Published in final edited form as:

J Arthroplasty. 2017 February ; 32(2): 616–623. doi:10.1016/j.arth.2016.07.046.

A Comparison of Radiographic Outcomes After Total Hip Arthroplasty Between the Posterior Approach and Direct Anterior Approach with Intra-operative Fluoroscopy

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Abstract

Background—Radiographic outcomes after total hip arthroplasty (THA) have been linked to clinical outcomes. The direct-anterior approach (DAA) for THA has been criticized by some for providing limited exposure and compromised implant position, but allows for routine use of intra-operative fluoroscopy. We sought to determine whether radiographic measurements differed by THA approach using prospective cohorts.

Methods—Two reviewers blinded to surgical approach examined 194 radiographs, obtained 4–6 weeks after primary THA, and obtained measurements for acetabular inclination angle, acetabular anteversion, radiographic limb length discrepancy (LLD), and femoral offset. All surgeries were performed at a tertiary academic medical center in rural New England by an experienced fellowship-trained arthroplasty surgeon. Measurements for inclination angle, anteversion, LLD, and offset were made into binary yes/no responses based on whether the mean measurement (between the two reviewers) was acceptable or not based on established criteria. Multivariate logistic regression analyses were performed using pre-operative and intra-operative characteristics to identify predictors of acceptability for each measurement.

[&]Dr. Keeney is partially funded on this project by the Multidisciplinary Clinical Research Center in Musculoskeletal Diseases at Dartmouth College (NIAMS P60-AR048094 and P60-AR062799). NIAMS had no involvement in study design; data collection, analysis, and interpretation; report writing; or the decision to publish. There was no other funding source.

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Results—The DAA group had higher rates of acceptable acetabular angle (96 vs. 85%, $P=0.005$), and was protective against an unacceptable angle in an adjusted predictive model (OR 0.16, $P=0.005$). There were no significant differences between approaches for acceptable anteversion, LLD, or offset. Body mass index of 30–34 was associated with higher odds of unacceptable inclination angle compared to the non-obese group (aOR 6.82, $P=0.013$).

Conclusion—DAA for THA was associated with lower odds of unacceptable inclination angle compared to the posterior approach, with no differences in anteversion, LLD, or offset.

Keywords

total hip arthroplasty; direct anterior approach; posterior approach; radiographic outcomes; acetabular inclination angle

Introduction

The direct anterior approach (DAA) to the hip for total hip arthroplasty (THA) takes advantage of the intermuscular and internervous plane between sartorius and tensor fascia lata superficially and gluteus medius and rectus femoris in the deep layer.¹ Several studies have demonstrated benefits of the DAA, including decreased narcotic consumption, more soft tissue and muscle preservation, faster recovery, shorter hospital stay, improved restoration of gait mechanics, and decreased dislocation rate.^{2–7}

Despite these potential benefits, cited sources of concern include increased operating time, increased blood loss, wound-healing problems, injury to the lateral femoral cutaneous nerve, and increased early failure.^{8–13} There is also a well-described learning curve with DAA leading to concerns with adopting this technique for THA.¹⁴ A small incision and minimal soft tissue dissection with the DAA may also lead to potential liabilities including suboptimal implant position, increased risk of femoral perforation, and increased risk of intraoperative fracture.^{10,13} Reaming and preparation of both the femoral and acetabular components using the DAA have been identified as being more difficult, especially for surgeons less familiar with the approach.¹³

The supine position utilized in the DAA facilitates the use of intra-operative fluoroscopy compared to other approaches. Intra-operative fluoroscopy allows real-time assessment of implant positioning and has been shown to improve component positioning when compared to freehand techniques.¹⁵ Poor component positioning has been associated with increased risk of dislocation, decreased range of motion, increased concentration of metal ions after resurfacing, and increased risk of polyethylene wear.^{16–19} Other studies have compared post-operative acetabular inclination and acetabular anteversion between the DAA with intra-operative fluoroscopy and the posterior approach. However, to our knowledge, post-operative femoral offset (offset) and limb-length discrepancy (LLD) between these approaches have not been studied. The purpose of this study is to compare differences in cup inclination angle, acetabular anteversion (anteversion), LLD, and offset after THA between the posterior approach and DAA with intra-operative fluoroscopy based on 4–6 week postoperative X-rays.

