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Single center evaluation of outcomes of modular dual mobility liners during revision total hip arthroplasty: A five-year follow-up

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ABSTRACT

Introduction: Revision total hip arthroplasty (rTHA) is at increased risk for postoperative instability when compared to primary cases, which has been mitigated to some extent with the introduction of dual mobility (DM) reconstructions. These constructs were designed to lower dislocation rates and to improve impingement-free range of motion. As a follow-up to our prior institutional study, we expanded on a cohort of DM reconstructions compared to non-DM constructs. We examined a modular dual mobility system in rTHA to measure loosening of the acetabular component, as well as revision and dislocation rates in comparison to an historical cohort of single articulation prostheses.

Materials/Methods: This retrospective cohort study from a single center included 254 patients who underwent rTHA with a dual mobility liner by three fellowship-trained surgeons between January 1, 2014 and December 1, 2019. This was a follow-up to an historical cohort of revisions performed with a single articulation prosthesis (n = 120) from the same surgeons performed between January 1, 2011 and December 23, 2013. The inclusion criteria included consecutively performed rTHAs that had a minimum follow-up of 2 years. We excluded patients who had femoral revisions and head/liner revisions only. The average follow-up in the dual mobility cohort and the single articulation cohort was 5 years (range, 2–10 years) and 2.5 years (range, 1.5–4.3 years), respectively. The primary outcomes were dislocation, aseptic loosening, and re-revision rates. Secondary outcomes were radiographic analyses of cup migration and osteolysis.

Results: There were 4 out of 256 (1.6%) dislocations from the dual mobility cohort compared to 7 out of 120 (5.8%), $P < 0.001$ from the single articulation cohort. The rates of aseptic loosening were 3.2% (8 out of 254) and 4.2% (5 out of 120), $P = 0.124$, respectively, between the cohorts. The re-revision rate was 5.9% for the DM liners and 8.3% in the control cohort, $P = 0.38$. Radiographic analyses revealed no cup migration and osteolysis in any of the patients that had no dislocations.

Conclusion: The dual mobility articulations in rTHA demonstrated improved results in terms of lower dislocations rates when compared to a single articulation prostheses. Our center uses these articulations for revisions and surgeons should consider the use of these bearings when performing rTHA.

1. Introduction

Failures of revision total hip arthroplasty (rTHA) are dominated by instability, ranging from 5 to 25% at 7 years.[1] Causes of instability after rTHA are complex and multifactorial: implant malpositioning, inadequate restoration of leg length, poor quality of soft tissue, or impingement between implants and/or bone.[2] To address instability, several options have been utilized including, jumbo cups, constrained acetabular components, soft tissue reconstruction, and dual mobility (DM) cups with varying success.[3]

The DM cup was invented by Gilles Bousquet and Andre Rambert in 1977 to increase range of motion and jump distance, which can minimize prosthetic neck impingement before dislocation occurs.[3] These bearings combine the stabilizing effect of a large polyethylene femoral head with a smaller metal or ceramic head within the plastic bearing. The literature has reported dislocation rates between 0 and 10.4% following the use of DM in rTHA.[4,5] This can be complicated by advanced age, concomitant neurological disease, and limited

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Table 1
Demographic Characteristics between Modular Dual Mobility and Control Cohort

Table 1: Demographics	MDM cohort	Control cohort
Variable	n = 254	n = 120
Age (years)	60 (30–92)	59 (20–84)
Women	134 (52.8)	68 (56.7)
Men	120 (47.2)	52 (43.3)
Mean follow-up (years)	5.0 (2.0–10.0)	2.5 (1.5–4.3)

Table 2
Most Common Reasons for Revision

Table 2: Most Common Reasons for Revision	MDM cohort **n=254 (%)**
Dislocation	104 (40.9)
Aseptic loosening	40 (15.7)
Peri-prosthetic fracture of the acetabulum	11 (4.3)
Infection	88 (34.6)
Implant fracture	11 (4.3)

compliance.[6] Modern DM constructs introduces modularity, allowing for the choice between a polyethylene liner and a DM liner into a standard acetabular shell. This design allows for screw placement for cup fixation and placement of a metal liner.[7]

