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Research Article

Intraoperative Fluoroscopic Grid in Total Hip Arthroplasty in Supine Position: Improving Cup Position, Leg Length and Hip Offset

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Abstract

Introduction: Accurate placement of implants is important to prevent a variety of complications including dislocation, decreased range of motion, and premature polyethylene wear in Total Hip Arthroplasty (THA). In addition, the difference in leg length after THA affects postoperative gait and low back pain, and the femoral offset is related to gait and abductor muscle function.

The purpose of this study is to investigate whether implant placement, leg length difference, and hip offset are improved in supine THA using a 9-inch fluoroscopic HipGrid Drone.

Materials and Methods: We retrospectively reviewed consecutive 80 patients who underwent primary unilateral primary THA through direct anterior approach at supine position: 40 THAs with the use of fluoroscopy and 9-inch Drone, and 40 THAs with the use of fluoroscopy alone. We compared the accuracy of component positioning, leg length discrepancy, and hip offset with or without Drone.

Results: There was no significant difference in the inclination angle of the cup between the Drone group 37.9 degrees and the control group 39.0 degrees (p=0.175), but the variation from the target angle was more less in the Drone group compared with the control group (2.37 vs 3.82 degrees, p=0.013). With the use of the Drone, significantly more THAs had restoration of

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leg length compared with the control group (3.55 vs 4.95 mm, p=0.011). Hip offset restoration was also significantly improved in the Drone group compared with the control group (4.42 mm vs 5.56 mm, p=0.048). Surgical time was decreased in the Drone group (92.6 vs 97.8 minutes, p=0.043).

Conclusions: Using the easily adjustable grid system, we have demonstrated an efficient method for consistent and accurate cup positioning and restoration of hip offset for anterior supine THA. We recommend the use of this simple and effective device to anterior supine THA.

Keywords

Total Hip Arthroplasty; HipGrid Drone; Hip Offset; Computed Tomography

Introduction

Accurate placement of implants is important to prevent a variety of complications including dislocation, decreased range of motion, and premature polyethylene wear in Total Hip Arthroplasty (THA) [1-4], and is an indispensable factor in improving long-term results. In addition, the difference in leg length after THA affects postoperative gait and low back pain and the femoral offset is related to gait and abductor muscle function [5-7]. The navigation system is a typical intraoperative support tool for accurate implant placement, and many good results have been reported [2,8-10]. However, problems such as expensive equipment introduction cost, learning curve, additional invasion such as reference pin insertion, additional operation time due to registration work, and increase in bleeding amount have been pointed out.

Component positioning accuracy is suggested to improve when using the Direct Anterior Approach (DAA) in supine position, which simplifies Intraoperative Fluoroscopy (IF) [11,12]. Compared to DAATHA without IF, the use of IF did not show a significant difference in component accuracy and leg length correction, and the advantages of IF were not clear [13]. Recently, the use of a novel radiopaque grid, HipGrid Drone (Drone) improved component position accuracy and Leg Length Discrepancy (LLD) and Global Hip Offset differences (GHO) during DAA in supine position [14]. The Drone is an intraoperative support device developed for supine THA that is attached to an X-ray device. The abduction angle of the acetabular cup can be confirmed by the auxiliary line on the device when taking a fluoroscopic image during the operation. In addition, the grid marks on the device make it easy to see the difference between the left and right leg lengths and the femoral offset. The purpose of this study is to investigate whether implant placement, leg length difference and hip offset are

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improved in supine THA using a 9-inch fluoroscopic grid drone that can be easily attached, as compared with cases in which fluoroscopy alone is used.

