



Dual mobility total hip arthroplasty: should everyone get one?

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- Hip instability following total hip arthroplasty (THA) remains a major challenge and is one of the main causes of revision surgery.
- Dual mobility (DM) implants have been introduced to try to overcome this problem. The DM design consists of a small femoral head captive and mobile within a polyethylene liner.
- Numerous studies have shown that DM implants reduce the rate of dislocation compared to fixed-bearing inserts.
- Early designs for DM implants had problems with wear and intra-prosthetic dislocations, so their use was restricted to limited indications.
- The results of the latest generation of DM prostheses demonstrate that these problems have been overcome. Given the results of these studies presented in this review, surgeons may now consider DM THA for a wider patient selection.

Keywords: dislocation; dual mobility; total hip arthroplasty

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Introduction

The challenges of hip arthroplasty have evolved over the decades. There was a time when arguments flared between supporters and opponents of different fixation methods or bearing materials. More recently, in the era of personalized medicine, we aim to reproduce the patient's native anatomy and the physiological articular environment, aiming to improve prosthetic kinematics and restoring normal function. Our new quest is to offer a forgotten hip joint to our patients. Currently, two factors may compromise this achievement: hip range of motion (ROM) restrictions and hip instability. One option addressing

these two problems is the dual mobility (DM) articulation. This very old French invention, used since 1974 by Gilles Bousquet in Saint-Etienne (France), takes the double principle of a small articulation to minimize the problems of wear, coupled with a large articulation to stabilize the hip and prevent instability.¹⁻³

Dual mobility hip design and evolution

DM design consists of a small femoral head (22 or 28 mm) captive and mobile within a polyethylene (PE) liner.⁴ The large PE liner ball in turn articulates with a highly polished metallic acetabular shell (see Fig. 1). The polyethylene large head diameter is usually 6–8 mm smaller than the size of the outer metallic shell. There are two distinct articulations: a small articulation between the head and the PE liner, and a large articulation between the polyethylene head and the acetabular shell. The majority of movement occurs at the small articulation.⁴ Movement of the large articulation only happens when the stem's neck comes into contact with the polyethylene head. Wear can occur at three interfaces: the small and large bearing and at the neck–polyethylene contact area (third articulation) (see Fig. 2).

Wear of the third articulation can lead to intra-prosthetic dislocation (separation of the head from the liner). This complication was associated with non-round, larger-stem necks, rough neck surfaces and skirted metallic heads. Chamfering the polyethylene head rim to increase the surface of contact along with appropriate femoral stem neck design have reduced this problem over the short^{5,6} and medium⁷⁻⁹ terms. With regard to the metallic shell, in order to avoid a planeing effect between the polyethylene head and the metallic shell rim, the articulating surface should be supra-hemispheric (coverage angle of > 180 degrees) (See Fig. 3).^{10,11} These improvements in the prosthetic design should bring an end to the complications reported in the early ages of DM.



Fig. 1 Typical design of a ‘modern’ dual mobility (DM) cup, with a large polyethylene (PE) liner ball articulating with a highly polished metallic acetabular shell.

Hip instability remains the major challenge after total hip arthroplasty (THA)

Hip instability after THA has become a major problem. It was reported to be the main or second cause of failure with rates between 20–25% in multiple large-scale national studies.^{12–14} Furthermore, this problem may affect patients of any age. A study presented at the European Hip Society meeting in 2012 (Milan, Italy) compared 1634 patients over 70 years with 1030 under 60 years and found a significantly higher dislocation rate in the elderly (4.2% versus 2.5%), but a significantly higher rate of revisions for instability in younger patients (1.8% versus 0.9%) with instability being the second leading cause of failure in both groups.¹⁵ It is well known that some patient characteristics significantly increase the risk of post-operative dislocation, for example: abductor deficiency, THA for acute fracture, psychiatric problems, neurological disease. Some patients’ native anatomy or pathological anatomy deformed by the disease process may be a challenge for the surgeon, making it difficult to obtain hip stability during surgery with standard implants. For example, patients with small stature (acetabular diameter < 50 mm) are constrained to an implant with a limited head–neck ratio, limited ROM and increased risk of dislocation. Adding this bone morphology to obesity and a large inner thigh, produces a ‘cocktail’ for dislocation. As may be expected, there have been many proposed options to overcome this ubiquitous problem of instability after THA, and to better correct the anatomical particularities inherent in every prosthetic joint. All surgical approaches can give rise to dislocations (even if some are considered more at risk); all models of implants can be dislocated and finally, all