Analyses of outcomes and complications involving modular DM liners in rTHA are limited in the literature to multicenter studies, follow-ups<3 years, and underpowered studies.[8–10] The purposes of our study were to follow-up from a prior, institutional study comparing DM implants to non-DM implants in order to analyze complications, including dislocations, loosenings of the acetabular component, and re-revisions of DM liners following rTHA. This was a follow-up of previous single articulation prostheses performed by the same surgeons that was previously published.[8] To our knowledge, this study represents the largest number of rTHA with MDM from a single institution. We hypothesized that DM liners will have low dislocation rates and low re-revision rates in the revision setting with no radiographic evidence of cup migration and osteolysis when compared to mono-articular constructs.

2. Methods

Using our institution's registry of prospectively collected data, we identified a cohort of the consecutive patients undergoing rTHA using a DM cup by three surgeons from January 1, 2014 and December 1, 2019. In 2014, a historical switch was made from fixed bearing or non-DM liners to the DM liners as this became more commonplace throughout the hospital. We compared this cohort to an historical cohort as a continuation to our prior study of revisions performed with a single articulation prosthesis (n = 120) from the same surgeons performed between January 1, 2011 and December 23, 2013.[8] The prevision publication of the first group of 60 MDM liners performed by the same three surgeons at a mean followup of 30 months was previously published in comparison to the historical cohort utilized in this study.[8]

To make the comparison more appropriate, we: i) focused only on acetabular revisions; ii) restricted our query to the same manufacturing company of the devices; and iii) reported the most common causes for revision (Table 2). The inclusion criteria included: i) implants from the same manufacturing company; ii) consecutively performed rTHA; and iii) minimum follow-up of 2 year. There were 21 patients (8.2%) lost to follow up. The exclusion criteria included i) femoral only revisions and ii) head/liner exchanges. We recorded demographics and complications at an average follow-up of 5 years (range, 2–10 years).

From January 1, 2014 to December 31, 2019 a total of 360 rTHA were performed by three surgeons. There were 106 patients who had either a femoral stem revision or an isolated liner exchange and were excluded from the study cohort. Additionally, 20 patients did not meet the inclusion criteria, including having a follow-up less than two years (2 patients). This left a total of 254 patients who fulfilled the inclusion criteria. The average age (60 vs. 59 years) and women to men ratio (134–120 vs. 68 to 52) were similar between the groups (Table 1). The five most common reasons for revisions were prior dislocation 104 out of 254 (40.9%), infection 88 out of 254 (34.6%), aseptic loosening 40 out of 254 (15.7%), peri-prosthetic fracture of the acetabulum 11 out of 254 (4.3%), and implant fracture 11 out of 254 (4.3%).

2.1. Surgical implants

In the DM group, an MDM liner was inserted after a revision acetabular component was implanted. The modular cups were of the same principal design from the same manufacturer (Stryker, Mahwah, New Jersey). All of the surgeries performed were entire cup revisions and we excluded any stem revisions or isolated liners exchanges, who were removed from the study. The transition from non-DM to DM liners resulted in no overlap between the systems.

The Modular Dual Mobility (MDM) system is made up of a cobalt-chromium liner seated into a titanium acetabular shell (Stryker Trident Tritanium™) via a taper. Either a metal cobalt-chromium head or a delta ceramic head is captured within a highly crosslinked polyethylene liner that freely rotates within the MDM liner. The head-polyethylene liner construct is assembled using an intraoperative press.

2.2. Radiographic analyses

In all patients, standard antero-posterior radiographs lateral radiographs of the hip were evaluated to assess for cup migration, osteolysis, and instability at first and latest follow-up. This was performed by two of the authors (JD, SB) and confirmed by the senior author (RD).

2.3. Outcomes and complications

The primary outcome measurements were dislocation, aseptic loosening of the acetabular component, and re-revision rates. The secondary outcome measurements were radiographic analyses of cup migration and osteolysis.