Materials and Methods

After approval from our institutional review board, we retrospectively reviewed consecutive 80 patients who underwent primary unilateral primary THA through DAA at supine position. Exclusion from data analysis only occurred if the contralateral hip had anatomic deformity that would not be an appropriate target for symmetry. All surgeries were performed by a single, experienced surgeon (TY) using the DAA on a normal table. All patients received the cementless Ovation Tribute (Ortho Development Corporation, Draper, UT) short femoral stem and a cementless acetabular cup (Escalade or Legend Ortho Development Corporation). In the study group, 40 THAs were performed between May 16, 2019, and March 18, 2021, with the use of fluoroscopy and 9-inch Drone, a novel radiopaque grid fixed to the operative table made up of 1-cm squares and 40° abduction angles (Fig. 1). This allows improved intraoperative assessment of cup abduction, limb length, and hip offset. Prior to surgery, the Drone was attached to the fluoroscopic receiver and covered with standard sterile fluoroscopic drapes. This group consisted of 7 men (17.5%) and 33 women (82.5%). In the control group, 40 THAs were performed between October 17, 2017, and March 28, 2019, with the use of fluoroscopy alone. This group consisted of 9 men (22.5%) and 31 women (77.5%). There were no differences between the two groups in terms of diagnosis, age, Body Mass Index (BMI) and American Society of Anesthesiologist (ASA) score (Table 1).

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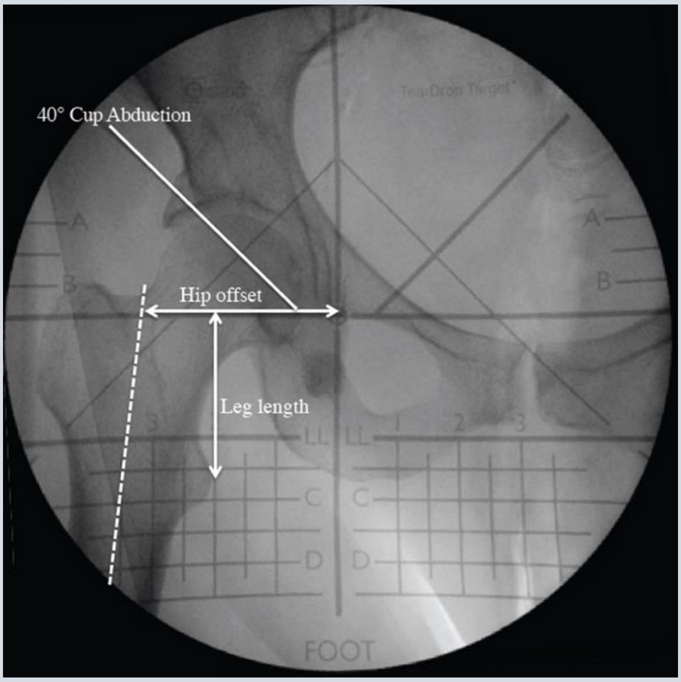
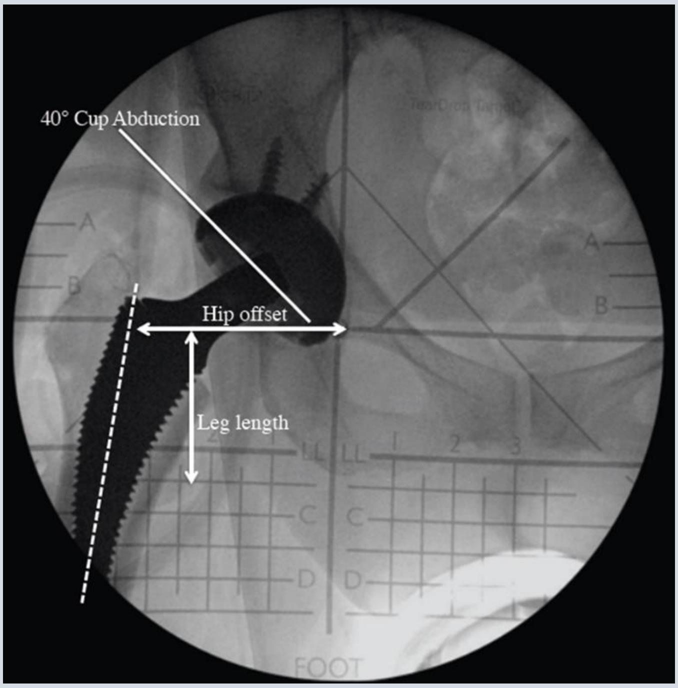


(A)



(B)

Figure 1: A: Fluoroscopic image with grid in place to aid in assessing limb length, hip offset, and acetabular component abduction. 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. B: Intraoperative fluoroscopic image using grid.