Materials and Methods

We received approval for this prospective cohort study through our institutional review board. Two hundred and seventy-two primary THAs were identified for inclusion from the practice of an experienced, arthroplasty fellowship-trained surgeon at a tertiary academic medical center in rural New England (Figure 1). None of the other arthroplasty surgeons at our institution transitioned from the posterior approach to the DAA exclusively, and their patients were therefore not considered for inclusion.

Between July 8, 2008, and February 24, 2010, 93 patients were identified as having undergone the posterior approach and were included in the posterior group. Beginning in February 25 through November 2, 2010, the surgeon selected patients for the DAA while still using the posterior approach for more complex cases. During this time, 66 THAs were performed: 14 using the DAA and 52 using the posterior approach. To remove the possibility of selection bias, these 66 surgeries were removed from analyses, although data were retained for comparative purposes. When comparing the 66 transition period surgeries to the surgeries included in the study, only surgery length was different ($P=0.001$). It is not surprising that surgery length was longer during the transition period due to the surgeon learning the DAA. After November 2, 2010, the surgeon switched to exclusive use of DAA: 113 patients underwent DAA THA through September 2012 and were included in the DAA group. Among the 93 posterior and 113 DAA surgeries, 12 surgeries (7 posterior and 5 DAA) were removed for having radiographs that were not amenable to technical review, leaving 194 (86 posterior and 108 DAA) surgeries available for analysis. All surgeries were performed with the participation of an orthopaedic surgery resident as the first assistant, with resident involvement in the surgery commensurate with their level of training.

Data on pre-operative patient factors and intra-operative surgical factors were collected prospectively (Table 1), including age, body mass index (BMI), gender, laterality, operative time, and whether procedures other than THA were performed during the same anesthetic. There were no differences between approaches with regard to patient age and gender. Patients in the posterior group had a higher mean BMI compared to the DAA group (29.9 vs. 27.8 kg/m², $P=0.012$). There was no difference between groups with regard to laterality or the number extra procedures done at the time of THA. The mean surgical time, defined as time from incision to skin closure, was significantly longer for the posterior approach compared to the DAA (95 vs. 81 minutes, $P=0.001$).

Surgical Technique

Posterior Approach—The patient was placed into the lateral decubitus position with the operative side up. A mini posterolateral approach was used with a curvilinear incision beginning just superior to the greater trochanter and extending distally approximately 10 cm. Iliotibial band was incised and the gluteus maximus was split. Piriformis tendon was peeled using electrocautery. The posterior hip capsule was repaired and the external rotators reattached during closure.²⁰ Straight inserter handles were used for acetabular cup positioning. Cup position was confirmed using anatomic landmarks as well as evaluating the relationship between the inserter handle and the pelvis orientation.

Anterior Approach—A HANA table was used for all DAA surgeries. However, the hydraulic hook was not utilized during femoral preparation for any surgery. Instead, the femur was elevated with a retractor placed carefully behind the greater trochanter, with the hip externally rotated to 100 degrees. A modified anterior Hueter approach, as described by Siguier *et al*,³ was used with the incision starting two cm lateral to the anterior superior iliac spine and proceeding 10 cm distally in a line 20 degrees divergent to the axis of the femur. The tensor fascia lata (TFL) fascia was split, mobilized and retracted laterally, allowing access to the anterior hip capsule through the interval between rectus femoris and gluteus medius. Intra-operative fluoroscopic images were obtained during acetabular reaming and insertion of the acetabulum and to confirm radiographic leg length and offset throughout the procedure using a C-arm. LLD was judged by comparing the position of the lesser trochanters on each hip using a straight, radiopaque instrument under fluoroscopy. Intra-operatively, acetabular inclination and version were judged based on an anterior and posterior (AP) pelvis view. Straight inserter handles were used for acetabular cup positioning.

