjects requiring radiographic reconstruction measurements. A sample size was calculated in SPSS v27 **(IBM, Chicago, Illinois, United States)** with the intention to detect a difference in cup anteversion of 10°, using an anteversion of 15°±10° as a reference[27]. A minimum of 16 patients per group was necessary to achieve sufficient power ($1-\beta=0.80$, $\alpha=0.05$).

Two arthroplasty fellowship-trained orthopedic surgeons performed the following measurements: (1) *leg length discrepancy (LLD)* – defined as the difference of the leg length between the ipsi- and contra-lateral hip, measured by the distance between the inter-teardrop line and the inferior margin of the lesser trochanter[28], (2) *cup inclination* – defined as the angle between the long axis of the cup and a transverse line connecting the bottom edge of the acetabular teardrops[29] and (3) *acetabular cup anteversion* – defined as the inverse sine of the division between the distance of the short and long axis of the elliptical projection of the rim of the acetabular component[30]. Intraclass correlation coefficient was calculated with a two-way mixed model. A value >0.75 was considered to have excellent reliability (0-1: no – absolute agreement)[31] (See Supplementary Table).

Outcome measurements

Clinical, surgical, and hospitalization notes were screened for adverse events. The Clavien-Dindo classification was used to grade complications[32]. Grade 1 complications needed no treatment, these included transient nerve dysesthesia, conservatively treated post-operative hematoma, or greater trochanteric fractures. Grade 2 complications required pharmacologic treatment including superficial wound infections necessitating antibiotics. Grade 3 complications resulted in reoperation, and these included dislocations requiring closed reduction or revision, patients who had psoas tendinopathy requiring surgical release, superficial wound infections requiring debridement, peri-prosthetic joint infections needing revision, periprosthetic fractures requiring open reduction and internal fixation or revision, aseptic loosening or severe metallosis requiring revision and severe leg length discrepancies requiring revision. Grade 4 complications were potentially life-threatening complications or resulted in permanent disability, and grade 5 complications resulted in death.

Patient-reported outcome measures (PROMs) were obtained at 4 weeks pre-operatively, and at a minimum of 12 months post-operatively. Those included Oxford Hip Score (OHS)[33]. EuroQOL Five Dimensions Questionnaire (EQ5D)[34], Patient-Reported Outcome Measurement Information System (PROMIS)[35] in one Center, and Hip disability and Osteoarthritis Outcome Score (HOOS)[36] and 36-item Short Form Survey (SF-36)[37] in the second Center. Length of follow-up was determined from the date of surgery to the last clinical review.

Data Analyses

Statistical analysis was performed using SPSS v27 (IBM). Normal distribution of data was tested with Kolmogorov-Smirnov tests and Q-Q plots. Mann Whitney U tests or Kruskal-Wallis tests were used to compare continuous variables between different groups, for non-normally distributed data, and independent samples *t*-tests or ANOVA tests were used for normally distributed data. Paired samples *t*-tests were used to compare pre- and post-operative values and *Chi*-Square tests to compare categorical variables. Survival was calculated with failure defined as any re-operation in which any component was changed. Survival data was obtained by Kaplan-Meier analysis[38]. A p-value of <0.05 was considered significant.

Results

Radiographic measurements

Mean post-operative leg-length difference was 2.0 millimeters (range, -17.5 to 39.0) with a mean cup inclination of 34.8° (range, 14.0 to 58.0°), and anteversion of 20.3° (range, 8.0 to 38.6°). There was no significant difference in any of the radiographic parameters measured (cup anteversion, inclination, and leg length difference) between different obesity groups (See Table 2), with only a slight tendency towards increased cup inclination in patients with higher BMI, however, this difference was not significant (See Figure 2).

Complications and reoperations

There was no difference in incidence of intra-operative adverse events (calcar fracture or greater trochanteric fracture) (0.7%) among the different groups (p=0.612).

The overall rate for Clavien-Dindo grade 3 complications within this cohort was 2.5% (45/1,784). Thirty THA were revised (1.7%); the majority of these were peri-prosthetic fractures (12/1,784; 0.7%), followed by peri-prosthetic joint infection (PJI) (9/1,784; 0.5%), and instability (8/1,784; 0.5%) (See Table 3). There was no difference in survival rate between the different obesity groups (p=0.095) (See Figure 3). Patients who had obesity had the highest incidence of wound problems (6/324; 1.8%) in comparison to overweight (4/735; 0.5%; p=0.053) and not-overweight (1/571; 0.2%; p=0.012) patients. Similarly, patients who had severe obesity (BMI ≥35 kg/m^2) had a significantly higher risk to develop PJI (3/143; 2.1%) in comparison to overweight (3/739; 0.4%; p=0.024) and not-overweight (3/572; 0.5%; p=0.065) patients. The incidence of wound complications was lower among patients who had a horizontal 'bikini' incision (odds ratio 2.7; 95% Confidence Interval 0.9-8.5; p=0.039).

