International Orthopaedics (2019) 43:1071–1082
https://doi.org/10.1007/s00264-018-4062-0

ORIGINAL PAPER

The efficacy of dual-mobility cup in preventing dislocation after total hip arthroplasty: a systematic review and meta-analysis of comparative studies

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Received: 19 March 2018 / Accepted: 12 July 2018 / Published online: 21 July 2018

Abstract

Purpose Although long-term reports of total hip arthroplasty (THA) showed successful results, instability remains a major complication. Recently, dual-mobility cups (DMC) have gained more and more interest among clinicians, with encouraging results in terms of lower rate of dislocation associated with good clinical results, but a lack of evidence exists regarding the real efficacy of this implant design compared to traditional fixed-bearing total hip arthroplasties.

Methods A systematic search was performed in PubMed, Google scholar, Cochrane Library, and EMBASE by two independent reviewers for comparative studies available till December 2017, with the primary objective to demonstrate a real lower dislocation rate of DMC implants compared to unipolar fixed-bearing cup designs. A meta-analysis was conducted with the collected pooled data about dislocation rate, calculating the risk difference (RD) and relative risk (RR) with 95% CI for dichotomous variables. Heterogeneity was tested using the χ^2 and Higgins' I^2 tests. A fixed-effect model was used because the statistical heterogeneity was below 50%.

Results After performing a critical exclusion process, the number of eligible studies included for final synthesis considered was 15, describing the results of a total of 2408 total hip arthroplasties (50.6% with a dual-mobility acetabular cup design, 49.4% with a standard fixed-bearing design). The fixed-effect meta-analysis showed a slight significant risk ratio of 0.16 (95% CI, 0.09, 0.28; $I^2 = 0\%$, $p < 0.00001$); a statistically significant difference in favor of the DMC group was maintained also considering only primary or revision arthroplasties, traumatic fractures or elective patients with diagnosis of osteoarthritis, avascular osteonecrosis or rheumatic arthritis.

Conclusions With the intrinsic limitations of our study design and based on the current available data, this study demonstrates that dual-mobility acetabular components decrease the risk of post-operative instability also in high-risk patients, both in primary and revision hip arthroplasties. However, new high-quality studies, possibly with a randomized control design, should be undertaken in order to strengthen the present data.

Study design Level of Evidence III, therapeutic study.

Keywords Dual-mobility cup · Tripolar cup · Dislocation · Total hip arthroplasty

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Introduction

Instability following total hip arthroplasty remains a major complication. The reported dislocation rate ranges from 0.2 to 7% after primary procedures, and up to 21% in revision surgery [1–3]. Even if a general tendency toward a decreasing incidence of dislocations is reported [4], it is still the second reason for revision at any time and the first cause for early re-operation [5–8].

Several studies investigated the risk of dislocation, calling in question patient-related factors (female gender, advanced age, body mass index, neuromuscular comorbidities) [9, 10], procedure-related factors (surgical approach, components positioning, soft tissue tension, surgeon experience) [10], and duration of follow-up [9]; however, implant-related factors, like femoral head size or head-neck ratio, remain the main amendable issues on which the greatest efforts are concentrated [11].

In order to prevent dislocation, specifically constrained implants have been developed, but the increased strains have been described as a possible cause of higher risk of early loosening [12]. In this context, dual-mobility cups (DMC) have gained more interest among clinicians, with encouraging results in terms of lower rate of dislocation associated with good clinical results [13, 14], also in non-selected patients and in revision procedure [15]. Adding a further bearing with the interposition of a mobile polyethylene layer between the prosthetic head and the metal acetabular shell, it combines Charnley's low friction principle [16] with the Mckee-Farrar concepts of larger femoral heads [17] to enhance stability.

On the other side of the same coin, this prosthetic design could present several potential drawbacks, such as increased implant costs compared with conventional metal-on-polyethylene total hip arthroplasty implants [18], bearing wear with the additional "third articulation" between the neck and the polyethylene [13], and the presence of specific implant geometry complications like the intra-prosthetic dislocation [19].

In order to verify the real efficacy of DMC in preventing dislocation compared to traditional unipolar fixed-bearing cup designs, we conducted a systematic review and meta-analysis of two-arm studies with the primary objective of comparing the dislocation rate of the two prosthetic designs under examination.

Material and methods

A systematic review and meta-analysis of comparative studies was performed in December 2017, according the guidelines of preferred reporting items for systematic reviews and meta-analyses (PRISMA) [20]. The primary outcome measure was dislocation rate, both treated with closed reduction and requiring a surgical approach.

Eligibility criteria

All the articles included in the present study have to meet the following inclusion criteria: (1) randomized controlled trials (RCT) and two-arm controlled studies of patients who underwent total hip arthroplasty, with either a dual-mobility or standard fixed-bearing (FB) acetabular cup designs; (2) a separated report of results of both designs, either primary or revision surgery; (3) report of outcome measurements in the studies, in terms of dislocation rates, survival rates, clinical, and functional measurements. Implants with different tribology properties and different manufacturers, whether inserted with or without bone cement, were eligible for inclusion in this analysis.

Search strategy and data collection

Two independent reviewers conducted a systematic search on PubMed, Google scholar, Cochrane Library and EMBASE, for studies available till December 2017. The medical keywords used for initial screening were "dual mobility OR dual-mobility OR tripolar OR double-mobility OR double mobility AND hip OR cup OR total hip arthroplasty OR total hip replacement." No limit was set with regard to the year of publication. Figure 1 shows a summary of the review process.

