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Dislocated and Dissociated Dual-Mobility Components Are Easily Missed and More Than Half Fail Closed Reduction

Six Tips to Aid Management

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Background: Dual-mobility (DM) implants reduce the risk of dislocation in patients who have undergone total hip arthroplasty (THA); however, DM implants are at risk for large-head dislocation and intraprosthetic dissociation (IPD), where the inner femoral head dissociates from the outer polyethylene head. This study aimed to report the incidence of DM dislocation and IPD, evaluate the rate of recognition of IPD before and after reduction, investigate the outcomes of these complications, and provide treatment recommendations for their management.

Methods: Between 2010 and 2021, 695 primary and 758 revision THAs were performed with DM constructs at a single institution. There were 44 large-head dislocations (3.0%) and 10 IPDs (0.7%). Four additional IPDs occurred during attempted closed reduction, increasing the IPD incidence to 0.96%. We reviewed prior instability history, dislocation management, success of reduction, recognition of IPD, and subsequent rates of revision and complications. The mean follow-up was 2.5 years.

Results: Nine of 10 IPDs were missed at presentation and thus not treated as such. Sixty-three percent of attempted closed reductions in the emergency department failed and led to 4 IPDs and 1 periprosthetic fracture. Reduction success was associated with the following factors: use of general anesthesia with paralysis (p = 0.02), having the reduction performed by an orthopaedist (p = 0.03), and undergoing only 1 reduction attempt (p = 0.015). Two-thirds of dislocations required revision. The rate of redislocation was 33%, and 5 hips required subsequent revision at a mean of 1.8 years after the initial dislocation.

Conclusions: We present an evaluation of DM-implant dislocation and dissociation along with management recommendations based on these data. Given the low success and high complication rates of attempted closed reduction and the need for eventual revision, we recommend that all patients with dislocated DM implants be brought to the operating room for closed reduction as well as potential revision if the reduction fails.

Level of Evidence: Therapeutic Level IV. See Instructions for Authors for a complete description of levels of evidence.

With modern total hip arthroplasty (THA), dislocation is one of the most frequent complications and indications for revision[1,2]. Modular dual-mobility (DM) implants, designed in France in 1974, have been shown to reduce the risk of dislocation in primary and revision THA[2-10]. Their success has resulted in an increase in the use of DM implants as reported in the Swedish, Australian, and American total joint registries[1,2,10,11]. The 2021 American Joint Replacement Registry (AJRR) report indicated that 1 in 10 primary and 1 in 4 revision THAs used a DM articulation[1].

Despite their increased stability, dislocation of DM components may still occur. Reported DM dislocation rates are as low as 0% to 5% in the setting of all-cause THA revision[2-5,12-16]; however, the dislocation rate may be as high as 17% in revisions that are performed for instability[17]. Dislocated DM implants can present as a large-head dislocation

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from the acetabular component or as an intraprosthetic dissociation (IPD), a complication that is unique to DM components, where the smaller-diameter inner femoral head dissociates from the larger outer polyethylene head[18,19]. Because of the radiolucency of the polyethylene head, identifying DM-component dislocation is challenging, and identifying that an IPD has occurred is even harder as the smaller head most commonly remains within the acetabular component.

The reported rate of IPD ranges from 0.2% to 17.0%[4,20-24]. Analyses of explanted French DM components after IPD have suggested that chronic wear of the polyethylene retention ring within the mobile head may disrupt the locking mechanism and may be the most common reason for failure. Studies have also shown that intra-articular arthrofibrosis leads to less motion of the larger bearing, leading to more motion of the smaller head and eventual impingement-related damage to the retention ring; IPD can also be associated with acetabular component loosening[6,24-26]. When IPD occurs, surgical management is mandatory; thus, detection before and after reduction attempts is critical[27].

The rates of modern modular DM-implant dislocation and IPD are unknown, and there is a paucity of literature on the detection and management of these complications. We hypothesized that dislocation and dissociation are rare but not easily detectable at presentation. This study aimed to (1) report the incidence of modular DM-implant dislocation and IPD, (2) evaluate the rate of recognition of IPD before and after reduction, and (3) present recommendations for identifying and treating dislocated DM implants to assist orthopaedic surgeons and emergency department (ED) teams in the management of these complications.

