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Accuracy of Component Positioning in 1980 Total Hip Arthroplasties: A Comparative Analysis by Surgical Technique and Mode of Guidance

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ABSTRACT

The purpose of this multi-surgeon study was to assess and compare the accuracy of acetabular component placement, leg length discrepancy (LLD), and global offset difference (GOD) between six different surgical techniques and modes of guidance in total hip arthroplasty (THA). A total of 1980 THAs met inclusion criteria. Robotic- and navigation-guided techniques were more consistent than other techniques in placing the acetabular cup into Lewinnek's safe zone ($P<0.005$ and $P<0.05$, respectively). Robotic-guided surgery was more consistent than other techniques in placing the acetabular component within Callanan's safe zone ($P<0.005$). No statistically significant differences were found between groups in the frequency of patients with excessive LLD. Clinically significant differences between groups were not found in the frequency of patients with excessive GOD. Level of Evidence: IV

Performing a functional hip arthroplasty is challenging, as it depends on the surgical technique used, method of guidance, and patient characteristics [1–9]. Accurate restoration of hip biomechanics in THA requires proper implantation of the cup, as well as appropriate leg length (LL) and global offset (GO) in relation to the patient's parameters [10–12]. Improper component position is associated with higher rates of complications, such as accelerated weight-bearing surface wear [1–13], hip dislocations [3–5,14–16], and LLD [17–19], which may resulting in hip instability [10,20].

Many methods and guidelines have been used to gauge the accuracy of component positioning. Some of the most common, although not without critics, are the safe zones described by Callanan et al [4] and Lewinnek et al [5]. The term "safe-zone" was introduced by Lewinnek et al in 1978 based on the clinical observation that less dislocation occurred when the acetabular cup was placed within 30° to 50° of abduction and 5° to 25° of anteversion [5].

Dislocation is the primary indication reported for 22.5% of revision THAs and 33% of acetabular revisions [21]. LLD is one of the most common causes of medical litigation in orthopedic surgery in the United States [22–24] and may contribute to back pain [25–27], limping [12,28], and dislocation [3–6,14–16,28]. Furthermore, failure to restore GO may contribute to gait disorders, increased wear, and pain [1,2,13,29,30].

Multiple guidance modalities have been developed to improve the accuracy and consistency of component placement in THA, and multiple surgical techniques have been successfully employed [6,31–40]. Guidance modalities include robotic guidance, navigation guidance and intraoperative fluoroscopy. All have been developed with the goal of improving the acetabular component position, as well as maintaining adequate LL and GO [6,31–40]. The purpose of this multi-surgeon study was to assess the accuracy of acetabular component placement, LLD, and GOD in THA and to perform a comparative analysis by surgical approach and mode of guidance. As the study methodology was a retrospective review of acetabular cup placement, our study does not provide an assessment of patient-reported outcomes.

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to http://dx.doi.org/10.1016/j.arth.2015.06.059.

All nine authors were vital for this manuscript as this was a collaborative effort of several surgeons. Dr. Benjamin Domb headed the study at his institute and was response for both writing and revision, as well as the initial study idea. Dr. Carlos Suarez-Ahedo was vital for preparation of the manuscript, analysis of the data, and revision of the manuscript. Dr. Redmond assisted in creating the idea and writing the manuscript as well as revision. Dr. Louis, Dr. Alden, Dr. Daley, and Dr. LaReau were involved with the idea for the manuscript, data collection (as they performed many of the surgeries in the paper) and for revision of the final manuscript. Ms. Petrakos and Mr. Gui did extensive data analysis and data collection, as well as revision of the manuscript. All authors played a major role in this paper.

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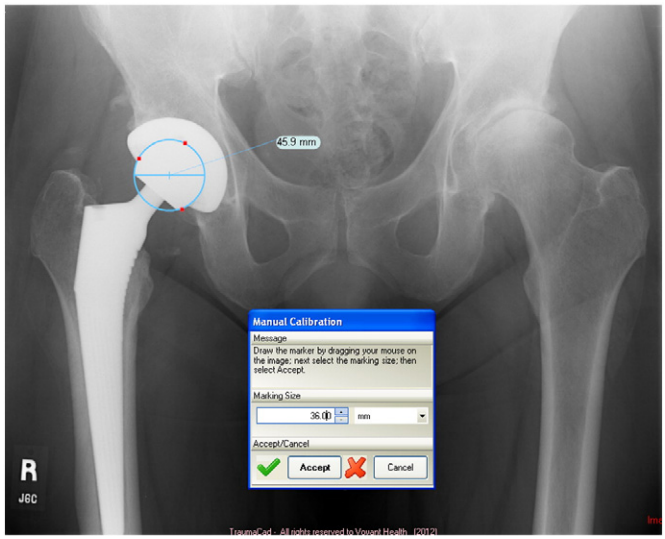

Fig. 1. Calibration of the AP pelvis view radiographs.

