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A Retrieval Analysis of Impingement in Dual-Mobility Liners

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ABSTRACT

Background: Implant-related impingement is likely a major causative factor of total hip arthroplasty (THA) instability. Dual-mobility (DM) cups can theoretically improve stability in THA, but impingement rates with DM cups are not well studied. We examined retrieved DM THA liners to determine if less evidence existed for prosthetic impingement between the neck and the polyethylene liner than historical studies from our institution on fixed-bearing THAs.
Methods: DM components from 93 THAs were identified from 164 THAs whose DM components were revised between 2008 and 2015 through our institutional review board–approved implant retrieval program. The mean age was 63 ± 11 years, mean body mass index was 30 ± 7 kg/m^2, and mean length of implantation was 2.08 ± 1.89 years. Two independent graders scored each liner for the presence and severity of impingement. Radiographs were evaluated for inclination, anteversion, change in leg length, and combined offset.
Results: Only 21.5% (20/93) of DM cups showed evidence of impingement compared to 77% (75/97) of fixed-bearing cups found in a previous study performed at our institution ($P < .001$). Of the revision components, 35.2% (5/14) demonstrated evidence of impingement compared to 19.7% (14/71) implanted in primary surgery ($P = .189$). In the cohort revised for instability, the rate of impingement was 35.3% (6/17); for the implants revised for any other reason, the impingement rate was 18.4% (14/77) ($P = .126$).
Conclusion: This study demonstrates that DM liners significantly reduce the rate of impingement (21.5%) when compared to fixed-bearing liners (77%).

Implant dislocation is the leading cause of failure in total hip arthroplasty (THA), and implant-related impingement is a major causative factor in such instability [1,2]. Impingement can also potentially cause implant loosening, wear, and pain [3]. Impingement is multifactorial and influenced by acetabular liner position, femoral stem position, restoration of offset and leg length, combined anteversion, head-neck ratio, soft-tissue integrity, and head size.

Among these factors, head size is modifiable by changes in implant selection. Computer modeling had demonstrated a decrease in component impingement as head size increases to 44 mm [4,5]. In an effort to decrease rates of instability, surgeons have increasingly begun using larger head sizes, including 36-mm heads, over the past decade [6]. The routine use of heads larger than 36 mm in primary total hip arthroplasty with polyethylene (PE) bearings is challenging due to concern over wear with thin PE[4]. However, technology has emerged to allow the use of so-called anatomic size heads including hard-on-hard bearings, resurfacing, and dual-mobility (DM) cups and liners. These designs have head sizes closer to that of the native hip. Metal-on-metal bearings and resurfacings have fallen out of favor, but DM remains a popular option for surgeons [7,8].

DM cups and 36 mm or larger femoral heads are both implant options that can improve stability in THA by increasing the jump distance and head-neck ratio [7,9–11]. Literature has emerged that both are effective options for decreasing the risk of frank hip instability events and that DM may indeed be superior to 36-mm heads for this purpose [7,9–11]. DM designs functionally incorporate the outer PE liner into the head size, thus making the head size at least 80% larger than it would be with a fixed-bearing head with the same size cup [12].

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However, less is known about the effect of DM liners on abnormal PE wear due to implant impingement. A prior study from our institution in 2005 looking at impingement in fixed bearings with head sizes including 22 mm, 26 mm, 28 mm, and 32 mm demonstrated acetabular liner impingement in 56% of 162 THAs [3]. A similar article by Marchetti et al [13] demonstrated impingement of 51.4% of retrieved liners. Tanino et al [14] showed an impingement rate of 27% in 48 retrieved liners with either 28- or 32-mm heads. A recent second study from our institution of 28 mm, 32 mm, and 36 mm heads demonstrated an overall impingement rate of 77.3% and specifically 70.3% for 36-mm heads [15].

DM cups have the unique failure mechanism of intraprosthetic dislocation (IPD) of the femoral head from the inner PE bearing. Philippot et al [16] identified 3 causes of IPD: type I was characterized by homogenous PE rim wear, type II was external obstruction of the motion of the PE component such as by arthrofibrosis, and type III was related to cup loosening. A recent study demonstrated wear of both the inner and outer PE surface of anatomic dual-mobility (ADM) cups (Stryker, Mahwah, NJ), suggesting that fibrosis is not a significant issue at least in the short term [17]. Nonetheless, the rate of impingement in DM heads has not been well studied with only one small study on modern highly cross-linked PE bearings available in the literature [18]. The study demonstrated 100% impingement of DM liners [18]. DM liners are designed to accommodate standard physiologic impingement, but excess or abnormal impingement, such as that driven by arthrofibrosis or ossification around the implant, can potentially lead to PE wear and component failure. Further, no comparisons of impingement rates have been performed between DM liners and 36-mm heads.

The goal of this study was to identify the rate of abnormal and excessive PE wear due to implant impingement and the severity of impingement in DM liners and to compare it to prior studies from our institution on fixed-bearing liners. As a secondary goal, we sought to identify radiographic or clinical factors associated with impingement with DM liners. To achieve these goals, we examined retrieved DM liners for evidence of impingement and compared the resulting data to data from the earlier implant retrieval studies from our laboratory [15].