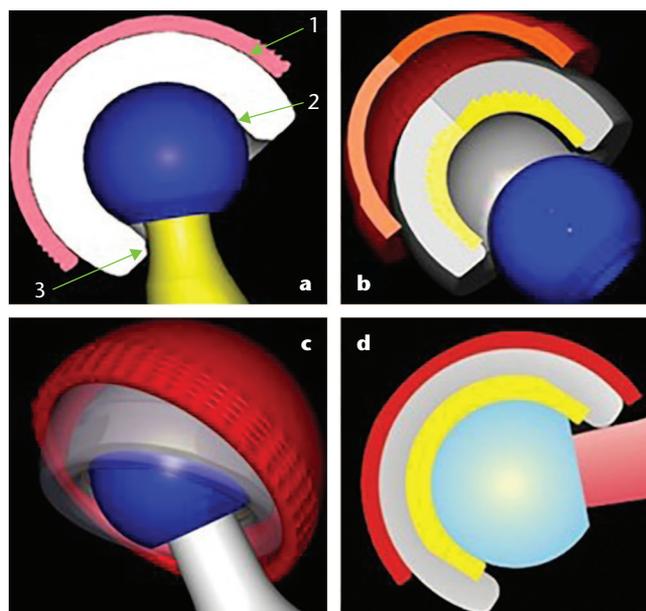


Fig. 2 The three articulating surfaces in dual mobility (DM) cups: (a) and (b) demonstrate these three bearings as the large one (a.1) between the polyethylene (PE) liner and metallic shell, the small one (a.2) between the femoral head and liner, and the so-called third articulation (a.3) between the femoral neck and the PE liner; (c) illustrates the rotation of the PE liner upon contact with the femoral neck while (d) shows the relationship during movements between the femoral neck on the one hand, and first the liner, and second the rim of the metallic shell.

surgeons (from the most novice to the most experienced) can experience episodes of dislocation.

DM is a proposed solution to restore hip stability

As a true prevention of dislocations after hip replacement, there seems to be a greater reliance on and a move towards the systematic use of larger diameter femoral heads (LDH). The improvements seen with new highly crosslinked polyethylene has allowed the evolution of increasingly large heads up to diameters of 36 mm and beyond, but at the expense of the available thickness of the PE insert in such cases, raising questions about the future of these ‘minimalist’ inserts. Using LDH with hard metal-on-metal bearings did not come without problems, and in particular the appearance of ‘trunnionosis’ and associated secondary local adverse reaction to metal debris.¹⁶ Another LDH joint is represented by DM implants. In comparison with conventional implants, DM cups can add an extra arc of movement before impingement of 30.5° in flexion, 15.4° in abduction and 22.4° in external rotation.¹⁷ Furthermore, the LDH increases the jump distance before dislocation and after joint capsular healing, the larger volume to displace would require a complete

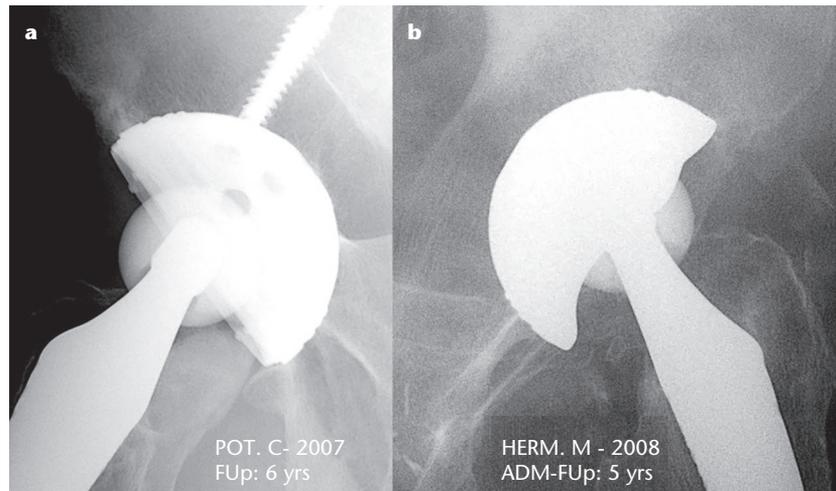


Fig. 3 In fixed-bearing cups, the articulating surface is generally hemispheric (a). Conversely, in dual mobility cups, the shell design should be supra-hemispheric (as shown in b), to ensure an optimal retention of the liner inside the metallic shell.

capsular rupture for a dislocation to occur, as in a traumatic native hip dislocation. This reduction in instability has been confirmed by Stroh et al,¹⁸ in a very complete review of the literature, both in primary arthroplasty with 0.1% for DM versus 2–7% for fixed inserts (FI), and in revisions (DM at 3.5% versus FI at 10–16%).

