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Trends in the use of dual mobility bearings in hip arthroplasty

AN ANALYSIS OF THE AMERICAN JOINT REPLACEMENT REGISTRY

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Aims

Dual mobility (DM) bearings are an attractive treatment option to obtain hip stability during challenging primary and revision total hip arthroplasty (THA) cases. The purpose of this study was to analyze data submitted to the American Joint Replacement Registry (AJRR) to characterize utilization trends of DM bearings in the USA.

Methods

All primary and revision THA procedures reported to AJRR from 2012 to 2018 were analyzed. Patients of all ages were included and subdivided into DM and traditional bearing surface cohorts. Patient demographics, geographical region, hospital size, and teaching affiliation were assessed. Associations were determined by chi-squared analysis and logistic regression was performed to assess outcome variables.

Results

A total of 406,900 primary and 34,745 revision THAs were identified, of which 35,455 (8.7%) and 8,031 (23.1%) received DM implants respectively. For primary THA, DM usage increased from 6.7% in 2012 to 12.0% in 2018. Among revision THA, DM use increased from 19.5% in 2012 to 30.6% in 2018. Patients < 50 years of age had the highest rates of DM implantation in every year examined. For each year of increase in age, there was a 0.4% decrease in the rate of DM utilization (odds ratio (OR) 0.996 (95% confidence interval (CI) 0.995 to 0.997); p < 0.001). Females were more likely to receive a DM implant compared to males (OR 1.077 (95% CI 1.054 to 1.100); p < 0.001). Major teaching institutions and smaller hospitals were associated with higher rates of utilization. DM articulations were used more commonly for dysplasia compared with osteoarthritis (OR 2.448 (95% CI 2.032 to 2.949); p < 0.001) during primary THA and for instability (OR 3.130 (95% CI 2.751 to 3.562) vs poly-wear; p < 0.001) in the revision setting.

Conclusion

DM articulations showed a marked increase in utilization during the period examined. Younger patient age, female sex, and hospital characteristics such as teaching status, smaller size, and geographical location were associated with increased utilization. DM articulations were used more frequently for primary THA in patients with dysplasia and for revision THA in patients being treated for instability.

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Introduction

Dual mobility (DM) articulations have been used in Europe since the 1970s with excellent outcomes at both mid-term and long-term follow-up.[1-3] The first FDA-approved DM articulation was made available in the USA in 2009. Recent reports of improved stability have fueled enthusiasm and expanded the utilization of these implants in both the primary and revision setting. This has occurred despite a lack of long-term data associated with the DM implants commercially available in the USA. Unlike the monoblock DM implants available throughout Europe, the vast majority of DM bearings used in the USA have a modular metal liner that locks into the acetabular shell. Given the recent interest in these implants, it is important to understand surgeon, patient, and hospital factors associated with the increased utilization of these bearing surfaces.

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Dislocation following THA remains a major concern after both primary and revision surgery even with the availability of larger diameter femoral heads. In addition, there are increased concerns about stability in high-risk patients including patients with abnormal anatomy (e.g. dysplasia), patients with small acetabular components that only accommodate a smaller diameter femoral head, and patients with spinopelvic pathology.[4] DM implants utilize a smaller diameter femoral head constrained within a larger polyethylene liner that articulates with a modular metal liner or a polished monoblock acetabular shell.[5] Unlike the original tripolar articulations, the intercalary DM insert is comprised entirely of polyethylene instead of a bipolar femoral head.[6] The combination of a large polyethylene liner and a mobile inner femoral head increases impingement-free range of movement and increases the jump distance to dislocate, thereby decreasing dislocation rates.[7]

National trends in the utilization of the most commonly used bearing surfaces (i.e. ceramic-on-polyethylene and metal-on-polyethylene) have been well described.[8,9] However, large administrative databases are unable to record DM bearing surfaces as there are no ICD-9 or ICD-10 modifier codes for this bearing surface. Therefore, a thorough description of DM bearing utilization in the literature is lacking. However, the American Joint Replacement Registry (AJRR) is able to record DM utilization and, for the first time, describe implanation trends in the USA.[10,11]

The purpose of this study was to describe trends for DM implanation in the USA for primary and revision THA by analyzing data from AJRR. The secondary purpose was to identify patient, surgeon, and hospital factors associated with the use of these articulations.