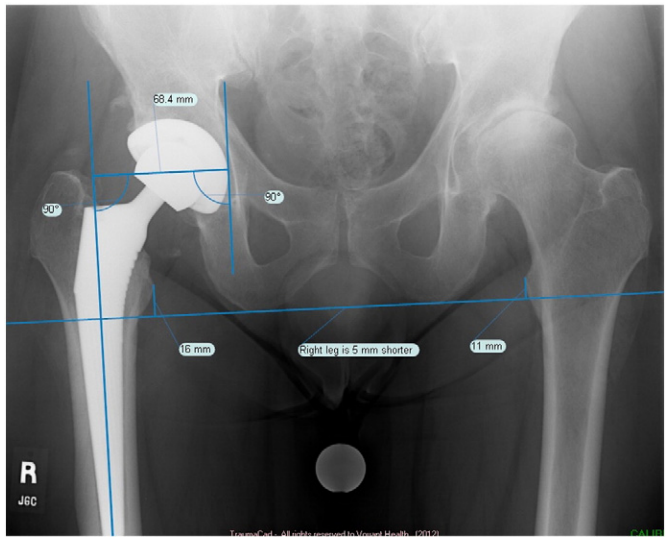

Fig. 3. Leg length discrepancy (LLD) and global offset (GO) measurements.

Materials and Methods

Between June 2008 and April 2014, THAs were performed by six surgeons at a single institution. The six modes of guidance were conventional posterior THA (CP-THA), intraoperative x-ray guided posterior THA (XP-THA), fluoroscopy-guided anterior THA (FA-THA), navigation-guided anterior THA (NA-THA), robotic-guided posterior THA (RP-THA), and robotic-guided anterior THA (RA-THA). Radiographic images from all patients were retrospectively measured using the TraumaCad® software for cup placement, LLD, and GOD. Cases with inadequate radiographic images were excluded from the study cohort. For a subset of one hundred cases, radiographic measurements were performed by two different blinded observers. Intraobserver and interobserver correlation and reliability were calculated ($r > 0.82$ and $P < 0.001$).

Patients were excluded if appropriately centered anteroposterior radiographic images of the pelvis were not of adequate quality. Specifically, we excluded patients whose post-operative AP pelvis radiographs were rotated, indicated a tilted pelvis, or where at least one lesser trochanter was hard to define.

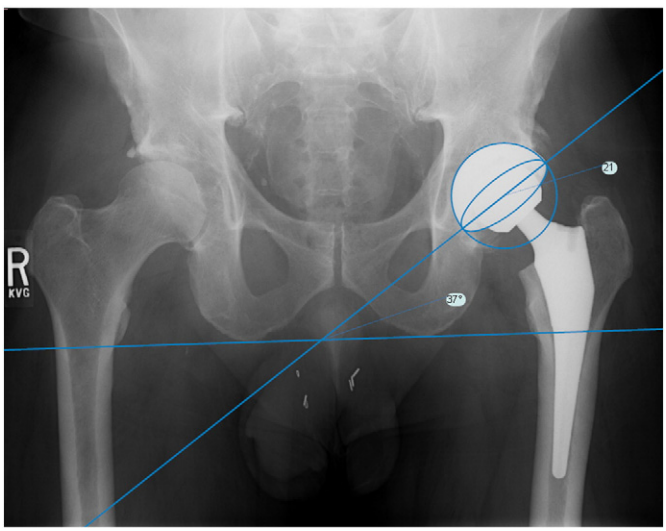

Fig. 2. Cup anteversion and inclination measurements.

Radiographic Measurements

The Trauma-Cad™ software (build number 2.2.535.0, Voyant Health®, 2012) was used to perform the radiographic measurements including acetabular cup inclination and version, LLD and GO on the AP view of the pelvis. All radiographs were calibrated using this software before performing any measurements. All patients underwent preoperative radiographs to plan component position and sizes, level of the neck cut, and amount of LL and GO. The use of this software in measuring parameters on radiographs has been validated in several studies [41–43] (Fig. 1).

For acetabular cup version and inclination, the software created a horizontal reference line along the inferior aspect of the pelvic inter-ischial line. The system also created a complex of lines comprising a sphere, a concentric ellipse, and a bisecting line that bisected the ellipse along its long axis. The lines that make up this complex could be manipulated individually, but their relation to each other remained unchanged. The sphere was then manipulated to fit the circumference of the acetabular cup, and the ellipse to fit the opening of the cup. The relative ratio of the axes of the ellipse gave the version angle of the cup. The angle formed by the bisecting line and the inter-ischial reference line shows the inclination angle of the cup (Fig. 2).

For LLD measurements, the program created a complex of three lines: one horizontal line and two vertical lines each perpendicular to that horizontal line. All three lines were connected in a way to ensure

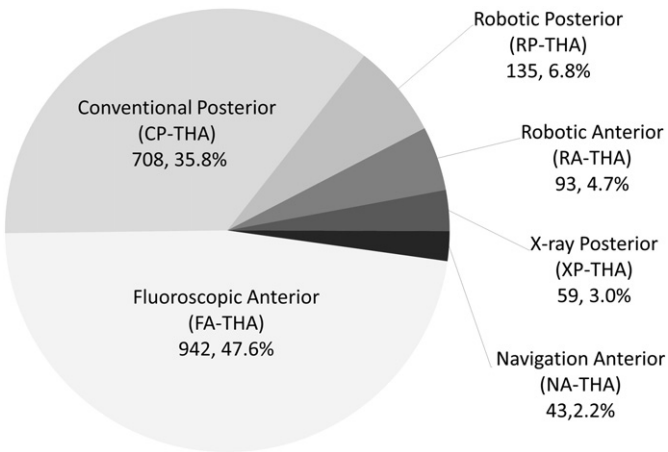

Fig. 4. Number of patients in each treatment group.