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Effect of Femoral Head Diameter on Risk of Dislocation after Primary Total Hip Arthroplasty

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Abstract

Dislocation is one of the most common complications of total hip arthroplasty. The diameter of the femoral head is one of the more important of the variables under the control of the surgeon. We followed 527 total hip arthroplasties in 469 patients after primary total hip arthroplasty with femoral head sizes ranging from 28 to 44 mm. All surgeries were performed by a single surgeon at one institution. The operative approach was the posterior approach in all patients. The patients were followed at defined intervals and asked about dislocation. There was a mean follow up of 60 months with a range of 12 to 138 months. In total hip arthroplasty, utilizing the posterior approach, we found no statistically significant association between the risk of dislocation and femoral head size.

Keywords: Dislocation risk; Total hip arthroplasty; Femoral head size

Introduction

Dislocation is one of the most common complications of Total Hip Arthroplasty (THA). Historical data shows the rate of dislocation after total hip arthroplasty to be unacceptably high with an incidence of dislocation after primary THA in several large series ranging between 0.4% and 5.8% [1-3]. Patient and surgical variables leading to increased risk of dislocation are neuromuscular and cognitive disorders, alcoholism, female gender, diagnosis of fracture, component malposition and patient noncompliance [4-7]. In addition to optimizing the femoral and acetabular component positioning, maximizing the diameter of the femoral head has been touted as another important intra-operative tool available to the surgeon to decrease dislocation rates. However, maximization of the femoral head size is limited and is not without consequence.

Femoral head size is determined intra-operatively by the surgeon and is dependent on the size of the acetabular component and the thickness of the liner if a modular acetabular component is utilized. If a modular acetabular component with a polyethylene liner is utilized, then there is an obvious trade off of minimization of the thickness of the polyethylene for maximization of the femoral head size. Additionally, as femoral head size increases, there is a consequent increase in volumetric wear of the bearing surface. With the advent of highly cross-linked polyethylene and the resultant decreased wear rates, there is a theoretical offset of the increased wear due to larger head sizes and this has led to more widespread use of larger femoral heads in THA.

However, despite the theoretical advantage of decreased dislocation rates with larger femoral heads, only a few studies have suggested that an increased femoral head diameter decreases the risk of dislocation [8-16], and the actual dislocation rate of larger femoral head sizes (38-44 mm) is largely unknown. We therefore decided to evaluate our experience with various femoral head sizes on highly cross-linked polyethylene bearings and we hypothesized that the use of larger femoral heads on highly cross-linked polyethylene would be associated with lower dislocation rates.

Patients and Methods

We retrospectively reviewed all primary total hip arthroplasties performed by a single surgeon (Aaron A. Hofmann) between January 1, 2001 and August 31, 2010. Using CPT codes and hospital records we evaluated all patients with minimum one year follow-up who were 18 years or older at the time of surgery and having had a primary THA performed by the lead surgeon Aaron A. Hofmann, MD at the University of Utah Medical Center during the aforementioned time period. Hospital records were reviewed for the patient demographic factors of age, gender and pre-operative diagnosis. Operative reports were reviewed to determine the femoral head size.

The operative approach in all patients was posterior with a capsular repair. Metal on highly cross-linked polyethylene articulations were utilized in all patients. The patients were followed at 6 weeks, 3 months, 12 months and then annually thereafter. At each visit, patients were questioned about dislocations, and any dislocation treated at our institution was identified in our chart review of emergency department records and operative reports. These THAs were then divided into two groups based on whether or not any dislocation had occurred. We then further subdivided the dislocation group into those that were stable after a single closed reduction and those that had persistent instability requiring revision. The radiographs of the dislocation group were evaluated for acetabular component malalignment based on the published Safe Zones of Lewinneck [17].

