**Use of Fluoroscopy is Equivocal to Conventional Methods in Reproducing Leg Length and Offset in Primary Total Hip Arthroplasty**

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**Introduction**

The optimum surgical approach to facilitate early recovery, increase component accuracy, restore anatomy, and maximize functional outcome in total hip arthroplasty is currently debated. In the last ten years, the use of intra-operative fluoroscopy has increased with the direct anterior approach and an orthopaedic table. Proponents of this method report greater accuracy in component positioning, reduced incidence of leg length inequality, and greater reproduction anatomic offset [1]. Other surgeons have reported the risks of fluoroscopic radiation, inability to directly measure leg lengths, and the technically demanding aspects of the procedure with a steep learning curve [2]. Leg length discrepancy after total hip arthroplasty is a well-described source of patient dissatisfaction and a frequent cause of litigation [3]. Many techniques to assess leg lengths and soft tissue tension have been described, including preoperative radiographic templating, the use of bony landmarks, calipers, and direct leg length measurement via palpation. All of these techniques do not require intra-operative imaging and are applicable to a patient in the lateral decubitus position with the leg free. Previous literature has compared the direct anterior approach with fluoroscopy to the mini posterolateral approach with regard to acetabular cup position and early functional outcome [4]; however, there is a paucity data regarding the accuracy of intra-operative fluoroscopy in reproducing leg length and offset. We hypothesize that the use of intra-operative fluoroscopy in the supine position provides greater control of leg length and offset in primary total hip arthroplasty when compared to a non-flouroscopic conventional techniques.

**Materials and Methods**

This comparative control study was performed on 140 consecutive primary total hip arthroplasty patients by two fellowship trained high volume hip arthroplasty surgeons (T.B) and (G.E.). IRB approval was obtained prior to any retrospective analysis. Patients were identified from the Emory Healthcare Total Joint database in a consecutive fashion beginning on 2/11/2009 and concluding 7/12/2010. A preliminary power analysis indicated and n= 70 for the fluoroscopic supine group, and an n= 70 for the non-fluoroscopic control group would be necessary to show statistical significance regarding leg length and offset. From this database 842 patients were identified. Patients were only included for operative indication of primary osteoarthritis. Exclusion criteria included diagnosis other than primary osteoarthritis, revision surgery, cemented implants, and contralateral hip surgery. Patients with fixed pelvic obliquity or spino-pelvic deformity were also excluded. This database with exclusion criteria produced 71 patients corresponding to senior surgeon (T.B.) and 71 patients corresponding to senior surgeon (G.E.). Retrospective review of the above cohorts included post-operative follow up of at least 12 months in all patients. The patient’s age, sex, BMI, surgical time, implants, preoperative leg length perception, postoperative leg length perception, radiographic preoperative leg length and offset, and postoperative leg length and offset were all recorded. The pre-operative goal for each total hip arthroplasty was reproduction of leg length and offset of the contralateral unaffected hip. This typically resulted in lengthening of the affected leg to match the unaffected longer limb in most cases. Any post-operative recorded radiographic data was then characterized as either having lengthened or shortened the operative extremity in comparison to the non-operative extremity. A similar method was used in recording post-operative offset accuracy.

Surgical Technique

Preoperative templating was performed in the fluoroscopic and non-fluoroscopic group. Pre-operative low anterior-posterior radiographs of the pelvis were obtained with the hips in neutral abduction and 15 degrees of internal rotation. Modified templates for the non-fluoroscopic group with the appropriate 20% reduced magnification were obtained and used. Templating was used to determine the height of the femoral neck cut, size of femoral stem, and size of acetabular component. Recreation of the femoral offset was also determined by preoperative templating. This was determined using the center of rotation of the femoral head and compared a line through the middle of the intramedullary canal.