Even without the occurrence of a dislocation event, using a standard diameter head THA often imposes ROM restrictions after surgery and/or ongoing activity restrictions on patients. Bearing in mind these limitations, many patients do not forget their hip joint, fearing to bypass the imposed limits. Because of the fear of dislocation, some patients may also have to abandon their job (plumber, roof worker, fireman, etc.) or leisure activities (kayaking, rock climbing, etc.). Dual mobility, with its supra-physiologic arc of motion, makes it a forgiving procedure, leaving some room for imprecision by the surgeon. It also permits a better reproduction of individual patient anatomy (femoral offset and leg length). Without post-operative ROM restrictions, bilateral and outpatient procedures are simplified, and patients are free to pursue unrestricted activities and vocations. For these reasons, it may increase the likelihood of having a forgotten hip.

Why not use DM for all patients?

It is still surprising to note the extreme pusillanimity of the orthopaedic literature with regards to proposed indications for DM, restricting the prosthesis to limited patients, particularly for elderly subjects or those with neurological and/or muscular deficiencies predisposing them to dislocations. These recommendations are based on several publications relating to the first models of DM cups, including by Philippon et al¹⁹ at 17 years follow-up who

reported loosening in 3.0%, significant wear in 1.6% and a high rate of intra-prosthetic dislocations at 5.3%. These complications, mainly due to premature wear of the polyethylene especially at the level of the retentive rim of the head, as well as poorly performing fixation of the cup, explain why these cups were considered as salvage solutions only, with limited indications.

Since the early 2000s, the so-called ‘modern cups’ with dual mobility have radically changed the situation, with implants that allow a totally different assessment of the risk–benefit ratio, and therefore potentially new indications for this DM option.²⁰ The current implants have nothing in common with the very first models apart from the basic ‘historical’ concept of DM. In the first place, the coatings of the metal shell now have optimized surfaces for bone fixation (with or without hydroxyapatite), resulting in resistance to loosening which is comparable to their fixed insert (FI) counterparts.²¹ Second, the prevention of intra-prosthetic dislocations is much more effective with a better design of the cups and also smooth and tapered femoral necks, with a better mechanism for retention of the head in the cup, but also and most importantly by the better quality of polyethylenes, whether or not they are stabilized and highly crosslinked (or ‘annealed HXLPE’). Advances in frictional torque, including improvements in the mechanical properties of the new polyethylenes, would suggest long-term survivorship of these modern DM implants, which should allow and encourage an extension of indications.

Encouraging early results, given this background of expanded indications, were presented at the 2015 EFORT congress (Prague), under the auspices of the International Society of Dual Mobility (IDMHS) according to a multicentric study (OrthoWave™), comprising data from 12 French

and US surgeons, involving 747 primary hips in 661 patients aged less than 55 years at the time of surgery (mean age at 49.2 years, range 18–55 years), for a mean follow-up of 41.8 months (max: 169 months, with 12% > 10 years) for five ‘modern’ DM cups (ADM, GYROS, QUATTRO, MDM and SUNFIT) with conventional PE in 52% and HXLPE in 48% (alumina heads for 60%, metal 40%, diameter 28 mm in 83%, 22 mm in 12%). The clinical results were excellent with mean Harris Hip Scores (HSS) of 93.4 points at the last follow-up, survival at 12.7 years with all-cause revision at 98.9% (0.976–1.000), with only three revisions (one early migration at 10 days, one neurotrophic pain at two years, one anterior impingement at three years). The most striking finding of this first study, devoted to an extension of indications for young and active patients aged < 55 years, concerned the complete absence of complications related to the DM concept – namely no dislocation, no instability, no loosening, no osteolysis or noticeable wear, and especially no intra-prosthetic dislocation. These very promising results must be supported by an evidence-based medicine approach. To this end, a global French national registry of DM is being created under the authority of the Data Commission of the French Orthopaedic Society (Sofcot), based on the exhaustive automatically generated data of the official Big Data collection structures in place.

The Australian Joint Registry reported on 5669 primary THAs using DM.²² Whilst there was an increased overall rate of revision for DM hips, this was a result of them being used more frequently in high-risk patients (e.g. fracture, tumour and failed internal fixation). For the diagnosis of osteoarthritis, there was no difference in the rate of revision with FI.

Do double articulations equal double the wear?