Implants

A Stryker Accolade femoral stem and Tritanium primary acetabular component were used for all procedures except in rare cases (Stryker Corporation, Kalamazoo, MI, USA).

Templating

Templating was used preoperatively using TraumaCad software (Voyant Health, Petach-Tikva, Israel) to determine approximate femoral neck cut position and implant sizes with the goal of restoring native offset and radiographic limb length.

Data Extraction

The patients' records were reviewed for data extraction by the attending surgeon. A blinding key was created that matched each patient's medical record number and approach used, as well as the date of surgery. One of the authors, blinded to surgical approach, then accessed each chart to extract the AP pelvis X-ray obtained at the first post-operative visit (occurring within the 4–6 week post-operative time period). Each subject was assigned a number from 1–272 in random order.

Radiographic Review

Two independent reviewers (an orthopaedic resident and a medical student) were blinded to treatment assignment and given a spreadsheet that linked the blinded random number with the size of the implanted femoral head (mm) and the operative laterality.

The reviewers independently reviewed each of the 272 radiographs to measure acetabular cup inclination angle, anteversion, LLD, and offset. The methods used are demonstrated in Figure 2. All measurements were made using TraumaCad software (Voyant Health, Petach-Tikva, Israel). The implanted femoral head diameter was used to calibrate each image to produce accurate measurements for LLD and offset.

Measurement of acetabular inclination

The acetabular inclination angle was measured, as described by Lewinnek *et al.*¹⁶ Acceptable acetabular inclination angle was defined as between 30–50 degrees, inclusive, based on the “safe zone” as defined by Lewinnek *et al.*¹⁶

Measurement of acetabular anteversion

The anteversion was measured on the anteroposterior (AP) pelvis radiograph using the version measurement tool in TraumaCad (Voyant Health, Petach-Tikva, Israel) using the technique described by Liaw *et al.* (Figure 3).²¹ Acceptable anteversion angle was defined as between 5–25 degrees, inclusive, based on the safe zone as defined by Lewinnek *et al.*¹⁶

Measurement of LLD

LLD was measured, as described by Ranawat *et al.*,²² by first creating a horizontal line tangential to the inferior pubic rami at the same level. The distance from a point on the lesser trochanter to the horizontal was measured. This was compared to the distance on the contralateral side from the symmetric point on the lesser trochanter. The LLD was denoted as positive if the operative extremity is longer than the contralateral side. For cases where the lesser trochanter was not visible in the radiograph or if symmetry between each side was questionable, distance from the tip of the greater trochanter on each side was compared as well, and the two measurements were averaged. Since there is no universally accepted value for meaningful difference in LLD, we chose five mm, as described by Jasty *et al.*, for our cutoff as a significant difference, where greater than five mm was considered unacceptable.²³

Measurement of offset

Offset was measured, as described by Lecerf *et al.*,²⁴ by first creating a line bisecting the femoral shaft on either side. The center of the femoral head was then identified using the circle tool. The perpendicular distance between the center of the femoral head and the line bisecting the femoral shaft was determined to be the offset. Offset was denoted as positive if it was greater on the operative side than the non-operative side. Change from native offset of greater than five mm was deemed to be unacceptable, as offset increase above five mm has been associated with decreased rates of polyethylene wear and decrease in offset more than five mm is associated with decreased function and abductor weakness.^{19,25}

Reconciling differences in measurements

After the reviewers completed independent radiographic measurements, the results were compiled to generate single measurements for analysis. We evaluated each pair of LLD or offset measurements for each radiograph to determine if they were both positive or both negative. If they matched, then we took the numerical average of the measurements to determine the final measurement. If one measurement was positive and the other negative, the measurement was repeated with both reviewers present and in agreement. Prior to excluding the subjects from the transition period, the LLD differed as above in 11 of 263 cases amenable for radiographic review (4.2%) and the offset differed as above in 13 of 262 cases (5.0%). All of these radiographs were re-reviewed together by the reviewers for a

consensus measurement used in analysis. We generated a mean of the two values for the acetabular cup inclination and anteversion measurements.

