Does Intraoperative Fluoroscopy Improve Component Positioning in Total Hip Arthroplasty?

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Abstract

Accurate placement of components is imperative for successful outcomes after total hip arthroplasty (THA). Although technology-assisted techniques offer the potential for greater accuracy in prosthesis positioning, the need for additional resources prevents their widespread use. The goal of this study was to compare primary THA procedures performed with and without intraoperative fluoroscopic guidance with regard to accuracy of prosthesis placement, operative time, and postoperative complications. The authors reviewed 341 consecutive cases (330 patients) undergoing primary THA at the authors’ institution from September 2007 to January 2010. Postoperative anteroposterior radiographs were used to measure acetabular inclination angle, leg length discrepancy, and femoral offset discrepancy. Operative time and postoperative complications related to implant positioning were recorded. Mean acetabular inclination angle, leg length discrepancy, and offset discrepancy for control vs study groups were 43.0° (range, 32.2°-61.4°) vs 43.8° (range, 29.0°-55.1°), 4.75 mm (range, 0-25) vs 4.24 mm (range, 0-27), and 8.47 mm (range, 0-9.7) vs 7.70 mm (range, 0-31), respectively. Complication rates were not significantly different between the control (8.1%) and study (5.3%) groups. Mean operative time was significantly higher in the study group compared with the control group (59.8 vs 52.8 minutes) (*P*<.0001). The findings showed that intraoperative fluoroscopy may not improve prosthesis accuracy or decrease postoperative complication rates compared with a freehand technique. Because of significantly increased operative time and cost associated with fluoroscopic guidance, the authors discourage the use of this technique in uncomplicated primary THA performed at high-volume arthroplasty institutions. [Orthopedics. 2015; 38(1):e1-e6.]
Accurate placement of components is important for successful outcome after total hip arthroplasty (THA), yet it remains one of the greatest challenges during surgery. Dislocation and subluxation, the most frequent early complications of THA, have been well correlated with implant malpositioning. Furthermore, malposition of the acetabular component during THA can increase the risk of impingement, reduce postoperative range of motion, and accelerate prosthetic wear rates.

To ensure accurate placement of acetabular components, precise determination of cup anteversion and inclination angle is required. Studies have suggested that alignment of the acetabular cup within the safe zone (40°±10° inclination; 15°±10° anteversion), as described by Lewinnek et al., may not be achieved with conventional surgical techniques, even by experienced surgeons. In addition to confirming correct acetabular cup placement, restoration of leg length and femoral offset is equally important for successful patient outcomes after THA. A variety of common postoperative complications, including pain, instability, stiffness, and even neuropathy, have been associated with leg length discrepancy and inability to restore femoral offset.

Conventional preoperative templating has long been the gold standard in helping to plan prosthetic component placement; however, intraoperatively, this method is completely dependent on a freehand technique. To improve accuracy with prosthetic wear rates.

The primary goal of this study was to determine whether the use of intraoperative fluoroscopy in primary THA results in greater accuracy of prosthesis placement compared with procedures done without fluoroscopic guidance. The authors used radiographic measurements of cup orientation, leg length, and femoral offset to assess this outcome. The secondary goals of this study were to compare rates of early postoperative complications and total operative time between primary THA procedures performed with and without fluoroscopy.

### MATERIALS AND METHODS

The authors used their institutional electronic database to retrospectively review all patients who underwent primary THA at a single institution from September 2007 to January 2010. Institutional review board approval was obtained before initiation of the study.

Patients who underwent revision arthroplasty were excluded. The authors’ institution initiated routine use of intraoperative fluoroscopy in August 2008. Patients treated from August 2008 to December 2008 were excluded from the study to allow for an adjustment period during which surgeons performed 50 procedures and learned to become proficient with the fluoroscopically guided technique.

From September 2007 to August 2008, 160 consecutive patients (163 procedures) underwent unilateral primary THA without fluoroscopic guidance (control group). From January 2009 to January 2010, 170 consecutive patients (178 procedures) underwent the same procedure with intraoperative fluoroscopic guidance (study group). Of these cases, 341 (in 330 patients) met the inclusion criteria. Two senior arthroplasty-trained surgeons (F.O. and A.O.) performed all procedures. All patients received spinal anesthesia and were operated on in the supine position using the same direct lateral approach (Hardinge). The control cohort included 69 men and 91 women, with a mean age of 64.6 years and a mean body mass index of 29.6 kg/m².