All articles were screened by title and abstract to assess their eligibility for inclusion. After exclusion of duplicated results and unsuitable studies, the full text of each study was reviewed. Moreover, the bibliographies of all evaluated articles were scanned for additional sources as well as the bibliographies of previous reviews and systematic reviews.

At this point, a stepwise exclusion process of studies not meeting aforementioned inclusion criteria was conducted, ruling out papers with case reports or case series [14, 21], review article, and expert opinion [13, 15], studies not reporting dislocation and revision rates [22, 23], studies comparing biomechanical behavior or involving animals or cadavers [24, 25], comparative data of DMCs with unsuitable geometry of implants (hemiarthroplasty) [26], and, in order to minimize potential bias (such as different implant design, cementation technique and surgeons' experience), studies elaborating data from national registries were not included [27]. Any disagreement between the two reviewers were resolved by consensus or consultation of a third orthopaedic surgeon to determine if the study should be excluded.

Data extraction and synthesis of results

Once the final studies' meeting inclusion criteria were determined, one of the authors extracted from each of them the study design, the number of study subjects with relative demographic data (age and gender), and time of publication. In addition, details regarding number of dislocations, with

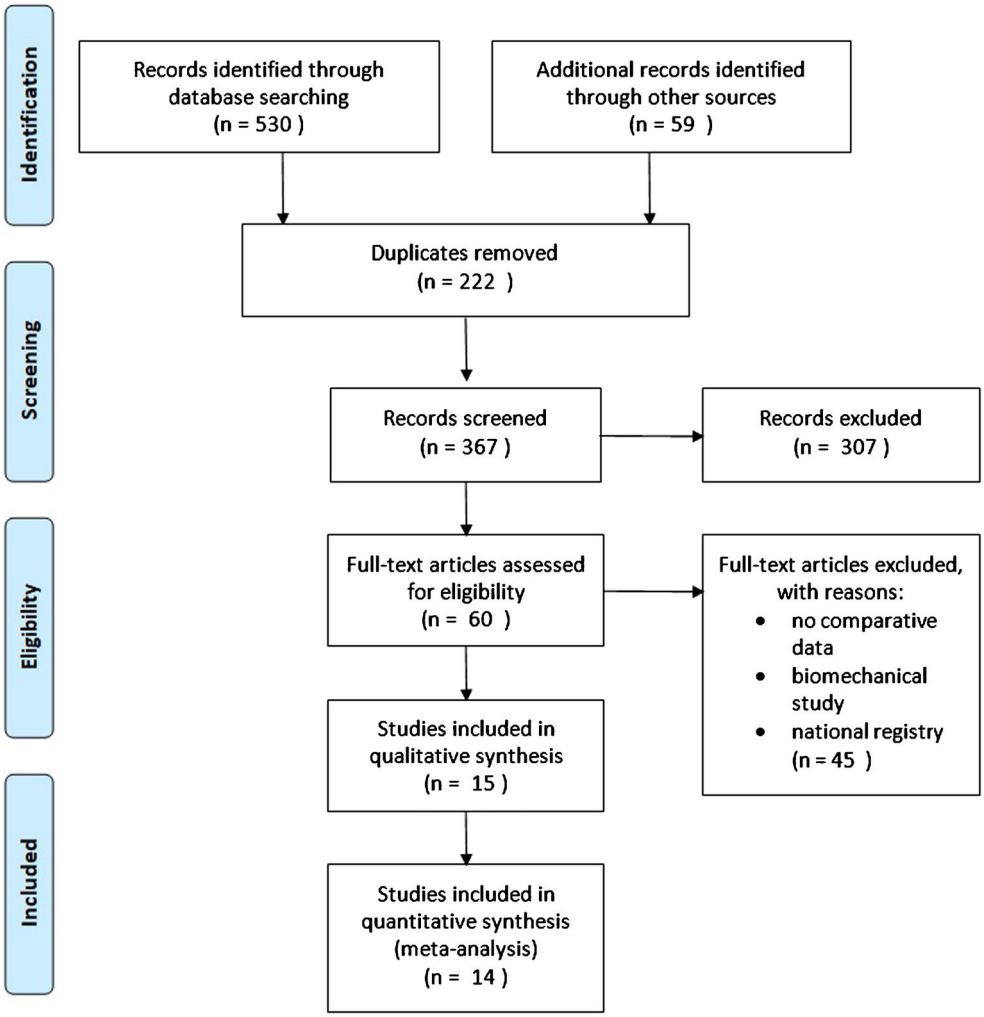

Fig. 1 The QUOROM flow diagram, depicting the number of studies identified, included and excluded with relative reasons for exclusion

relative percentage of closed reduction manipulations and revision surgeries, were provided. Extracted outcomes, where available, included also clinical data, hip functional score, range or motion (ROM), surgical approach, and duration of follow-up.

Risk of bias

All studies were evaluated and classified according to the level of evidence (LOE), using previously published criteria [28]. In order to establish potential bias in selected study from our protocol research, two reviewers independently assessed the methodologic quality of each study using the methodological index for non-randomized studies (MINORS) [29], as recommended by the Cochrane Observational Studies Methods Working Group [30]. It is a validated instrument designed for both comparative and non-comparative surgical studies, in origin also for RCT, containing 12 items scored from 0 to 2 according to the adequacy of the item reported. We considered an appropriate period with a minimum follow-up of six months, according to the evidence of literature that early dislocations within the first six months after surgery are the most common (50–70%). [31, 32]. The global ideal score for high-quality studies is 24; as a higher event rate allows to give a more precise estimate of the influence of studied determinants, the number of events was included in our risk of bias assessment. If the number of THA was > 100 (endpoints established on the basis of cumulative risk of first-time dislocation of 1% at one month and 1.9% at one year, published in Literature [9]) in each group of patients, the study was judged as high quality although the MINORS' global score was between 20 and 24. If there were any unresolved disagreements between reviewers, it was discussed and resolved with consensus of a third investigator.

