A SYSTEMATIC REVIEW

Aims
The aim of this systematic review was to report the rate of dislocation following the use of dual mobility (DM) acetabular components in primary and revision total hip arthroplasty (THA).

Materials and 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, Cochrane Library and Embase (Scopus) was conducted for English articles between January 1974 and March 2016 using various combinations of the keywords “dual mobility”, “dual-mobility”, “tripolar”, “double-mobility”, “double mobility”, “hip”, “cup”, “socket”. The following data were extracted by two investigators independently: demographics, whether the operation was a primary or revision THA, length of follow-up, the design of the components, diameter of the femoral head, and type of fixation of the acetabular component.

Results
In all, 59 articles met our inclusion criteria. These included a total of 17,908 THAs which were divided into two groups: studies dealing with DM components in primary THA and those dealing with these components in revision THA. The mean rate of dislocation was 0.9% in the primary THA group, and 3.0% in the revision THA group. The mean rate of intraprosthetic dislocation was 0.7% in primary and 1.3% in revision THAs.

Conclusion
Based on the current data, the use of DM acetabular components is effective in minimising the risk of instability after both primary and revision THA. This benefit must be balanced against continuing concerns about the additional modularity, and the new mode of failure of intraprosthetic dislocation. Longer term studies are needed to assess the function of these newer materials compared with previous generations.

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Dislocation following total hip arthroplasty using dual mobility acetabular components

HIP TECHNOLOGIES

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Total hip arthroplasty (THA) is recognised as one of the most common and successful surgical procedures.1 It reduces pain, improves function and quality of life.2 With the continuous improvement of healthcare and increasing life expectancy, the demand for THA will grow to reflect the more active, aging population. The number of THAs performed in the United States is projected to increase by 174% in 2030 compared with 2005, reaching 572 000 per year.3

Instability continues to be a troublesome complication after THA and has been reported to be the main indication for revision in the United States, accounting for 22.5% of revisions.3 Re-admission and revision surgery carry considerable economic burden as the surgical treatment of a dislocating THA can raise the costs by 148%.4 Surgical techniques including the use of the anterior approach, repair of posterior soft tissues, appropriate offset and restoration of the abductor function, and the design of the components including the use of larger femoral heads, dual mobility or constrained acetabular components have reduced rates of dislocation after primary THA from about 5% to about 1%.5 However, there remain patients who are at a high risk of dislocation, such as those with neuromuscular diseases, cognitive dysfunction, an American Society of Anesthesiologists score6 of more than three, those aged...
> 75 years and those with a history of previous surgery to the hip, in whom the rate of dislocation is still high, ranging from 4.8% to 13%, despite improvements in the surgical techniques.\(^7\) In addition, the rate of dislocation is higher in revision surgery, ranging from 7.4% to 14.4%.\(^8\)-\(^10\)

The use of the dual mobility (DM) acetabular components has been shown to increase stability after THA.\(^5\) The concept of dual articulation was introduced in France in 1974 by Gilles Bousquet and André Rambert\(^11,12\) and combined Charnley’s low friction principle\(^13\) with the McKee-Farrar concept of using larger diameter femoral heads\(^14\) to enhance stability. The first design was a cylindrical/spherical uncremented stainless steel component with a porous plasma sprayed alumina coating and an inner polished surface; an external anchor clip for a 4.5 mm screw, and two Morse taper pegs provided additional initial fixation.\(^15\) The mobile liner was made from ultra-high molecular weight polyethylene (UHMWPE), gamma sterilised in air and articulated with metal femoral head with a diameter of 22.2 mm. While the polyethylene (PE) liner and the introduction of ceramic femoral heads have improved the overall tribology, the underlying concept of the “unconstrained tripolar”\(^16\) THA is still the same. The purpose of this kind of component is to provide increased range of movement (ROM)\(^17\) and head-neck ratio,\(^18\) a larger effective head size\(^19\) and a greater jump distance,\(^20\) all of which lead to increased stability. While the DM articulation has been used in Europe for more than 25 years, it only became available in the United States in 2009. Recently, however, concerns have been raised about the possibility of accelerated PE wear, osteolysis and aseptic loosening following the use of these components,\(^21\) in addition to a new mode of failure, intraprosthetic dislocation.\(^5\) This systematic review summarises the outcomes of the use of DM components in primary and revision THA and specifically evaluates its efficacy in reducing the rate of dislocation.

