The University of Pennsylvania Orthopaedic Journal
15: 17–19, 2002

Enhanced Stability of Total Hip Replacement Implants Resulting from Use of an Elevated-Rim Acetabular Liner and 32-mm Femoral Head

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Abstract: The use of an elevated-rim acetabular liner in total hip arthroplasty (THA) is widely accepted. We sought to determine quantitatively the amount of additional stability provided by the elevated-rim liner as compared to the standard non-elevated liner. Furthermore, the stability of the hip with a 32-mm femoral head was compared to the standard 28-mm head. Our results show that a 15° elevated-rim acetabular liner placed in the posterior quadrant increased hip stability by an additional 8.9° of IR. Similarly, the 32-mm head provided 8.1° of additional IR. The increases were statistically significant ($P < 0.0001$). In addition, we did not encounter increased anterior dislocation intra-operatively. The findings of this study indicate that the 32-mm head may contribute to hip stability in primary THA, and in instances where a posterior approach is used, an elevated-rim liner placed in the posterior quadrant may also independently contribute to hip stability.

Introduction

The use of an elevated-rim acetabular liner in total hip arthroplasty (THA) is seen by many surgeons as a means of improving stability of the operative hip. First used by Charnley in the early 1970s to attempt to decrease the tendency for posterior dislocation of the femoral head [1,2], the elevated-rim is widely available and commonly used by surgeons in primary as well as revision THA procedures. In a retrospective clinical study, Cobb et al. [3] first demonstrated improved stability after THA when an elevated liner is used. In the present study, we sought to determine the quantitative amount of additional stability provided by the elevated-rim liner as compared to the standard non-elevated liner. Additionally, a theoretical relationship between the femoral head size and hip stability has been suggested. To examine this hypothesis, the stability of the hip with a 32-mm femoral head was compared to that of a 28-mm head. To address these issues, twenty patients undergoing primary THA were studied intra-operatively to determine the position of posterior dislocation comparing those hips receiving an elevated-lip liner versus a standard liner as well as hips receiving a 28-mm versus a 32-mm femoral head.

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Materials and Methods

Twenty patients undergoing primary THA with ceramic-on-ceramic components were enrolled in this study. The age of the patients was 44.5 ± 8 years, and 65% of the patients were male. Surgery was performed in a lateral decubitus position, using a Kocher-Langenbeck approach. All components were determined intraoperatively in a standard fashion and then fixed into position. In all study subjects, both the acetabular and femoral components were placed into anteversion to closely approximate the patient's native anatomy.

The initial components placed during the operative procedure included a 32-mm ceramic femoral head and a non-elevated ceramic acetabular liner. A trial reduction was performed with these initial components. Of note, ball head length and offset were determined based on preoperative templating and then minor adjustments were made intraoperatively when necessary in order to optimize abductor tension to achieve optimum stability, at which point experimental trials were begun. It is important to note that the 32-mm head and non-elevated liner, which were initially placed during the procedure, were the final components that were ultimately permanently fixed into place in all patients within the study following experimental trials. Following removal of the control group components, three additional trial reductions were performed using replacement component groups consisting of the following: (a) 28-mm head and non-elevated liner; (b) 28-mm head and 15° elevated liner; (c) 32-mm head and 15° elevated liner (Fig. 1).

All trial acetabular components were placed into position and secured by a screw-in mechanism, preventing tilting, subluxation, or rotation of the trial component with the elevated lip from the desired 2 or 10 o'clock position, for the left and right hip respectively, during trial maneuvers. After positioning of both the acetabular cup and femoral head for each trial group, trial components were compared to determine the position of posterior dislocation. The femoral head was independently observed by the assistant surgeon while the hips were ranged by the senior author (J.P.G.). The point of instability was determined by direct visual inspection and was predefined as the position at which the head began riding out of the liner. The amount of internal rotation (IR) at which the hip began to dislocate (at 90° flexion and 0° abduction/adduction) was recorded for each group. A goni-

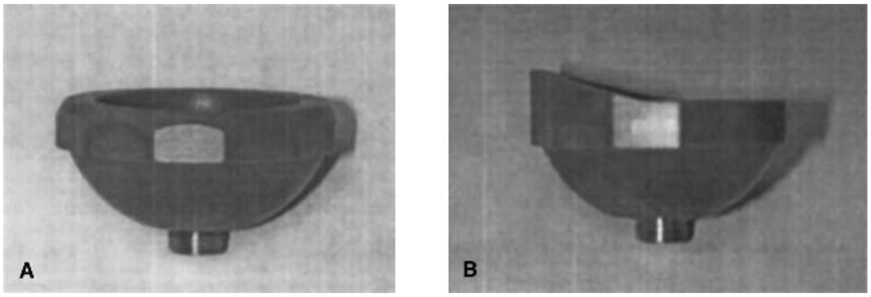

Fig. 1. Neutral liner **(A)** and elevated liner **(B)** placed in 2 or 10 o'clock position for left and right hip, respectively.

ometer was used with one arm parallel to the floor and the other parallel to the tibia to determine hip rotation during trials relative to the floor. Hips were also tested for anterior dislocation in the position of hyperextension and external rotation. All trials were repeated three times on all patients for each component group and an average measurement for the degree of internal rotation required for hip dislocation was used for statistical comparison. Analyses were performed with paired *t*-tests.