Statistical analysis

The meta-analysis was performed using RevMan V.5.0.18.33 (The Cochrane Collaboration, Copenhagen, Denmark) in order to calculate pooled summary estimates and generate forest plots. Continuous variables were extracted and analyzed as mean ± standard deviation (SD). If the SD was not reported,

a surrogate SD was calculated from the available data, according to a previous validated formula [33] or, if it was not possible, the highest SD was used. Risk difference (RD) and relative risk (RR) with 95% CI were calculated for dislocation rate. Heterogeneity was tested using the χ^2 and Higgins' I^2 tests [34]. A Mantel-Haenszel random-effect model was adopted if statistical heterogeneity was > 50% at I^2 test; a fixed-effect model was used if statistical heterogeneity was below 50% [35].

A subgroup analysis, evaluating the influence of study design (retrospective or prospective), surgeries (primary or revision procedures), and diagnosis (elective or traumatic patients), was conducted to obtain more specific conclusions if the data were present. Forest plots were used to present the results of the individual studies and respective pooled estimates of effect size.

Moreover, publication bias was assessed using funnel plot for all papers and for each aforementioned subgroup.

Institutional board review and funding source

An institutional review board endorsement was not obtained because all data were extracted from previously published studies. No external funding was received for the initiation or completion of this study.

Results

Studies' selection and demographic characteristics

After performing a critical exclusion process as described above (Fig. 1), the number of eligible studies included for final synthesis considered was 15 [36–50]; of those, only one paper was classified as randomized controlled trial (RCT) [42], and the rest were observational studies, with four classified as LOE 2 [41, 42, 46, 47] and ten studies as LOE 3 [36–39, 43–45, 48–50], according to previous published criteria [28]. All articles were published between 2010 and 2017, describing the results of a total of 2408 total hip arthroplasties (50.6% with a dual-mobility acetabular cup design, 49.4% with a standard fixed-bearing design). Six studies were conducted in France [36, 37, 40, 43, 44, 47], four in the USA [38, 39, 46, 48], two in Lithuania [49, 50], one in Switzerland [41], one in the UK [42], and the last one in Japan [45].

The sample size for each study ranged from 20 to 320 patients, with a mean age ranging from 48.5 to 78 years in the DMC group and from 48.4 to 79.5 in the fixed-bearing cohort; the mean follow-up period of all studies was included between six and 144 months. There was a statistically significant difference in body mass index (BMI) in only one study [43], as intrinsic feature of specific study design. The description of characteristics of included articles and demographic data of patients enrolled in each paper is resumed in Table 1.

Where declared, a single surgical approach (anterior [45] or posterolateral approach [36, 37, 40, 43, 44, 47–50]) was performed in most of them; only Gonzalez et al. [41] reported three different surgical approaches (anterior, anterolateral, and posterolateral).

The behavior of primary implants was described in ten studies (72% of all THA, including 932 DMC and 835 FB components) [36, 37, 39, 40, 42, 43, 45, 48–50] whereas five articles focused their interest on revision procedures (for a total of 285 DMC and 356 FB cups) [38, 41, 44, 46, 47]. None of the present studies included concurrently data both from primary and revision surgery.

The main diagnosis for primary implants was osteoarthritis, followed by femoral neck fractures and avascular necrosis (Fig. 2), whereas in revision procedures, the most common cause was aseptic loosening in both designs (Fig. 3).

Methodological quality of included studies and publication bias

The quality of studies selected was judged moderate, with a mean MINORS score of 15.3 points (range 11 to 18). None of the papers achieved an ideal global score (> 20), also considering the influence of number of events (Table 2). A minimum post-operative follow-up greater than six months was defined as having a low risk of selection bias; based on this cutoff, all studies except one [41] were judged at low risk of bias; moreover, a significant loss of patients during follow-up was detailed in five of them [38, 41, 43, 44, 49].

Prospective collection of data was described in eight studies [38, 40–42, 45, 47, 49, 50], but only three of them can be considered prospective with regard of calculation of the study size [42, 47, 49]. As a blind evaluation of objective endpoints in reports of surgical procedures cannot be achieved because of the intrinsic nature of topic discussed, this represents an unavoidable source of potentially high performance bias. The control group was adequate in all cases, although not always respecting contemporaneity at time of surgery [36, 41, 43, 45–50] and baseline equivalence of demographics data [36, 37, 39–43]; however, where a statistically significant difference in the two groups of patients were declared, all demographic figures that could represents a possible risk factor (age [36, 37, 39–41], BMI > 30 [43]) were in favor of the DMC group.

Funnel plots for all papers included and for each subgroup analyzed (primary surgeries, revision procedures and diagnosis) did not show any asymmetry, excluding any possible publication bias, as shown in Fig. 4.