Materials and Methods

We conducted an institutional review board-approved retrospective review of an institutional total joint registry at a single academic center from 2010 to 2021. The registry database has prospectively followed total joint arthroplasties since 1969. We queried the database for patients who underwent primary or revision THA with a DM articulation since our institution began using DM constructs in 2010. We excluded patients with DM components that had been implanted at outside institutions. We identified 1,453 DM THAs from a total of 13,442 THAs during the study period: 695 primary (6.8% of primary cases), and 758 revision THAs (22.6% of revisions) were performed with DM constructs.

Complications were prospectively collected for each patient enrolled in the registry, including any reported dislocations that occurred outside our institution. Patients were specifically asked about dislocation events at 2 and 5 years and every 5 years thereafter, and medical records were queried for any postoperative complications by 4 full-time employees. Of the 1,453 DM THAs, 54 hips in 48 patients sustained ≥1 DM dislocation or IPD, which was confirmed by medical records and a review of radiographs. Within this group, the most frequent indication for a DM articulation was instability; other indications for DM use are detailed in Table I. DM components were implanted via a posterior approach in 72.2% of cases and an anterior approach in 27.8% of cases. Fifty-one patients had femoral heads with an inner diameter of 28 mm, and 3 had femoral heads with an inner diameter of 22 mm.

TABLE I Patient Demographics, Preoperative Factors, and Surgical Details* (N = 54)

Demographics	
Age at surgery *(yr)*	64 (38-85)
Women	29 (53.7%)
BMI *(kg/m²)*	29.8 ± 7.6
Time to dislocation	41 wk (1 day-6 yr)
Follow-up *(yr)*	2.5 ± 1.2
Preoperative factors	
Primary/revision	10/44
Prior instability	2/37
Prior spine fusion	3/19
Abductor insufficiency	2/7
Conversion arthroplasty	4/NA
Cognitive impairment	4/13
Surgical factors	
Approach	
Anterior	15 (27.8%)
Posterior	39 (72.2%)
DM manufacturer	
DePuy Synthes	2
Smith & Nephew	7
Stryker	26
Zimmer Biomet	19
Head size	
22 mm	3
28 mm	51
Indication for DM THA	
Primary osteoarthritis	6
Posttraumatic osteoarthritis	4
Instability	37
Adverse local tissue reaction	4
Periprosthetic fracture	1
Infection	6
Aseptic loosening	2

*The values are given as the mean (range), mean ± standard deviation, or number with or without the percent in parentheses. NA = not applicable.

Some dislocated DM implants were treated at outside EDs; radiographs and clinical records regarding these dislocation episodes were obtained for this study. We collected information regarding risk factors for instability, management

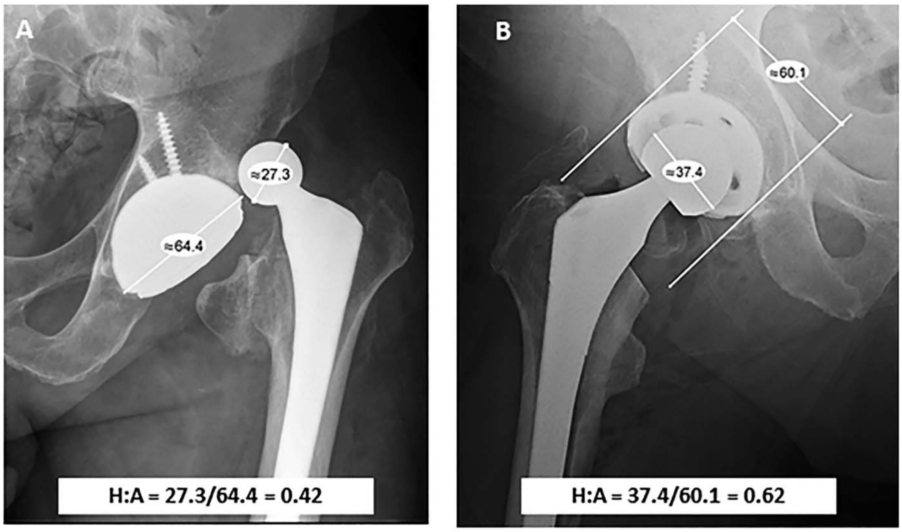

Fig. 1

Figs. 1-A and 1-B Radiographs of THAs with different types of implants. **Fig. 1-A** A left THA with a DM implant demonstrating the occlusion of the screw holes by the metal acetabular liner, which is a characteristic of DM articulations; the calculation of the H:A ratio for this implant is illustrated. **Fig. 1-B** A right THA with a standard-articulation implant demonstrating clearly visible screw holes in the acetabular shell due to the radiolucent polyethylene liner; the calculation of the H:A ratio in this hip is also shown. Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.

of the dislocation, recognition of IPD, success of closed reduction, and subsequent revision and complications rates for the study cohort.