2.4. Data analyses

Data was inserted into an Excel spreadsheet (Excel, Microsoft Corporation, Redmond, Washington) for tabulation of results. Normally distributed continuous data was compared using Students *t*-test data. Categorial variables, including demographics and complications utilized Pearson *Chi*-square tests. A *P* value of <0.05 was determined to be statistically significant. The reference cohort for all variables was the historical cohort of patients who underwent revisions performed with a single articulation prosthesis (n = 120) from the same surgeons. Analyses were performed using R Studio (Statistics Department of the University of Auckland, New Zealand).

Table 3
Postoperative Complications between Modular Dual Mobility Cohort and Control Cohort

Table 3: Complications	MDM cohort	Control cohort	p-value
Variable	n = 254	n = 120	
Dislocations	6 (2.4)	7 (5.8)	<0.001
Aseptic Loosening	8 (3.2)	5 (4.2)	0.124
Osteolysis	1 (0.39)	NA	NA
All-cause revisions	15 (5.9)	10 (8.3%)	0.38

3. Results

The number of dislocations after revision was 4 out of 256 (1.6%) from the MDM cohort compared to 7 out of 120 (5.8%), $P < 0.0001$ from

Table 4
Literature review of risk of dislocation after dual mobility liners during revision THA.

Author	Year	Level of Evidence	Number of Dual Mobility Liners	Risk of Dislocation	Risk of Aseptic Loosening
Philippot et al.[26]	2009	IV	163	3.7%	2.9%
Langlais et al.[27]	2008	IV	88	1.1%	2.2%
Van Heumen et al.[28]	2015	IV	50	0%	NA
Schmidt et al.[29]	2020	IV	184	1.1%	1.6%
Wegrzyn et al.[30]	2015	IV	994	1.5%	NA
Mohaddes et al.[31]	2017	IV	436	1.6%	0.5%
Gonzalez et al.[32]	2017	IV	316	2.7%	2.7%
Hailer et al.[33]	2012	IV	228	2.0%	2.0%
Stucinskas et al.[12]	2018	IV	247	2.0%	NA
Harwin et al.[9]	2018	IV	85	1.2%	NA

the historical cohort of single articulation prostheses. The rates of aseptic loosening of the acetabular components were 3.2% (8 out of 254) and 4.2% (5 out of 120), $P = 0.124$, respectively, between the cohorts. The re-revision rate was 5.9% (15 out of 254) for the DM liners and 8.3% (10 out of 120) for the control cohort, $P = 0.380$. (See Table 3).

Radiographic analyses revealed no cup migration and osteolysis in any of the patients that had no dislocations. Radiographic evidence of instability was identified in the four patients who dislocated, which was appropriately corrected after undergoing rTHA. All four patients who had dislocations with MDM constructs had no evidence of a re-dislocation at follow-up as well as adequate functional and radiographic outcomes.

4. Discussion

To our knowledge, this study represents one of the largest number of rTHA with MDM from a single institution. This is a follow-up from a previous publication comparing 60 MDM liners performed by the same three surgeons to the historical cohort utilized in this study.[8] The DM liners had low re-revision rates, and dislocation rates at 5.0 years follow-up. Overall, we found the low dislocation rate and revision rate to be consistent with the literature for both DM (Table 4 and Table 5) and MDM, specifically, after rTHA.

The dislocation rate of 1.6% in the DM group after rTHA is consistent with several other low-rate studies. Harwin et al. found a dislocation rate of 1.1% in a matched cohort of 85 DM implants and 170 non-DM implants at 4 years and 10 years, respectively.[9] Huang et al. found a dislocation rate of 2.9% at a 3-year follow-up of 315 patients using just the MDM construct in revisions, but involving several institutions.[10] Also, a study using DM constructs from the Swedish Hip Registry found a re-revision rate of 2% (4 of 228) due to recurrent instability.[11] Also, in a similarly designed study, Stucinskas et al. and Sutter et al. found a dislocation rate of 2 and 3%, respectively.[12,13] An additional study performed by Abdel et al. support improved stability (3% dislocation rate for DM compared to 10% dislocation for non-DM) without a significant difference in fretting and corrosion in the MDM inserts.[14] The modular design of the MDM construct allows for screw placement for additional cup fixation providing extra stability.