Table 1 Demographic details and dislocation rate of the studies included

Study	Level of evidence	Journal	Sex (female percent)		Age		BMI		Num. of implants		Follow-up (month)		Dislocation		*p* value
			DM (%)	FB (%)	DM	FB	DM	FB	DM	FB	DM	FB	DM	FB	
Bouchet et al. [36]	3	Orthopaedics & Traumatology: Surgery & Research, 2011	57.14	51.85	76.6 ± 5.65	74.2 ± 5.9	27.1 ± 2.46	26.9 ± 2.34	105	108	> 12	> 12	0	5 (4.63%)	$p > 0.05$
Caton et al. [37]	3	International Orthopaedics, 2014	59.8	57.5	78.0 (39.8–93.5)	70.8 (50–88)	NA	NA	215	105	120	120	1 (1%)	26 (12.9%)	$p = 0.0018$*
Chalmers et al. [38]	3	The Journal of Arthroplasty, 2017	75	46	75 (57–93)	69 (19–92)	29 (19–47)	31 (19–42)	16	13	36 (24–60)	36 (24–60)	0	1 (8%)	$p > 0.05$
D'Apuzzo et al. [39]	3	The Journal of Arthroplasty, 2014	NA	NA	NA	NA	NA	NA	78	78	NA	NA	0	0	$p > 0.05$
Epinette et al. [40]	2	The Journal of Arthroplasty, 2015	64	57.6	70.63 ± 9.49	65.5 ± 12.72	28.44 ± 5.26	28.42 ± 5.43	143	130	24–53	24–80	0	7 (5.38%)	$p = 0.0176$*
Gonzalez et al. [41]	2	Acta Orthopaedica, 2017	56	46	73 ± 11.1	65 ± 15.2	26 ± 5.8	26 ± 5.2	150	166	31 (6–136)	52 (6–128)	1 (0.7%)	7 (4.2%)	$p > 0.05$
Griffin et al. [42]	1	The Bone & Joint journal, 2016	NA	NA	NA	NA	NA	NA	10	10	12	12	0	0	$p > 0.05$
Hernigou et al. [43]	3	Clin Orthop Relat Res, 2016	62.7	60.7	72 ± 13	71 ± 8	39.9 ± 5.4	27.6 ± 4.2	85	85	132 (84–180)	144 (84–180)	5 (3%)	13 (15%)	$p > 0.05$
Hernigou et al. [44]	3	International Orthopaedics, 2017	56.3	57.1	74.7 ± 6.4	72.1 ± 6.4	> 30	> 30	35	32	84	84	1 (2.8%)	7 (21.8%)	$p = 0.04$*
Homma et al. [45]	3	Eur J Orthop Surg Traumatol, 2016	79.3	87.7	75.6 ± 6.4	74 ± 6.14	23.5 ± 3.7	23.4 ± 3.5	60	60	6	6	0	1 (1.6%)	$p > 0.05$
Jauregui et al. [46]	2	Hip international, 2016	57	57	57 (26–87)	59 (31–84)	30 (19–50)	30 (20–48)	60	120	30 (18–52)		1 (1.7%)	7 (5.8%)	$p > 0.05$
Perrin et al. [47]	2	Eur J Orthop Surg Traumatol, 2017	64	62.5	78 (50–92)	79.5 (61–92)	NA	NA	24	25	6	6	1 (4.2%)	5 (20%)	$p > 0.05$
Rowan et al. [48]	3	The Journal of Arthroplasty, 2017	54.40	58	48.5	48.4	28.5 ± 6.5	28.5 ± 6.1	136	136	38 (1–71)	41 (2–109)	0	7 (5.1%)	$p = 0.01$*

Table 1 (continued)

Study	Level of evidence	Journal	Sex (female percent)		Age		BMI		Num. of implants		Follow-up (month)		Dislocation		*p* value
			DM (%)	FB (%)	DM	FB	DM	FB	DM	FB	DM	FB	DM	FB	
Tarasevicius et al. [49]	3	BMC Musculoskeletal Disorders, 2010	73.80	58.90	75	74	NA	NA	42	56	12	12	0	8 (14.3%)	$p = 0.01$*
Tarasevicius et al. [50]	3	Hip international, 2013	78.10	67.40	75	76	NA	NA	58	67	12	12	0	5 (7.4%)	$p > 0.05$

NA not available

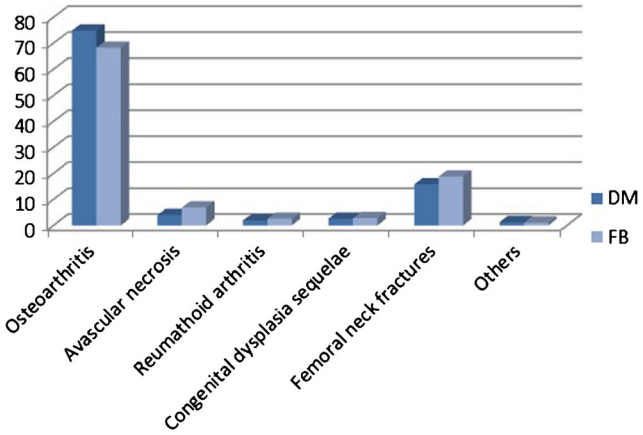

Fig. 2 Causes for primary arthroplasties for dual-mobility cups and fixed bearing implants. Others includes Legg-Calve-Perthes disease, traumatic sequelae and not reported causes

Dislocation rate

In order to ensure methodological homogeneity, one paper was excluded from quantitative analysis because of the different study design (RCT) [42]; the fixed-effect meta-analysis from the remaining 14 articles providing details on dislocation rate (Fig. 5) showed a slight significant risk ratio of 0.16 (95% CI, 0.09, 0.28; $I^2 = 0\%$, $p < 0.00001$), with a statistically significant difference between the two groups in questions in five papers [37, 40, 44, 47, 48].