Radiographs were retrospectively reviewed for DM dislocation and IPD. We evaluated the ratio of the head and acetabulum diameters (H:A ratio) on the presenting radiographs (Fig. 1) in order to confirm the presence of a DM component. All 54 dislocated DM implants in this cohort were measured and compared with the 10 standard THA components that had been implanted at our institution. The H:A ratio for each combination involving a DM or standard head can be calculated from charts that are available from the implant companies (Tables II and III).

Descriptive statistics are reported as the median (range), mean ± standard deviation, or as the number (percentage). The association of patient-specific variables with the rates of successful reduction, redislocation, and rerevision was assessed using multivariable logistic regression analyses. A p value of 0.05 was considered significant.

Results

Patient Cohort

Of the 54 DM dislocations, 10 were in primary THAs and 44 were in revision THAs. The mean age at the index arthroplasty was 64 years (Table I). THA was performed in 29 women (53.7%) and 25 men (46.3%). The mean time to dislocation

TABLE II The H:A Ratio for Standard THA Articulations in Each Available Head and Shell Combination*

Head Diameter *(mm)*	Acetabular Shell Diameter *(mm)*															
	42	44	46	48	50	52	54	56	58	60	62	64	66	68	70	72
22	*0.52*	*0.50*	0.48	0.46	0.44	0.42	0.41	0.39	0.38	0.37	0.35	0.34	0.33	0.32	0.31	0.31
28	**0.67**	**0.64**	**0.61**	*0.58*	*0.56*	*0.53*	*0.52*	*0.50*	0.48	0.47	0.45	0.44	0.42	0.41	0.40	0.39
32		**0.73**	**0.70**	**0.67**	**0.64**	**0.61**	*0.59*	*0.57*	*0.55*	*0.53*	*0.52*	*0.50*	0.48	0.47	0.46	0.44
36				**0.75**	**0.72**	**0.69**	**0.67**	**0.64**	**0.62**	**0.60**	*0.58*	*0.56*	*0.55*	*0.53*	*0.51*	*0.50*
40						**0.77**	**0.74**	**0.71**	**0.69**	**0.67**	**0.65**	**0.63**	**0.61**	*0.59*	*0.57*	*0.56*
44								**0.79**	**0.76**	**0.73**	**0.71**	**0.69**	**0.67**	**0.65**	**0.63**	**0.61**

*As surgeons today are most likely to select a larger femoral head implanted into an acetabular shell in a standard THA, standard articulations are more likely to have a ratio of ≥0.6 (boldfaced numbers). The most common size head, 36 mm, will always produce an H:A ratio of ≥0.50. Italicized numbers represent a ratio between 0.50 and 0.59.

TABLE III The H:A Ratio for THA with DM Articulations in Each Available Head and Shell Combination*

Head Diameter *(mm)*	Acetabular Shell Diameter *(mm)*											
	46	48	50	52	54	56	58	60	62	64	70	72
22	0.48	0.46	0.44									
28	**0.61**	*0.58*	*0.56*	*0.54*	*0.52*	*0.50*	0.48	0.47	0.45	0.44	0.40	0.39

*DM constructs use either a 22.2-mm or 28-mm head. Therefore, nearly all DM constructs will have an H:A ratio of <0.60. Italicized numbers represent a ratio between 0.50 and 0.59. The only exception involves a 46-mm acetabular component (boldfaced number).

following surgery was 41 weeks. The mean follow-up after dislocation was 2.5 years (range, 6 months to 9 years). There were several risk factors for instability in this cohort: prior instability in 72.2%, spinal fusion in 40.7%, abductor insufficiency in 16.7%, and cognitive impairment in 31.5%. Therefore, it is critical to obtain a detailed history because prior instability, neurologic comorbidities, and prior spine surgery may all suggest the presence of a DM implant (Tip 1).

