Hip Offset and Leg Length Equalization in Direct Anterior Approach Total Hip Arthroplasty without Preoperative Templating

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Abstract

The standard practice of preoperative templating may be less important for direct anterior approach (DAA) total hip arthroplasty (THA) with intraoperative fluoroscopy (IF). However, this has yet to be tested. The purpose of this retrospective review was to report the hip offset (HO) and leg length (LL) equalization accuracy following 304 consecutively performed DAA THA with IF and no preoperative templating. A supplemental fluoroscopic gridding tool was used to assess hip symmetry. Operative and fluoroscopic times were also documented to assess for surgical efficiency. The mean HO and LL difference was 3.5 ± 2.6 mm (range: 0.0-9.3) and 2.9 ± 2.2 mm (range: 0.0-9.9), respectively. Hip offset and LL equalization within 10 mm was achieved in all patients. The mean operative time for unilateral THA was 72.2 ± 12.0 minutes, and the mean fluoroscopy time per hip was 10.5 ± 4.5 seconds. These results suggest that for surgeons with adequate experience performing DAA THA with IF, preoperative templating may not be necessary to reliably and efficiently achieve clinically acceptable HO and LL.

Keywords

Total Hip Arthroplasty; Direct Anterior Approach; Preoperative Templating; Hip Offset; Leg Length

Abbreviations

AP = anteroposterior
DAA = direct anterior approach
HO = hip offset
IF = intraoperative fluoroscopy
LL = leg length
THA = total hip arthroplasty

Introduction

Preoperative templating has been considered a necessary exercise to ensure the proper execution of total hip arthroplasty (THA).[1-5] The primary objective of preoperative templating is to guide surgical decisions, such as determining the implant size and position required to produce symmetric hip offset (HO) and leg length (LL). This in turn may increase surgical efficiency, ensure that the proper implants and materials needed are available, and reduce the potential for intraoperative complications. Despite these benefits, there are limitations associated with preoperative templating, including those associated with errors in human measurement, suboptimally positioned pelvic radiographs, and magnification errors.[3,6] Even digital templating has been associated with a high degree of predictive inaccuracy as rates as low as 36%-38% have been reported.[1-3,7-9]

Significant HO and LL discrepancies after THA have been associated with poor patient outcomes, persistent pain, gait impairment, nerve palsies, instability, and risk for early failure.[10-14] Compared to posterior and lateral approaches, direct anterior approach (DAA) THA has been associated with greater HO and LL equalization accuracy.[15,16] In contrast, the predictive accuracy of preoperative templating has not been shown to be any more effective between anterior and posterior approaches.[8] This suggests that the improved accuracy in HO and LL equalization associated with DAA THA may be unrelated to the benefits of preoperative templating. For example, DAA THA facilitates the use of intraoperative fluoroscopy (IF), which can be used to evaluate implant size and position, and consequently HO and LL.

For surgeons performing DAA THA with intraoperative fluoroscopy (IF), the time consuming process of preoperative templating may be less important. This has not been studied previously. Therefore, the purpose of this retrospective review was to report the accuracy of HO and LL equalization following a consecutive series of DAA THAs performed with IF and no preoperative templating.

Methods

This institutional review board approved, retrospective review included a consecutive cohort of unselected patients undergoing primary unilateral or single-stage bilateral THA via the DAA between January 2016 and May 2018. This included patients with standard indications for THA as well as those with pre-existing contralateral hip replacement. Revision THA and cases performed for displaced femoral neck fractures were excluded. Additionally, one patient was excluded for review due to a periprosthetic femur fracture of a previously placed contralateral THA that required open reduction and internal fixation. This resulted in an abnormally shortened limb and that could not serve as a target for equalization. The final analysis included an unselected cohort of 245 patients.

A single, fellowship-trained orthopedic surgeon performed all THAs via the DAA utilizing a specialized fracture table (Hana, Mizuho OSI, Union City, CA, USA) and methods similar to that described by Matta, et al.[17] However, no preoperative templating was performed on any subject. Intraoperative fluoroscopy with OrthoGrid Drone (OrthoGrid Systems Inc., Salt Lake City, UT, USA) was used in each case (Figure 1).