In the fluoroscopic group, the senior author (T.B.) performed the direct anterior approach in the supine position on an orthopaedic table (Mizuho HanaR, Inc., Union City, CA). All patients received PinnacleR acetabular components and CorailR Femoral components (Depuy, Warsaw, IN).The contralateral leg was place in neutral rotation, abduction-adduction, and extension to serve as the radiographic control. Preoperative templating gave an initial determination of neck cut, offset, and femoral and acetabular component sizing. A 9 cm incision was made beginning 3 cm distal and 3 cm lateral to the ASIS. The incision was carried down to the tensor fascia lata and a subcutaneous wound protractor was placed. The tensor fascia was incised in line with the skin incision and the tensor muscle was mobilized laterally. Electrocautery was used for hemostasis of the lateral ascending femoral circumflex vessels. A rectus sparing capsulotomy allowed placement of retractors within the capsule to expose the femoral neck. The lesser trochanter was palpated and an in situ femoral neck cut was performed based on preoperative templating. The acetabulum was then sequentially reamed and the component was implanted under fluoroscopic guidance. The appropriate radiographic anteversion and cup abduction angles were confirmed with imaging. A hook was then placed in the potential space between gluteus maximus and the femur. The leg is the extended and externally rotated to facilitate exposure. The posterior hip capsule was released from the base of the trochanter and the femur was elevated to allow adequate exposure. The femur was sequentially broached until axial and rotational stability were obtained. A trial head was placed and the femoral head relocated. C-arm fluoroscopy was then position for an AP pelvis with the sacral tip 3 cm above the pubic symphysis, and confirmation of symmetric iliac wings and obturator foramen. Using c-arm fluoroscopy a digital horizontal line was created and juxtaposed along the inferior aspect of the obturator foramen. The line was extended laterally in both directions so it would overly the proximal femur. The relationship of this reference line to the lesser trochanters was utilized to assess leg lengths. A decision was then made regarding the appropriate femoral component, neck length, and head ball diameter. The final implants were then implanted and position confirmed with c-arm fluoroscopy.

The postoperative change in leg length and offset was measured using the preoperative and postoperative anteroposterior pelvic radiographs. Standardization between radiographs with regard to hip abduction and internal rotation was performed by the radiology technician. Only true anteroposterior radiographs with symmetric obturator foramen, iliac wings, and with the sacrum 3 cm superior to the pubic symphysis were deemed suitable for measurement. Leg length was measured using a horizontal line through the inferior most portion of the ischium. A second line 90o to the horizontal was drawn and the distance measured to the greater trochanter. Offset was measured using the lateral most aspect of the tear drop with a vertical line drawn there. A second vertical line was drawn on the lateral most aspect of the greater trochanter. A horizontal line was then made at 90o to the vertical lines and recorded as offset.

In the non-fluoroscopic group a posterolateral approach was performed by the senior author (G.E.) and all patients in this group received Stryker (Mahwah, NJ) AccoladeR femoral stems and TridentR acetabular components. The method of the posterolateral approach and intraoperative leg length assessment were performed as previously described by Maloney [5]. The patients were placed in the lateral decubitus position on a peg board. Before prepping and draping, the knees were symmetrically flexed and the relative position of the patellar tendons was noted. The up leg usually appeared slightly shorter than the down (non-operative leg) because of the adducted position. Approximately 9 cm incisions were used overlying the greater trochanter. Dissection was carried through the external rotators, and the piriformis and capsule were tagged. The capsule was opened from the superior neck to the edge of the acetabulum and anteriorly along the rim. A dislocation was performed and the preoperatively template femoral neck was used. Once the neck cut was the length of the femoral neck to the lesser trochanter was measured to confirm the appropriate level. The acetabulum was then prepared in the usual way using intraoperative landmarks and jigs to determine appropriate anteversion and cup abduction angles. After acetabular preparation and implantation, the femoral canal was broached until axial and rotational stability were obtained via press fit. Trial reduction was performed and combined anterversion assessed using Ranawat’s Test (the femoral neck and head are aligned coplanar to the acetabular mouth, the degree of internal rotation to produce a coplanar head and cup is the combined anteversion) [6]. Impingement of the femoral neck on the posterior acetabular implant was evaluated in in 0o of flexion and external rotation as well as anterior impingement in maximum flexion and internal rotation. Leg lengths were then assessed by palpating the patella tendon with the hips in slight symmetrical extension and knee flexion to 900. If the preoperative templating revealed the affected extremity to be short than an implant was chosen to lengthen the extremity by the pre-operatively measured leg length discrepancy which was determined by palpating the patellar tendons. The leg length was further checked by confirming the center of the femoral head to be at the level of the greater trochanter using a Myerding retractor as a right angle. Once leg length was determined intraoperatively the overall soft tissue tension was confirmed by the Ober test as well as schucking the operatively leg. Once these checks were done the final implants were placed and appropriate posterior capsular repair performed.