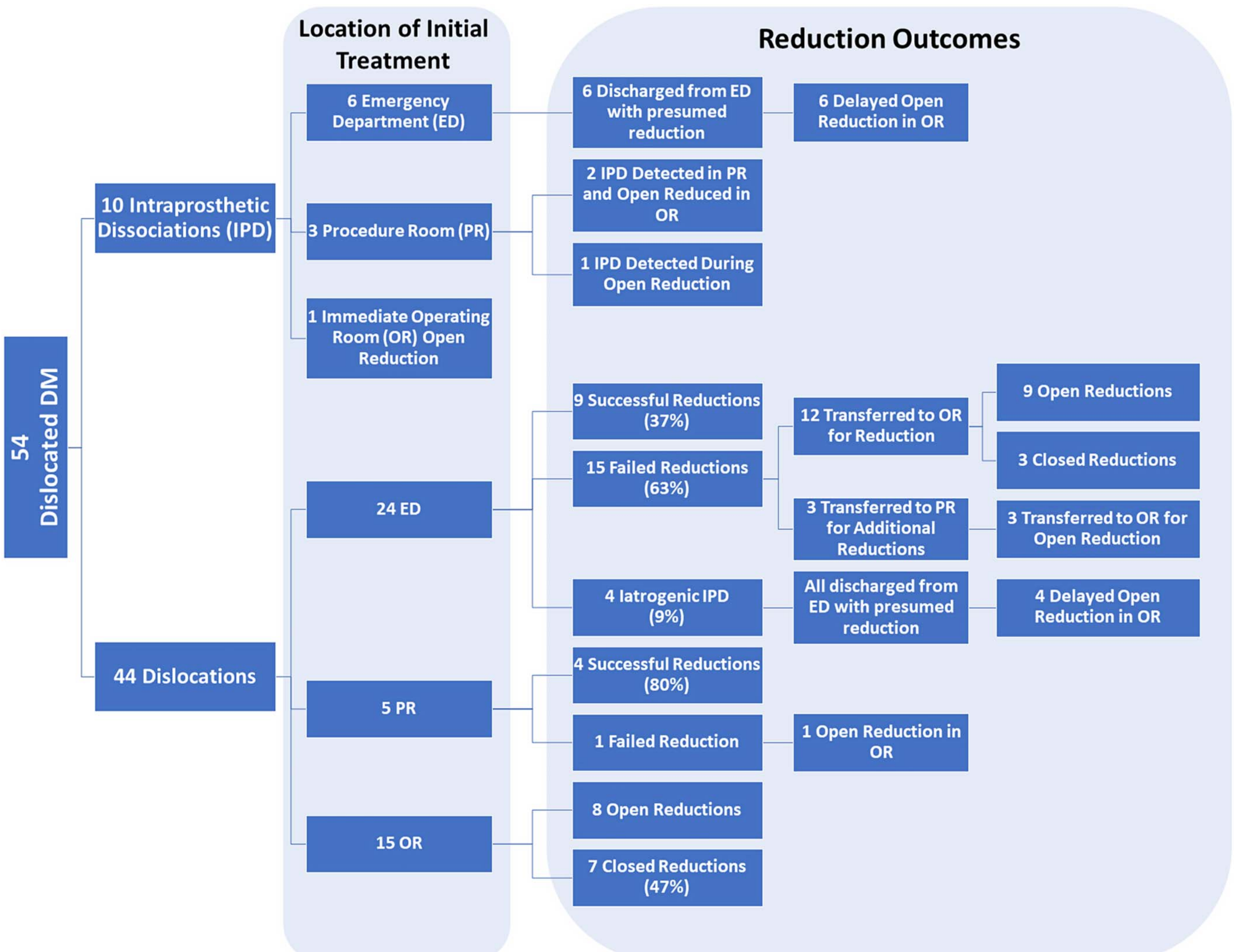

Fig. 2

A flowchart demonstrating the progression of each dislocated DM construct from initial presentation to final management. Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.

