



Systematic review

Early intraprostatic dislocation in dual-mobility implants: a systematic review

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ABSTRACT

Background: Dual mobility implants are subject to a specific implant-related complication, intraprostatic dislocation (IPD), in which the polyethylene liner dissociates from the femoral head. For older generation designs, IPD was attributable to late polyethylene wear and subsequent failure of the head capture mechanism. However, early IPDs have been reportedly affecting contemporary designs.

Methods: A systematic review of the literature according to the preferred reporting items for systematic reviews and meta-analyses guidelines was performed. A comprehensive search of PubMed, MEDLINE, Embase, and Google Scholar was conducted for English articles between January 1974 and August 2016 using various combinations of the keywords "intraprostatic dislocation," "dual mobility," "dual-mobility," "tripolar," "double mobility," "double-mobility," "hip," "cup," "socket," and "dislocation."

Results: In all, 16 articles met our inclusion criteria. Fourteen were case reports and 2 were retrospective case series. These included a total of 19 total hip arthroplasties, which were divided into 2 groups: studies dealing with early IPD after attempted closed reduction and those dealing with early IPD with no history of previous attempted closed reduction. Early IPD was reported in 15 patients after a mean follow-up of 3.2 months (2.9 SD) in the first group and in 4 patients after a mean follow-up of 15.1 months (9.9 SD) in the second group.

Conclusions: Based on the current data, most cases have been preceded by an attempted closed reduction in the setting of outer, large articulation dislocation, perhaps indicating an iatrogenic etiology for early IPD. Recognition of this possible failure mode is essential to its prevention and treatment.

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Introduction and background

The dual mobility (DM) bearing designs were introduced in Europe in the 1970s and more recently in the United States in 2009 after Food and Drug Administration's approval [1]. They have been shown to reduce the frequency of postoperative dislocation after primary and revision total hip arthroplasty

(THA) [2]. The DM couple mates a fixed femoral head to a mobile polyethylene (PE) liner, which articulates with a smooth metal shell. Thus, there is an inner, small diameter articulation, with a capture mechanism between the head and the liner, and a larger, unconstrained, outer articulation. Because there is an additional bearing interface compared with fixed bearing THA, DM THA can suffer a unique failure mechanism known as an intraprostatic dislocation (IPD), in which the inner prosthetic femoral head disengages from the outer PE bearing. IPD is irreducible by closed means and always requires surgical management and DM bearing component revision [3]. Missing this type of dislocation can result in acetabular component damage because the femoral head (metallic or ceramic) articulates directly with the smooth metallic shell, leading to acetabular damage that may necessitate shell revision [4,5]. Therefore, early recognition of IPD is essential to its management.

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IPD may occur any time after the index procedure. However, the European experience suggests that IPD was predominantly a late complication with early DM designs. In particular, with conventional PE liners, the reported incidence of this complication was between 2% and 5% at long-term follow-up (mean 9 years, range 3–16 years) [2,6–8]. Philippot et al [9] classified 3 types of IPD, using radiographic and perioperative features: Type I, IPD secondary to wear of the PE retentive rim with no evidence of arthrofibrosis or cup loosening; Type II, IPD secondary to an extrinsic phenomenon (arthrofibrosis or heterotopic ossifications) as cause for the blockage of the larger articulation, and thus accelerated wear of the PE retentive rim; Type III, IPD secondary to cup loosening as cause of wear of the PE retentive rim. These cases represent relatively late dislocations with a mean time to failure of 8–11 years after surgery. With the introduction of highly crosslinked PE and dramatic reduction in wear, there was a corresponding 10 times reduction in the rate of IPD [9]. Of note, all types were attributable to PE wear, leading to failure of the capture mechanism between the liner and femoral head.