Data were analyzed by an independent statistician using commercially available software (STATA version 11, College Station, TX). Student's T-test was used for comparing all continuous variables. The chi-squared test was used to compare the binary variables if the expected frequencies were all greater than five. Fisher's exact test was used to compare those binary variables where the expected frequencies

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were not adequate for the chi-squared test. Of the variables evaluated, gender was identified as a potential confounder as the p-value for this variable was non-significant but less than 0.25. A linear regression controlling for this potential confounder was performed for the continuous variable of head size. Logistic regressions controlling for this potential confounder were performed for the various femoral head sizes.

Results

We identified 469 patients with a total of 527 primary THAs that met our inclusion criteria with a mean follow up of 60 months (range 12 to 138 months). These THAs had femoral head sizes ranging from 28 mm to 44 mm. The femoral head diameter was 28 mm in 73 patients, 32 mm in 128 patients, 36 mm in 74 patients, 38 mm in 207 patients, and 44 mm in 54 patients. We identified 510 THAs in 452 patients that did not have any dislocation event and 17 patients that had at least one dislocation. This gave us an overall dislocation rate of 3.2%. In the 17 dislocators the mean time to dislocation was 60 days, with a range from 3 days to 18 months. The majority of dislocations (94%) occurred during the first 3 months after surgery. Of the dislocators, 10 (59%) had no further dislocations after a single closed reduction, while 7 (41%) were revised for recurrent instability.

When comparing the non-dislocators and dislocators, the groups were similar demographically in terms of age, gender and pre-operative diagnosis (Table 1). The mean age of the non-dislocators was 62.2 compared to 61.9 for the dislocators (p=0.361). In both groups, the majority of pre-operative diagnoses were found to be either osteoarthritis or inflammatory arthritis. While not statistically significant, we did find a trend toward a higher percentage of women in the dislocators compared to the non-dislocators (71% vs. 52%, p=0.123). When comparing these two groups in terms of individual femoral head sizes and mean femoral head size, we found no difference (Table 2). Mean head size as a linear variable was found to be 36.5 mm in the dislocators group and 35.8 mm in the non-dislocator group (adjusted p-value=0.361). Additionally, when comparing the groups on head sizes by those larger than 28 mm, 32 mm, 36 mm, and 40 mm respectively, we again found no difference between the groups (Table 2).

When comparing the dislocators based on whether or not revision was required for recurrent instability, the groups were found to be similar in terms of patient demographics, mean femoral head size, and number of acetabular components in the abduction safe zone, version safe zone, and both of these safe zones (Table 3). The mean acetabular abduction angle of the dislocators was 41.94° with a Standard Deviation (SD) of ± 8.56°. The mean acetabular version of the dislocators was 7.94° with a standard deviation of ± 9.47°. Of those 17 THAs that dislocated, 24% were in the abduction safe zone of 30° to 50°, 53% were in the version safe zone of 5° to 25°, and 18% were in both the abduction and version safe zones.

	Non-Dislocators (n=452 patients)	Dislocators (n=17 patients)	p-value
Age	62.2	61.9	0.951
Gender	219 M 48% 233 F 52%	5 M 29% 12 F 71%	0.123
Pre-Op Diagnosis	**(n=510 hips)**	**(n= 17 hips)**	**p-value**
Osteoarthritis	73%	76%	>0.999
Inflammatory Arthritis	2%	6%	0.305
Perthes Disease	1%	0%	>0.999
SCFE*	1%	0%	>0.999
Post-Traumatic Arthritis	7%	0%	0.620
DDH*	7%	12%	0.326
AVN*	9%	6%	>0.999

*SCFE=Slipped Capital Femoral Epiphysis, DDH=Developmental Dysplasia of the Hip, AVN=Avascular Necrosis

Table 1: Patient Demographics by Dislocation (n=527 hips in 469 patients).