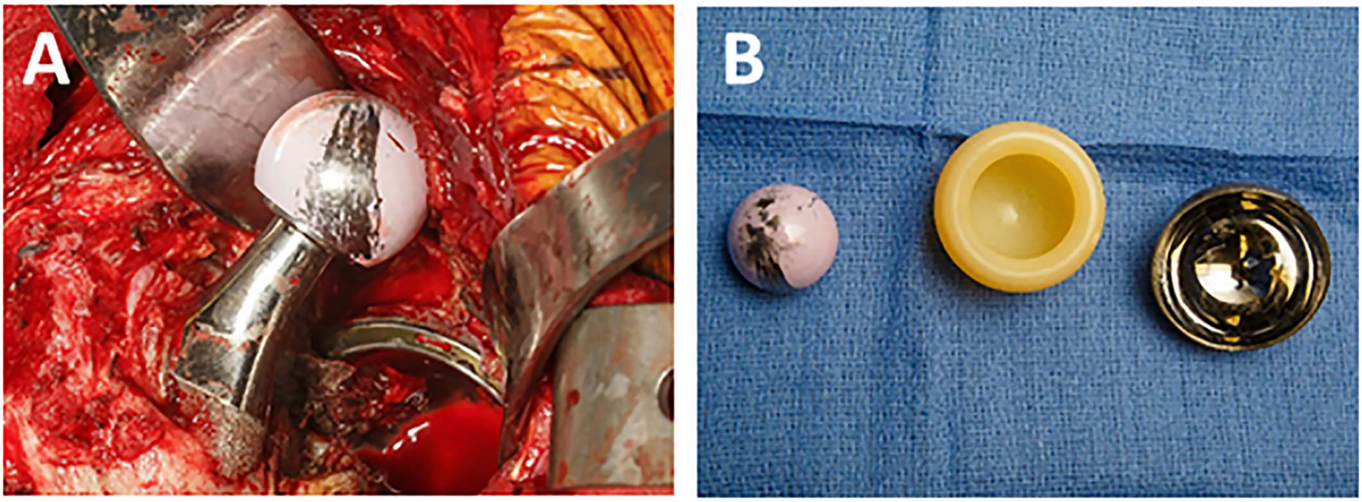

Fig. 3

Figs. 3-A and 3-B Intraoperative clinical photographs of an IPD that had not been detected on initial reduction attempts in a procedure room setting or during closed reduction attempts in the operating room. **Fig. 3-A** In situ evaluation of the dissociated head with clear ceramic damage from articulation without the polyethylene shell. **Fig. 3-B** Explanted DM components. Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.

Incidence and Management of Large-Head Dislocation or IPD

Fifty-four of 1,453 hips presented with either dislocation or IPD, representing an incidence of 3.7%; 44 (3.0%) were large-head dislocations and 10 (0.7%) were IPDs. Four iatrogenic IPDs occurred during attempted closed reduction, bringing the total IPD incidence to 0.96%. On regression analysis, when controlling for age, sex, revision or primary surgery, prior instability, abductor insufficiency, and time to dislocation, IPD was associated with increased body mass index (BMI) ($p = 0.045$) and spinal fusion ($p = 0.027$).

Nine of 10 IPDs were missed at presentation and underwent ≥1 closed reduction attempt; the 1 IPD that was detected at presentation was identified by an orthopaedic surgeon at an outside hospital (Fig. 2). It is critical to evaluate the acetabular component for occlusion of the screw holes and to evaluate the H:A ratio (Tables II and III) (Tips 2 and 3). For each IPD, retrospective review of the radiographs demonstrated evidence of a polyethylene "bubble" sign in the soft tissues or lack of a "halo" of polyethylene around the radiopaque femoral head component. It is critical to emphasize the importance of scrutinizing the soft tissues for these radiographic findings (Tip 4). Two IPDs were detected after an unsuccessful reduction attempt, and the patients were taken for immediate revision. A third IPD was detected during open reduction following failed closed reduction attempts (Fig. 3). The 6 patients with IPDs that were managed in the ED with closed reduction were discharged home with persistent IPD after presumed reduction.

Management of the Initial Dislocation

Seventeen (31%) of the dislocated DM hips were initially managed at an outside hospital. Including the 9 unrecognized IPDs, 53 of the 54 hips underwent ≥1 reduction attempt (19 were attempted by ED staff, including 12 at an outside ED). Sixteen underwent attempted reduction by an orthopaedic resident, and 19 underwent attempted reduction by orthopaedic faculty. Closed reduction was successful in 23 (52%) of 44 hips with large-head dislocations. Twenty-four of the 44 underwent an initial reduction attempt in the ED under intravenous sedation, with a 37% success rate, and 12 of the 15 failed ED reductions required conversion to open reduction. Among all cases, 38% of the dislocations were successfully reduced on the first attempt; only 5% of the 30 second attempts at reduction and none of the third attempts were successful. If we include all of the reduction attempts, 24 occurred under procedural sedation, and 9 (38%) of these hips were successfully reduced. General anesthesia with paralysis was used in 29 of the closed reduction attempts, with success in 14 (48%).

