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Original Article

Acetabular Placement Accuracy With the Direct Anterior Approach Freehand Technique

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ABSTRACT

Background: Acetabular cup placement in total hip arthroplasty (THA) has been recognized as an important factor in operative success, and accurate cup placement has been the impetus for novel medical technologies.

Methods: This article examines the cup placement in 955 THAs using a freehand Direct Anterior Approach on a standard operating table. Acetabular anteversion and inclination were determined using the circle theorem. Measurements were divided into safe zone placement determined by Callanan et al as 5°-25° for anteversion and 30°-45° for inclination, as well as by Lewinnek et al as 5°-25° for anteversion and 30°-50° for inclination. Dislocation rate was determined and correlated to safe zone placement.

Results: Although technology has advanced for cup placement, this investigation shows that a freehand technique demonstrates 0.31% dislocation after THA with an accuracy of 85% for the Lewinnek safe zone and 61% for Callanan, potentially because of the sparing of the posterior hip capsule.

Conclusion: The direct anterior approach to the hip on a regular operating table is safe and reliable. Our results demonstrate improvement in cup positioning compared with other freehand techniques. Surgeon awareness and control of the position of the pelvis within space optimizes acetabular component accuracy and precision without the need for special equipment, such as intraoperative fluoroscopy.

Over the next 2 decades, a projected 572,000 primary total hip arthroplasties (THAs) are expected to be performed [1]. This growing demand for hip arthroplasty is occurring at a tumultuous time in health care, where surgical outcomes are measured with regard to cost-effectiveness, patient satisfaction, length of stay, and rate of complications. Nevertheless, the principles of a successful primary THA remain unchanged: symptom relief, stability, longevity, and functional range of motion. Although improvements in materials have increased the durability of the primary THA, obtaining stability and range of motion remain the responsibility of the surgeon. Alongside prosthetic joint infection, hip instability and dislocation remains a predominant cause for early (within 3 months) revision [2]. Although soft-tissue tensioning, femoral component position, and patient factors can affect stability, one of the most studied factors is acetabular component position.

In 1978, Lewinnek et al [3] defined the safe zone for acetabular component positioning as 5°-25° of anteversion and 30°-50° of abduction. Cup placement outside these parameters has been associated with an increased risk of dislocation. Others have corroborated these findings [4–6]. In addition to instability, acetabular component malposition can result in the following: polyethylene liner fracture, accelerated wear rates, pelvic osteolysis, impingement, limb length discrepancy, and diminished range of motion [7–10]. As such, the desire for precise and accurate cup placement has been the impetus for various novel technologies, such as fluoroscopic guidance, computer navigation, patient-specific instrumentation, and robotics [1,11,12]. Although these technologies have been shown to improve accuracy and precision (less variance) for acetabular component placement, the cost, radiation exposure, need for well-trained operating room staff, and setup time remain significant concerns [13,14].

The effect of surgical approach on freehand acetabular component placement has been studied. The term “freehand” used here

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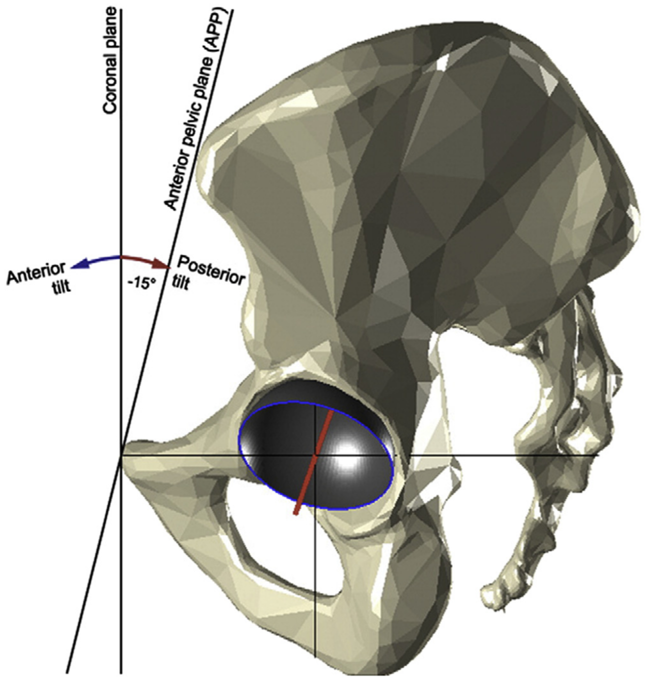

Fig. 1. The surgeon adjusts the pelvic position using the rectangular sacral bump to bring the anterior pelvic plane collinear with the coronal plane. This aspect of the direct anterior approach using a regular table facilitates surgeon awareness of the position of the pelvis in space and therefore precise and accurate acetabular cup placement [15].

indicates that surgical placement of the acetabular cup is accomplished without a specialized operating table or the use of image-guidance techniques. We believe that performing the approach on a standard operating table allows the surgeon to place the pelvis in a known position in space and with respect to the coronal plane. This investigation seeks to determine if acetabular component placement accomplished using the direct anterior approach on a standard operating table without fluoroscopy can generate a comparable accuracy and outcome on the basis of dislocation to those techniques using a specialized operating table and image guidance.