Statistical analysis was performed using Microsoft Excel and includes the mean leg length and offset difference and the standard deviation of offset and leg length for each group. The non-parametric Wilcoxon-Mann-Whitney and the parametric two sample *t*-test were used to determine which method reached statistical significance with regard to accuracy in restoring leg length and offset.

**Results**

The patient characteristics can be found in Table 1. There were 71 patients in each group with sixty total males (29 flouroscopic, 31 non-flouroscopic) and eighty-two females (33 flouroscopic, 40 non-flouroscopic) in the study. The average age in the study was 62.5 years (62.1 years flouroscopic and 63 years non-flouroscopic). The range of ages in the study was from 32 years old to 90 years old. The average BMI in the study was 28.6 kg/m2. The average “wheels in, wheels out,” O.R. time in the fluoroscopic cohort was 1 hour 47 minutes and the average operative time in the non-flouroscopic cohort was 1 hour 34 minutes. The most commonly used femoral head size average was 32mm with an average +1mm offset in the flouroscopic cohort and 36mm with an average +4 offset in the non-flouroscopic cohort. The most commonly used acetabular cup size in the flouroscopic cohort was 52mm whereas the most commonly used acetabular cup size in the non-flouroscopic cohort was 56mm. Ten patients in the flouroscopic cohort had elevated polyethylene liners (all +4.0mm) and two patients in the non-flouroscopic cohort had elevated polyethylene liners (one with a 3.5 elevated offset, another with a 10 degree posterior lip). In total, 86 patients in the study received polyethylene on cobalt-chrome bearing surfaces (27 in the fluoroscopic cohort, 59 in the non-fluoroscopic cohort). 52 patients received polyethylene on ceramic constructs (40 in the fluoroscopic cohort, 12 in the non-fluoroscopic cohort) and 4 patients received metal-on-metal constructs, all in the fluoroscopic cohort.

**Subjective Leg Length Discrepancy**

In total, 134 patients (94.4%) did not perceive a leg length discrepancy preoperatively, nor was one discovered on physical examination. The operative goal was recreation of limb length and offset of the unaffected limb. Eight patients (5.6%) perceived their affected leg to be either shorter or longer than their non-operative leg preoperatively, which was confirmed on physical exam (4 fluoroscopic cohort, 4 non-fluoroscopic cohort). Of the four patients in the fluoroscopic cohort, two reported a continued leg length discrepancy (2.8%). Of the four patients in the non-fluoroscopic cohort, one continued to experience a leg length discrepancy which was confirmed on physical exam postoperatively (1.4%). .

**Objective Leg Length and Offset**

Radiographic evaluation of the fluoroscopic cohort revealed that the operative leg was shortened by a mean -0.3mm and that the leg was under-offset by a mean of -1.7mm (Table 2). The maximum limb lengthening was 25.9 mm and he maximum shortening was -13.8.

Radiographic evaluation of the non-fluoroscopic cohort revealed that the operative leg was lengthened an average of 2mm and the leg was under-offset by -1.4 mm on average, (Table 2). The maximum limb lengthening was 30. 7 mm and the maximum shortening was 30.7 mm. Within the fluoroscopic cohort, 64% of patients had a final leg length restoration between -8.0 mm and +8.0 mm compared to 49% in the non-fluoroscopic group (p<??). With regard to offset, 78% of patients in the fluoroscopic group had recreation of offset between -8.0 mm to +8.0 mm compared to 73% in the non-fluoroscopic group (p<??) (Figure 2 and Table 4).

**Dislocations**

One patient (1.4%) in the non-fluoroscopic cohort experienced a postoperative dislocation which eventually required revision surgery 23 months after the initial surgery. The patient was revised from a 32+4 head to a 36+5 head with a polyethylene liner exchange without further instability. The patient has not experienced any dislocations since the revision surgery. The complication rate for the non-fluoroscopic group was 1.4%. There were no dislocations in the fluoroscopic group.