A statistically significant difference in favor of the DMC group was maintained also considering only primary total hip arthroplasties (95% CI, 0.07, 0.29; $I^2 = 0\%$, $p < 0.00001$), as shown in Fig. 6, or only revision arthroplasties (95% CI, 0.07, 0.51; $I^2 = 0\%$, $p = 0.0009$), reported in Fig. 7; moreover, splitting each subgroup analysis according to the study design (prospective or retrospective), a significant lower risk of revision was reported, thus not affecting our findings.

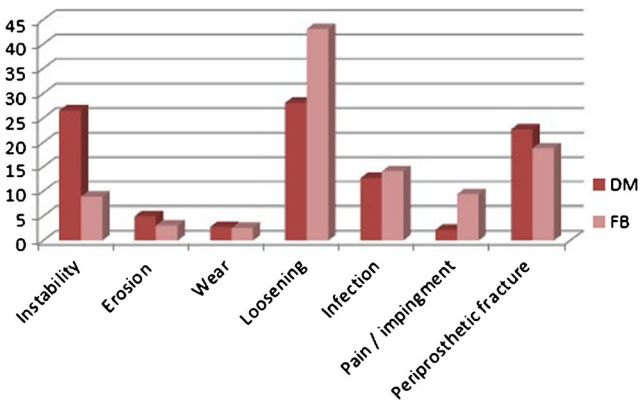

Fig. 3 Causes for revision arthroplasties for dual-mobility cups and fixed bearing implants

Table 2 Methodological quality of studies included in the meta-analysis, using the methodological index for non-randomized studies (MINORS)

	Clearly stated aim	Inclusion of consecutive patients	Prospective data collection	Endpoints appropriate to study aim	Unbiased assessment of study endpoint	Follow-up period appropriate to study aim	< 5% lost to follow-up	Prospective calculation of study size	Adequate control group	Contemporary groups	Baseline equivalence of groups	Adequate statistical analyses	Total	Adequate number of patients	Risk of bias
Bouchet et al. [36]	2	2	0	2	NA	2	2	0	2	0	0	2	14/24	YES	HIGH
Caton et al. [37]	2	1	0	2	NA	2	2	0	2	2	0	2	15/24	YES	HIGH
Chalmers et al. [38]	2	2	2	2	NA	2	0	0	2	2	2	2	18/24	NO	HIGH
D'Apuzzo et al. [39]	0	1	0	2	NA	2	2	0	2	2	1	2	14/24	NO	HIGH
Epinette et al. [40]	2	2	2	2	NA	2	2	0	2	2	0	2	18/24	YES	HIGH
Gonzalez et al. [41]	2	2	2	2	NA	0	0	0	2	0	0	2	12/24	YES	HIGH
Griffin et al. [42]	2	0	2	2	NA	2	1	2	2	2	1	1	17/24	NO	HIGH
Hernigou et al. [43]	2	0	0	2	NA	2	0	0	2	0	1	2	11/24	NO	HIGH
Hernigou et al. [44]	2	2	0	2	NA	2	0	0	2	2	2	2	16/24	NO	HIGH
Homma et al. [45]	2	0	2	2	NA	2	2	0	2	0	2	2	16/24	YES	HIGH
Jauregui et al. [46]	2	0	0	2	NA	2	2	0	2	0	2	2	14/24	NO	HIGH
Perrin et al. [47]	2	0	2	2	NA	2	1	2	2	0	2	2	17/24	NO	HIGH
Rowan et al. [48]	2	0	0	2	NA	2	2	0	2	0	2	2	14/24	NO	HIGH
Tarasevicius et al. [49]	2	2	2	2	NA	2	0	2	2	0	2	2	18/24	YES	HIGH
Tarasevicius et al. [50]	2	0	2	2	NA	2	2	0	2	0	2	2	16/24	NO	HIGH