Methods

Using the hospital medical records database, 992 THAs performed by a single surgeon (ASU) from January 2010 through May 2016 were identified. All surgeries were performed on a regular operating table with standard instruments using the direct anterior approach. Cementless acetabular and femoral components were used for all patients, unless otherwise indicated for specific patients. The medical records database was used to obtain demographic information for each patient, including gender, body mass index (BMI), age, and laterality of operated hip. All patients involved in this investigation had the diagnosis of osteoarthritis with unilateral hip arthritis. All patients were required to have a digital 6-week postoperative radiograph to measure acetabular cup inclination and anteversion angles. Thirty-seven patients were excluded owing to implant selection (modular dual mobility, Birmingham hip resurfacing), femoral neck fractures, Parkinson's disease, or acetabular dysplasia. A total of 74 hips did not have data for BMI and were therefore excluded from statistical analysis for the BMI portion of the study. A total of 955 hips were included in analysis, of which 597 (62.5%) were female and 358 (37.5%) were male. The mean patient age was 71.2 ± 9.8 years (range, 26-97 years), and the mean BMI was 26.3 ± 4.9 kg/m^2 (range, 15.4-46.5 kg/m^2).

Surgical Procedure

The patient is placed supine on the operating table. A 2-inch thick sacral pad was used in all patients, keeping the anterior pelvic plane of the patient and coronal plane collinear with the operating table. This positioning of the acetabular component with respect to the coronal plane can be visualized in Figure 1 [15]. The value of this technique is to allow adipose tissue to fall away from the hip to facilitate better prepping and draping of the patient. The pad is 16 inches wide by 2.5 feet long by 2 inches thick, fitting across the patients' sacrum and does not rotate the pelvis. An 8- to 10-cm incision is made over the tensor fascia lata (TFL) muscle belly. The superficial fascia of the TFL is incised and muscle retracted posterolaterally. The interval between the sartorius and TFL is bluntly developed. The lateral femoral circumflex vessels are identified and cauterized. The deep interval is developed between the rectus femoris and greater trochanter, curving medially proximally to avoid the abductor musculature. The reflected head of the rectus femoris is released, and a capsulotomy is made. The femoral neck osteotomy is performed at the level of the greater trochanter base ("saddle.") The acetabulum is reamed sequentially, and final acetabular component is placed on a straight handle with attention to the handle position relative to the patient's body to assess appropriate anteversion and inclination. Optimal position was targeted as 15° anteversion and 40° inclination. The femur is then prepared with sequential broaches. Trial components are placed before final component implantation.

Measurements

The acetabular cup inclination and anteversion angles were measured by an independent observer on a single anteroposterior (AP) hip radiograph taken 6 weeks postoperatively in the Merge PACS system using the circle theorem, validated by others [16]. Using the circle theorem, the following geometry of the hip is outlined as seen in Figure 2.

This geometry then shows that the angle of version can be calculated using the formula $version = \cos^{-1}\left(\frac{line\ 5}{line\ 6}\right)$ [17]. When using the direct anterior approach in the supine position on a standard operating room table, there is reassurance that the placement of the acetabulum is anteverted, which will be made by the parallax changes from the AP hip position to the AP pelvis position. Anteversion angle measured from AP pelvis to AP hip increases, which confirms that the cup is anteverted [8]. The inclination angle was measured by using the transischial line as a reference to determine the lateral inclination placement of the acetabulum.

To ensure accuracy and repeatability of measurement by the independent observer, a set of 10 randomly selected AP pelvic radiographs were each read until the independent observer was within 1 standard deviation of the previous reading in the measurement 3 times. All measurements in this investigation were completed by a single observer.

The measurements of anteversion and inclination were divided into different safe zones as defined by Lewinnek et al [3] and Callanan et al [7]. The Lewinnek safe zone is defined as an anteversion from 5° to 25° and an inclination from 30° to 50°. The Callanan safe zone is defined as an anteversion from 5° to 25° and an inclination from 30° to 45°. The precision and consistency of cup placement over time was determined and analyzed using a regression line of inclination values, allowing examination of the spread of residuals around this line and the changes in cup placement over time.