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ORIGINAL PAPER

A comparative study about the incidence of dislocation and peri-prosthetic fracture between dual mobility versus standard cups after primary total hip arthroplasty

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Abstract

Purpose Dislocation and peri-prosthetic fracture (PPF) are major reasons for revision THA (total hip arthroplasty). The main advantage of dual mobility (DM) cups is to minimize the incidence of dislocation compared to single mobility (SM) cups. We hypothesized that the use of DM would lead to an increased risk of PPF because of its greater stability. In contrast, standard cups would be at higher risk of dislocation.

Methods A retrospective comparative study was performed in our institution including 126 revision THAs between January 2013 and December 2017. Collected data included gender, age, BMI, Parker score, ASA score, the etiology for primary THA, type of cup (SM or DM), cortical index, Noble index, and the stem fixation.

Results Overall, 53 standard and 73 DM cups were included for study. In the dislocation group, 29 had standard cups (83%) and 6 had DM cups (17%). Dislocation was 12-fold higher in SM cups ($p < 0.001$). In the PPF group, 24 had standard cups (26%) and 67 had DM cups (74%). PFF was 12-fold higher for DM cups ($p < 0.001$). A higher Parker score and a higher cortical index had a protective effect on the risk of PPF (OR = 0.76 ($p = 0.03$), OR = 0.57 ($p = 0.048$)).

Conclusion The use of DM increased hip stability but led to a higher rate of PPF by load transfer on the femur. Further studies with larger cohort and follow-up are needed to confirm these findings and measure the incidence of these complications.

Keywords Total hip arthroplasty · Dual mobility · Peri-prosthetic fracture · Dislocation · Standard cups

Introduction

Total hip arthroplasty (THA) is one of the most important surgical procedures of the last century according to Learmonth et al. [1]. Despite improvements in the techniques, approaches, prosthetic materials, and designs, THA survival remains limited and the frequency of revision THA is increasing steadily [2, 3], including dislocation and peri-prosthetic fracture (PPF).

The dual mobility concept was developed in the 1970s by Pr G. Bousquet [4]. The device has two bearings—a small head, usually 22 to 28 mm in diameter, that fits inside a larger polyethylene hemisphere which articulates with a smooth metal surface [5]. Primary movement occurs at the inner bearing, while the outer bearing only moves at the extreme ranges of movement [5]. The secondary articulation, between the polyethylene liner and the acetabular shell, is engaged during activities that exceed the normal range of movement, when the femoral component impinges on the rim of the liner [5]. The main advantage of dual mobility (DM) cups is to minimize the incidence of dislocation compared to single mobility cups [6, 7].

In the Swedish [8], the American [9], the Australian [10], the New Zealand [11], and the Great Britain and Wales [12] registries, dislocation appears as the first or second reason for revision THA and PPF ranks in the fourth or fifth position for

Level of evidence: Retrospective case study, Level IV.

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revision THA. However, in the French registry [13], PPF ranks as the second reason for revision THA and dislocation appears as the fifth reason for revision THA. In France, the use of DM in primary THA is widespread. Could this increasing use of DM explain the differences between national registries concerning the incidence of dislocation and PPF?

We hypothesized that the use of DM would lead to an increased risk of PPF because of its greater stability. On the opposite, standard cups would be at higher risk of dislocation. Thus, we aimed to compare the incidence of dislocation and PPF between single mobility (SM) versus DM after THA.

Patients and methods

A descriptive retrospective monocentric comparative study was performed in our institution. Between January 2013 and December 2017, 126 revision THAs were retrieved: 91 for PPF and 35 for prosthetic hip dislocation. Inclusion's criteria were THA dislocation, PPF, patients more than 65 years old, and minimum post-operative period of three months following their primary hip surgery. Patients having the same event several times were recorded only once for each complication. Exclusion's criteria were retentive cups and metal-on-metal bearings. During this same period of inclusion, between 2013 and 2017, it is important to notice that in our institution, 500 primary THAs were performed each year including 400 DM cups and 100 SM cups. Thus, 2000 primary THAs were performed in our institution during the period of study, including 1600 DM cups and 400 SM cups.