	Non-Dislocators (n= 510 hips)	Dislocators (n= 17 hips)	p-value
Mean Head Size	35.8	36.5	0.361*
28 mm Head (n=67 hips)	13%	6%	0.416**
32 mm Head (n=121 hips)	23%	24%	0.875**
36 mm Head (n=66 hips)	12%	18%	0.839**
38 mm Head (n=194 hips)	37%	35%	0.847**
40 mm Head (n=25 hips)	5%	6%	0.938**
42 mm Head (n=1 hip)	0.2%	0%	>0.999**
44 mm Head (n=53 hips)	10%	12%	0.500**
Head Size>28 mm (n=460 hips)	87%	94%	0.416**
Head Size>32 mm (n=339 hips)	64%	71%	0.477**
Head Size>36 mm (n=273 hips)	52%	53%	0.573**
Head Size>40 mm (n=54 hips)	10%	12%	0.938**

*A linear regression controlling for the potential confounder of gender was performed for the continuous variable of head size

**Logistic regressions controlling for the potential confounder of gender were performed for the various femoral head sizes

Table 2: Head Size Analysis by Dislocation (n=527 hips).

	Stable after Single Closed Reduction (n=10 hips)	Revised for Recurrent Dislocations (n=7 hips)	p-value
Age	61.3	62.9	0.813
Gender	4 M 40% 6 F 60%	1 M 14% 6 F 86%	0.338
Osteoarthritis	80%	71%	>0.999
Inflammatory Arthritis	0%	1%	0.412
Perthes Disease	0%	0%	>0.999
SCFE*	0%	0%	>0.999
Post-Traumatic Arthritis	0%	0%	>0.999
DDH*	10%	14%	>0.999
AVN*	10%	0%	>0.999
Mean Head Size	36.4	36.6	0.938
Abduction Safe Zone	10%	43%	0.250
Version Safe Zone	50%	57%	>0.999
Both Safe Zones	10%	29%	0.537

*SCFE=Slipped Capital Femoral Epiphysis, DDH=Developmental Dysplasia of the Hip, AVN=Avascular Necrosis

Table 3: Dislocation Sub-Analysis by need for Revision (n=17 hips).

Discussion

Despite major advances in total hip arthroplasty, dislocation following total hip arthroplasty remains a serious complication that occurs more frequently than is desirable. Many studies have explored the factors contributing to this complication with the goal of identifying those the surgeon can control. Since the advent of highly cross-linked polyethylene bearings there has been a trend toward using larger femoral heads in total hip arthroplasty with the thought that the increased impingement free range of motion and greater amount of femoral head translation would decrease the rate of dislocation as suggested by a few studies [18-23]. We hypothesized that larger femoral head size would be associated with a decreased rate of dislocation when tested in vivo. Therefore the purpose of our study was to determine if femoral component head size when used with highly cross-linked polyethylene bearings had any effect on the dislocation rate of primary total hip arthroplasties.

Laboratory studies using experimental models have shown that larger femoral heads do in fact increase impingement free range of motion. These studies have also demonstrated a difference in jump distance, or translation, with the larger head sizes [24]. However none of the current studies have been done in vivo on heads greater than 32 mm to see if there is added benefit to using sizes larger than 32 mm. The aforementioned laboratory data is indicative that there would be an in vivo advantage to the larger head sizes with greater Range of Motion (ROM) and joint stability. This increased ROM without component-to-component impingement will reduce the possibility of dislocation. In fact it was shown at femoral head sizes 38 mm and greater there is almost complete elimination of component on component impingement [24]. More precisely, once the femoral head reached 38 mm, it was bone-on-bone impingement, which is dependent on individual bony anatomy and not related to artificial components. This translates to the ROM most closely approximating natural anatomical limits. While theoretically true there has not been consistent in vivo support of this theory, including the results of our current study.