The study group included 83 men and 87 women, with a mean age of 63.9 years and a mean body mass index of 28.9 kg/m². No significant differences were found in demographic features between the 2 groups (Table 1). All patients included in the study had moderate to severe osteoarthritis without significant leg length discrepancy preoperatively. None of the patients had severe developmental dysplasia (beyond Crowe I). Most of the cohort had no dysplasia.

All surgical procedures in the study group were performed on a radiolucent table to allow for intraoperative fluoroscopic imaging. During the procedure, fluoroscopy was used on 3 separate occasions. During implantation of the acetabular component, imaging was used to access cup inclination, anteversion, and cup position relative to the teardrop and medial wall. Care was taken to ensure that the pelvic image was a true anteroposterior view.

Fluoroscopy was then used to assess femoral sizing after broaching of the femoral canal was completed (the broach was left in situ to gauge fit and fill of the

### Table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Radiograph</th>
<th>No Radiograph</th>
<th>P</th>
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<tbody>
<tr>
<td>Male, %</td>
<td>48.8</td>
<td>43.1</td>
<td>.32</td>
</tr>
<tr>
<td>Age, mean (range), y</td>
<td>63.9 (36-88)</td>
<td>64.6 (44-88)</td>
<td>.54</td>
</tr>
<tr>
<td>Body mass index, mean, kg/m²</td>
<td>28.9</td>
<td>29.6</td>
<td>.15</td>
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final implant). The proximal femur was assessed in multiple planes by rotating the limb internally and externally to obtain an accurate assessment of implant fit and position. Finally, fluoroscopy was used to assess femoral offset and leg length. Offset was compared with the ipsilateral limb, and leg length was measured by a line through the lesser trochanters, parallel to the inferior pubic rami.

To assess the effect of intraoperative fluoroscopy on component positioning, radiographic parameters of acetabular cup inclination angle, leg length discrepancy, and femoral offset were measured electronically. All measurements were made from postoperative weight-bearing anteroposterior pelvis radiographs using the authors’ institution’s picture archiving and communication system software (SECTRA PACS IDS7; Sectra Medical Systems, Linköping, Sweden). Two independent observers each conducted all measurements at 2 time points with a 2-week interval between measurements. All radiographs assessed were taken at initial postoperative follow-up office visits between 1 and 3 months after surgery.

Acetabular cup inclination angle was measured as the acute angle between 1 horizontal line across the most inferior point on the ischial tuberosities and a second line connecting the 2 edges of the acetabular component (Figure 1). The safe zone for cup inclination angle was defined as 40°±10°, according to the original description by Lewinnek et al.1 Leg length was determined by drawing the same horizontal line through the inferior aspect of the ischial tuberosities and measuring the length of a vertical line from the most prominent tip of the lesser trochanter of each leg to the horizontal line (Figure 2). Leg length discrepancy was calculated as the absolute difference in these distances between the legs. Femoral offset was determined by drawing a vertical line through the pubic symphysis and measuring the length of a horizontal perpendicular line from the tip of the lesser trochanter of each leg to the vertical line (Figure 3). Discrepancy in femoral offset between the legs was then calculated.

A random effects model was used to determine the effect of several variables, including age, sex, body mass index, intraobserver variation, and use of intraoperative fluoroscopy on the 3 radiographic parameters of interest. The model was set up to examine correlation of the variables to the accuracy of cup inclination within the safe zone (40°) and minimization of leg length discrepancy and offset discrepancy (0-mm difference between limbs). With a thorough review of electronic medical records, all early postoperative surgical complications were recorded. Complications were included if they occurred within 2 years of the index arthroplasty. Total complications were recorded. Complications were assessed in multiple planes by rotating the final implant. The proximal femur was placed outside the safe zone; however, this difference was not statistically significant (P=.789). The random effects regression model showed no significant correlation between the use of fluoroscopy and the accuracy of cup placement (Table 2).

Mean±SD leg length discrepancies for the control and study groups were 4.75±5.20 mm (range, 0-25) and 4.24±4.69 mm (range, 0-27), respectively (P=.17). Additionally, average offset discrepancy in the control and study groups were 8.47±8.55 mm (range, 0-9.7) and 7.70±5.48 mm (range, 0-31), respectively (P=.10). Again, the random effects regression model showed no statistically significant correlation between the use of fluoroscopy and minimization of leg length discrepancy or offset discrepancy between limbs (Table 2).

