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Accuracy of Fluoroscopic Guided Acetabular Component Positioning During Direct Anterior Total Hip Arthroplasty

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ABSTRACT

Acetabular component malposition contributes to increased complications and early revision. Supine positioning during direct anterior approach (DAA) THA facilitates the use of fluoroscopy to improve component positioning. This study evaluated the accuracy of acetabular component orientation using intraoperative fluoroscopy in DAA THA. A total of 780 surgeries by two surgeons were retrospectively reviewed over a 3-year period. Ranges for abduction (30°–50°) and version (5°–250) were employed. Overall, 92% fell within the targeted abduction range, 93% fell within the targeted anteversion range, and 88% met both criteria. The accuracy of component positioning for combined abduction and anteversion improved yearly (79.2%, 2011; 90.9%, 2012; and 95.6%, 2013). Fluoroscopy in DAA THA is a useful tool to improve acetabular component orientation, though a learning curve exists with its interpretation.

Component positioning influences the function and durability of total hip arthroplasty (THA) [1]. Acetabular component malposition contributes to increased dislocation risk, impingement, accelerated polyethylene wear, and early revision [2–5]. Dislocation and aseptic loosening after THA remain leading causes for revision surgery [6].

Numerous studies have been performed to evaluate the optimal position of the acetabular component in THA [4,7–9]. Lewinnek et al [4] defined target ranges for abduction and version angles for acetabular component positioning (30°–50° and 5°–25° respectively). These safe zones have been described under ideal circumstances and do not reflect the variability and dynamic nature of the true pelvic orientation, which includes the anatomic pelvic plane and pelvic tilt. This orientation is particular to each patient. The final acetabular component orientation is determined not only by the intraoperative positioning but also by the functional pelvic tilt and sagittal plane balance. Many technologies have been employed to improve component positioning during THA. Intraoperative navigation systems utilize anatomic landmarks of the pelvis to define the anterior pelvic plane and direct cup positioning accordingly, however many of these have been found to be inaccurate [10].

Although bony anatomy can be recognized, intraoperative patient positioning also affects our ability to accurately estimate pelvic orientation. Patients in the lateral position present disadvantages with regards to pelvic orientation. McCollum and Gray [9] reported that patient positioning in the lateral decubitus position led to high variability in pelvic orientation that could lead to malposition of the acetabular component.

In determining the true orientation of the acetabulum, the surgeon must consider the functional pelvic tilt. Recreation of functional pelvic orientation during patient positioning facilitates accurate patient-specific cup placement. The functional pelvic tilt can be recreated intraoperatively by simulating the preoperative standing AP radiograph. Attention is paid to the position of the coccyx relative to the pubic symphysis and the appearance of the obturator foramen on both the preoperative film and intraoperative scout film to neutralize pelvic rotation and tilt (Fig. 1).

The direct anterior approach (DAA) for THA is performed with the patient in the supine position, which facilitates the use of intraoperative C-arm fluoroscopy to assist in component positioning [11–14]. Furthermore, it allows the surgeon to prepare and place the component based on the functional pelvic orientation, which is recreated and viewed with the C-arm. Recreation of preoperative patient-specific pelvic tilt and neutral rotation with the use of fluoroscopy during the surgical procedure enhances accurate component orientation [10,15,16]. Pelvic rotation can change during the course of the procedure and inconsistency may alter the interpretation of intraoperative radiographs. Failure to recognize changes in rotation or tilt during the surgical procedure can affect true acetabular version during component placement (Fig. 2).

While in DAA THA the stability of the supine position of the patient is not guaranteed, fluoroscopy can be adjusted accordingly throughout the surgical procedure in order to maintain consistency in the preparation

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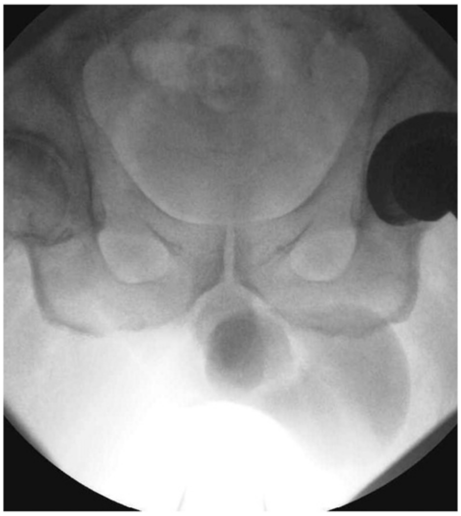

Fig. 1. Recreation of neutral pelvic image using fluoroscopy. A neutral AP image obtained by recreating symmetrical appearance of the obturator foramen and alignment of the coccyx with the pubic symphysis.

and placement of the acetabular component. Numerous studies have examined the early complication rate of this approach [11,12]. There are reports of longer surgical times, increased blood loss, and higher fracture rates during a surgeon's first experiences [11]. In addition, reports regarding the interpretation of intraoperative fluoroscopy demonstrate a likewise learning curve [14]. Longer operative fluoroscopy times, increased variation in radiographic cup abduction and anteversion, and more common radiographic leg length discrepancy were noted in the first 100 cases [14].