In situations where one reviewer was not able to determine a given value due to poor contrast on the radiographic image, the single obtained value was used as the final measurement. This was the case for 18 images (5 in the posterior group and 13 in the anterior group).

Inter-observer reliability analysis was performed to compare the frequency with each of the two reviewers categorized inclination angle, anteversion, LLD and offset as acceptable or not acceptable. The percentage agreement and Kappa scores for whether the two reviewers agreed with whether a measurement was acceptable are as follows: acetabular inclination angle (95% agreement, Kappa 0.74); anteversion (80% agreement, Kappa 0.53); LLD (70% agreement, Kappa 0.37); and offset (74% agreement, Kappa 0.44). As described by Altman,²⁶ our inter-observer reliability for inclination angle is “good,” “moderate” for anteversion and offset, and “fair” for LLD.

Using a post-hoc power analysis with mean anteversion as an example, we determined that we had sufficient power (power=0.96) to determine mean differences between the posterior and DAA for comparisons of mean anteversion, acetabular angle, LLD, and offset. Logistic regression techniques were used for all binary predictive models. All analyses were conducted using StataMP 12.1 (StataCorp, College Station TX, 2012).

Results

We reviewed 194 radiographs that represented 194 THAs in 172 individuals (Figure 1).

Acetabular Inclination Angle

One hundred ninety four radiographs were amenable to reviewing acetabular inclination angle. The majority of subjects had an acetabular inclination angle that was acceptable (30–50 degrees) in each group, however there was a lower percentage of subjects in the posterior group that had an acceptable acetabular angle compared to the DAA group (85% vs. 96%, $P=0.005$).

A multivariate model predicting unacceptable inclination angle (Table 2) based on pre-operative and operative variables (approach, age group, gender, BMI, head size, laterality) showed that approach and obesity were significant, with moderate/severe obesity trending towards significance. The DAA was protective against an unacceptable angle compared to the posterior approach after adjustment ($aOR=0.23$, $P=0.032$). Odds of having an unacceptable inclination angle were higher in the obese group compared to the non-obese group ($aOR=7.40$, $P=0.013$). Odds of having an unacceptable inclination angle trended towards being significantly higher in the moderate/severe obesity group compared to the non-obese group ($aOR=6.82$, $P=0.051$). No other variables were significant. These same adjusting variables were included in the following models as well.

Acetabular Anteversion

One hundred eighty seven radiographs were amenable to reviewing acetabular anteversion. The majority of subjects had an anteversion angle that was acceptable (5–25 degrees) with no difference between approaches (Posterior 72% vs. DAA 66%, $P=0.383$). The unadjusted mean anteversion in the posterior group was lower than the DAA group (18.9 degrees vs. 22.7 degrees, $P=0.0002$).

In the multivariate predictive model of unacceptable anteversion (Table 3), no variables individually predicted unacceptable anteversion.

Lewinnek Safe Zone

Figure 4 compares the number of acetabular components placed within the Lewinnek safe zone between the posterior approach and DAA.

Radiographic LLD

One hundred ninety four radiographs were amenable to reviewing LLD. The majority of all subjects had acceptable LLD (<5 mm difference compared to contralateral side), with no statistically significant difference between the posterior and DAA groups (posterior 63% acceptable vs. anterior 60% acceptable, $P=0.596$).

In the multivariate predictive model of unacceptable LLD (Table 4), no variables individually predicted unacceptable LLD.

Offset

One hundred ninety three radiographs were amenable to reviewing offset. The majority of all subjects had acceptable (<5 mm difference compared to contralateral side) offset, with no difference by approach (68% posterior vs. 75% anterior, $P=0.299$).

In the multivariate predictive model of unacceptable offset (Table 5), no variables independently predicted an unacceptable offset, although BMI of 30–34 trended towards predicting unacceptable offset compared to the non-obese group (OR 2.57, $P=0.07$).

Acceptable combined acetabular inclination angle, anteversion, LLD and offset

A model (Table 6) of pre-operative and operative variables showed that no individual variable, including surgical approach, was able to predict higher odds of having one or more unacceptable radiographic measurements of all four included categories (inclination, anteversion, LLD and offset).