Results

The average amount of IR for each group needed to fulfill the criteria for posterior dislocation in this study is illustrated in Table 1. Overall, comparison between the non-elevated liner versus the elevated-lip liner groups, revealed that there was an average of 8.9° increase in the amount of internal rotation necessary to cause posterior dislocation. Similarly in the group of patients receiving the 32-mm head, there was an increase of 8.1° in the amount of internal rotation needed to cause posterior dislocation when compared to those patients receiving a 28-mm head (Table 2).

The increases were statistically significant ($P < 0.0001$) as shown in Table 2. None of the hips in any group could be dislocated anteriorly during range of motion testing.

Discussion

Dislocation following THA remains a serious complication and may result from several factors as identified by Amstutz and Markoff [4] including poor tissue tension allowing the head to climb out of the socket, bony impingement, and component impingement. The majority of modern total hip systems provide the surgeon with a variety of options with regard to neck lengths, head sizes, and acetabular liner configurations, allowing the surgeon to "fine tune" the components chosen for final implantation with the goal of providing the patient with optimum stability and range of motion. Unfortunately, the impact of such component combinations on dislocation and possible impingement remains unclear.

To our knowledge, a prospective well controlled in vivo study examining the impact of elevated liners and head size on stability in THA has not been performed. A serious limitation of this study is that there have not been rigid orientation standards employed in this study such that the exact position of the pelvis in space relative to the operating room floor is available. Such a study would have required placement of orientation pins into the pelvis, post-positioning X rays, and/or use of a navigation system, adding additional risk of pin placement and possible contamination to each patient. However, the use of an acceptable trial reduction in terms of clinical stability could serve as a valuable control and the study performed sought only to accurately evaluate differences in the stability of the trial component groups relative to the control.

Our results show that a 15° elevated-rim acetabular liner placed in the posterior-superior quadrant increased hip stability by an additional 8.9° of IR. This finding is consistent with the findings of Cobb et al. [3], which demonstrated improved stability following THA in which an elevated liner was used. Similarly, one study which made use of a bench-top method for evaluating modular total hip component combinations found that when compared to neutral liners, in one hip system (Depuy) lipped liners on average added 8° of motion in the direction of dislocation [5]. In contrast, in a biomechanical study of the effect of elevated-rim acetabular components on prosthetic range of motion and stability, Krushell et al. [6] was unable to demonstrate the potential benefit of routine use of elevated-rim liners in instances in which the acetabular component was otherwise satisfactorily positioned.

Several concerns have been raised with regard to use of elevated-lip liners in THA particularly with regard to the long-term effect on wear and loosening. Indeed, some investigators have suggested that the biomechanical characteristics of hips in which an elevated-lip liner is used may

Table 1.

Head size	Liner type	Average internal rotation for dislocation
28 mm	Non-elevated	37.3° ± 9.9°
28 mm	Elevated	47.7° ± 11.4°
32 mm	Non-elevated	46.9° ± 9.1°
32 mm	Elevated	54.3° ± 11.6°

Table 2.

Comparison groups	Increase in IR before dislocation	*P* value
Non-elevated vs. elevated	8.9°	$P < 0.0001$
28-mm vs. 32-mm head	8.1°	$P < 0.0001$

predispose the implant to early failure [7]. In a case report, Bosco and Benjamin [8] implicated the use of an extended-lip acetabular cup liner in the loosening of a femoral stem. Despite these concerns, one recent study failed to show any increase in the rate of revision in hips making use of elevated-lip liners as compared to hips with standard liners at an average follow-up of 5 years [9].

An additional concern regarding the use of an elevated-rim acetabular liner is the potential for increased incidence of anterior dislocation of the hip. This concern is based on the potential for the femoral neck to impinge on the posteriorly placed elevated rim as the hip is externally rotated, levering the femoral head out of the cup in an anterior direction. This complication, however, was not observed in any of the study patients intra-operatively.

In the present study, additional stability was also found with use of the 32-mm head, which provided 8.1° of additional IR prior to dislocation. A direct relationship between the use of a larger head-to-neck ratio and an increase in hip range of motion was initially identified by Swanson and Mech [10]. Indeed, some reports in the literature have confirmed a direct but inverse relationship between femoral head size and the rate of total hip dislocation [4,11]. However, this relationship has not been observed by all investigators [12].

Although there exists the potential advantage with regard to improved hip stability resulting from use of a larger femoral head, there remain concerns of adverse effects resulting from use of this larger component. Livermore et al. [13] noted that use of a 32-mm femoral head as compared with 22- and 28-mm sizes resulted in the greatest amount of volumetric wear. The 22-mm head was associated with the greatest amount of linear wear. Furthermore, these investigators discovered that the amounts of resorption of the proximal part of the femoral neck and lysis of the proximal part of the femur were found to correlate positively with the extent of linear and volumetric wear. Based on these findings, Livermore et al. [13] recommended use of a prosthetic femoral head of intermediate size, the 28-mm head, as it appeared to provide the best wear characteristics. Although such concerns are valid with regard to use of polyethylene technology in THA, the present study made use of ceramic-on-ceramic bearing surfaces which have been shown to have approximately one-tenth the rate of wear reported for metal-on-polyethylene total hip bearings [14]. Therefore, in instances where alternate bearing surfaces are used and wear debris in less of a concern, it may be advisable to use the larger 32-mm head for purposes of increasing hip stability.

The findings of this study indicate that, in instances where a posterior approach is used, an elevated-rim liner placed in the posterior quadrant may contribute to hip stability. In addition, use of a 32-mm head may also independently contribute to hip stability.

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