NA not applicable

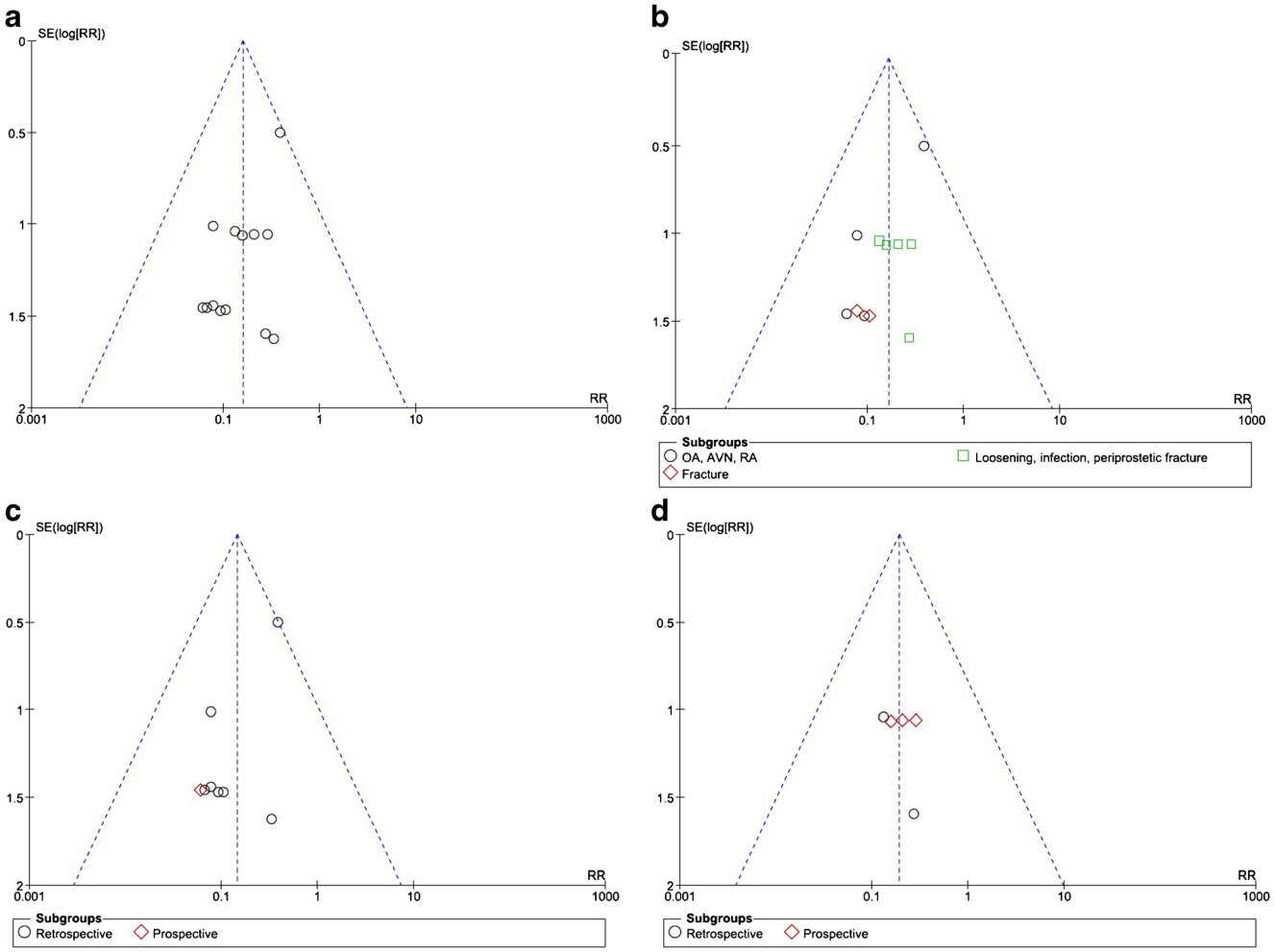

Fig. 4 Funnel plot for all studies included (a), and splittng papers according indications (b), primary procedure (c), and revision surgeries (d)

At last, splitting papers according to diagnosis (Fig. 8), our statistical analysis showed a significant lower dislocation rate both for traumatic fractures, degenerative diseases (both primary and secondary osteoarthritis related to avascular osteonecrosis or rheumatic arthritis), and revision surgery not related to instability (loosening, infection, periprosthetic fractures).

Discussion

The concept of a design with two distinct articulations in total hip arthroplasty was introduced in France in 1974 by Gilles Bousquet and Andrè Rambert [51], with the goals to decrease the risk of dislocation. The widespread success of this technology is based on the greater range of motion before

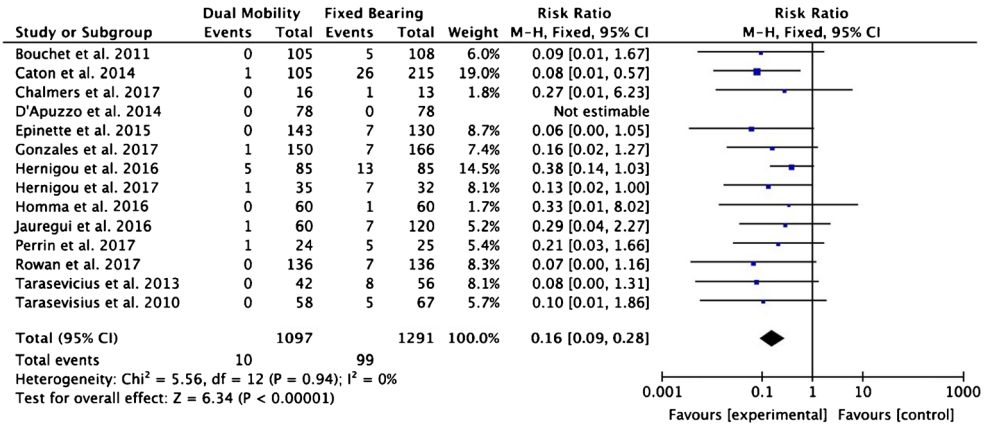

Fig. 5 Forest plot for dislocation rate of all papers between dual-mobility and fixed-bearing acetabular components