**Discussion**

The optimal approach to maximizing outcomes in primary total hip arthroplasty is currently debated. The surgical technique of intra-operative fluoroscopy via an anterior approach with a specialized orthopaedic table has been developed to improve component positioning, decrease leg length discrepancy, and improve clinical outcomes. Although a significant amount of literature has been dedicated to decreased dislocation rates, preservation of musculature, and expedited recovery; there is a little data comparing intra-operative fluoroscopy and non-fluoroscopic conventional methods in accurately re-establishing leg length and offset. In our study, we hypothesized that intra-operative fluoroscopy via a direct anterior approach is superior to non-fluoroscopic conventional methods in reproducing leg length and offset.

Intra-operative fluoroscopy with an anterior approach has been touted to have improved accuracy in component placement, leg length, and offset [1,3]. Other potential advantages including muscle sparing, quicker post-operative recovery, and lower dislocation rates [7]. Investigation into the muscle sparing nature of the approach was investigated by Unger et al [8] who used serum creatine kinase as on objective measurement of muscle damage and found higher serum CK levels in the posterolateral approach compared to the direct anterior approach. Nakata et al [4] in his comparative study reported on early functional outcome in the direct anterior approach with quicker time to perform single leg stance, earlier resolution of Trendelenberg gait, and faster walking velocity at 3 weeks. Similar results were found in favor of the direct anterior approach vs. the posterior approach at 6weeks and 12 weeks reported by Mayr et al [9]. In addition, Restrepo et al [10] reported that the discontinuation of postoperative hip precautions for total hip arthroplasties performed through anterior approaches did not influence early dislocation rates.

Opponents of the use of intra-operative fluoroscopy via the direct anterior approach state that there is a significant learning curve, increased frequency of complications, higher cost associated with orthopaedic table, and no difference in long term clinical outcomes. Furthermore the use of intra-operative fluoroscopy exposes the patient and health care providers to increased radiation [11]. Jewett et al [12] reported high complications rate with the direct anterior on an orthopaedic table reviewing 800 arthroplasties and reported 19 trochanteric fractures, 3 femoral perforations, and 37 with wound healing problems. Lombardi et al [2] defined his learning curve as 40 cases or about six months in a high volume arthroplasty center. Hungerford et al [13] has reported on lateral femoral cutaneous nerve injury citing a 14% incidence of neuropraxia and has been further discussed by Kim et al [14]. Matta et al [1] has cited a complication unique to using an orthopaedic table, reporting 3 ankle fractures in his series of 497. Furthermore, Leunig et al [15] reported that six months after total hip arthroplasty surgery, gait characteristics were comparable between subjects having received the direct anterior approach and the posterior approach.

Our study has several limitations including those associated with retrospective analysis including potential selection bias. The patients were not randomized into groups and were selected in a consecutive manor over a time period from 2009-2010. Another limitation and possible source of error is the radiographic determination of leg length and offset. Although the manner in which the radiographs were obtained is standardized, slight changes in abduction and internal and external rotation of the hip can affect the measured leg length and offset.

Our study confirms that intra-operative fluoroscopy via a direct anterior approach yields similar results in reproducing leg length and offset (p<.2298 and p<.4737) compared to the conventional non-fluoroscopic approach. The incidence of dislocation was very similar between groups with no dislocations in the in the fluoroscopic group and 1 (1.4%)in the non-fluoroscopic group. Although the outcomes did not reach statistical significance, there was a trend in favor of the fluoroscopic group having improved accuracy in reproducing leg length and offset with 64% of patients having a postoperative leg length discrepancy between -8.0 mm and + 8.0 mm vs. 49% in the non-fluoroscopic group. There was also a trend toward greater accuracy in reproducing offset in the fluoroscopic group with 78% of patients between -8.0 mm and +8.0mm vs. 73% in the non-fluoroscopic group. Interestingly, only one patient in the non-fluoroscopic group and no patients in the fluoroscopic group reported a subjective leg length discrepancy despite some outliers having leg length discrepancies as large as 30 mm.

This study shows that the use of intra-operative fluoroscopy is at least as accurate as conventional methods at reproducing leg length and offset, with a trend towards increased accuracy in the fluoroscopic group. Further study is needed in to refine intra-operative methods of reproducing leg length and offset to decrease outliers and improve long term patient outcomes.