On multivariable logistic regression analysis, reduction success was associated with an orthopaedist performing the reduction ($p = 0.03$), the use of general anesthesia with paralysis ($p = 0.02$), and only 1 reduction attempt ($p = 0.015$) when controlling for age, sex, BMI, time to dislocation, history of instability, and abductor insufficiency. Based on these data, we suggest that reduction be performed under a general anesthetic with paralysis because the success rate is higher with the first attempt (Tip 5).

It is important to highlight that 4 additional iatrogenic IPDs were caused during attempted reduction, for a total of 14 IPDs. The patients with the 4 iatrogenic IPDs were discharged from the hospital with presumed reduction. This highlights the importance of scrutinizing postreduction radiographs for signs of IPD (Tip 6). Ten patients with IPD were discharged with the inner femoral head articulating directly with the acetabulum. All were detected later via radiographs or advanced imaging (computed tomography [CT] and magnetic resonance imaging [MRI]) when the patients presented with difficulty with ambulation at the time of follow-up (Fig. 4). Twelve IPDs were revised within 1 month, 1 remained undetected for >2 months before revision, and 1 patient died with an IPD at 5 months.

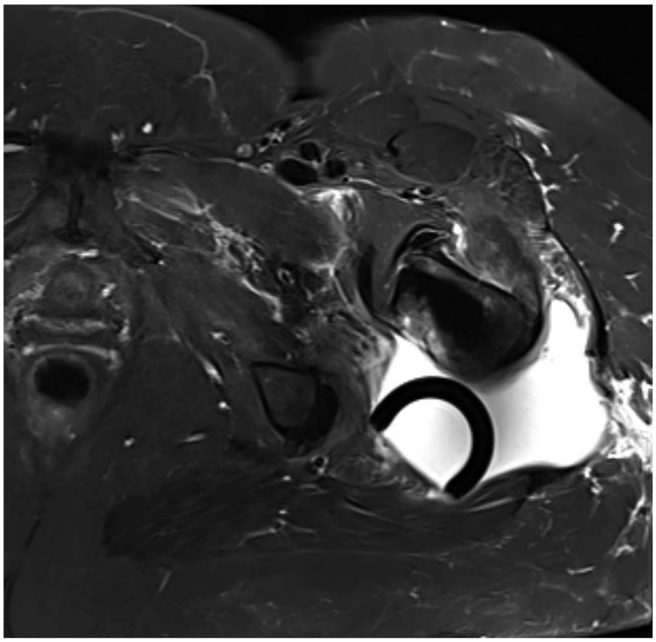

Fig. 4
Axial T2-weighted MRI of a left hip with an IPD of the DM implant, which had been detected at a follow-up visit for continued groin pain and difficulty with ambulation after presumed reduction in the ED. Used with permission of Mayo Foundation for Medical Education and Research, all rights reserved.

Radiographic Review
All 54 dislocated DM implants had an H:A ratio of ≤0.50 (mean, 0.46 ± 0.04). The mean H:A ratio in 10 standard articulations was 0.68 ± 0.04, and all were >0.60. Nonconcentric head reduction was seen in 6 patients with IPD. The bubble sign was present in 5 IPDs at presentation; a polyethylene halo around the femoral head was absent in the other 5 IPDs.

Revisions
Of the 54 dislocated DM implants, 35 (65%) ultimately required open reduction and component exchange to treat the dislocation. Twenty-two patients underwent revision to a constrained liner, 13 underwent DM component exchange, 1 required revision of the metal DM acetabular liner, and 9 underwent acetabular component revision with implantation of a component with increased anteversion. Five hips required subsequent revision after the initial dislocation treatment, at a mean of 1.8 years (range, 3 months to 7 years) after dislocation. When controlling for age, sex, BMI, a primary or revision index procedure, and open dislocation treatment, regression analysis revealed that rerevision was associated with a history of IPD ($p < 0.001$) and ≥2 closed reduction attempts ($p = 0.048$). In this series, the rate of later redislocation following reduction or revision was 33%. Redislocation was significantly associated with IPD ($p = 0.019$) and open dislocation treatment ($p = 0.003$) on multivariable regression analysis that controlled for age, sex, BMI, approach, a primary or revision index procedure, prior instability, abductor insufficiency, and spinal fusion.