Comparing our DM outcomes to a historical cohort in rTHA from a single surgeon's experience allows for an appropriate comparison group. Following revision THA, Dabis et al. found a dislocation rate of 7% for non-DM hips at a minimum of 2-year follow-up and De Martino et al. found a dislocation rate of 11% for non-DM hips in a systematic review analysis.[15,16] Stucinskas et al. found a dislocation rate of 9% for non-DM constructs.[12] The DM group may mitigate the need for a constrained liner. These DM bearings may decrease stresses at the implant bone interface, which decreases risk of loosening or failure. The articulations are able increase jump distance without including many of the disadvantages of constrained liners.[16]

In terms of re-revision for the DM liners, our low percentage of 5.9% is consistent with several other studies. Harwin et al. found a re-revision rate of 4.7% in a cohort of 85 patients (3 aseptic and 1 septic revisions) in the DM group and a re-revision rate of 5.3% in the non-DM group (6 due to dislocation and 2 septic revisions).[8] Stucinskas et al. found consistent revision rates (4.86% for DM group and 13% for non-DM group).[12]

The biomechanics of DM constructs throughout the literature has shown positive results to prevent dislocation.[17–19] This study supports the stability of the 28 mm head in the DM group as 236 out of 254 (92.9%) implants in this study were 28 mm head size. Harwin et al. found that a 28 vs. a 22 mm inner head size is protective against recurrent dislocation in their cohort of 315 patients.[9] In the non-DM group, the stability of the 36 mm head (dislocation rate of 4.9%) is consistent with several large studies. Lachiewicz et al. found a dislocation rate of 4% using a 36 and 40 mm diameter head in a series of 122 hips at high risk for dislocation.[20] In a prospective randomized clinical trial, Garbuz et al. found a dislocation rate of 1.1% for the 36 and 40 mm head diameters compared to 8.7% with 32 mm head diameter,[21] which is consistent with our findings with an average head diameter of 44.7 mm.

Concerns exists regarding the use of MDM prosthesis as there is potential for corrosion between the cobalt-chrome liner and titanium acetabular component and subsequent adverse local tissue reaction.[22,23] One systematic review of 248 MDM prosthesis found 13 patients (5.2%) had elevated cobalt ion levels and 4 patients (1.6%) had elevated chromium levels.[24] The authors recommend the continued metal ion surveillance to ensure the safety of DM constructs. Matsen et al. obtained serum cobalt and chromium levels for 100 patients undergoing THA with MDM and showed that four patients (4%) had elevated serum cobalt levels.[22] In our study, no patients had re-revision due to ALTR.

We acknowledge potential limitations in our study. A single institution contributed to reduced generalizability, but can emphasize the effectiveness of an implant because of similar techniques. In addition, the size of the rTHA DM cohort was small, but this represents the largest single institution cohort of rTHA DM liners. We hope to include a larger group of dual mobility rTHA as well as longer follow-up, but expect to

Table 5
Literature review of risk of dislocation after modular dual mobility liners during revision THA.

Author	Year	Level of Evidence	Number of Institutions	Number of MDM Liners	Risk of Dislocation	Risk of Aseptic Loosening
Huang et al.[10]	2019	III	Multi-Center	315	2.9%	2.5%
Sutter et al.[13]	2017	III	Single	64	3.1%	2.0%
Diamond et al.[34]	2018	III	Single	60	5.0%	NA
Jauregui et al.[8]	2015	IV	Single	60	1.7%	1.7%
Hernandez et al.[35]	2021	IV	Single	126	11%	4%

obtain similar results. Patient reported outcome measurements of an MDM cohort could provide additional support for the implant, but this has been described in the literature in a smaller cohort for primary THA and rTHA.[9,25] We maintain the strength of the study due to the homogeneity in surgeon protocol and outcomes consistent with the literature.

Our study provides more insight into DM bearings in rTHA. Although our analysis has an average 5-year follow-up and would benefit from a larger cohort and longer follow-up, we maintained homogeneity inclusion of only consecutive rTHA at a single institution. The use of a DM constructs in rTHA shows consistently low dislocation and revision rates.

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