At our institution, an emergency registry is filled out for each surgery case arriving by the emergencies. We looked through this file to collect patients who were admitted for either a PPF or a prosthetic hip dislocation. Thus, many patients included in this study did not have their primary THA performed in our institution. Collected data included gender, age, BMI, Parker score [14], ASA score, and the aetiology for primary THA.

A radiologic analysis, on plain X-rays, was performed by two independent authors (ESM and RD) including four parameters: cortical index, Noble index [15], type of the cup (SM or DM as shown in Figs. 1 and 2), and the stem fixation.

Statistical analysis

Statistical analyses were performed using R software. Between groups, comparisons of quantitative variables were performed by Wilcoxon's test and comparisons of categorical data were performed by the chi-square or Fisher exact test. The predictive risk factors of having a PPF or dislocation were evaluated by stepwise logistic regression analysis (odds ratio) comparing DM group to SM group. Multivariate analysis was performed by logistic regression. Odds ratio and 95% confidence intervals were produced in all analyses. Factors having a p value < 10% during the univariate analysis were maintained for the multivariate analysis. Statistical significance was set at $p < 0.05$.

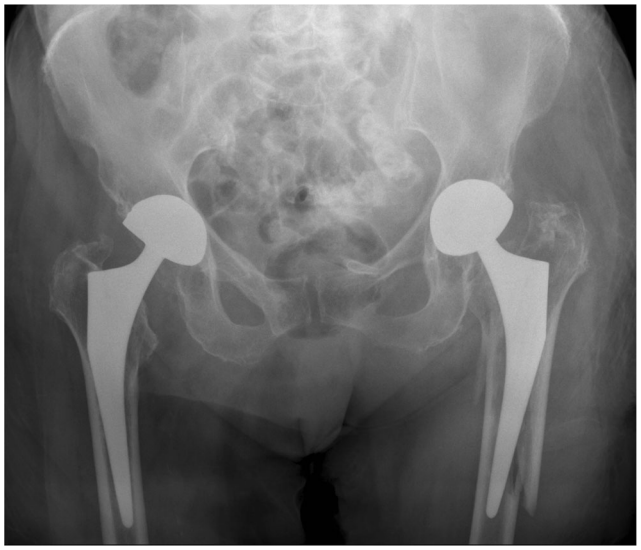

Fig. 1 Example of peri-prosthetic fracture with a dual mobility device

Results

The main characteristics of DM compared with SM patients are reported in Table 1. There was no difference between the two groups in terms of patient characteristics except for the stem fixation. Single mobility cups were statistically more often implanted with cemented stem.

Overall, 53 SM and 73 DM cups were included for study. In the dislocation group, 29 had SM cups (83%) and 6 had DM cups (17%). In the PPF group, 24 had SM cups (26%) and

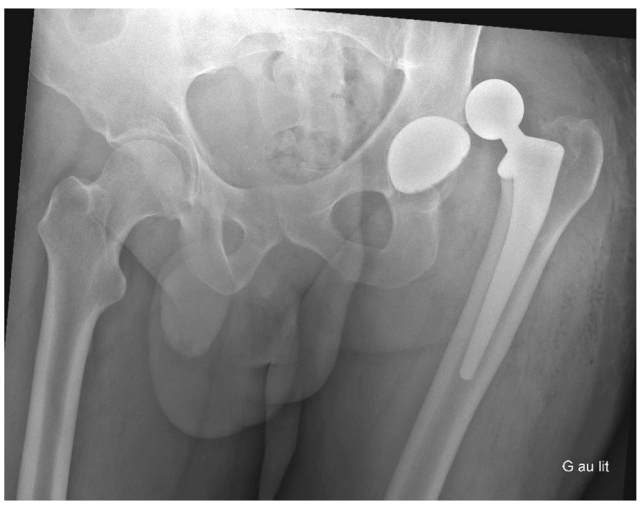

Fig. 2 Example of THA dislocation in a standard cup (ceramic-on-ceramic bearing)