Discussion

This study shows that after adjusting for potentially confounding patient variables, the DAA with intra-operative fluoroscopy is associated with higher odds of acceptable acetabular inclination angle compared to the posterior approach following THA, with no difference for acceptable anteversion, LLD, or offset measurements. BMI of 30–34 is associated with having unacceptable acetabular inclination angle and trended towards a higher odds of

unacceptable offset compared to the non-obese group. Much of the success of THA has been linked to the position of the components, including acetabular inclination angle, acetabular version, LLD, and femoral offset, but to our knowledge LLD and offset have not been compared between the DAA and posterior approach to THA.^{16–19}

The anterior approach has been criticized as being too restrictive, leading to increased risk of poor implant position, intraoperative fracture, or femoral perforation.^{16–19} Proponents of the DAA dispute this and suggest that the DAA does not limit positioning, but adds the benefit of facile fluoroscopic imaging throughout the case, which has been shown previously to improve acetabular anteversion and inclination.¹⁵ In addition to confirming what others have shown, that the DAA is associated with better inclination angle outcomes compared to the posterior approach, our study shows that the DAA does not lead to worse outcomes of anteversion, LLD, or offset.

A recent systematic review suggests early physical function and pain as well as dislocation rates may be better with the DAA, compared with the posterior approach, and a recent comparative study showed improvement in physical function at three months post-operatively in the DAA group compared with posterior group; however, radiographic outcomes have been less studied.^{7,27} Rathod *et al* published a similar study in 2014 comparing radiographic outcomes between the DAA with intra-operative fluoroscopy and the posterior approach and found results similar to ours with regard to acetabular inclination. They did not compare offset or LLD.²⁸ They found less variance for cup inclination and anteversion in the DAA group and achieved target inclination and anteversion better in the DAA group compared to the posterior group, which may be due to use of fluoroscopy.

Two other studies compared acetabular inclination and anteversion between the posterior approach and DAA. Similar to our study, they both found trends toward improved radiographic outcomes with the DAA. Barrett *et al* in 2013 compared the posterior approach and DAA. Though it did not reach statistical significance, fewer acetabular components were implanted in Lewinnek's safe zone using the posterior approach compared with the DAA (57% vs. 73%, $P = 0.17$), however LLD and offset were not measured.⁶ Matta *et al* reviewed 458 arthroplasties performed through the DAA using fluoroscopy and found 96% of hips within the target abduction angle (35–50 degrees) and 93% within the target anteversion (10–25 degrees).² Matta's results with regard to percentage of acetabular components within target inclination and anteversion angles are higher than ours, however the reason is unclear. Our average anteversion angle is higher than that of Matta's cohort, 22.7 vs. 19.4 degrees.

Controlling for patient variables, including approach used, our study shows that a BMI of 30–34 is associated with a 7.4 higher odds of having unacceptable acetabular inclination angle compared to non-obese subjects, $P=0.013$. Subjects with a BMI over 35 have a 6.8 higher odds of unacceptable inclination angle compared to non-obese subjects, though this did not reach full statistical significance, $P=0.051$. There is also a trend towards BMI of 30–34 predicting unacceptable offset with an adjusted odds ratio of 2.6, $P=0.07$. The subjects in our study have a higher BMI (28.9), which is closer to the average American adult BMI (28.1)²⁹ than the subjects studied by Rathod *et al* (average BMI 25.2–26.4). Matta *et al* did

not publish data on BMI. It is possible that our higher average BMI may have led to lower percentages of acceptable inclination angle than previous studies.

We did not isolate the effects of the approach and the use of fluoroscopy, as this was not a goal of our study. The use of fluoroscopy has become standard of practice for many who utilize the DAA and we wished to keep our results generalizable. Future studies comparing the DAA without the use of fluoroscopy to the posterior approach without fluoroscopy in order to isolate the effects of the approach, or comparing the DAA without fluoroscopy to the DAA with fluoroscopy, may be helpful.