Methods

Patient demographics. When assessing DM usage by age, there was an increase across all age groups during the study period (Figure 1). Patients < 50 years of age showed the highest rates of DM utilization increasing from 8.8% of primary THA in 2013 to 13.7% in 2018. Patients ≥ 80 years of age received DM implants at the second highest rate, increasing from 5.9% in 2013 to 12.5% of cases in 2018.

All patients with data submitted to AJRR who underwent a primary or revision THA between 2012 and 2018 with bearing surface data were screened for inclusion in our analysis. Internally, AJRR manages a component database which is cross-referenced with the International Prosthesis Library. DM implants were identified by catalogue or lot numbers submitted to AJRR matched with the information in the component database. AJRR has been collecting component information since the beginning of the Registry. As reported in their 2019 AJRR *Annual Report,* completeness of selected attributes range from 57% to 99%.[12] Patients without implant information were excluded. Characteristics including age and sex were recorded for each patient. Hospital size and academic affiliation was recorded as major teaching institution, minor teaching institution, or non-teaching institution based on the 2018 American Hospital Association Survey.[13] Geographical region was based on the 2010 United States Census.[14]

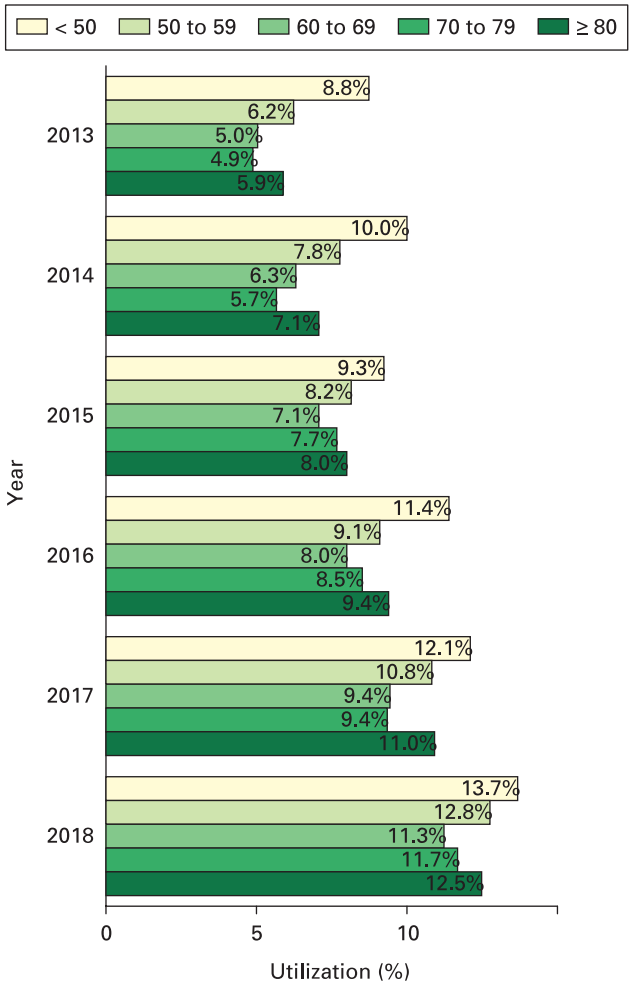

Fig. 1

Dual mobility utilization by age group from 2013 through 2018. In every year assessed, patients < 50 years of age showed the highest rate of dual mobility utilization. (Note: 2012 data were not graphed due to the low number of cases and contributing institutions)

The mean patient age of the DM cohort was 65.6 years (SD 12.3 years) compared to the non-DM cohort with a mean age of 65.9 years (SD 11.5). A total of 406,900 primary THAs were identified in the study period of which 35,455 (8.7%) received a DM articulation (Table I).

Statistical analysis. The proportion of patients who received a DM articulation was calculated annually and reported as a trend using descriptive statistics. Temporal trends were also assessed based on patient age, geographical region, and practice characteristics. Chi-squared analysis was used to assess differences in patient and hospital characteristics between patients who received a DM articulation and those who received another bearing type. Two separate logistic regression analyses were performed: one to assess patient, geographical, and hospital factors associated with DM utilization in primary THA and the second to identify factors associated with DM utilization during revision THA. Chi-squared analysis was also used to assess the utilization of DM articulations based on the operating diagnosis for primary and revision THA.

Table I. The number of primary and revision THA patients available for analysis by year.