**Materials and Methods**

We performed a systematic review of the literature in order to identify articles reporting the rate of dislocation following the use of DM components in THA. PubMed/Medline, Cochrane Library and Embase databases were searched for articles published up to March 2016 using the following search terms: 1) dual mobility OR dual-mobility OR tripolar OR double-mobility OR double mobility and 2) hip OR cup OR socket. No limit was set with regard to the year of publication. Inclusion criteria were original articles investigating DM in primary and revision THA with an adequate follow-up (minimum six months). Exclusion criteria consisted of case reports or series with < 20 patients, review articles, expert opinions, letters to editors, biomechanical reports, instructional course lectures, studies involving animals or cadavers, or *in vitro* investigations, book chapters, abstracts from scientific meetings, and unpublished reports.
Search results. Figure 1 shows an outline of the review process. The initial search yielded 720 citations. After screening for duplicate publications, 249 were excluded, leaving 471. After reviewing the abstracts of these, 73 were screened for eligibility and 59 were identified for inclusion.\textsuperscript{7,12,16,21-76}

Two independent reviewers (IDM and VGS) separately conducted the search by title and abstract. If the title and abstract of each study contained insufficient information to determine its appropriateness for inclusion, the full manuscript was reviewed. A cross-reference search of the selected articles was also performed to obtain other relevant articles. The full texts of the chosen papers were obtained to decide whether they were suitable for the purpose of the study. If there was disagreement between the two reviewers, a third (RD) was consulted and consensus was reached. The 27-item Preferred Reporting Items for Systematic Reviews and Meta-Analyses checklist was used.\textsuperscript{77} The original two reviewers (IDM and VS) independently extracted the data including the title, year of publication, authors, study design, number, age and distribution of patients by gender, whether the procedure was primary or revision, length of follow-up, implant design, diameter of the femoral head, and type of fixation of the acetabular component. The primary outcome was the rate of dislocation and the secondary outcome was the rate of intraprosthetic dislocation.

Assessment of bias. The level of evidence of each article was recorded.\textsuperscript{78} In order to assess the quality of the studies, the Methodological Index for Non-Randomised Studies (MINORS)\textsuperscript{79} was used. This validated instrument was developed to determine the quality of observational and non-randomised studies. Two investigators (IDM and RD) independently assessed the quality of each article. They were scored on a 12 item scale: aim of the study, inclusion of consecutive patients, prospective collection of data, appropriateness of the endpoints, unbiased assessment of the endpoint, appropriateness of length of follow-up, percentage of loss to follow-up, prospective calculation of the sample size, comparable control group, contemporary control groups, baseline equivalence of groups and the adequateness of the statistical analysis. The studies were scored from 0 to 2 points for each of these items. Low-quality and high-quality studies were defined as earning < 16 and >16 points, respectively, as previously described.\textsuperscript{80} The global ideal score was 16 for non-comparative studies and 24 for comparative studies.

Statistical analysis. Categorical variables are presented as frequency and percentages. Continuous variables are presented as means with standard deviations (SD). A p-value < 0.05 was considered statistically significant.

Results

The 59 articles that met the inclusion criteria were divided into two groups: studies dealing with DM components in primary THA and those dealing with these components in revision THA.

DM components in primary THA. A total of 12 844 hips with a mean age at the time of surgery of 68.8 years (SD 9.7) were included. The mean follow-up was 6.8 years (SD 5.1). The mean rate of dislocation was 0.9% (SD 1.9) and the mean rate of intraprosthetic dislocation was 0.7% (SD 1.4). The details and demographic data are shown in the supplementary material.

DM components in revision THA. A total of 5064 hips with a mean age at the time of surgery of 69.3 years (SD 4.6) were included. The mean follow-up was 4.4 years (SD 2.4). The mean rate of dislocation was 3.0% (SD 3.0) and the mean rate of intraprosthetic dislocation was 1.3% (SD 2.2). The details and demographic data are shown in the supplementary material.

Quality assessment. The mean MINORS score was 12.6 points (9 to 21), showing that the quality of the studies was low. A meta-analysis was not undertaken due to the general poor quality of the studies.

Discussion

Our main finding was that DM-THA is a successful procedure with low rates of dislocation both in primary and revision THA. Several aspects should, however, be considered further.

Dislocation is one of the most common complications of THA and its incidence increases with the passage of time.\textsuperscript{81} Data about the incidence and prevalence are biased by the fact that most articles on this subject are from high-volume centres, restricting their generalisation for low-volume centres and community practices.\textsuperscript{22} According to the Australian Orthopaedic Association National Joint Replacement Registry (2015), the most common indications for revision of a conventional primary THA are loosening/osteolysis (28.0%), dislocation (24.2%), fracture (18.2%) and infection (17.3%) whereas dislocation following a first revision is the most common reason for a further revision THA (31.1%).\textsuperscript{82} Dislocation after THA is a cause of much comorbidity.\textsuperscript{83} Risk factors for instability are patient-related and surgery-related. Amongst the former are female gender, advancing age,\textsuperscript{84,85} previous hip surgery,\textsuperscript{86-88} neuromuscular disorders, cognitive disorders, alcohol abuse and abductor weakness.\textsuperscript{85,87,89-93} Amongst the latter are surgical approach,\textsuperscript{87,94} malpositioning of components,\textsuperscript{94-96} failure to restore leg length or offset,\textsuperscript{90,92} preserving the abductor mechanism, capsular repair,\textsuperscript{97,98} impingement,\textsuperscript{99} the experience of the surgeon,\textsuperscript{81,89,100} the size of the femoral head\textsuperscript{89,101} and the head-neck ratio.\textsuperscript{102} The last two are related to choice of implant rather than surgical technique.