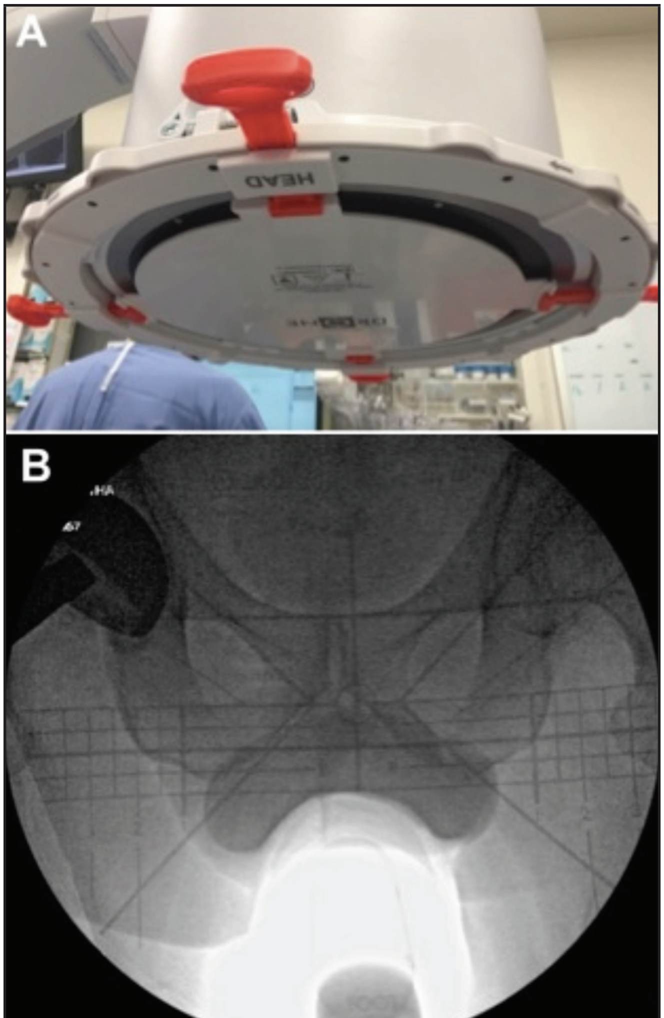

Figure 1. OrthoGrid Drone C-arm Attachment (A). Intraoperative Anteroposterior Pelvic Image with Projected Grid System for Better Visualization of Hip Offset and Leg Length (B).

Table 1. Implants	
Implant	**Number**
Femoral Stem	
Ortho Development Corporation, Tribute	282
Ortho Development Corporation, Alpine	3
Zimmer-Biomet, Taperloc Microplasty	11
Zimmer-Biomet, Fitmore	5
Zimmer-Biomet, Echo Bi-Metric	3
Femoral Head	
Ceramic	304
Acetabular Shell	
Ortho Development Corporation, Escalade	285
Zimmer-Biomet, G7	19
Polyethylene	
Ortho Development Corporation, HXPLE	285
Zimmer-Biomet, E1	19

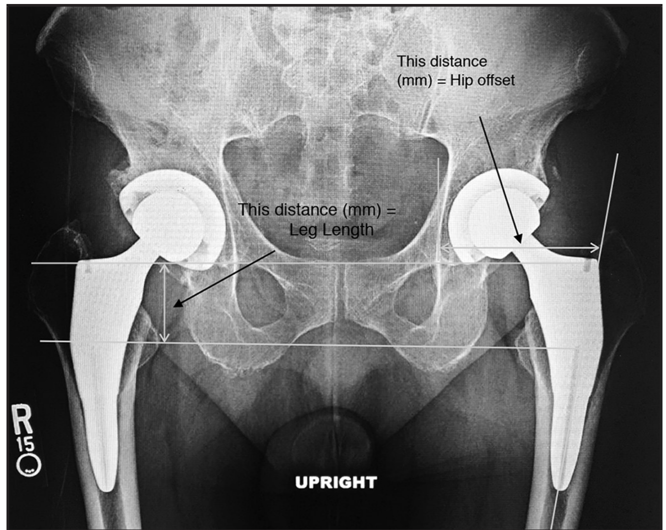

Figure 2. Six-week Anteroposterior (AP) Bilateral Hip Radiograph with Hip Offset (HO) and Leg Length (LL) Determination Methods. Hip Offset was Determined by Measuring the Horizontal Distance (mm) from the Longitudinal Axis of the Femur to the Medial Edge of the Radiographic Teardrop. Leg Length was Determined by Measuring the Vertical Distance from the Trans-teardrop Reference Line to the Center Point of the Lesser Trochanter.

Prior to surgery and at six-weeks postoperatively, all patients completed weight bearing anteroposterior (AP) bilateral hip radiographs, as well as a frog leg lateral radiograph of the operative hip. Intraoperative pelvic images were aimed to match the pelvic tilt demonstrated on preoperative weight bearing radiographs. This was achieved by adjusting the tilt of the fracture table and/or the c-arm. Care was also taken to achieve a rotationally centered pelvic image with symmetric obturator foramen. Standard uncemented implants were used in all cases and are summarized in Table 1.