Although IPD secondary to PE wear was the most common mode of failure in that report [9], IPD can also occur iatrogenically without PE wear, during closed reduction of a large articulation dislocation. Loubignac and Boissier [10] termed this the “bottle-opener” effect. The likely mechanism for this type of IPD is engagement of the outer PE liner on the rim of the metal cup or on pelvic bony prominences, with subsequent dissociation of the inner bearing couple during the closed reduction maneuver. This mechanism is not directly related to the PE wear. Thus, although iatrogenic dissociation via this mechanism might be more likely in the setting of liner wear or damage to its retentive rim, IPD can occur either early or late after the index procedure. Speculation exists regarding the implant-related risk factors for early IPD, including pairing of femoral heads and PE liners from different manufacturers, 22.2 mm femoral heads, and skirted femoral heads [11–13].

This systematic review analyzes the risk factors of early IPD in primary and revision THA with contemporary DM designs.

Material and methods

A systematic review of the literature was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines [14], to identify risk factors of early IPD after the use of contemporary DM components in THA.

A search of the PubMed, MEDLINE, Embase, and Google Scholar was conducted using various combination of the keywords “intra-prosthetic dislocation,” “dual mobility,” “dual-mobility,” “tripolar,” “double mobility,” “double-mobility,” “hip,” “cup,” “socket,” and “dislocation.” No limit was set regarding the year of publication.

Two independent researchers (I. D. M. and R. D. A.) scanned all the articles for title and abstract. Disagreements were resolved by arbitration, and consensus was reached after discussion. The last search was performed in August 2016. Only articles in English were included. Papers reporting early IPD, defined as occurring within 24 months postoperatively, were considered for inclusion in the present study. Literature reviews, biomechanical studies, technical notes, letters to editors, and instructional courses were excluded. In addition, reference lists of the included articles were manually checked by the authors for missed studies.

The following data were extracted: type of arthroplasty (primary or revision), type of implant (manufacturer), length of implantation to IPD, head size, off-label use, and location of the dislocated PE liner. Continuous data were presented as means with standard deviations. Absolute numbers and percentages were presented for categorical data.

Results

The literature search and cross-referencing resulted in a total of 730 references. After screening for duplicate publications, 231 were excluded, leaving 499. After reviewing the abstracts of these, 75 were screened for eligibility and 16 were identified for inclusion. Fifty-nine articles were excluded because reporting no IPD episodes (30 articles) [7,15–43], IPD episodes were not mentioned (13) [44–56], reporting delayed IPD episodes (13) [8,57–68], reporting early IPD episodes with old DM designs with small femoral heads (2) [9,69], and reporting a suspicious IPD episode (1) [70] (Fig. 1).

Of the 16 included articles, 14 were case reports and 2 were retrospective case series. A total of 19 implants in 19 patients were considered. We divided the reports in 2 groups: the first one including early IPD after attempted closed reduction, and the second one including cases of early IPD with no history of previous attempted closed reduction. Early IPD was reported in 15 patients after a mean follow-up of 3.2 months (2.9 SD) in the first group and in 4 patients after a mean follow-up of 15.1 months (9.9 SD) in the second group. Twelve IPDs were in revision THAs and 7 were in primary THAs. When reported, the femoral head was always a 28 mm.

Tables 1 and 2 summarize the extracted data.

Discussion

The findings of this literature review lead us to make some general consideration about early IPD and to clarify some common beliefs.

First presumption, mixing DM components with different manufacturer components is commonly performed during revision THA to retain a well-fixed femoral stem. In this instance, the surgeon selects a properly sized femoral head from a different manufacturer than the maker of the PE liner. It is an off-label practice and unsupported by both the Food and Drug Administration and manufacturers, but it reduces complications associated with removal of well-fixed components. Of the 19 reported cases, only 6 cases of early IPD [3,5,13,74,78,81] occurred in patients with a mismatch between femoral head and PE liner manufacturers, whereas 9 cases occurred in patients with no mismatch and in 4 cases was not specified.

A second presumption is that “iatrogenic IPD” is associated with the head size of the inner bearing. The diameter of the inner bearing ranges between 22.2 mm (typical in the original French design) and 28–32 mm associated with the introduction of highly crosslinked PE. A larger head diameter increased the head-neck ratio at the inner articulation, which may reduce component impingement. Yet, in the published literature, there were no cases of IPD occurring in patients with a femoral head smaller than 28 mm [3–5,13,71,74,75,77,78,80]. Third presumption, it has been suggested that skirted femoral heads may increase the risk of IPD because of decreased range-of-motion before impingement between the skirt and the PE liner [11–13]. From the available literature, early IPD has not been reported in conjunction with a skirted femoral head.