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Intraoperative Imaging

Our intraoperative fluoroscopy protocol with and without the grid was similar. We first obtained an anteroposterior pelvis image centered over the symphysis and adjusted the rainbow and tilt until we had an adequate image in which the coccyx was centered and within 2 cm of the top of the pubic symphysis. Next, the fluoroscopy unit was telescoped into position, and an anteroposterior image was saved of the contralateral hip. This image was then transferred to the opposing screen on the fluoroscopy unit and was used for comparison when assessing the operative hip. The fluoroscopy unit was then telescoped into position over the operative hip. In this position, fluoroscopic imaging was obtained while acetabular reaming, cup impaction, LLD, GHO assessment. The grid lines allowed for visual estimation of LLD and GHO and the abduction 40 degree line.

Radiographic Measurement

We evaluated AP bilateral hip radiographs and lateral images of both hips prior to surgery and 8 weeks postoperatively for accuracy of component positioning. LLD was the measured vertical distance from the transteardrop line to the apex of the lesser trochanter [15]. GHO was the measured horizontal distance between the longitudinal axis of the femur and the medial edge of the radiographic teardrop [16]. Radiographs were reviewed by 2 independent surgeons.

Along with obtaining demographic information, records were reviewed for operative start time and end time, allowing us to calculate elapsed surgical time for each case.

Statistical Analysis

Statistical analysis of differences between the two groups was performed using GraphPad Prism 5 version 5.0. Chi-square test was used for qualitative variables, and Student's t-test was used for quantitative variables. Levels of significance reaching 95% or more were accepted.

Results

There was no significant difference in the inclination angle of the cup between the Drone group 37.9 degrees and the control group 39.0 degrees (p=0.175), but the cases of 40 degrees or more were 1 case in the Drone group and 7 cases in the control group (0.25% vs 1.75%, p=0.025), and the variation from the target angle was more less in the Drone group compared with the control group (2.37 degrees vs 3.82 degrees, p=0.013) (Table 2). With the use of the Drone, significantly more THAs had restoration of leg length compared with the control group (3.55

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mm vs 4.95 mm, p=0.011). Hip offset restoration was also significantly improved in the Drone group compared with the control group (4.42 mm vs 5.56 mm, p=0.048) (Table 2). Mean elapsed surgical time was significantly less in the Drone group, with a mean operative time of 92.6 minutes compared with 97.8 minutes in the control group (p=0.043) (Table 2).

The percentage of patients meeting criteria previously classified as acceptable were measured for all patients (Table 3). Although the use of Drone had a higher percentage of patients achieving all three surgical targets, the cup abduction goal, LDD, and GHO were not significantly improved with the use of the Drone.

	HipGrid Drone	**cont**	**P-value**
No. of hips	40	40	
Gender F/M	7/33	9/31	0.781
Age at operation	66.9 (11.4)	64.6 (11.6)	0.411
BMI (kg/m^2)	22.6 (3.75)	23.2 (4.43)	0.574
Diagonosis (OA/ANF)	36/4	38/2	0.675
ASA (I//II/III)	11/27/2	10/26/4	0.733
OA; osteoarthritis, ANF; aseptic necrosis of femoral head			

Table 1: Characteristics of the patients.

	HipGrid Drone	**cont**	**P-value**
Cup Abduction Angle	37.9 (2.13)	39.0 (3.93)	0.175
	(34-42)	(33-46)	
Variance	2.37 (1.73)	3.82 (2.19)	0.013
	(0-7.3)	(0-9.5)	
Leg length discrepancy	3.55 (1.86)	4.95 (2.82)	0.011
	(0-9.6)	(0-15.2)	
Hip offset	4.42 (1.95)	5.56 (3.43)	0.048
	(0.3-8.7)	(0.5-12.1)	
SD: Standard Deviation			

Table 2: Outcome by surgical approach and surgical time.

	HipGrid Drone	**cont**	**P-value**
Cup abduction angle (35-55 degree)	97.50%	87.50%	0.089
Leg length discrepancy <10 mm	97.50%	87.50%	0.089
Hip offset <10 mm	95%	85%	0.136
Success for all	92.50%	75%	0.034

Table 3: The percentage of patients meeting goal zone.