There were 50 THA (2.8%) patients who had a mean BMI >40 and a mean age of 63 years (range, 34 to 84). There were 54% women, who had a mean BMI of 42.8 (range, 40.0 to 50.8);

Their mean follow-up 2.7 years (range, 2.0 to 3.6)]. Of these, one THA was revised (2.0%) because of a PJI, which was not significantly different in comparison to other obesity groups (p=0.102). No other intra- or post-operative complications were present in this group.

Patient-reported outcome measures

Patients who had a higher BMI had lower preoperative PROM scores (OHS, HOOS, and SF-36) in comparison to patients who had a lower BMI (See Table 4 and Figure 4). Patients who had severe obesity (mean OHS 15.4, range 1.0 to 36.0) had lower pre-operative OHS scores than not-overweight (mean OHS 21.2, range 4.0 to 44.0; p<0.001), overweight (mean OHS 19.9, range 1.0 to 45.0; p=0.002) and obesity patients (mean OHS 18.7, range 1.0 to 42.0; p=0.031). Patients who had severe obesity had a higher change in OHS, HOOS and SF-36 scores than the other groups, although the only significant for change in HOOS quality of life (p=0.006) (See Table 4 and Figure 4). PROM scores at latest follow-up were lower in groups of patients who had a higher BMI for EQ5D and OHS, but not anymore for HOOS and SF-36 (See Table 4 and Figure 4). *Post hoc* analyses revealed that patients who had severe obesity (mean OHS 42.0, range 23.0 to 48.0) had lower post-operative OHS scores than not-overweight (mean OHS 43.9, range 11.0 to 48.0; p<0.001) and overweight (mean OHS 43.9, range, 11.0 to 48.0; p=0.001) patients, but similar post-operative OHS scores than obese patients (mean OHS 42.1, range 14.0 to 48.0; p=0.603).

Discussion

This large, multi-center, multi-surgeon, consecutive case series showed that AA-THA is safe and effective in obese patients, even among those who have a BMI ≥35 kg/m^2. Reconstruction with AA allowed for reliable component orientation and hip reconstruction even in obese patients, in contrast to other approaches[39, 40]. At a follow-up of 2.7 years (range, 2.0 to 4.1), overall complication and revision rates were 2.5 and 1.7%, respectively. The low dislocation (0.5%) and periprosthetic fracture risk (0.7%) was not higher in obese patients. However, patients who had severe obesity had a higher risk to develop PJI (2.1%). Patients who had a higher BMI had lower preoperative PROM scores, but sustained a similar improvement in PROMs, further illustrating the efficacy of AA-THA. The risk of infection in obese patients remains a challenge, regardless of approach, even among experienced surgeons, and special attention should be paid to adjunct measure, including post-operative wound management, to minimize this.

The AA has been shown in some studies to lead to superior reconstruction and component orientation accuracy[41, 42]. This accuracy does not seem to be adversely affected by BMI. Although BMI did not have effect on cup position, nor orientation with AA-THA, there was a tendency towards an increased inclination and anteversion in patients who have obesity. It is plausible that during cup positioning, anterior soft tissues push the handle towards increased anteversion and inclination. We would therefore recommend the use of an offset handle during cup placement to help avoid cup malpositioning. One other study assessed the influence of obesity on acetabular cup positioning in AA-THA and also found no significant difference in cup anteversion/inclination[18], while studies of antero-lateral or posterior THA showed that high BMI is a risk factor of cup malpositioning[39, 40]. A significantly increased inclination and decreased anteversion among obese patients[43-45] led to the suggestion of using navigation to improve cup orientation when conducting antero-lateral or posterior approach THA in obese patients[46-48]. A large depth of fat can influence the angle of the acetabular component inserter, and pelvic positioning in lateral decubitus is more difficult in obese patients, risking intraoperative pelvic motion[40]. All patients in our study underwent an AA in the supine position, which likely contributes to a more reproducible position of the pelvis during surgery. Leg length restoration was not affected by obesity in our study, while BMI was found to affect leg-length restoration in posterior approach THA[49].