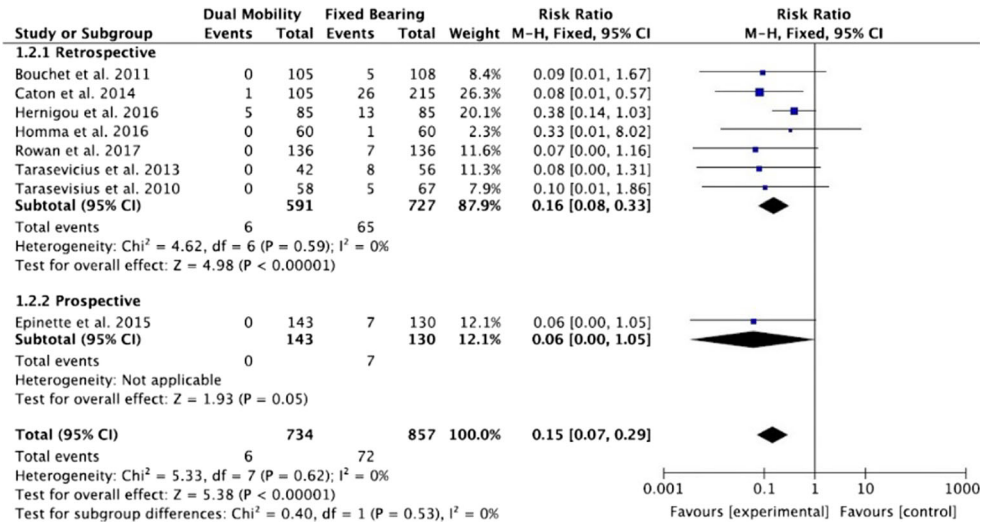

Fig. 6 Subgroup analysis splitting all papers reporting primary surgery according the study design (retrospective or prospective) maintains a statistical difference of dislocation rate in favour of dual-mobility cups

complete dislocation allowed with the use of a larger effective head diameter. It has been previously demonstrated that a larger head size of 36 mm or more increases the head/neck ratio and the "jumping" distance and reduces impingement between the neck and the cup rim, with consequent increased stability [52–54].

The main finding of the present study is that DMCs are more effective compared to standard fixed-bearing cup in terms of prevention of dislocation at medium follow-up, according to the currently available evidence and taking into account the paucity and the low methodological quality of the included studies that could support a robust statistical analysis. A lower number of dislocation in DMC group was signaled in all but two papers [39, 42], although a statistically significant difference between the two groups in questions was reported in the five articles [37, 40, 44, 48, 49] with the highest number of patients included, showing that sample size could affects results. The superiority is confirmed also considering only results from papers where procedure was considered at high risk, such as in revision surgery or patients with femoral neck fractures, as demonstrated in our analysis.

These findings are in line with results published in Literature, both from single-centre clinical reports [14, 15] and from national registry data [27], and seems to be a plausible explanation of the lower revision rate for THA instability reported by French authors [55].

In primary procedures, the use of modern dual-mobility systems has been associated with low dislocation rates, ranging from 0 to 4.6%, both in patients at high risk for dislocation and in non-selected patients [13]. Moreover, unlike conventional implants [9], the cumulative risk for dislocation seems not to increase proportionally with duration of follow-up time [14]. Also in revision procedures, a remarkably low dislocation rate has been reported, ranging from 0 to 1.5% at short- to mid-term follow-up [56]; however, the strength of these results are affected by the low number of patients included in the more recent reports, less than 500 in the vast majority of cases, and by the short period of supervision.

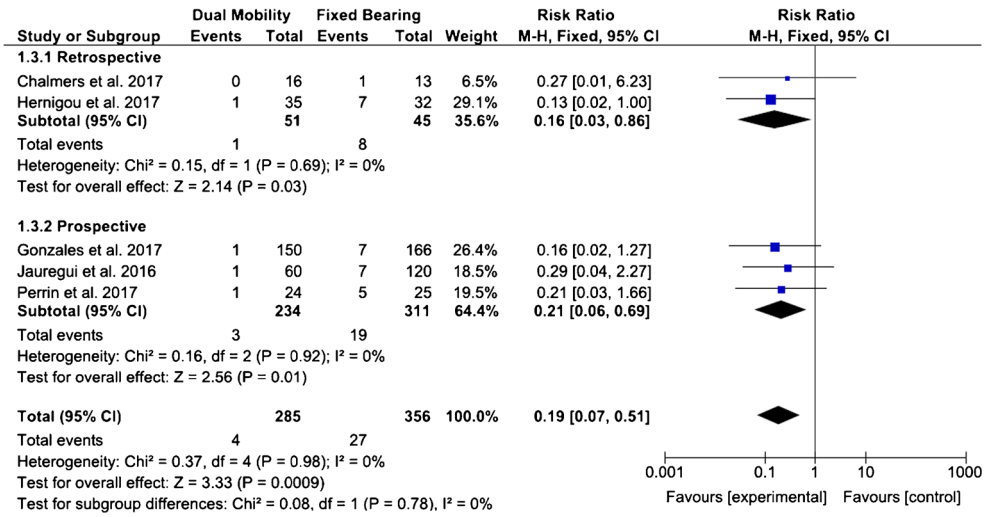

Fig. 7 In both retrospective and prospective studies describing revisionsurgery, a significant lower dislocation rate in dual-mobility cup group was reported