Year	Primary, n			Revision, n			p-value*
	Dual mobility	Conventional bearing	Total	Dual mobility	Conventional bearing	Total	
2012	940	13,196	14,136	299	1,233	1532	< 0.001
2013	1,721	28,494	30,215	633	3,027	3660	< 0.001
2014	3,755	50,846	54,601	1,223	5,590	6813	< 0.001
2015	5,587	66,591	72,178	1,729	6,253	7982	< 0.001
2016	8,159	84,725	92,884	1,974	5,327	7301	< 0.001
2017	9,457	84,650	94,107	1,544	3,859	5403	< 0.001
2018*	5,836	42,943	48,779	629	1,425	2054	< 0.001
Total:	35,455	371,445	406,900	8,031	26,714	34,745	< 0.001

*Chi-squared analysis.
†The analysis was performed in the first quarter of 2019. The 2018 dataset is therefore incomplete as institutions were still submitting data at this time.

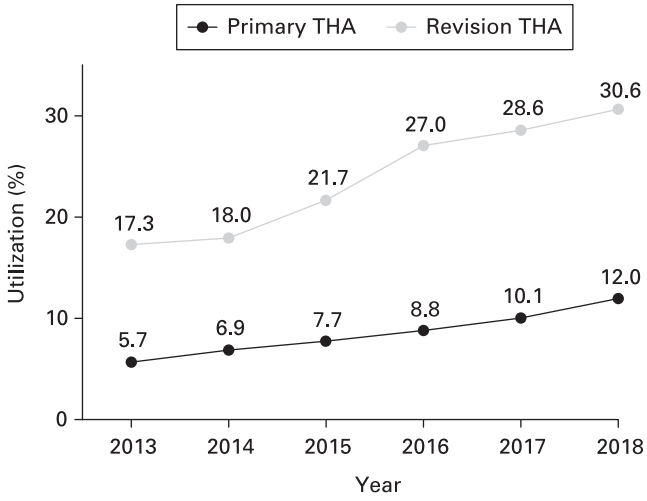

Fig. 2

Dual mobility utilization from 2013 through 2018. Dual mobility utilization showed a year-on-year increase for primary and revision THA during the period examined. (Note: 2012 data were not graphed due to the low number of cases and contributing institutions)

Table II. Odds ratios for dual mobility utilization from logistic regression analysis assessing patient, geographical, and hospital factors for dual mobility utilization in primary total hip arthroplasty.

Variable	Odds ratio	Confidence interval	p-value
Year of surgery	1.198	1.190 to 1.206	< 0.001
Age	0.996	0.995 to 0.997	< 0.001
Sex (female vs male)	1.077	1.054 to 1.100	< 0.001
Region (Reference: Northeast)			
Midwest	0.672	0.650 to 0.696	< 0.001
South	0.666	0.643 to 0.690	< 0.001
West	1.427	1.383 to 1.472	< 0.001
Teaching status (Reference: major teaching institution)			
Minor teaching institution	0.742	0.720 to 0.765	< 0.001
Non-teaching	0.603	0.580 to 0.627	< 0.001
Hospital size (Reference: > 400 beds)			
1 to 99 beds	1.273	1.228 to 1.320	< 0.001
100 to 399 beds	1.254	1.223 to 1.287	< 0.001

Results

Descriptive statistics. Among primary THA procedures, DM utilization increased from 6.7% in 2012 to 12.0% in 2018 (Fig. 2). Over the same time interval, 34,745 revision THAs were identified of which 8,031 (23.1%) received a DM implant. Among revision THA, DM utilization increased at an even more rapidrate with 19.5% revisions receiving a DM implant in 2012 and 30.6% receiving a DM implant in 2018.

Logistic regression analysis for primary THA. The year the surgery was performed was associated with utilization of DM articulations such that for each subsequent year assessed there was an approximately 20% increase in utilization (OR 1.198, $p < 0.001$) of DM implants for patients undergoing a primary THA (Table II). For every year increase in age, there was a 0.4% decrease in the rate of DM utilization (OR 0.996, $p < 0.001$). Females were more likely to receive a DM implant compared with males (OR 1.077, $p < 0.001$). The western USA (Washington, Oregon, California, Idaho, Nevada, Arizona, Montana, Wyoming, Utah, New Mexico, and Colarado, as defined by the census bureau)[12] was associated with the highest rate of DM usage compared to the other regions of the USA. Lastly, major teaching institutions and smaller hospitals were associated with higher rates of utilization.