Primary surgical outcomes included HO and LL differences. Hip offset and LL were measured on both preoperative and six-week postoperative weight bearing AP bilateral hip radiographs. Hip offset was determined by measuring the horizontal distance between the longitudinal axis of the femur and the medial edge of the radiographic teardrop (Figure 2).[18] Leg length was determined by measuring the vertical distance from the trans-teardrop reference line to the center point of the lesser trochanter (Figure 2).[19] Discrepancies were then calculated and recorded as the absolute difference between the measured hip and the contralateral side.

Operative and fluoroscopic times were analyzed as secondary surgical outcomes. Surgical time was defined from the opening incision to the end of wound closure and dressing application. For single-stage bilateral THAs, operative time was recorded from the opening incision of the first operative hip to the end of wound closure and dressing application of the second operative hip. This also included an approximately 30-minutes period between completion of the first operative hip and start of the contralateral side. This time period was required for sterile preparation and draping of the second operative hip. Intraoperative fluoroscopy was used at four main time points: acetabular reaming, cup impaction, HO and LL assessment and final stem placement. Fluoroscopy times were recorded directly from the c-arm unit. Bilateral THA fluoroscopy times were recorded separately for each hip.

Descriptive statistics for all outcome variables, including mean, standard deviation and ranges, were determined for the enture cohort, as well as uni- and bilateral THA patient groups.

Results

Two hundred and forty-five patients (304 hips) underwent DAA THA without preoperative templating. This consisted of 114 males (47%) and 131 females (53%), with a mean age at surgery of 66.0 ± 10.7 years, and a mean body mass index of 27.9 ± 13.6 kg/m^2 (Table 2).

Postoperatively, the mean HO difference for the entire cohort was 3.5 ± 2.6 mm (range : 0-7.9) and the mean LL difference was 2.9 ± 2.2 mm (range : 0-9.9) (Table 3). The mean postoperative HO difference for unilateral and bilateral THA was 3.7 ± 2.4 mm (range: 0.0-9.3) and 3.0 ± 2.1 mm (range: 0.3-7.9), respectively. The mean postoperative LL difference for unilateral and bilateral THA was 3.1 ± 2.2 mm (range: 0.0-9.9) and 2.3 ± 2.0 mm (range: 0.0-7.3), respectively.

The mean operative time for unilateral THA was 72.2 ± 12.0 minutes and 175.1 ± 16.2 minutes for bilateral THA (Table 4). The mean fluoroscopic time per hip was 10.5 ± 4.5 seconds (Table 4).

Table 2. Patient Demographics

Gender	Male: 114; Female: 131	
Laterality	Unilateral: 186; Bilateral: 59	
	Mean ± SD	Range
Age (years)	62.0 ± 10.7	(28,90)
Height (centimeter)	165.9 ± 11.1	(139.7,195.6)
Weight (kilogram)	74.6 ± 17.3	(42.5,139.3)
Body Mass Index	26.9 ± 4.6	(16.7,45.8)

SD = Standard Deviation

Table 3. Pre- and Postoperative Hip Offset and Leg Length Differences

Length Differences	Mean ± SD	Range
Preoperative, Hip Offset (mm)		
Unilateral	4.5 ± 3.7	(0,17.2)
Bilateral	3.9 ± 3.4	(0,13.9)
All	4.3 ± 3.6	(0,17.2)
Preoperative, Leg Length (mm)		
Unilateral	5.5 ± 5.6	(0,36.7)
Bilateral	4.8 ± 9.4	(0,71.9)
All	5.3 ± 6.7	(0,71.9)
Postoperative, Hip Offset (mm)		
Unilateral	3.7 ± 2.4	(0,9.3)
Bilateral	3.0 ± 2.1	(0.3,7.9)
All	3.5 ± 2.6	(0,9.3)
Postoperative, Leg Length (mm)		
Unilateral	3.1 ± 2.2	(0,9.9)
Bilateral	2.3 ± 2.0	(0,7.3)
All	2.9 ± 2.2	(0,9.9)

SD = Standard Deviation; mm = millimeter

Table 4. Operative and Fluoroscopic Times

	Mean ± SD	Range
Operative Time (Minutes)		
Unilateral	72.2 ± 12.0	(45.0,127.0)
Bilateral	175.1 ± 16.2	(141.0,215.0)
Fluoroscopy Time (Seconds)		
Unilateral	10.4 ± 4.5	(5.0,25.0)
Bilateral	10.8 ± 9.4	(2.0,23.5)

SD = Standard Deviation

Discussion

To our knowledge, no previous study has evaluated the accuracy of HO and LL equalization following DAA THA with IF and no preoperative templating. In the current study, HO and LL differences were achieved on average within 4 mm of the contralateral side. Additionally, 100% of HO and LL differences were within 10 mm. Similar HO and LL mean differences and accuracy rates have been reported in the setting of preoperative templating.[8,15,20] This suggest that preoperative templating may not be necessary for DAA THA with IF when performed by experienced surgeons.