Different studies found a higher complication rate after primary THA in patients who have obesity, including instability, periprosthetic fracture, and infection[2, 8, 9, 50, 51]. The overall dislocation rate was very low in this cohort (0.5%), and was similar among the different BMI-groups. AA appears to be protective against instability, even among obese patients. For other approaches, a dislocation risk up to 3 to 7% has been described in severely obese patients[8, 9, 50]. This is likely the consequence of improved cup positioning and preservation of the muscle envelope with AA. Femoral exposure is one of the technical difficulties associated with AA-THA[15]. Soft tissues in patients with obesity might impede the access to the femoral canal, risking femoral stem malpositioning and femoral fractures. Although we found a relatively higher periprosthetic fracture rate among patients with severe obesity (1.4%), this was not significantly different than in other groups (0.5 to 0.7%). We found no perioperative calcar fractures among patients with obesity, the overall risk was 0.6%. Although no significant differences in periprosthetic fracture risk were found in this study, it should be acknowledged that femoral exposure can be more difficult in obese patients. All surgeons included in this study are very experienced with AA and femoral exposure in AA is an important aspect of the learning curve[52].

Patients who have severe obesity have a higher risk of PJI (2.1%) in comparison to an overall risk within this cohort (0.5%), and patients who have obesity have a higher risk of wound complications (1.8%) compared to an overall risk (0.6%). Patients who have obesity have been shown to be at higher risk for wound complications and infection, due to the increased fat tissue envelope and deeper surgical exploration, adjacency of waist crease with overlying abdominal pannus, and higher prevalence of co-morbidities such as diabetes mellitus or immunodeficiency[17-20]. Delayed wound healing compromises the natural skin barrier allowing for bacterial migration in the wound leading to PJI[53]. The wound complication and infection rate was similar or lower in comparison to other studies on the outcome of AA-THA in patients who have obesity. Purcell et al reported a 2.5% incidence of PJI and 2.0% of superficial wound dehiscence among patients who had severe obesity[19]. Antoniadis et al reported a 4.6% incidence of infection requiring reoperation[18]. Jahng et al reported 11.5% wound complications of which 1.9% required a reoperation[54]. Studies on primary THA through antero-lateral approach found a rate of 11% superficial wound problems and 4% deep infection among severely obese patients[50]. Similar to our findings, some studies suggested a horizontal 'bikini' incision to be beneficial for wound healing[53, 55]. The bikini incision is oriented along Langer's line, allowing for tension free healing during the early-post-operative period[55]. To minimize the risk of wound-complications, possibly contributing to PJI, the bikini incision is recommended. Although incision length was not measured as part of this study, it is plausible that some vertical incisions reached the skin groin crease, which could be associated with an increased risk of slower wound healing[53] due to increased bacterial skin flora[56]. However, the use of the bikini incision is associated with other pitfalls (e.g., not extensile) and should thus be utilized with caution, especially during the learning curve of the AA.

The difference between pre- and postoperative PROM scores was not different between BMI-groups. While patients who had obesity had lower pre-operative PROM scores, they can expect similar clinical improvement after THA. Most studies that include PROM scores have found good functional outcomes among obese patients[2, 18, 57]. Registry data has shown that increased BMI is associated with significantly smaller improvements in post-operative outcome scores, although these studies did not include AA-THA[58, 59]. Due to the increased complication risk, the American Association of Hip and Knee Surgeons workgroup released a statement recommending to delay arthroplasty in patients who have a BMI>40 kg/m^2 [60]. Recently, the Cleveland arthroplasty group stated that operative eligibility based on BMI alone could potentially restrict access for patients who would benefit from primary THA and can expect improvement in pain, function and overall quality of life[61], which is supported by our data.

This study has some limitations. It is a retrospective study of prospectively recorded data, and there was a lack of complete pre- and post-operative PROM scores, which were available in only 60 and 70% of patients, respectively. This might have caused bias in interpreting these results. Also, all patients underwent THA through AA, and there was no control group to compare risk of complications between different approaches. In addition, all authors have a large experience with AA and therefore these results might not be representative to surgeons in an early stage of the learning curve. The mean follow-up was only 2.7 years (range, 2.0 to 4.1 years); longer follow-up would be necessary to evaluate the longer-term survival among obese patients treated with AA-THA.

Conclusion

The AA is a safe and effective approach for obese patients undergoing THA. It allows for excellent and reproducible cup orientation and hip reconstruction, even among severely obese patients, without the need for navigation. The risk of dislocation and periprosthetic fractures was low, even among patients who had obesity. Patients who have obesity are at higher risk to develop wound complications and PJI following AA-THA. A horizontal 'bikini' incision can help to avoid wound complications. Patients who have higher BMI had lower preoperative PROM scores in comparison to patients who had lower BMI, but similar improvement can be expected post-operatively.

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