Discussion

There are several reports which showed excellent accuracy in achieving cup abduction angle targets, it is clear that the use of fluoroscopy produces widely inconsistent results [11,17-23]. A previous study reported that using the 12-inch fluoroscopic grid system having 40 degree cup abduction angle guidelines in a supine THA with a traction table allowed for more accurate cup position and significantly improved LLD and GHO compared with IF alone [14]. In addition, 82% of components met all 3 targeted goals while decreasing surgical times with use of the grid to supplement IF. Recent report also showed the use of manual and digital Drones having 35 and 45 degree abduction angle guidelines in supine THA significantly improved cup abduction angle, LLD, and GHO [24]. In the current study, using the 9-inch Drone having 40 degree cup abduction guidelines in a supine THA on a normal table, the variation of the cup abduction angle, LLD and GHO were significantly improved compared with IF alone. Although the bilateral hip joints do not fit in one field of view with the 9-inch Drone, it is considered that good results were obtained by using the Drone properly.

The initial evaluation reporting use of the grid system reported better consistency compared to use of IF alone and reported achieving LLD <10 mm in 100% of cases. However, achieving GHO <10 mm was not as satisfied and, compared to the IF only group, the use of a grid improved GHO success from 67% to only 85% of cases. In the current study, the results with or without the Drone had better results compared with the previous study. The increased accuracy reported in our study compared to the previous evaluation of both IF alone and to the first generation grid system is likely multifactorial. Similar to the first generation grid, the Drone also allows for visual representation of IF distortion but the placement of the grid directly on the c-arm unit provides the advantage of easy adjustment to anatomic landmarks.

We found significantly shorter operative times in the Drone group compared with the use of IF alone. In prospective randomized clinical studies by Kalteis, et al., cup abduction was evaluated after freehand placement as compared with the assistance of Computed Tomography (CT) -based and imageless navigation systems [10]. Navigation was found to improve cup abduction from 45% in the safe zone with freehand technique to 83% and 93% with imageless navigation and CT-based navigation, respectively. However, the operative time was increased by 8 minutes with imageless navigation and by 17 minutes with CT-based navigation. Another prospective randomized study by Lass, et al., also reported that navigation system was found to improve cup abduction angle and LLD with imageless navigation [25]. However, the additional time was needed for the navigation group by 18.1 minutes including pin placement. We found similar improvement in cup abduction and LLD with the use of the Drone. However, unlike the previous studies, we did not find increased operative time with the use of the Drone compared with IF alone. We do believe that the Drone has the potential to improve efficiency over IF alone for several reasons. First, it allows for an easy comparison of leg length and hip offset compared with the contralateral side and requires less fluoroscopic images to be obtained

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because the Drone provides a static frame of reference from image to image. In addition, it can be used to assess the direction of reaming and the cup abduction in real time while reaming and impacting the cup, respectively. This allows for accurate placement of the cup without having to go back and adjust for malposition seen with trailing images.

There are several limitations regarding our study. First, our study was retrospective without any randomization. All of the nongrid THAs were performed during an earlier period in this surgeon's experience with anterior supine THA. Increased surgeon experience may be a confounding factors when evaluating accuracy of component positioning and operative efficiency. However, we did not include the first 50 anterior supine THA performed by the surgeon, as a surgeon's first 50 anterior supine cases have been shown to reflect the learning curve related to complications [26].

A second limitation is that this study reflects a single experienced surgeon at an academic center. Use of the Drone by additional surgeons will be essential to support that these favorable results associated with use of the Drone are reproducible in the hands of surgeons with varying levels of experience and THA volume.

In conclusion, using the easily adjustable grid system, we have demonstrated an efficient method for consistent and accurate cup positioning and restoration of hip offset for anterior supine THA. With this system, there is no additional invasion and no additional operation time. We recommend the use of this simple and effective device to anterior supine THA.

Ethical Standards

The study was approved by the ethics committee. This study was performed in accordance with the ethical standards established in the 1964 Declaration of Helsinki and its amendments.

Declaration of Competing Interest

The authors declared no potential conflicts of interest with respect to the research, authorship and/or publication of this article.

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