Effectiveness of an Acetabular Positioning Device in Primary Total Hip Arthroplasty

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Abstract To evaluate the efficacy of a commercially available acetabular positioning device, we performed a prospective evaluation of 40 consecutive patients undergoing primary total hip arthroplasty. All surgery was performed by the same surgeon, in the same operating room, and on the same operating table. The acetabular positioning device was designed to place the component in 45° of abduction. At 6 weeks, all radiographs were evaluated by 3 investigators not involved with the surgery. Each radiograph was evaluated by each reviewer on 3 separate occasions, blinded to the findings of the other reviewer to assess interobserver and intraobserver variability.

The mean cup abduction angle was 42.1°, with a range from 23° to 57° (SD 8.3°). Intraobserver and interobserver variability were 0.2 and 0.3°, respectively. The findings of this study demonstrate a wide variability in acetabular cup placement in primary total hip arthroplasty. We believe this is due to movement of the pelvis, which may occur during preparation, draping, and retracting during surgery. We feel surgeons should not rely solely on positioning devices when implanting the acetabular component in total hip arthroplasty. Identification of bone landmarks and determination of superolateral implant coverage noted on preoperative templating is advocated to improve the precision of component position.

Introduction

Total hip arthroplasty is an effective treatment for pain, stiffness, and loss of function as a result of arthritides of

the hip [1]. The long-term success of total hip arthroplasty is determined in no small part by the precision and accuracy of component placement. Component malposition has been implicated in loosening and wear as well as instability [2–4]. Whereas femoral component position is largely determined by femoral geometry, acetabular component position has much greater freedom in placement related to abduction and version. Ideal acetabular component position varies but most authors suggest acetabular abduction between 35° and 45° to maximize stability of the articulation [5, 6]. Several series of total hip arthroplasty have documented large variations in acetabular component abduction ranging from 22° to 62° [7, 8]. The reasons for these wide variations are unclear. To improve the accuracy of component position, many orthopedic manufacturers have developed commercially available positioning devices to aid in acetabular component placement and most specifically, cup abduction. The purpose of this study was simply to validate the efficacy of a commercially available cup positioner in a consecutive series of patients undergoing primary total hip arthroplasty.

Materials and methods

After obtaining approval from the institutional review board, a prospective, consecutive series of patients undergoing primary total hip arthroplasty was performed. All patients with a diagnosis of osteoarthritis or any form of inflammatory arthritis were enrolled. Patients undergoing conversion arthroplasty after failed osteosynthesis were excluded.

All procedures were performed by the senior author (D.E.P.). Surgery was performed with all patients in the lateral decubitus position, on the same operating room table, in the same operating room, and by using a standard posterolateral approach to the hip. The height of the pelvic support was adjusted by the senior author in all cases to ensure that the pelvis and lumbar spine were level (Fig. 1). Acetabular preparation was performed by using hemispherical reamers, which were sequentially enlarged until bleeding bone was

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encountered in the ilium, ischium, and pubis. Reaming was directed in approximately 45° of abduction and 20° of anteversion. The implanted component size was 2 mm larger than the final reamer. Before implantation, the reamer size corresponding to the diameter of the actual implant was used to open the mouth of the acetabulum to facilitate implantation. A cementless, hemispherical, fibermesh titanium alloy implant (HGII, Zimmer, Warsaw, IN, USA) was impacted and the orientation checked with the aid of the manufacturer's positioner. According to the manufacturer, this positioner places the component in 45° of abduction and 20° of anteversion when the handle of the guide is parallel to the operating room floor and aligned with the long axis of the body (Fig. 2) (Zimmer Surgical Technique). Independent verification of cup inserter angles was performed by an independent biomechanics laboratory (HSS Biomechanics laboratory). Once adequate seating of the implant was ensured, adjuvant screw fixation of the implant into the ilium was performed as determined by the senior surgeon on a case by case basis. In instances where supplemental screw fixation was used, cup position was determined after screw insertion. Standard polyethylene liners without elevation were used in all cases. Femoral component preparation was performed in a routine manner and the decision to employ cement or cementless fixation was determined by factors including age, bone quality, and implant stability.

The postoperative protocol included early mobilization, gait training, and muscle retraining. Weight-bearing status was determined by method of fixation: 50% weight bearing for uncemented implants and full weight bearing for cemented implants. Standard hip precautions were emphasized for 6 weeks and anticoagulation was maintained using warfarin.