From isolated case reports, it is difficult to make conclusions with any great confidence regarding the association between DM implant features and the risk of early IPD, because denominator values for each feature are unknown. However, we note that only in one published case of early IPD, the PE liner was found in situ within the acetabulum [13]. Therefore, we contended that early IPD has a high likelihood of iatrogenic etiology, whereby dissociation of the head and liner occurs during a closed reduction attempt of a large articulation dislocation. Closed reduction of a dislocated DM component is more difficult than the reduction of a conventional

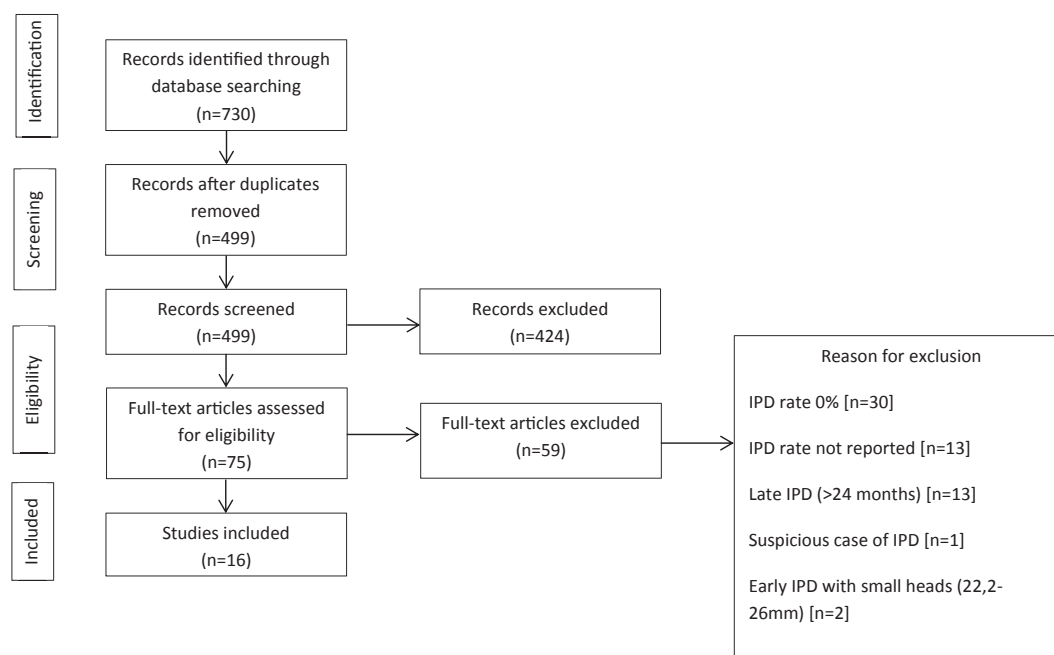


Figure 1. PRISMA flow diagram outlining the systematic review process. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

THA because of the larger diameter of the outer PE bearing. The larger outer diameter requires greater distraction to clear the PE from the rim of the acetabular shell. Unless the PE liner fully clears the acetabular rim, PE-rim impingement and iatrogenic IPD secondary to the “bottle-opener” effect is possible. This mechanism accounts for the 79% (15 of 19) of the early IPD published cases (Table 1). The other reported cases with no history of previous attempted closed reduction were due to PE wear caused by femoral neck impingement [13] and poor impaction of the PE insert over the femoral head [80] (Table 2). Of note, all types were attributable to PE wear leading to failure of the capture mechanism between the liner and femoral head.

Furthermore, in the cases with no history of previous attempted closed reduction, the mean length of implantation to IPD was higher than the others (15.1 months vs 3.2 months). However, with only 4 cases in the second group, we cannot make any statement.

A big limitation of this literature review was the dearth of quality articles. The 16 included articles (14 case reports and 2 retrospective case series) were all level IV evidence, so the reliability of the data is low and are, therefore, sensitive to change if better quality studies are published on this topic.