Discussion

The use of DM components is growing globally; therefore, surgeons are increasingly likely to encounter a dislocated or dissociated DM implant. To our knowledge, this study represents the largest series of DM dislocations to date; the incidence of DM dislocation was 3.0% and that of IPD was 0.96%. This is consistent with prior work, including a fairly recent systematic review of DM components in THA[28], and the 3.0% dislocation rate is relatively low compared with the rate for standard THA articulations[3,14].

Detecting the presence of a DM component at the time of dislocation is paramount, and we recommend that all patients with dislocations be evaluated for the presence of a DM component. In this series, all of the DM components were implanted at our institution; therefore, the practitioner had access to the operative reports. However, implant details may not be available if a dislocation is treated outside of the surgical center, which was the case for one-third of this cohort. Evaluation of the H:A ratio is a radiographic technique for the identification of DM implants. In this series, all 54 dislocated DM components had an H:A ratio of ≤0.50 (mean, 0.46 ± 0.04). This ratio is applicable to any radiograph of a THA and does not require calibration of the radiograph scale. We propose an H:A ratio cutoff of 0.60: patients with an H:A ratio of <0.60 are likely to have a DM implant. Detection of a dislocated DM articulation should prompt orthopaedic consultation because reduction by an orthopaedist was more successful in our cohort and there was a high rate of open reduction or revision.

After confirming a DM articulation, evaluation for IPD is necessary. IPD was associated with increased BMI and spinal fusion; in this series, IPD was missed in all but 1 patient. Radiographs should be scrutinized for the presence of a halo around the femoral head or a bubble in the soft tissues[29] (Fig. 5). Evaluation of the acetabular component for the presence of a metal liner, seen as occlusion of screw holes, should also raise awareness of a DM bearing (Fig. 1). These guidelines aim to decrease the rate of missed IPDs, which was 90% in this study. An IPD requires open reduction and, at minimum, a modular-component exchange. A missed IPD presents a substantial risk as the inner head articulates directly with the acetabular shell, releasing metal debris.

Standardizing the management of a dislocated DM component is critical. In our study, most (63%) of the attempted reductions in the ED with intravenous sedation were unsuccessful. Attempted closed reduction in the ED caused iatrogenic IPD in 4 patients and a periprosthetic fracture in 1—complications that required surgical management. The 65% rate of eventual open management in this series supports closed reduction under general anesthesia by an orthopaedist to maximize the odds of reduction success, with a low threshold for converting from closed reduction to open reduction or revision in the operating room. It is also critical to evaluate postreduction radiographs for IPD, since 4 IPDs occurred at the time of reduction and all 4 patients had been discharged home. One must look for eccentricity of the femoral head relative to the acetabulum, indicative of IPD[27] (Fig. 6).

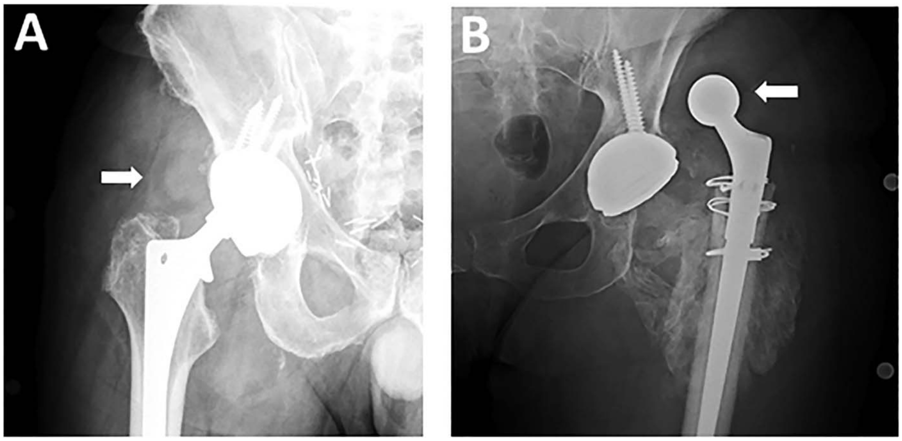

Fig. 5

Figs. 5-A and 5-B Radiographs of hips with DM implants. **Fig. 5-A** IPD with a bubble sign (arrow) that is lateral to the articulation demonstrating dissociation of the polyethylene shell. **Fig. 5-B** True dislocation of a DM component, with a halo sign (arrow) around the ceramic femoral head demonstrating that the polyethylene shell remains intact.