Logistic regression analysis for revision THA. Patients undergoing revision surgery also saw a year-on-year increase in utilization of approximately 17% (OR 1.172, $p < 0.001$). Similar to primary THA, DM utilization for revision THA was associated with younger age (OR 0.996, $p < 0.001$), female sex (OR 1.077, $p < 0.001$), and was most commonly used in the western USA. However, unlike DM utilization during primary THA, DM usage for revision surgery was not associated with hospital size or teaching status.

Dual mobility selection by diagnosis. Patients undergoing primary THA for dysplasia (OR 2.448, $p < 0.001$), post-traumatic arthritis (OR 1.886, $p < 0.001$), femoral neck fracture (OR 1.834, $p < 0.001$), or osteonecrosis (OR 1.212, $p < 0.001$) were more likely to receive a DM articulation compared to patients undergoing a THA for osteoarthritis (Table IV).

Patients undergoing revision THA for instability (OR 3.130, $p < 0.001$), periprosthetic fracture (OR 2.669, $p < 0.001$), aseptic loosening (OR 2.204, $p < 0.001$), and infection (OR 2.002, $p < 0.001$) were more likely to receive a DM implant compared

Table III. Odds ratios for dual mobility utilization from logistic regression analysis assessing patient, geographical, and hospital factors for dual mobility utilization in revision total hip arthroplasty.

Variable	Odds Ratio	Confidence interval	p-value
Year of surgery	1.172	1.152 to 1.191	< 0.001
Age	0.996	0.993 to 0.998	< 0.001
Sex (female vs male)	1.116	1.061 to 1.175	< 0.001
Region (Reference: Northeast)			
Midwest	0.796	0.734 to 0.862	< 0.001
South	0.955	0.883 to 1.033	0.2486
West	1.244	1.149 to 1.346	< 0.001
Teaching status (Reference: major teaching institution)			
Minor teaching institution	0.989	0.926 to 1.056	0.7450
Non-teaching	1.011	0.920 to 1.111	0.8213
Hospital size (Reference: > 400 beds)			
1 to 99 beds	1.05	0.955 to 1.155	0.3148
100 to 399 beds	0.955	0.898 to 1.015	0.1396

Table IV. Odds ratios for dual mobility utilization by operating diagnosis for primary and revision total hip arthroplasty surgery.

Diagnosis	Odds ratio	Confidence interval	p-value
Primary THA (Reference: osteoarthritis)			
Osteonecrosis	1.212	1.143 to 1.285	< 0.001
Dysplasia	2.448	2.032 to 2.949	< 0.001
Femoral neck fracture	1.834	1.741 to 1.932	< 0.001
Rheumatoid arthritis	1.225	0.961 to 1.561	0.116
Post-traumatic arthritis	1.886	1.743 to 2.040	< 0.001
Revision THA (Reference: wear/osteolysis)			
Infection	2.002	1.741 to 2.302	< 0.001
Periprosthetic fracture	2.669	2.287 to 3.115	< 0.001
Aseptic loosening	2.204	1.928 to 2.520	< 0.001
Instability	3.130	2.751 to 3.562	< 0.001

with patients undergoing revision THA for wear and osteolysis (Table IV).

Discussion

DM utilization increased markedly over the study period, accounting for 12% of primary THAs and 30% of revision THAs in 2018. The utilization of this bearing was seen more commonly in patients < 50 years of age who underwent a primary THA, a finding that warrants justification and longer-term follow-up to further understand the implications of this practice. DM utilization was also associated with female sex and a diagnosis of dysplasia for primary THA. However, the largest increase in DM usage was seen for revision THA; DM bearings accounted for approximately one-third of all bearings utilized for revision surgery in the final year of our analysis. These results highlight the concern of arthroplasty surgeons with respect to postoperative instability after revision surgery. Recent studies have reported decreased rates of dislocation and reduced rates of reoperation for instability in patients who undergo a revision THA and receive a DM bearing.[15–21] While these reports show promising early and mid-term results, long-term data regarding the performance of these implants in the revision setting is necessary.