In our study, only 20% of the posterior group and 30% of the DAA group have all four radiographic parameters in the acceptable range, meaning 80% of the subjects in the posterior group and 70% of the subjects in the DAA group have at least one unacceptable value. The goal of LLD and offset may not always be to match the contralateral side, as soft tissue tensioning and the presence of contralateral arthrosis may dictate intra-operative decisions, and these variables were not measured for this study. It may be useful in future investigations to prospectively state pre-operative goals for LLD and offset in order to determine the ability of the approach to recreate this radiographically. Our data also suggest that it may not be realistic to expect every THA to have acceptable values of inclination, anteversion, LLD, and offset. It has still not been demonstrated which radiographic parameters are most important with regard to functional outcome, and this may differ between approaches.

Abdel *et al* recently analyzed radiographs of all dislocated primary THA's done from 2003–2012. They concluded that acetabular component position within the safe zone may not be a good predictor of instability as 58% of dislocated THA's had acetabular components within the safe zone for both inclination and anteversion. Their study compared the posterior to the anterolateral approach rather than the DAA, and they did not analyze radiographs for the patients who did not dislocate, so it is possible that the THA's that did not dislocate had a higher percentage of components in the safe zone. The safe zone of Lewinnek was determined based on the use of the posterior approach. It is customary to use the same safe zone to compare results of the posterior approach and DAA. However, it is possible that the anterior approach may require a different safe zone, particularly with regard to anteversion. Abdel's study showed that only 33% of dislocated THA's done with the anterolateral approach were in the safe zone whereas 65% of THA's done with the posterior approach were in the safe zone suggesting that the safe zone may be "safer" for one approach compared to another. Further study is warranted to determine if the different patterns of instability between approaches are associated with different safe zones.

Our study has several limitations. First, our data, while prospectively collected, are observational and non-randomized, with some key pre-operative differences between the surgical approach cohorts. While we recognize the benefit of comparing surgeries performed by a single surgeon at a single site to optimize consistency, this decreases the generalizability of our results. Our two blinded reviewers were not in excellent agreement, as defined by Altman,²⁶ for determining whether the measurements were acceptable with regard to anteversion, LLD, and offset, and in the future it may be helpful to ensure both

reviewers have a similar level of training. We used patients of a high-volume, fellowship-trained arthroplasty surgeon at a tertiary academic medical center, and thus these results may not be applicable to dissimilar practices. Additionally, the surgeon used the posterior approach exclusively for approximately 8 years in his practice prior to learning and switching to the DAA; the findings may be related to the surgeon continuing to refine and improve surgical skills over time. A unique strength of this study is the comparison of LLD and offset between the DAA and posterior approach, which have not been previously studied to our knowledge.

Our study showed that even after adjusting for gender, BMI and other patient characteristics, the DAA is associated with improved acetabular inclination angle compared to the posterior approach, and shows no difference in anteversion, LLD, or offset. Additionally, obesity, with BMI between 30–34, is associated with having unacceptable acetabular inclination angle compared to the normal weight group. A prospective, randomized study with more than one surgeon and more subjects may provide more generalizable insight into this research question. Radiographic outcomes after THA are just one portion of a patient's outcome; however, there is mounting evidence that the DAA leads to improved acetabular inclination, and no difference in LLD or offset, while our data does not confirm others that suggest anteversion is also improved.

Acknowledgments

The authors thank Stacey T. Chu, BA, a medical student at the Geisel School of Medicine at Dartmouth, for her immense contributions to this project and manuscript.

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Figure 1.
Subject flow diagram

Figure 2.
 Method of performing measurements of acetabular inclination, offset and LLD on an AP radiograph
 Acetabular Inclination Angle = A
 Femoral Offset = $E - D$
 LLD = $B - C$

Figure 3.
Method of performing measurement of acetabular anteversion on an AP radiograph

Figure 4.

Placement of the acetabular component in the Lewinnek "safe zone" (inclination angle between 30–50 degrees and anteversion angle between 5–25 degrees) based on approach

Table 1

Counts and percentages of variables comparing the posterior approach and DAA.