We performed a retrospective radiographic analysis to evaluate the accuracy of acetabular component orientation using intraoperative fluoroscopy in DAA THA. We hypothesized that the use of intraoperative fluoroscopy would be a useful tool to improve acetabular component positioning.

Methods

After obtaining institutional review board approval and using our prospectively constructed database, we identified 780 consecutive THA surgeries performed via a direct anterior approach by two fellowship-trained surgeons from March 2010 through December 2013. Both surgeons were 3 years removed from their fellowships with no formal training in direct anterior approach during residency or fellowship. The database was used to obtain the date of operation, performing surgeon, and laterality. Radiographic measurements were conducted using the first postoperative anteroposterior in office standing pelvis and hip radiographs. Component positioning was measured using specialized software following the method previously described by Barrack et al [17]. Radiographic inclination was defined as the angle between the longitudinal axis of the body and the acetabular axis in the coronal plane. Radiographic anteversion was defined as the angle between the acetabular axis and the coronal plane and was measured as the angle between the face of the cup and the transverse axis. Acetabular component anteversion was calculated from the relative size of the major and minor diameters of the ellipse (Fig. 1). A single author interpreted all radiographs. Based on the technique described previously by Gross et al [18], to ensure reproducibility, the authors measured the first 50 radiographs in the series at random three separate times and found no statistical significant difference in those measurements. Analysis of those measurements determined little variation in the data and confirmed reproducible calculation of the minor and major axes. The remaining 730 radiographs were measured a single time. Target ranges for abduction and version angles were defined (30°–50° and 5°–25° respectively) according to the "safe zone" established by Lewinnek et al [4].

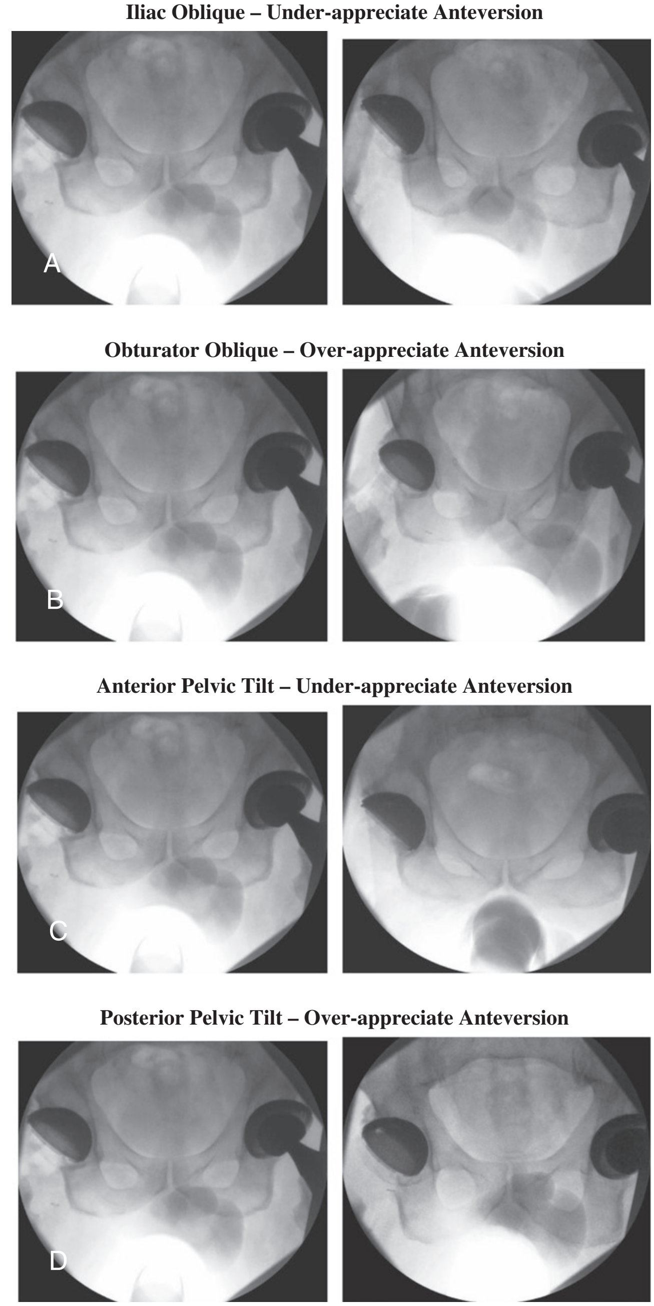

Fig. 2. Changes in component appearance due to alterations in pelvic position. (A) Iliac oblique—under-appreciate anteversion. (B) Obturator oblique—over-appreciate anteversion. (C) Anterior pelvic tilt—under-appreciate anteversion. (D) Posterior pelvic tilt—over-appreciate anteversion.

Results

The four-year study period began March 2010 and culminated in December 2013. During this collection range, 780 primary DAA THA surgeries were performed. For the 780 DAA THAs, the mean inclination angle was 37.6° and the mean anteversion angle was 18.7°. Overall, 718 (92.1%) fell within the targeted abduction range, 723 (93%) fell within the targeted anteversion range, and 698 (89.5%) simultaneously met