In this series, 5 hips required rerevision, and the rate of redislocation was 33%. Redislocation and rerevision were both significantly associated with IPD; therefore, these data may be used to counsel patients on these increased risks after IPD. Rerevision was also associated with multiple closed reduction attempts, which emphasizes the importance of maximizing success on the first attempt. Previous work has reported failure rates of up to 18% following isolated DM-component exchange after IPD, and further investigation is necessary to determine the most durable revision protocol[24]. When revising a DM component, it is crucial to scrutinize the liner and shell interface for corrosion as this is a source for metal debris[30].

There were limitations to the current study. This was a retrospective review limited by the data available in the medical record. Dislocation management varied according to institutional resources. There may have been DM-component dislocations that were not reported to our prospective registry; therefore, this study may have underestimated the true event incidence. Additionally, the measured size of the DM components in the H:A ratio may have been biased by the direction of the dislocation and the projection of the radiograph. Finally, the small number of DM dislocations limited the statistical analysis.

To help in the detection of DM dislocation and IPD, new generations of DM implants may add a radiopaque marker within the polyethylene to aid in radiographic visualization. This may help to detect IPD and confirm reduction. In this study, IPD was associated with spinal fusion; therefore, future work is needed to determine whether consideration of the spinopelvic relationship would avoid instability in THAs with DM constructs.

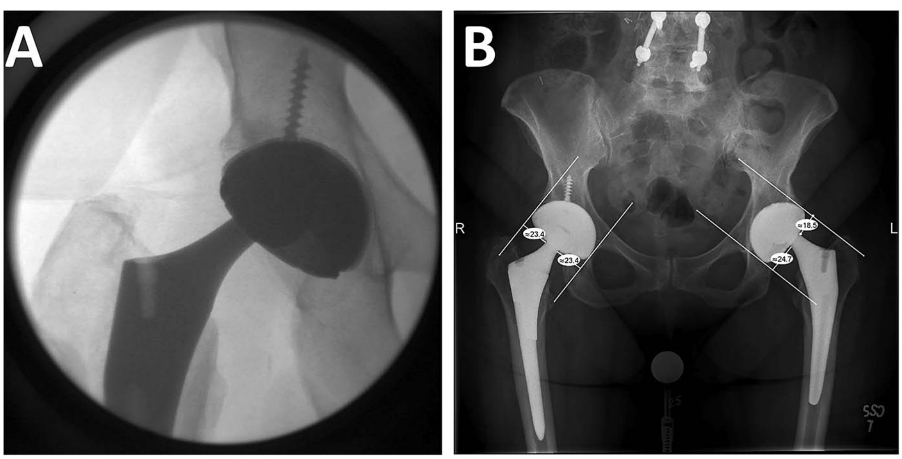

Fig. 6

Figs. 6-A and 6-B Imaging of DM constructs. **Fig. 6-A** Fluoroscopic image during attempted closed reduction of a hip with a DM construct. Axial loading revealed the eccentric position of the head component within the acetabulum, indicating IPD. **Fig. 6-B** Postreduction radiograph of a left DM component; the DM component demonstrates subtle, but measurable, eccentricity of the left femoral head relative to the acetabular component when compared with the well-aligned DM component on the right side.

As discussed throughout the text, we recommend the following 6 tips for the evaluation and management of DM dislocations:

(1) Obtain a detailed patient history, because previous instability and prior spine surgery may suggest the presence of a DM implant.
(2) Evaluate the acetabular component for occlusion of the screw holes, which indicates a metal DM liner.
(3) Calculate the H:A ratio. A ratio of <0.60 likely represents a DM implant (Table III).
(4) Examine radiographs for a halo around the femoral head or a bubble sign in the soft tissues (Fig. 5) to determine the presence of an IPD.
(5) Closed reduction of a DM implant should be performed under general anesthesia, and the operating room team should be ready for open management if necessary.
(6) Scrutinize the postreduction radiographs for eccentricity of the femoral component (Fig. 6), which may indicate IPD. ■

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