Variable	Posterior (N=86) n %	Anterior (N=108) n %	P-Value
Mean Age at Surgery Years (SD)	60.7 (12.2)	61.2 (12.6)	0.766
Age Group (ref = <55)	30 (35)	27 (25)	0.366
55 – 64	23 (27)	40 (37)	
65 – 74	19 (22)	23 (21)	
75 – 91	14 (16)	18 (17)	
Gender (ref = Male)	39 (45)	50 (46)	0.895
Female	47 (55)	58 (54)	
Mean BMI at Surgery (SD)	29.9 (7.6)	28.1 (6.3)	0.076
BMI Group (ref = Normal, < 25)	28 (33)	32 (30)	0.407
Overweight 25 – 29	27 (31)	45 (42)	
Obese 30 – 34	16 (19)	19 (18)	
Moderate/Severe Obese 35+	15 (17)	12 (11)	
Laterality (ref = Left)	36 (42)	45 (42)	0.978
Right	50 (58)	63 (58)	
Extra procedures (ref = No)	80 (93)	106 (98)	0.075
Yes	6 (7)	2 (2)	
Mean Surgery Length Minutes (SD)	95 (37)	81 (19)	0.001
Surgery Length (ref = < 70 minutes)	21 (24)	30 (28)	0.006
70 – 89 minutes	29 (34)	55 (51)	
90 – 119 minutes	21 (24)	18 (17)	
120 + minutes	15 (18)	5 (5)	
Acceptable Avg. Angle (30 – 50 Degrees) (ref = Yes)	73 (85)	104 (96)	0.005
No	13 (15)	4 (4)	
Acceptable Version (5-25 Degrees) (ref = Yes)	60 (72)	69 (66)	0.383
No	23 (28)	35 (34)	
Acceptable Avg. LLD (<5mm change) (ref = Yes)	55 (64)	65 (60)	0.591
No	31 (36)	43 (40)	
Acceptable Avg. Offset (<5mm change) (ref = Yes)	58 (68)	81 (75)	0.299
No	27 (32)	27 (25)	
Total number of unacceptable values	16 (20)	31 (30)	0.135

Variable	Posterior (N=86) n %	Anterior (N=108) n %	P-Value
(angle + offset + limb + version) (ref = 0)			
1	46 (56)	41 (39)	
2	18 (22)	31 (30)	
3	1 (1)	0 (0%)	
4	1 (1)	1 (1)	
Any unacceptable values (ref = No)	16 (20)	31 (30)	0.109
Yes	66 (80)	73 (70)	

DAA = Direct anterior approach; THA=Total hip arthroplasty; LLD = Limb Length Discrepancy

Table 2

Model of predictors of unacceptable avg. angle (<30 or >50 degrees) using variables known before surgery begins (N=194)

Variable	Odds Ratio	95% CI	P-Value
Approach (ref = posterior)			
Anterior	0.16	0.04 – 0.57	0.005
Age Group (ref = < 55)			
55 – 64	1.69	0.47 – 6.04	0.417
65 – 74	0.34	0.03 – 3.33	0.354
75 – 91	0.61	0.08 – 4.69	0.634
Gender (ref = Male)			
Female	2.27	0.57 – 9.11	0.246
BMI Group (ref = Normal, <25)			
Overweight, 25 – 29	0.33	0.04 – 2.66	0.297
Obese, 30 – 34	7.40	1.52 – 36.13	0.013
Moderate/Severe Obese, 35 +	6.82	0.99 – 47.07	0.051
Head Size, mm (continuous)	0.96	0.85 – 1.08	0.514
Side (ref = Left)			
Right	0.69	0.25 – 1.87	0.461

Clustered on the 172 persons that underwent the 194 surgeries.