Methods

Two hundred DM liners were identified from a series of 2684 retrieved THA liners collected during revision surgery between August 2008 and September 2015 as part of our ongoing institutional review board–approved implant retrieval program. Implants were excluded if they had been severely damaged during removal, permanently damaged from use in other studies; other implants were unavailable, having been released to patients before the study. This left 93 liners recovered from 92 patients.

Following retrieval, all liners were soaked in a 10% bleach solution for 20 minutes, and then washed with a mild detergent and tap water. Liners were rinsed in ethanol and allowed to air-dry overnight. Patient demographic data including sex, height, weight, body mass index (BMI), length of implantation (LOI), patient age at index procedure, reason for index surgery, and reason for revision were collected. Implant type and sizes were also noted (Table 1). Ages at index procedure, BMIs, and reasons for revision were available for all patients. For 85 patients (92.6%), the reason for index surgery with a DM liner was also known; the other 8 patients had had surgery performed at outside hospitals. The mean age of our cohort was 63 ± 11 years, mean BMI was 30 ± 6 (17-49) kg/m^2, and mean LOI was 2.1 ± 1.9 years. Sixty-seven (72%) of the 93 retrieved components were ADM cups, and the remaining 26 (27.9%) were modular dual-mobility (MDM) cups. All but one of the

Table 1
Demographics of Retrieved Dual-Mobility Liner Cohort.

Age (years)	63.01 ± 10.93
Sex (female:male)	56 (60.2%):27 (39.7%)
Height (m)	1.68 ± 0.1
Weight (kg)	85.45 ± 22.7
BMI	30.06 ± 7.3
Length of implantation (y)	2.08 ± 1.89
MDM:ADM	26 (27.9%):67 (72.0%)
Evidence of neurologic compromise	8 (8.6%)
Reason for implantation	Primary surgery, 71 (76.4%)
	OA, 62; RA, 2; proximal femoral fracture, 5; AVN, 1; SCFE, 1
	Revision surgery, 14 (15.1%)
	Instability, 10; replant, 3; HO, 1
	Unknown, 8 (8.6%)
Reason for revision	Recalled implants, 56 (60.2%)
	Instability, 17 (18.3%)
	Periprosthetic fracture femur, 7 (7.5%)
	Infection, 6 (6.5%)
	Acetabular osteolysis/failure of fixation, 5 (5.4%)
	Acetabular malpositioning, 1 (1.1%)
	Psoas impingement, 1 (1.1%)

ADM, anatomic dual mobility; BMI, body mass index; MDM, modular dual mobility; OA, osteoarthritis; RA, rheumatoid arthritis; AVN, avascular necrosis; SCFE, slipped capital femoral epiphysis; HO, heterotopic ossification.

patients had a 28-mm head; one of the MDM cups had a 22.2-mm head. Seventy-one of the 93 implants (76.4%) were originally placed as primary surgeries; the majority (87.3%) of which were for osteoarthritis. Fourteen DM cups (15.1%) were implanted in revision surgery of which 10 were implanted to treat instability. Fifty-six (60.2%) of the 93 cups were well functioning at the time of revision but were explanted for revision of a concomitantly implanted recalled dual modular neck stem; another 17 (18.3%) were explanted for instability (Table 1).

Liners were scored for evidence of impingement using a scoring system adapted from our previous impingement study [3]. Impingement was defined as wear or surface deformation on the rim of the liner based on visual and stereomicroscopic examinations. Two independent graders (blinded) grouped the liners into 5 groups based on the evidence of impingement: none (no evidence of impingement, score of 0); minimal (small areas of evidence of impingement, score of 1); mild (minimal evidence of impingement extending ≤1 mm into the rim, score of 2); moderate (evidence of impingement 1-2 mm onto rim, score of 3); and severe (damage due to impingement extending to the edge of the rim, score of 4) (Fig. 1).

Prerevision patient radiographs, available for 86 of the 93 THAs, were assessed for acetabular component inclination and version. In each case, the anteroposterior radiograph was used to measure acetabular inclination; the cross table radiograph was used to measure acetabular anteversion using the method proposed by Woo and Morrey [19]. Preindex surgery radiographs (anteroposterior pelvis and Lowenstein cross-table lateral) were available for 68 of 93 patients and were used to calculate changes in leg length and total offset after surgery.

For statistical analyses, impingement was described in 2 ways for each liner: incidence of impingement (yes or no) and severity of impingement (none, minimal, mild, moderate, or severe). The DM liners were compared to the historical fixed-bearing controls using both criteria. Subgroups, including implantation for revision cases vs primary, were examined for impingement rate and severity. Finally, MDM (Stryker) and ADM cohorts were compared. An analysis of variance test was used to determine significant differences ($P < .05$) in the following variables between the instability group and other cause revision group and between the ADM and MDM groups: rate of impingement, severity of impingement,