Does DM induce more wear compared with FI? In this regard, wear resistance in DM cups has been evaluated using radiosterometric analysis (RSA) techniques, in particular by a French team²³ in several still unpublished works that have been presented at conferences. Both in vitro and after explantation, they found that the wear rates with conventional polyethylene were no greater than in implants with FI. This confirms the work of Philippe Adam (and the ‘Ecole Stéphanoise’),²⁴ as reported in the article by Michel-Henry Fessy in *Maîtrise Orthopédique* in 2006),¹ concluding on 40 DM cup retrievals: ‘Total reported wear for these 40 inserts with well-functioning *in vivo* dual mobility, are not higher than the typical values reported for a standard metal-on-polyethylene bearing, with femoral heads of 22.2 millimetres in diameter. Wroblewski, in 1986, reported an estimated wear of 96 micrometres per year for 116

Charnley prostheses. The figures that we report in terms of global wear, are equivalent. Our figures are even lower with regard to the wear of the concavity, probably because, for the same ROM, only part of the angular displacement is between the head and the concavity; the other angular displacement takes place between the convexity and the metal back. This work thus demonstrates that DM, contrary to what is often advanced, is not accompanied by an increase in wear.’

Using a modular dual mobility acetabular cup, average serum cobalt and chromium values were low (0.7 mcg/L and 0.6 mcg/L respectively) at minimum two-year follow-up in 100 consecutive THA patients.²⁵ There were no revisions due to allergic reaction in the whole series.

Is the contribution of new highly crosslinked polyethylenes (HXLPE) for DM the decisive factor?

Numerous publications have been generated about the resistance to wear of new HXLPE, first for fixed inserts with more than 10 years of clinical follow-up²⁶ in *in vivo* studies, but also *in vitro* studies, and in terms of wear particles generated. We were able to report the complete absence of PE particles on histological examination of the per-articular capsule from four explants of (fixed) HXLPE inserts at more than 10 years, after revision for fracture. Moreover, the penetration rates measured for these explants were 0.019 and 0.030 mm/year respectively for wear calculated in 2D and 3D. Will that excellent performance in FI translate to an equally good performance with DM?

The real questions are in regard to the mechanical strength of these new stabilized polyethylenes in the context of the particular biomechanics of DM. In the first place, the question is in respect to the mechanical resistance of this plastic material *vis-à-vis* the impact caused by contact with the prosthetic femoral neck (called the ‘third joint’), but this is a ‘cushioned’ impact since, as long as the insert remains mobile, it will in principle ‘dampen’ the contact, hence the critical importance of maintaining a mobile insert by avoiding any reactive inflammatory fibrosis. This may be achieved, first, by using a material with no release of fibrosis-generating particles over the years, and then during the surgical procedure by avoiding suturing of the capsule to prevent later scarring and constriction. This resistance to wear will also be crucial in the prevention of premature wear of the retentive rim at the neck of the insert, eliminating the risk of the infamous ‘intra-prosthetic dislocations’. Opponents of the systematic use of HXLPE argue that there is loss of both mechanical strength and the elastic capacity of the material. However, this is crucial when the head is forcefully introduced into the retentive cavity of the insert.

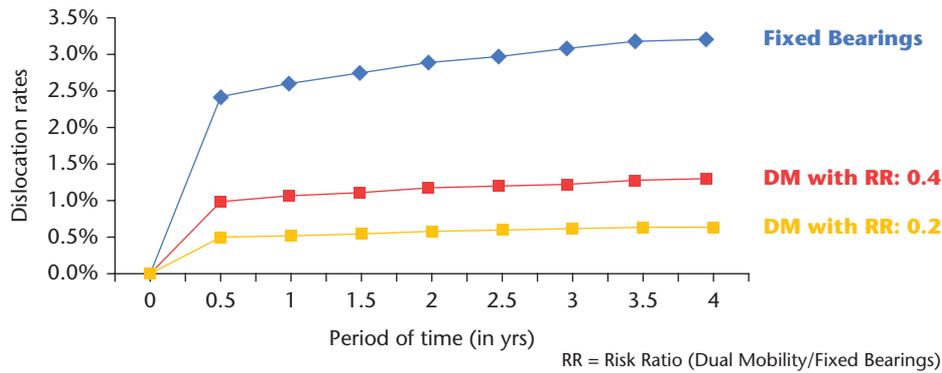


Fig. 4 Comparative rates of dislocation over time based upon fixed bearings (FB, in blue) versus dual mobility (DM) cups with two potential relative risks DM/FB of 0.4 (in red) and of 0.2 (in orange).