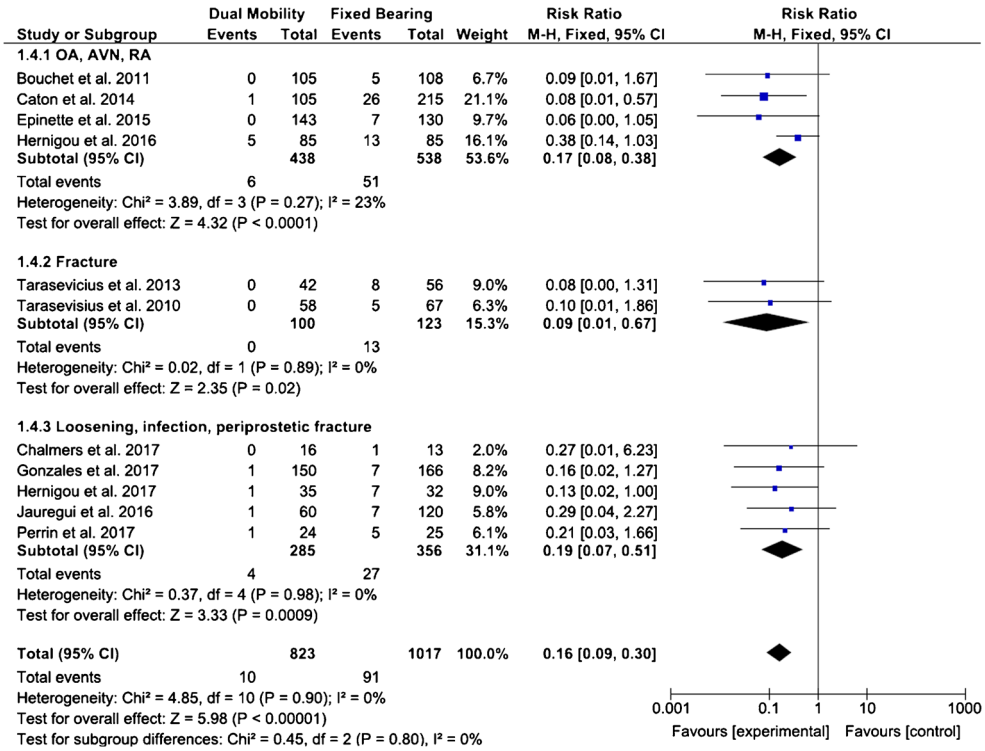

Fig. 8 The influence of diagnosis on revision rate. A significant dislocation rate in favor of fixed bearing acetabular components is maintained also in high risk patients

Despite these encouraging results and the widely increasing application of this technology, concerns have been raised related to additional bearing surface, first of all, the possibility of accelerated wear and consequently increased risk of aseptic loosening following the use of these components [14].

Although comparable total volume of wear as in conventional metal-polyethylene bearings with 22.2 mm femoral heads [57, 58] and promising results at medium term of follow-up with the introduction of highly cross-linked polyethylene were reported recently [59], long-term benefit has not been yet demonstrated. Considering that late dislocations after five years, often related to polyethylene wear, may reach up to 32% [31, 32], conclusive findings cannot yet be drawn.

Another potential limitation of dual-mobility designs is the intra-prosthetic dislocation (IPD) that is a specific mode of failure reported in the first generation of implants. As the main mechanism seems to be depending to wear, and because sporadic reports of early IPD have recently emerged also for newer implants [60, 61], further studies with longer period of surveillance are necessary.

In our systematic review, none of the aforementioned complications was reported; however, the average follow-up period is too short for conclusive statement, and the effects of these limitations on implant survivorship and patients' health are unknown.

Another issue which deserves consideration is cost. Several advocates [23, 62] considered DMC implants effective in cost saving compared with primary fixed-bearing THA, emphasizing the reduced risk of dislocation and its consequent costs. However, the probability of intra-prosthetic dislocation exerted the most influence on results, and until the real incidence of this complication is accurately appreciated, the definitive cost-effectiveness cannot be determined.

This review shows several limitations. First, only one of the studies included is a randomized controlled trial, and a retrospective study design is adopted in the majority of cases, except in four papers [40, 41, 46, 47]; moreover, the methodological quality is low. This, in practice, limits the level of evidence of our review. However, as shown in funnel plot, no evidence of publication bias could be reported. Secondly, patients enrolled in the studies selected were extremely heterogeneous in terms of demographics, diagnosis, and indications for the operation. Nevertheless, a statistically significant difference in the two groups of patients was intrinsic of the study design of most of papers, in order to justify the use of DMC technology in higher risk patients, and this could be interpreted as a further strength of our statistical analysis. Thirdly, most of the authors of the present review were French and/or declared conflict of interest. Fourthly, as the surgery was performed by the same surgeon just in three articles [36, 37, 40] technical skills could pose a risk of bias; confirming our concerns, none of the studies selected reported the position of the acetabular cup implanted or possible differences between the two groups examined. At last, but not the least, the follow-up period is too short to clarify if the efficacy in reducing dislocation rate can be confirmed at long follow-

up period, although it can be considered sufficient because the most dislocations episodes occur in the first six months after surgery, as previously reported.

Conclusion

In conclusion, with the intrinsic limitations of our study design and based on the current available data, this study demonstrates that dual-mobility acetabular components decrease the risk of post-operative instability in high-risk patients, both in primary and revision hip arthroplasties. However, due to the poor quality of the studies in the Literature, we believe that new high quality studies, possibly with a randomized control design, should be undertaken in order to strengthen the present data. Ongoing surveillance and longer term follow-up are warranted before recommending the widespread use of the newer DMC implants for routine primary total hip arthroplasty. At the present state, clinicians should consider all concerns reported in Literature and limit these devices where the risk-benefit ratio justifies their use.

Compliance with ethical standards

Conflict of interest statement Dr. Romagnoli M, Costa G.G., and other authors have nothing to disclose. Prof. Zaffagnini reports personal fees from DePuy, A Johnson & Johnson Company, and Smith & Nephew as speaker bureau, and from Springer, outside the submitted work.

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