In randomised controlled trials, larger femoral heads (≥ 36 mm) have shown a lower incidence of dislocation both in primary\textsuperscript{103} and in revision\textsuperscript{104} THA. The reasons for the improved stability in larger femoral heads are the increased jump distance, increased head-neck ratio, and possibly the mismatch between the size of the head and the outer diameter of the acetabular component.\textsuperscript{104,105} However caution is advised in using larger femoral heads in young or...
more movement occurred at the inner PE bearing. The force in-
nantly on the inner surface of the liner, suggesting that
data are still lacking. Epinette et al recently reported that considering the

impingement of the neck on the rim of the retentive PE
coupling, with the convex surface of the PE articulating
the material in these conditions. Another paper from the
context, French. This design of component was developed
exclusion of many other languages and in particular, in this
articles, we decided not to introduce this additional bias.

This study demonstrates that dual mobility acetabular compo-
more friction and wear have been reported in laboratory studies, but independent clinical
data are still lacking.

Another issue to be considered with DM components is cost. Epinette et al recently reported that considering the

reduced risk of dislocation and its consequent costs, DM-

THA may have substantial cost savings compared with primary fixed bearing THA, in France.

Further concerns about the use of DM components are related to the inability to assess its seating, due to the lack of holes on the surface of the component with the mono-
block design. Furthermore, many designs do not offer

additional external slots for screws. This represents a prob-
lem in revision surgery when bone loss does not permit a
stable initial fixation. This can be overcome, for example, by cementing the component in a cage. Newer highly
porous coatings and supplementary screw hole helps to
provide better fixation.

We found a mean rate of dislocation of 0.9% (SD 1.9) in
12 844 primary THAs with a mean follow-up of 6.8 years
(SD 5.1). This result is in line with the rate of dislocation
reported by several authors and registries. However, it
should be noted that DM components in our review were
used mostly in patients with a high risk of dislocation. The
mean rate of dislocation in 5064 revision THAs was 3.0%
(SD 3.0) at a mean follow-up of 4.4 years (SD 2.4). This also
compares favourably with other reports of rates which vary
between 5% and 30%. All but ten of the studies
included in our review were single-arm studies; hence, no
comparisons can be made between fixed bearing and DM-
THAs based on these data.

This review has several limitations. First, the studies are
level III evidence or less and the design is often retrospec-
tive. Moreover their overall quality was low. This, in turn,
limits the level of evidence of our paper. Secondly, there is
selection bias as we extracted specific data from the articles.
Thirdly, patients in the studies were extremely heteroge-
nous in terms of demographics, diagnosis and indications
for the operation. Fourthly, we used only three databases in
our search of the literature, potentially excluding some
papers from analysis. We decided to use only the most com-
mon databases and chose not to include other more periph-
eral literature, which could have reduced the publication
bias. However, considering the absence of a rigorous peer-
review process for such literature and the frequent differ-
ences between conference abstracts and final published
articles, we decided not to introduce this additional bias.
Fifthly, we only included papers in English, causing the
exclusion of many other languages and in particular, in this
context, French. This design of component was developed
in France and the literature in French initially contributed
more than others to this topic. Most authors, however,
reported their results both in French and in English, reduc-
ing the linguistic bias of our review.

Based on the current data, it appears that DM compo-
ents are effective in minimising dislocation in high-risk
patients in primary and revision THA. This benefit must be
balanced with continuing concerns about the additional
modularity and the new failure mode of intraprosthetic dis-
location. Due to the poor quality of the studies in the liter-

ate, we believe that a large, randomised control study
should be undertaken to further analyse the reduction in
the incidence of dislocation after THA.

Take home message:
This study demonstrates that dual mobility acetabular compo-
ents decrease the risk of post-operative instability both in
primary and revision hip arthroplasties.
Supplementary material

Tables showing the details and demographic data of the included studies can be found alongside this paper online at www.bbj.boneandjoint.org.uk

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I. De Martino: Literature search, Data collection, Data abstraction, Data analysis, Writing and editing of manuscript.
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T. P. Sculco: Editing and approval of manuscript.

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