Several modern DM articulations have a modular acetabular metal liner, giving surgeons the intraoperative flexibility to change from a traditional bearing surface to a DM articulation if intraoperative stability is difficult to obtain. However, this flexibility introduces a new metal-on-metal interface between the metal liner and the acetabular shell that may be prone to fretting corrosion, abrasive wear, and potential adverse local tissue reaction (ALTR). Lombardo et al[22] examined 18 retrieved DM implants and found minimal back side fretting and corrosion on the metal liners. However, there was one liner with marked backside fretting damage and metal transfer from titanium screws placed into the acetabulum. Another study by Tarity et al[23] examined 18 retrieved DM articulations and found only minimal fretting and corrosion of the metal liners. Both studies[22,23] had a mean length of implantation of less than two years, which highlights the need for longer-term follow-up. While several studies have documented low serum metal ion levels in the vast majority of patients who received DM constructs at short- to mid-term follow-up[5,24–26], one report in the literature described two patients who received a modular DM implant who developed subsequent pain with high serum cobalt levels.[27] These patients had findings consistent with ALTR on metal artifact reduction sequence (MARS) MRI. Unfortunately the authors did not report whether this diagnosis was confirmed with a surgical procedure. While metal-backed modular DM implants are the most commonly used implants used in the USA, they are used far less frequently throughout Europe mitigating the concern of this potential failure mechanism.[28]

DM articulations also have a convex polyethylene surface that articulates with a metal liner, introducing a new potential source of polyethylene wear debris that is unique to these types of implant. A recent study by Deckard et al[29] assessed wear rates in 63 consecutive patients and found a steady state linear wear rate at five years of 0.27 mm/year. However, this study was limited in that only five of 63 patients had five-year follow-up and the authors relied on plain radiographs to measure wear. In contrast, a study by Adam et al[30] assessed 40 hips at a mean follow-up of eight years or 96 months (36 to 186) and found a steady state linear wear rate of 0.082 mm/year, much lower than the previous report. The monoblock DM implant is not commercially available in the USA limiting the translatability of these findings. A recent in vitro wear study by Loving et al[31] found a low steady state volumetric wear rate of DM articulations at 2.5 million cycles. The authors of this study noted that this wear rate increased almost ten-fold when the inner bearing seized, a finding of particular concern as this mechanism has been described previously at long term follow with DM implants used in Europe.[32] In contrast, several studies from Europe have reported promising wear data, both in vivo[1,33] and in vitro.[34] However, the implants utilized in these studies are different from the ones used throughout the USA and, as such, these findings may not translate to the trends reported in the current study.

DM implants have gained increased popularity since they were introduced into the USA market approximately ten years

ago[35] because of the potential to decrease dislocation following primary and revision THA. A recent meta-analysis by Reina et al[36] found that patients with a traditional solid bearing articulation were approximately four times more likely to suffer a dislocation (OR 4.06, $p < 0.001$) and almost three times more likely to undergo a revision for instability (OR 2.97, $p = 0.04$) compared to patients who received a DM implant. Similarly, patients who underwent a revision THA were over three times more likely to have a dislocation (OR 3.59, $p < 0.001$) and almost five times more likely to require a rerevision for instability (OR 4.88, $p = 0.007$) than patients who received a DM articulation. Several other recent meta-analyses and registry studies have reported similar findings, providing an explanation of the trends noted in the AJRR data.[21,37,38]

This study is not without limitations. First, conclusions about nationwide trends are limited as the data obtained from AJRR may not be representative of nationwide trends given over-representation of geographical regions such as the western USA and under-representation of non-teaching hospitals.[39] Nevertheless, the AJRR represents the largest representative sampling of patient data containing DM implant records and, as such, we believe the AJRR offers a relevant description of DM utilization trends. Second, because teaching hospitals contribute more data to AJRR than non-teaching hospitals and teaching hospitals reported a higher rate of DM utilization, the trends in the current study may overestimate the true rate of DM utilization in the USA. Third, like all databases, the data presented herein rely on accurate coding of implants and are subject to reporting error. However, the AJRR undergoes a rigorous process of internal auditing to ensure the accuracy of the collected data. Lastly, the results from our logistic regression describe associations with DM utilization and are not meant to imply a causal relationship between any of the factors identified. As such, we are unable to make any conclusions about the influences behind the patient, hospital, and geographical factors associated with increased DM utilization. While the factors associated with increased DM utilization identified herein are likely driven by surgeon concerns of increased instability, further study is needed to understand these influences in more detail to determine if increased DM utilization for these specific subgroups is warranted.

In summary, DM implantation has increased markedly in the USA. These devices are being used more frequently in younger female patients, patients with dysplasia, and in the revision setting, particularly for instability. Given the recent broad utilization of these implants, long-term follow-up studies assessing survival and complications are needed to optimize the utilization of this bearing surface.

Take home message

- Dual mobility utilization has increased markedly in the USA.
- Younger patient age and female sex were associated with increased utilization.
- Dual mobility implants were used most commonly in primary THA for dysplasia and in revision THA performed for instability.

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