Based on the current data, some additional consideration can be made.

The rapid increase in the utilization of DM implants may lead to a corresponding increase in the incidence of iatrogenic IPD during closed reduction. In the era of highly crosslinked PE, this may become the dominant failure mode for this device making it essential for practitioners to understand the risk for iatrogenic IPD and accurately identify IPD in the emergency department. Schirmers et al [4] underscore the clinical sequelae of missed iatrogenic IPD. They reported on a patient who was discharged from the emergency department because the THA was believed to be

Table 1
Reports of early intraprostatic dislocation of dual mobility following attempted closed reduction.

Study, y	Primary/revision	Implant (manufacturer)	Length of implantation to IPD	Small head size, mm	Off-label use (Y or N)	Location of the polyethylene liner
Stigbrand and Ullmark (2011) [71]	Revision	Dual Mobility (Amplitude)	4 mo	28	N	NM
	Primary	Avantage, (Biomet)	2 wk	28	N	NM
	Revision	Avantage, (Biomet)	7 mo	28	N	NM
Loubignac et al (2012) [72]	Primary	NM	9 mo	NM	NM	NM
Schirmers et al (2014) [4]	Primary	ADM (Stryker)	26 d	28	N	Gluteal musculature
McPherson and Sherif (2012) [73]	Revision	Active (Biomet)	4 wk	NM	N	Lesser troch area
Ward et al (2013) [74]	Revision	MDM (Stryker)	2 mo	28 + 1.5	Y	Gluteal musculature
Banzhof et al (2013) [75]	Revision	MDM (Stryker)	2 mo	28	N	Psoas sheath
Banka et al (2014) [76]	Revision	MDM (Stryker)	NM	NM	NM	Gluteus musculature
Cvetanovich et al (2015) [77]	Revision	MDM (Stryker)	7 mo	28 + 0	N	Greater troch area
	Revision	MDM (Stryker)	3 mo	28 + 6	N	Gluteal musculature
Fehring and Berry (2015) [78]	Revision	MDM (Stryker)	5 mo	28 + 8.5	Y	Intrapelvic
Waddell et al (2016) [3]	Primary	ADM (Stryker)	3 d	28 + 0	Y	Postero-infero-medial aspect of the thigh
Samona et al (2016) [79]	Revision	E1 Active Articulation (Biomet)	Months (less than 1 y)	NM	N	NM
Nich et al (2016) [80]	Primary	NM	10 d	NM	NM	NM

ADM, anatomic dual mobility; MDM, modular dual mobility; NM, not mentioned.

Table 2
Reports of early intraprosthetic dislocation of dual mobility with no history of previous attempted closed reduction.

Study, y	Primary/revision	Implant (manufacturer)	Length of implantation to IPD	Small head size, mm	Off-label use (Y or N)	Location of the polyethylene liner	Reason for failure
Odland and Sierra (2014) [13]	Revision	MDM (Stryker)	23 mo	28	Y	Within the metal liner	PE wear due to impingement with femoral neck
Plummer et al (2016) [81]	Revision	NM	19 mo	NM	Y	NM	Vertical cup placement (abduction angle 67°)
Nich et al (2016) [80]	Primary	NM	18 d	28	NM	NM	Poor impaction of the PE insert over the femoral head
Mohammed and Cnudde (2012) [5]	Primary	Apogee (Biotechni)	18 mo	28	Y	NM	NM

MDM, modular dual mobility; NM, not mentioned.

reduced when in fact only the inner bearing was reduced and left articulating with the acetabular shell. The patient redislocated and had to undergo acetabular component revision due to severe damage of the acetabular component [4].

When treating a patient with a dislocated DM bearing, it is important to recognize that the dislocated bearing is indeed a DM bearing. Most DM bearings have characteristic appearance on anteroposterior radiographs. The Stryker Modular DM implant has a second cobalt chrome liner that can be identified on radiographs. The Anatomic DM has an iliopsoas cut out on the rim and is not hemispherical and has a characteristic appearance. In addition, the Anatomic DM is cobalt chrome producing a characteristic homogeneous radiodensity that differs from standard titanium shells. Frequently, the PE liner also creates a subtle halo-like radiodensity around the femoral head, when there is a large articulation dislocation [4,14,75–77].