Surgical complications occurred in both groups; however, there was no statistically significant difference between the complications (Table 3). Other com-
Complications included excessive heterotopic ossification (1), subsidence (1), fracture nonunion (1), aseptic loosening (3), polyethylene wear (1), and iliopsoas tendon impingement (1). No patients in either cohort had postoperative instability or dislocation.

Mean±SD operative time from incision to skin closure was 52.8±10.5 minutes in the control group and 59.8±12.9 minutes in the fluoroscopy group (P<.0001). Multivariate analysis showed that fluoroscopy use (P<.001) and patient age (P=.040) were significantly associated with longer operating room time.

**Discussion**

Successful outcome after THA relies on accurate positioning of the prosthetic components. Although radiographic templating has been the traditional method of ensuring proper implant size and positioning, technology-assisted methods to confirm prosthesis placement intraoperatively are being increasingly used in arthroplasty practice. However, the effectiveness of these methods, including intraoperative fluoroscopy, has not been definitively proven, and drawbacks, such as increased cost, longer operating room time, and unnecessary radiation exposure, have limited their use. This study examined the accuracy of component positioning, postsurgical complication rates, and operative time for primary THA procedures performed using fluoroscopic guidance compared with surgery using the conventional freehand technique.

With regard to acetabular cup placement, extensive literature has shown that accurate alignment of components reduces mechanical wear, improves range of motion, and lowers the risk of dislocation, all of which may lead to the need for reoperation. The authors’ study showed that more cups were outside of the safe zone of 40°±10° in the fluoroscopy study group than in the freehand control group. However, the difference was not statistically significant (17.5% vs 7.8%; P=.789). Although few studies have been published on the use of fluoroscopy during THA for comparison, Gililland et al retrospectively evaluated 99 patients and concluded that intraoperative fluoroscopic grid guidance significantly improved component positioning compared with standard fluoroscopic guidance. With standard fluoroscopic guidance, 17% of acetabular cups were positioned outside the safe zone, which is comparable to their result of 17.5%. This study, however, was a small retrospective cohort and did not directly compare the results of fluoroscopic guidance and the freehand technique.

Other intraoperative guidance techniques besides fluoroscopy have led to disappointing results for the accuracy of cup placement within the safe zone described by Lewinnek et al. With the use of a computed tomography (CT) scan-based navigation system to control the position of prostheses intraoperatively, DiGioia et al observed that 78% of acetabular components were oriented outside of the safe zone. These results were confirmed by others who reported similarly high rates of cup malposition. Kalteis et al reported a rate of 50% and Wines and McNicol reported a rate of 45% with image-free navigation and CT navigation, respectively. Several authors, including Kennedy et al and McGrory et al, showed that accurate and increased restoration of initial femoral offset improves stability, abductor strength, and range of motion. In addition to finding no difference in acetabular cup placement, the current study showed no significant statistical or clinical difference in the radiographic parameters of leg length discrepancy and femoral offset.

### Table 2

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cup Placement (P)</th>
<th>Leg Length Discrepancy (P)</th>
<th>Femoral Offset (P)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>0.003 (.65)</td>
<td>0.018 (.29)</td>
<td>-0.045 (.15)</td>
</tr>
<tr>
<td>Sex, male</td>
<td>-0.953 (.01)</td>
<td>0.680 (.16)</td>
<td>1.488 (.07)</td>
</tr>
<tr>
<td>Body mass index</td>
<td>-0.006 (.84)</td>
<td>0.016 (.70)</td>
<td>-0.086 (.21)</td>
</tr>
<tr>
<td>Observer 1 vs observer 2</td>
<td>0.433 (&lt;.001)</td>
<td>-0.236 (.47)</td>
<td>1.021 (.10)</td>
</tr>
<tr>
<td>Intraoperative fluoroscopy</td>
<td>0.096 (.78)</td>
<td>-0.66 (.17)</td>
<td>-1.545 (.06)</td>
</tr>
</tbody>
</table>