Table 3

Predictors of unacceptable avg. version (<5 or >25 degrees) using variables known before surgery begins.
(N=187)

Variable	Odds Ratio	95% CI	P-Value
Approach (ref = Posterior)			
Anterior	1.23	0.63 – 2.41	0.549
Age Group (ref = < 55)			
55 – 64	0.80	0.35 – 1.84	0.602
65 – 74	0.73	0.30 – 1.79	0.493
75 – 91	1.00	0.37 – 2.67	0.994
Gender (ref = Male)			
Female	1.70	0.85 – 3.38	0.133
BMI Group (ref = Normal, <25)			
Overweight, 25 – 29	1.10	0.48 – 2.49	0.825
Obese, 30 – 34	0.90	0.33 – 2.45	0.836
Moderate/Severe Obese, 35 +	0.72	0.24 – 2.20	0.566
Head Size, mm (continuous)	0.97	0.87 – 1.08	0.528
Side (ref = Left)			
Right	0.95	0.50 – 1.80	0.866

Clustered on the 166 persons that underwent the 187 surgeries.

Table 4

Predictors of unacceptable avg. limb length discrepancy (>5 mm) using variables known before surgery begins. (N=194)

Variable	Odds Ratio	95% CI	P-Value
Approach (ref = Posterior)			
Anterior	1.44	0.72 – 2.85	0.301
Age Group (ref = < 55)			
55 – 64	0.60	0.27 – 1.33	0.206
65 – 74	0.63	0.27 – 1.47	0.283
75 – 91	0.64	0.24 – 1.71	0.374
Gender (ref = Male)			
Female	0.59	0.30 – 1.17	0.128
BMI Group (ref = Normal, <25)			
Overweight, 25 – 29	0.75	0.36 – 1.58	0.451
Obese, 30 – 34	1.20	0.48 – 2.96	0.695
Moderate/Severe Obese, 35 +	1.21	0.41 – 3.57	0.726
Head Size, mm (continuous)	1.04	0.61 – 2.05	0.442
Side (ref = Left)			
Right	1.12	0.61 – 2.05	0.708

Clustered on the 172 persons that underwent the 194 surgeries.

Table 5

Predictors of unacceptable avg. offset (>5 mm) using variables known before surgery begins. (N=193)

Variable	Odds Ratio	95% CI	P-Value
Approach (ref = Posterior)			
Anterior	0.74	0.36 – 1.53	0.420
Age Group (ref = < 55)			
55 – 64	1.22	0.53 – 2.79	0.642
65 – 74	0.86	0.33 – 2.26	0.761
75 – 91	1.07	0.36 – 3.17	0.899
Gender (ref = Male)			
Female	0.64	0.30 – 1.38	0.259
BMI Group (ref = Normal, <25)			
Overweight, 25 – 29	1.03	0.41 – 2.59	0.945
Obese, 30 – 34	2.57	0.93 – 7.11	0.070
Moderate/Severe Obese, 35 +	2.34	0.82 – 6.66	0.112
Head Size, mm (continuous)	1.00	0.92 – 1.09	0.991
Side (ref = Left)			
Right	0.92	0.48 – 1.77	0.800

Clustered on the 171 persons that underwent the 193 surgeries

Table 6

Predictors of having at least 1 unacceptable radiographic outcome (unacceptable angle <30 or >50 degrees OR version <5 or >25 degrees OR length change >5mm OR offset change >5mm) using variables known before surgery begins. (N=186)

Variable	Odds Ratio	95% CI	P-Value
Approach (ref = Posterior)			
Anterior	0.58	0.28 – 1.22	0.150
Age Group (ref = < 55)			
55 – 64	0.95	0.39 – 2.35	0.919
65 – 74	0.49	0.20 – 1.22	0.125
75 – 91	0.84	0.27 – 2.60	0.759
Gender (ref = Male)			
Female	0.86	0.42 – 1.74	0.667
BMI Group (ref = Normal, <25)			
Overweight, 25 – 29	0.80	0.36 – 1.76	0.575
Obese, 30 – 34	1.48	0.49 – 4.44	0.486
Moderate/Severe Obese, 35 +	1.02	0.34 – 3.06	0.970
Head Size, mm (continuous)	1.01	0.91 – 1.12	0.874
Side (ref = Left)			
Right	1.29	0.62 – 2.69	0.502

Clustered on the 165 persons that underwent the 186 surgeries. Only includes surgeries with radiographic results for all 4 outcome categories.