The 6-week radiograph was considered our initial postoperative film. No recovery room films were included in the analysis. Radiographic analysis was performed on the anteroposterior pelvis. All films were assessed by drawing the interteardrop line, marking the most eccentric

Fig. 2. Commercial implant positioning device designed to implant the component in 45° of abduction and 20° of anteversion

portions of the cup from the center of rotation, which outlines the equator of the cup, drawing in the cup line with a marking pencil, and measuring the cup inclination angle along the interteardrop line (Fig. 3). We used the interteardrop line as our reference line because of its reproducibility as an anatomic landmark least susceptible change due to changes in pelvic rotation [9]. Radiographic markings and measurements of cup angle were performed independently by 3 investigators not involved with the surgical procedure. Measurements were made with a standard scoliometer and recorded to the nearest degree. After each measurement, alcohol swabs were used to erase all pencil marks. Each reviewer was required to perform 3 measurements of each anteroposterior radiograph on 3 different days and measurements were recorded blinded to the previous measurement and blinded to the measurements of the other reviewers. Mean cup angle, standard deviation, as well as intraobserver and interobserver variability were calculated.

Fig. 1. Patient positioned in the lateral decubitus position with pelvic positioner adjusted to maintain a level pelvis and spine

Fig. 3. An example of a postoperative radiograph demonstrating the interteardrop line and cup inclination angle measuring 42° of lateral opening (abduction)

Results

Forty patients with 40 hips were prospectively enrolled in this study. None of the patients in this group sustained a perioperative complication such as dislocation, infection, or fracture. There were no clinically detectable thromboembolic complications, although routine surveillance was not performed. All patients were available for the 6-week radiograph.

The mean cup abduction angle in the group was 42.1° . The standard deviation in cup abduction was 8.3° . The range of cup abduction was from 23° to 57° . Intraobserver variability was 0.2° and interobserver variability was 0.3° . There were no instances of pelvic fracture related to cementless cup placement. In addition, there were no complications related to supplemental screw placement, such as intrapelvic placement, leading to neurovascular compromise.

Discussion

Acetabular component malposition has been implicated in both instability as well as predisposing to material wear. On the positive side, our mean cup abduction angle of 42.1° is clearly within the recommended 40° to 45° suggested by previous authors. One might assume that the use of the cup positioner was helpful in achieving this desired angle and therefore endorse its routine use.

However, we were concerned regarding the outliers in this study. Our finding of a range of cup positions from 23° to 57° of abduction and a standard deviation of 8.3° was extremely troubling. Repeat verification of the positioning guide by our mechanics department confirmed the proper angulation of the device.

We hypothesize that the large variation in cup placement is a function of patient movement during the procedure. It is our suspicion that pelvic rotation occurs commonly during total hip arthroplasty, both in forward/backward rotation as well as shifting of the pelvis in a

Fig. 4. Limb in abduction during preparation for total hip arthroplasty. Note the pelvic rotation as the leg is held in this position

Fig. 5. Preoperative radiograph demonstrating the templated acetabular socket. The amount of bone covering the implant when positioned at 40° is observed and should be reproduced at the time of implantation

cranio-caudad manner. These movements clearly can occur during the preparation phase of the surgery whereby abduction of the limb causes the pelvis to roll either cephalad on the pelvic rest or even rotate caudally when the limb is brought back down to neutral (Fig. 4). In addition, excessive force used with anterior and/or posterior pelvic retractors may result in similar pelvic rotations. These unrecognized movements of the pelvis will have significant effects on the position of the pelvis during cup insertion; while the positioning device is aligned properly with the floor, the patient at this time is no longer in a level position on the operating room table, resulting in these variations in socket position.

Based on these findings, we have concluded that surgeons should not rely solely on any commercial cup positioner. Although cup positioners are a useful adjunct, we would recommend the use of osseous landmarks identified on the preoperative templating and verified intraoperatively in conjunction with the positioning device. Currently, on all preoperative radiographs, we now determine the amount of coverage that can be anticipated when the socket is placed at 40° to 45° of abduction (Fig. 5). This observation is quite helpful in situations such as dysplasia whereby the properly oriented socket is often not covered by bone superolaterally. The intraoperative observation of a dysplastic hip socket with circumferential bone coverage may be the result of an excessively abducted socket.

In conclusion, we feel that acetabular component positioners can be a useful tool to aid in socket position during primary total hip arthroplasty. However, our series has demonstrated the significant limitations of relying solely on the positioner to determine socket placement. We feel that precise preoperative templating and identification of bone landmarks and degree of socket coverage, coupled with the use of acetabular component positioners, should improve the accuracy and precision of socket placement. Future work with navigated positioners may play a role in improving outcomes [10]. The role of navigation has been

debated for some time in adult reconstruction. Arguments against navigation have focused on cost of implementation, time required for use in the operating theatre, and the argument that it really is not necessary. However, the effect of component position as related to wear, instability, and loosening appear to justify all attempts at improving the precision with which total hip arthroplasty is performed. Recent work by Nogler and associates [11] using an imageless navigated system clearly demonstrated the improvement in both precision and accuracy of acetabular cup placement in a cadaveric study. Although validation of navigated tools is ongoing, the goal of improving the methods of component insertion during total hip arthroplasty justifies its continuing investigation.

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