Strengths of our study include participants selected from a single surgeon, the same hospital, equivalent post-surgical care instructions and only one surgical approach. Additionally, compared to registry and multi-center studies, we had minimum diversity between prosthetic implants. Furthermore we have evaluated dislocation in vivo, which by design includes all of the patient risk factors together, as opposed to the in vitro studies, which isolate each risk factor and ignore the synergistic effects of multiple risk factors working together. Controls in this study were all done at the same time and none of the included study participants and controls were taken from historical registries.

Limitations of this study may include possible confounders related to use of multiple implant designs that may each have differing dislocation rates due to their unique design geometry. Studies suggest that certain aspects of implant design may influence dislocation risk. Such factors include the use of skirted heads, chamfered acetabular liners, larger trunion geometry, and using a trapezoidal, rather than circular, neck cross-section [25-27]. There is also the concern that this sample size may be too small since there were only 17 dislocations to use in the calculations. With the wide variety of prosthetic devices currently in use today the results we present here will not be representative of the differences in dislocation rates due to the differing design features and the biomechanical factors specific to each of those designs. Furthermore the generalizability of the results may be questioned because the work of a single surgeon was used here whereas other studies have used multiple surgeons, which adds to the number of confounders including those due to the differences caused by individual surgical technique.

Despite the findings of the experimental models our study of in vitro total hip arthroplasties found the null hypothesis to be correct. We found no statistically significant difference in the dislocation rate between any of the patient groups. With the numbers available from this study the dislocation rate after primary THA utilizing the posterior approach with highly cross-linked polyethylene bearings is not associated with femoral head size. These findings are consistent with other clinical studies that have also shown no significant decrease in the rate of dislocation with the use of larger femoral heads [3,4,28-33]. This discrepancy arises because of the multifactorial nature of dislocation. The major determinant may not be head size but some other confounding factor whose magnitude exceeds that of head size [3]. Some of these confounding factors could be component position, sources of femoral-acetabular impingement, soft-tissue tension, trauma, bearing surface wear, diagnosis or prior surgery. Within the dislocation group in this study we found only 18% of our acetabular components in the safe zone for both abduction and version, which suggests that acetabular cup malpositioning may have a greater impact on dislocation rate than the size of the femoral head component. While the data is inconsistent on the effect of femoral head size of dislocation rate, many studies have consistently shown that acetabular cup position near the “safe zone” is crucial in minimizing dislocation risk [6,17,34,35]. Although no studies have directly compared head size to cup position, Dudda et al. found a larger relative effect of cup malposition versus femoral head size on dislocation. Cup malposition had an odds ratio of 2.59 versus a ratio of 0.84 for a femoral head size [11].

Another question we do not address in this study is whether there is a limit to the effectiveness of larger femoral heads or some upper limit beyond which there is diminishing benefits to larger head size. One study actually indicated that there was no additional advantage after reaching a head size of 32 mm because it was bone on bone impingement [24]. As discussed there is greater impingement free range of motion with larger heads which decreases the incidence of levering the femoral head out of the acetabular component during normal anatomic range of motion. However there are anatomic limitations to just how much range of motion each patient can ultimately gain so at some point there will not be any additional benefit to increasing the femoral head size. The question that begs to be answered is, ‘What is the upper limit of femoral head size after which no further meaningful difference is made’? In addition, data is emerging that suggests that the use of larger femoral head may lead to adverse effects and early failure [36]. Larger heads (>36 mm) may lead to increased volumetric wear and osteolysis and increased corrosion at the head-neck taper due to greater torque at the taper interface with larger femoral heads [37-40]. The increased corrosion has been linked to adverse local tissue reactions similar to those seen with a metal-on-metal bearing [41]. This new data further highlights the concern that there may be limited benefit, and risks, to using larger femoral heads.

Dislocation remains a multifactorial complication following total hip arthroplasty. While this study does not provide a concrete solution to decreasing the dislocation rate it does provide additional support to the body of evidence that head size, while important, is not the ultimate determinant of dislocation risk. It is the experience and judgment of each surgeon taking all contributing factors into consideration and reaching a decision on what is the best component combination for the patient.

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