Direct anterior approach THA facilitates use of IF due to the supine position of the patient. Furthermore, the bed can be tilted so that the patients' pelvic tilt matches that of preoperative standing radiographs. This likely explains the high HO and LL accuracy rates observed in the current study as well as those reported in others. Previous research has demonstrated lower HO and LL differences after DAA THA compared to those performed via posterior or lateral approaches despite the implementation of preoperative templating on all patients.[8,15,16,20]

In the current study, IF was used with the addition of a commercially available grid system to aid in the visual assessment of hip symmetry. To our knowledge, only one previous study has examined the use of IF with a grid system, and similar results were reported.[21] Gililland, et al, reported HO and LL equalization within 10 mm at rates of 95% and 100%, respectively.[21] These rates were significantly higher compared to those performed with IF alone.[21] Although more studies are needed, fluoroscopic grids may represent a tool that can further enhance the intraoperative assessment of hip symmetry.

Computer navigation is often presented as the most accurate method for restoring HO and LL in THA. While HO and LL outcomes after computer navigated DAA THA have not been reported, the results of this study are comparable to those reported after computer navigated THA performed via other approaches.[18,22-5] Hip offset equalization has been reported at rates of 85%[23] and 95%[18,22] when using 10 mm and 6 mm cut-offs, respectively. Leg length equalization rates have also varied, with reports ranging from 90% to 100% when using a 10 mm cut-off,[22,24] and 80% to 99% with a cut-off of 6 mm or less.[18,23] In the current study, 10 mm was used as the clinically relevant cut-off for HO and LL differences, with 100% of patients falling within 10 mm. When using a 6 mm cutoff, LL equalization was still achieved in 88.6% of patients in the current study.

Multiple factors may influence surgical efficiency during THA. Operative and fluoroscopy times are two factors that are easily and objectively measured. By predicting the implant size and position needed to restore native HO and LL prior to the start of surgery, one would expect less operative and fluoroscopy time needed to confirm an appropriately sized and placed implant. However, the results of this study do not suggest this. Both operative (72 minutes) and fluoroscopy (10.5 seconds) times in the current study were less than those previously reported. Contemporary studies of unilateral DAA THA using preoperative templating have reported operative times ranging from 83 to 114 minutes,[26-28] and fluoroscopy times ranging from 11.1 to 18.5 seconds.[29] Varying methodologies for single-stage bilateral DAA THA make it difficult to compare surgical efficiency between studies. However, the mean operative time for bilateral THA in the current study was 175 minutes, which is comparable to the 180 minutes reported by Parcells, et al.[27]

There are several limitations to this study. First, there was no preoperative templating control group to compare and assess for differences in HO and LL equalization. However, the primary goal of this report was to describe the current practice at the study site and to compare the results of this study to those previously published. Second, the addition of a grid system may be a confounding factor to the results of this study as the previously mentioned grid study reported superior HO and LL results with the addition of a grid system compared to IF alone. As such, these results may not be reproducible in settings where IF during DAA THA is utilized without a grid system. However, this also suggests that imaging tools such as fluoroscopic grids may be helpful when preoperative templating is not performed as it may further enhance the intraoperative assessment of hip symmetry. Finally, the results of the current study represent the practice of a single, high volume surgeon with more than ten years of experience in DAA THA with IF. Multiple studies indicate an improvement in surgical outcomes and a reduction in major complications with increasing DAA surgical experience.[30,31] As such, the authors recognize that these results may not be reproducible in less experienced or low volume surgeons.

It is also important to note that the authors do not believe preoperative templating is unimportant. For surgeons in training or those with limited experience, the exercise of preoperative templating is critical for learning and understanding the surgical goals of THA. It is not a step in the growth of any developing hip surgeon that should be overlooked.

Conclusion

The results of this study demonstrate that IF with a commercially available gridding system may provide adequate information to accurately restore HO and LL following DAA THA, even when preoperative templating is not performed. Additionally, the lack of preoperative templating did not appear to negatively impact surgical efficiency in terms of operative and fluoroscopy times. Based on these results, the time consuming practice of preoperative templating may not be necessary to accurately and efficiently achieve symmetric HO and LL for surgeons with adequate experience performing DAA THA with IF.

Conflict of Interest

None of the authors identify a conflict of interest.

Disclosure Statement

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