This is where the distinction between stabilized-annealed HXLPE versus remelted is crucial. Indeed, all the tests carried out have confirmed that the reshaping after irradiation significantly changes the crystalline structure of the polyethylene: the higher the irradiation dose, the more the recasting compromises the mechanical strength of the plastic material, up to 35% loss of elasticity for irradiation at 10 megarads, and 16% for irradiation of 5 megarads. On the contrary, stabilized HXLPEs retain 100% of their mechanical strength and their elasticity, with performance equal to conventional PE. We have seen in clinical practice the absence of any wear problems, or intra-prosthetic dislocations at the current follow-up of five years with this type of HXLPE. This may be further confirmed by several other publications. According to Stulberg,²⁷ wear rates measured with the new generation of highly crosslinked polyethylenes for DM cups are significantly lower than for any wear rate reported with any other type of implant. Similarly, the performance of HXLPEs for a ‘modern’ DM has been measured by several authors.^{28,29} Loving et al,³⁰ in a simulator study, reported on both the inner and outer surface of the mobile insert, under multiple test conditions in different situations (impingement, abrasion, loss of mobility of the insert): the authors concluded that the performance in terms of wear was dictated mainly by the smaller articulation, as well as by the polyethylene material used, with for the most severe tests a 75% lower rate of wear compared to a fixed insert of conventional polyethylene sterilized under gamma rays in an inert atmosphere.

Using DM cups for all patients may also be economically advantageous

A final element in the assessment of DM versus fixed insert bearings concerns the medico-economic aspect of this prosthetic option. Rehospitalizations for hip dislocations (even closed reduction), or for revisions in case of

instability, have a significant overall cost to the national health budget. In a recently published article in *OTSR*,³¹ in collaboration with the CEMKA institute (Paris, France) we performed a socio-economic modelling at the national level concerning the comparative costs of these instabilities, comparing DM with FI cups. Although the contribution of dual mobility in the prevention of instability in primary surgery has been clinically demonstrated compared to fixed inserts, this contribution has now also been confirmed economically with modelling according to the Markov method by measuring the cost-effectiveness ratio (CER). One of the aims of this work was to estimate, according to the PMSI databases, the direct costs related to dislocations and revisions for instability, and, using deterministic and probabilistic sensitivity analyses, to arrive at an estimate of potential average annual savings at the national level. The analysis was conducted from the 2009 PMSI database over a four-year period (2009–2012), with an analysis sample of 80,405 patients. This cost-effectiveness study evaluated the costs of all resources required following a prosthetic dislocation, including the expenses of health insurance and other payers. With a relative risk of dislocation of 0.4 (DM/IF), the analysis concluded that 3283 dislocations were avoided per 100,000 patients in DM, with a potential annual gain for 140,000 prostheses of €39.62 million. With a risk of 0.2 this gain would be €56.28 million (see Fig. 4). According to the probabilistic sensitivity analyses, the DM option is a favourable strategy in all hypotheses of the dislocation ratio, and likely to exceed €100 million per year in savings in France. What was demonstrated in France would naturally be similarly observed on an international scale.

In the end . . . is DM a valid choice for all our patients?

We know that DM implants are performing very well for cases of primary THA with a high risk of dislocation

(neurological patients, major muscle deficit, etc.) and complex prosthetic revisions. Should we then endorse the extension of indications for DM to most of our THA patients? Improvements in the prosthetic design, in the design of the neck-cup assembly, as well as in the frictional torque of the materials, allow us to consider a definitive end to the complications related specifically to DM; in particular, intra-prosthetic dislocations and polyethylene wear. This should also be expected in the long term, as well as for young and active subjects. The supra-physiologic arc of motion provided by the large head–neck ratio makes it a forgiving procedure, leaving some room for imprecision by the surgeon. It also permits a better reproduction of individual patient anatomy (femoral offset and leg length). Bilateral and outpatient procedures are simplified. It allows unrestricted range of motion (ROM), for activities and work occupations. For these reasons, it may increase the likelihood of having a forgotten hip. Dual mobility may enable us to significantly reduce the major complication for both our patients and at the national economic level, that prosthetic failures for instability (both in primary and in revisions) constitute. In this context, the option ‘DM for all’ would help to improve the double problem of instability and quality of life, whilst also producing significant savings in the cost of health. It may therefore be judicious from now on, in the context of this family of LDH, to consider the answer ‘yes’ to the question of whether it is ‘reasonable’ to have dual mobility for all, to achieve an optimal outcome from hip prostheses.

Although it is the opinion of the authors that the wealth of new evidence that we have provided on DM cups should encourage surgeons to use them more widely, it should be noted that there is currently not an abundance of published long-term (follow-up 10–20 years) clinical trials for the newer designs of DM. As with any new technology, surgeons should continue to monitor results over time and adapt practice to the best available evidence.

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LICENCE

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