Table 1 Patients' characteristics at revision

Variables	DM ($N = 73$)	SM ($N = 53$)	p value
Age, mean ± SD (range)	86 ± 8.6 (66–100)	87 ± 7.1 (69–104)	0.62
BMI (kg/m^2), mean ± SD (range)	24 ± 5.7 (12.6–36)	24 ± 4.9 (14–42)	0.87
Women, *n* (%)	53 (73)	37 (70)	0.89
Parker score, mean ± SD (range)	7 ± 2 (2–9)	6.9 ± 2.2 (2–9)	0.69
Cortical index, mean ± SD (range)	0.45 ± 0.1 (0.2–0.6)	0.48 ± 0.1 (0.3–0.7)	0.14
Noble index, mean ± SD (range)	3.2 ± 0.7 (1.8–5.1)	3.3 ± 0.6 (2.0–4.9)	0.40
Cemented stem, *n* (%)	14 (19)	29 (55)	< 0.001*
Etiology for primary THA			
Osteoarthritis (OA), *n* (%)	59 (81)	46 (86)	0.11
Osteonecrosis (ON), *n* (%)	1 (1)	4 (8)	0.11
Femoral-neck fracture (FNF), *n* (%)	13 (18)	3 (6)	0.11

*Statistically significant ($p < 0.05$)

67 had DM cups (74%). The incidence of PPF and dislocations according to the type of the cup are reported in Table 2.

Patients from our institution

Among patients included in this study, 37 underwent their primary surgery at our institution: 19 DM cups (19/1600 = 1.2%) and eight SM cups (8/400 = 2%). In the dislocation subgroup, 13 had SM cups (81%) and three had DM cups (19%). In this PPF subgroup, five had SM cups (24%) and 16 had DM cups (76%).

Univariate analysis

A univariate analysis was performed to determine the risk factors of PPF. Results are reported in Table 3.

The cortical index and a cemented stem fixation had a significant protective effect on the risk of PPF with respectively ORs of 0.005 (95% CI [0.00–0.47]; $p = 0.02$) and 0.25 (95% CI [0.11–0.58]; $p < 0.001$).

The analysis of the type of mobility indicated that dual mobility cup was strongly associated with the risk of PPF with an OR of 13.5 (95% CI [4.99–36.5]; $p < 0.001$).

The age, the gender, the BMI, the Noble index, the Parker score, the etiology, and the operative time to surgery had no effect on the risk of PPF.

Table 2 Incidence of peri-prosthetic fractures and total hip dislocations depending on the type of the cup implanted

	Peri-prosthetic fracture	Dislocation	Total
Dual mobility	67	6	73
Single mobility	24	29	53
Total	91	35	126

Multivariate analysis

In order to confirm these results, confounding factors were researched, and the stem fixation appeared to be a cofounding factor. Therefore, a multivariate analysis was performed including the cortical index, the Parker score, the stem fixation, and the type of mobility of the cup. Results are reported in Table 4.

A higher cortical index had a protective effect on the risk of PPF (OR = 0.57 (95% CI [0.33–0.99]; $p = 0.048$)). A higher Parker score had a protective effect on the risk of PPF (OR = 0.76 (95% CI [0.59–0.98]; $p = 0.034$)). Having a cemented stem seemed to have a protective effect on the risk of PPF with an OR at 0.37, but it was not significant (95% CI [0.13–1.05]; $p = 0.062$).

Having a double mobility cup increased significantly the risk of PPF (OR = 12 (95% CI [3.9–34.6]; $p < 0.001$)). On the opposite, for the same Parker score and the same cortical index, having a simple mobility cup increased significantly the risk of dislocation (OR = 12 (95% CI [3.9–34.6]; $p < 0.001$)).

Table 3 Results of univariate analysis for peri-prosthetic fracture

Variables	OR	Lower 95% CI	Upper 95% CI	p value
Age	1.05	0.99	1.10	0.06
Gender	0.5	0.21	1.37	0.18
Body mass index	0.94	0.87	1.01	0.098
Cortical index	0.005	0.00	0.47	0.02*
Noble index	0.62	0.34	1.12	0.11
Parker score	0.83	0.68	1.02	0.07
Follow-up	0.96	0.92	1.01	0.11
ASA score	1.95	0.88	4.29	0.096
Cemented stem	0.25	0.11	0.58	< 0.001*
Dual mobility cups	13.5	4.99	36.5	< 0.001*