Once a DM bearing has been identified, more caution should be taken during the reduction maneuver and confirmation of reduction. First, it is necessary to have appropriate sedation and muscle relaxation to avoid excessive traction during reduction. Although conscious sedation is commonly used in the emergency room setting, a recent report states that this may not provide satisfactory muscle relaxation [71]. Neuroaxial anesthesia which leads to lower extremity muscle paralysis may be a safer and more efficient anesthetic option for reduction of DM bearing and potentially reduce the risk of iatrogenic IPD [77]. Alternatively, general anesthesia may be considered [11]. The reduction maneuver may be best performed under fluoroscopic guidance, with gentle reduction maneuvers rather than forceful levering, which may avoid the bottle opener effect.

After DM bearing reduction, the inner bearing should be concentric within the acetabular shell in both anteroposterior and cross table or frog leg lateral radiographs. Eccentric position of the inner femoral head bearing within the acetabular shell is concerning for an IPD (Fig. 2). IPD can also be confirmed if the outer PE liner is identified in the soft tissue. Although the outer PE liner is radiolucent, soft tissue shadows often produce the “bubble sign” [3]. In addition, the outer PE bearing may migrate away from the hip joint and even become intrapelvic [78]. If conventional radiographs do not sufficiently confirm reduction and absence of IPD, dynamic fluoroscopy or a computer tomography scan may be necessary [3]. A CT scan should be performed if there is any suspicion that this may have occurred and the “bubble sign” is not evident on conventional radiographs, as a CT scan will clearly identify and localize a dislodged outer PE bearing.

Conclusions

In conclusion, although DM bearings have demonstrated successful clinical outcomes and appear to reduce the risk of dislocation in complex primary and revision THA [2], the additional bearing articulation introduces an additional failure mode that must be recognized and appropriately treated. In the setting of large articulation dislocations, precautions during closed reduction should be taken to prevent iatrogenic IPD. Reducing the risk of iatrogenic IPD includes adequate muscle relaxation and to consider fluoroscopic guidance for real-time feedback that may reduce the risk of IPD and more dynamically confirm the position of the femoral head at the end of the procedure. Further study is required to define implant-related features that may predispose patients to IPD.

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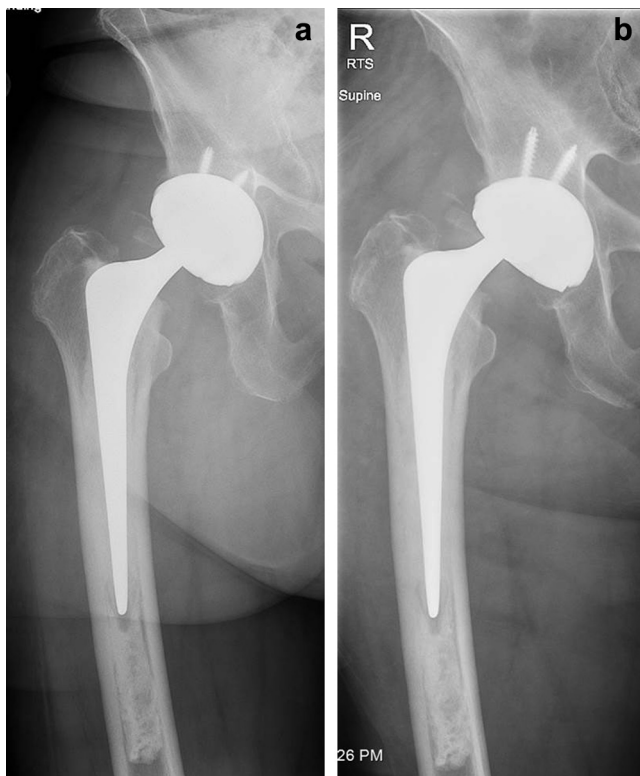


Figure 2. (a) Six-week postoperative radiograph of modular dual mobility cup in place. (b) Same patient after an intraprosthetic dislocation, the femoral head is eccentric inside the acetabular cup.

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