### Table 3

<table>
<thead>
<tr>
<th>Complication</th>
<th>Intraoperative Fluoroscopy (No./Total No.)</th>
<th>No Intraoperative Fluoroscopy (No./Total No.)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Periprosthetic joint infection</td>
<td>1.2% (2/170)</td>
<td>0.6% (1/160)</td>
<td>1.00</td>
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<tr>
<td>Leg length discrepancy</td>
<td>1.8% (3/170)</td>
<td>2.5% (4/160)</td>
<td>.72</td>
</tr>
<tr>
<td>Iliopsoas tendonitis</td>
<td>1.2% (2/170)</td>
<td>1.3% (2/160)</td>
<td>.98</td>
</tr>
<tr>
<td>Other</td>
<td>1.2% (2/170)</td>
<td>3.8% (6/160)</td>
<td>.16</td>
</tr>
<tr>
<td>Overall complication rate</td>
<td>5.3% (9/170)</td>
<td>8.1% (13/160)</td>
<td>.37</td>
</tr>
</tbody>
</table>
discrepancy between patients who underwent THA with and without fluoroscopic guidance. Further, the authors found no significant difference in component positioning related to early complications after THA between the 2 groups. These results show that intraoperative fluoroscopy may not be warranted in primary THA because it achieves neither better radiographic outcomes nor better clinical outcomes.

Despite the lack of consistently promising outcomes with a variety of intraoperative imaging tools, some studies conducted at lower-volume institutions showed that the use of navigation and guidance during surgery can lead to improvements for cup and component positioning.\textsuperscript{5,19,22} Although the authors did not use a comparison low-volume institution for analysis, their study findings may be affected by the experience of high-volume arthroplasty surgeons’ use of the free-hand technique. To differentiate between high-volume and low-volume institutions, the specific criteria of Katz et al\textsuperscript{23,24} that objectively distinguished between low-volume and high-volume institutions for total joint arthroplasty were used. Further substantiating the idea that institutional volume contributes to the accuracy of prosthesis placement, Callanan et al\textsuperscript{25} studied 1823 primary THA procedures and found a two-fold increased incidence of cup malpositioning in low-volume vs high-volume institutions.

Although the risks of THA failure as a result of component malpositioning are well noted, intraoperative guidance techniques, including fluoroscopy, carry their own dangers. The current study showed that operative time with fluoroscopic guidance was significantly longer than that without the use of intraoperative fluoroscopy (mean, 59.8 minutes vs 52.8 minutes, \(P<.001\)). This 7-minute increase in average operative time per case translates into significant health care expenditures. At the authors’ institution, the cost of operating room time is $538.87/min. Other reports confirmed that the use of intraoperative fluoroscopy increases operative time, procedural cost, and unnecessary radiation exposure.\textsuperscript{26,27} Although fluoroscopy may expose the surgeon and patient to less radiation than other guidance tools, the long-term effects of low-dose radiation are unknown.\textsuperscript{28} Finally, intraoperative fluoroscopic-based guidance increases the need for resources, individuals, and time in the operating room.\textsuperscript{27}

The authors’ study is limited by its retrospective design and its use of a single high-volume joint arthroplasty center where a limited number of surgeons performed the procedures. Also, the use of plain radiographs rather than CT scans to measure prosthesis positioning may have led to slight variations based on patient pelvic tilt and rotation. Furthermore, although the current study analyzed fluoroscopy only in uncomplicated cases of primary THA, the authors recognize that navigation may help to ensure accurate component placement in more difficult cases, including patients with congenital hip dysplasia, posttraumatic arthritis, existing hardware, and morbid obesity. A strength of the study is standardization of THA procedures performed in both the study and control groups with regard to patient positioning, surgical approach and technique, and operating surgeon. This standardization allowed for valid comparison of primary and secondary outcomes between patients who underwent THA with and without fluoroscopic guidance.

**CONCLUSION**

The current study at a high-volume arthroplasty center found that fluoroscopic guidance had no significant advantage in accurately restoring femoral offset, minimizing leg length discrepancy, or improving cup positioning compared with traditional freehand operative techniques. Significant costs were associated with fluoroscopy use, including increased operative time, without any decrease in postoperative complication rates related to component positioning. Attention should be focused on the results of a prospective randomized trial comparing traditional techniques with the use of fluoroscopic guidance. Given these findings, it seems as though the associated risks and costs of intraoperative fluoroscopy outweigh the potential benefits; therefore, the authors suggest that technology-assisted techniques for uncomplicated primary THA may be unnecessary.

**REFERENCES**

11. Paratte S, Argenson JN. Validation and