*Statistically significant with $p < 0.05$. *CI*, confidence interval

Table 4 Results of multivariate analysis for peri-prosthetic fractures

Variables	OR	Lower 95% CI	Upper 95% CI	*p* value
Cortical index *10	0.57	0.33	0.99	0.048*
Parker score	0.76	0.59	0.98	0.034*
DM cups	12	3.94	34.65	< 0.001*
Cemented stem	0.37	0.13	1.05	0.062

*Statistically significant with $p < 0.05$

Discussion

Our hypotheses were confirmed by the current study: PPF was at higher risk with DM cups and dislocation was at higher risk with standard cups. The incidence of PPF may be increased in DM cups because of its greater stability leading to an increased load transfer on the femur in extreme movements. To our knowledge, it is the first study about these specific complications according to the kind of cup used in THA.

Dual mobility cups may be used in patients with a higher risk of dislocation such as those who are older, with increased comorbidities or a higher ASA [16], or with neuromuscular diseases [17–19]. Also, dual mobility cups have been used successfully in revision for instability [6, 19–23]. The use of a dual mobility cup increases the range of motion before impingement and dislocation [5]. In our study, dislocation appears to be less frequent in the DM group, confirming the recognized efficiency of the DM concept in preventing dislocation [19, 24].

Thus, DM cup seems to be the "best way" in complex hip replacement, patients with neuromuscular disease, or total hip revisions, reducing THA dislocation. However, in our study, the use of DM led to an increase risk of PPF compared to the use of SM. Ehlinger et al. [2] found the same results; a dual mobility cup appeared to be an associated factor of PPF.

In France, one study reported the causes for failures of primary hip arthroplasties in 2012 [13]. PPF ranked at the second position and dislocation ranked at the fifth position of causes for revision. Contrary to other registries [9], the dislocation was not the main cause for failure of primary THAs maybe due to the use of DM [25]. In contrast, our study suggested that the second rank of PPF after THA in France could be due to the use of DM. Indeed, the incidence of dislocation among patients who had their primary THA in our institution equaled 0.8% and was at a lower rate than PPF complications (1%). DM cups allow a greater implant stability but this device may also be responsible of an increased number of PPF.

Risk of PPF included poor bone stock, elderly patients, chronic use of corticosteroids, inflammatory arthritis, stress risers, and various neurological conditions [16]. The number of PPF following THA remains low, but it is increasing [26]. Focusing on the results of the patients who initially had their primary THA at our institution, the incidence of PPF averaged 1% and was in accordance with Meek et al. [27] who showed an incidence of PPF of 0.9% in primary THAs and 4.2% in revision THAs. They highlighted three predictive factors of PPF: increased age, female gender, and revision procedure were associated with a higher risk of fracture. For Ehlinger et al. [2], the typical patient with PPF was a woman younger than 80 years old who was in fair general health and self-sufficient but with a low level of physical activity. In our study, the gender did not appear to be a prognostic factor of PPF; however, a higher Parker score and a higher cortical index were protective factors on PPF complication.

We may hypothesize that in primary THA for OA, a stronger cortical bone would resist to PPF. However, we found the same results than Ehlinger et al. in their study [2]; osteoarthritis was the most common reason in rTHA for PPF. These results differ from those in the Norwegian registry [28], in which THA for femoral-neck fracture (FNF) was a risk factor for PPF.

Finally, in our study, cemented stems tend to be at a lower risk of PPF although it remained not significant with the multivariate analysis. This observation is described by other authors [29] as an un-well fixed uncemented stem resulting in a PPF. PPF remains a complication, still increasing. Thus, this study must be interpreted as a preliminary report identifying a potential link between PPF and the use of DM.

This study had several limitations. First, we were limited by the retrospective design of the study. However, all patients admitted for dislocation and PPF were included. Second, this study reported only the results of one institution.

Further studies are required to confirm these results with larger cohort and prospective follow-up to assess specific complications after primary THA. This fact emphasizes the need for establishing a national registry. Finally, patient-specific factors that are not related to surgery were not collected and maybe a bias in this study.

Conclusion

The use of DM increases hip stability but may lead to a higher rate of PPF by load transfer on the femur. This preliminary study gives some trends on the specific complications of standard and DM cups.

Compliance with ethical standards

Conflict of interest M-H. Fessy received royalties from Serf and Depuy. The other authors declare that they have no conflict of interest.

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