HIP

The double-mobility acetabular component in revision total hip replacement

THE UNITED KINGDOM EXPERIENCE

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We present our experience with a double-mobility acetabular component in 155 consecutive revision total hip replacements in 149 patients undertaken between 2005 and 2009, with particular emphasis on the incidence of further dislocation. The mean age of the patients was 77 years (42 to 89) with 59 males and 90 females. In all, five patients died and seven were lost to follow-up. Indications for revision were aseptic loosening in 113 hips, recurrent instability in 29, peri-prosthetic fracture in 11 and sepsis in two. The mean follow-up was 42 months (18 to 68). Three hips (2%) in three patients dislocated within six weeks of surgery; one of these dislocated again after one year. All three were managed successfully with closed reduction. Two of the three dislocations occurred in patients who had undergone revision for recurrent dislocation. All three were found at revision to have abductor deficiency. There were no dislocations in those revised for either aseptic loosening or sepsis.

These results demonstrate a good mid-term outcome for this component. In the 29 patients revised for instability, only two had a further dislocation, both of which were managed by closed reduction.

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The most common indications for revision total hip replacement (THR) are aseptic loosening, dislocation and infection.[1,2] Regardless of the indication, revision is more complex than the primary procedure. Scarring, attenuated and dysfunctional musculature, as well as femoral and acetabular bone loss, all add to the challenge of the surgery. This is reflected in the higher incidence of complications and failures after revision when compared to primary THR.[3-6]

Instability is a complication of revision THR with dislocation rates of 7.4% to 25% being reported.[4-9] The incidence can be as high as 35% in selected indications.[5] For example, a review of Medicare claims in the United States, involving over 12 000 revision and 55 000 primary THRs, found that the rate of dislocation after revision THR was more than three times that of primary THR (14.4% *versus* 3.9%).[4]

Many techniques have been proposed to address the problem of instability,[10] including change of modular components,[11] trochanteric advancement,[12] use of liners with an elevated rim,[13] acetabular augments,[14] constrained liners,[15-17] constrained tripolar acetabular components[18,19] and use of large prosthetic femoral heads.[20] Despite the pantheon of options available, uniform success has not been reported.[21-26]

An acetabular component of interesting design that originated in France more than two decades ago has been shown to reduce the incidence of dislocation.[27] Known variously as a dual-mobility, double-mobility (DM) or unconstrained tripolar acetabular component,[27-29] it has a mobile polyethylene liner articulating with both the femoral head and a fixed metal acetabular shell with a highly polished inner surface. The design effectively makes the large-size liner the actual femoral head in extreme flexion, ab-/adduction and rotation, consequently improving stability (Fig. 1).[30]

To date, most outcome reports dealing with this component have come from French authors who have an association with the originating centre.[27-29,31-35] They describe various models and designs of the component and their use in both primary and, to a lesser extent, revision THR. The literature lacks independent reports on the DM implant outside of its originating centres in France. We have been using a double mobility implant (Saturne, Amplitude, France, distributed by Spine-issimus Ltd, Walden, United Kingdom) since 2005, predominantly for revision THR where risk factors for instability have given cause for concern. This study reviews our experience.

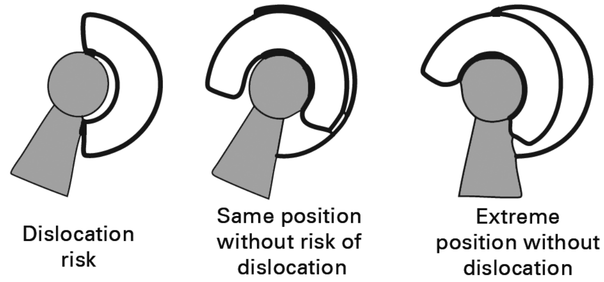

Fig. 1

Line drawings showing how in the initial range of movement the head moves within the liner, yet at extreme ranges of movement the liner acts as a large head to prevent dislocation.

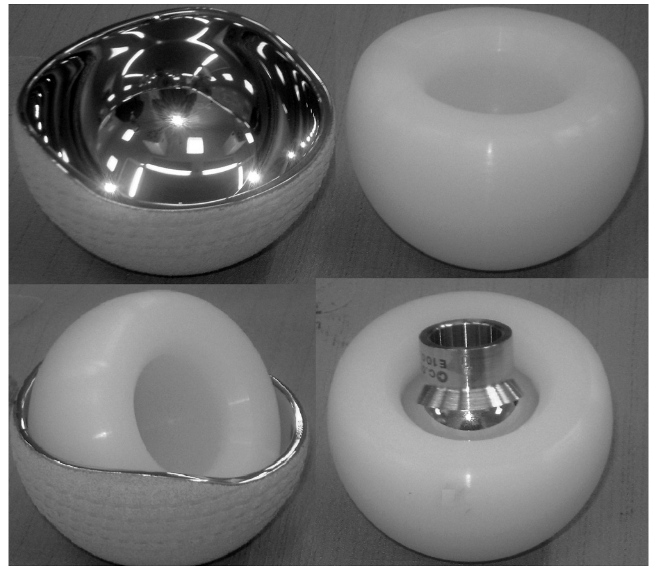

Fig. 2

Photographs showing the double-mobility shell (top left) and the mobile ultra-high molecular-weight polyethylene (UHMWPE) liner (top right), the two components united (bottom left), and the head captured within the liner (bottom right).

Fig. 3

Radiograph of a 60-year-old female patient at one year after revision total hip replacement using an uncemented double mobility implant.

Patients and Methods

This is a retrospective review of 149 patients who underwent 155 consecutive revision THRs between October 2005 and November 2009. All patients undergoing acetabular revision with the DM acetabular component were included in the study. The mean age of the patients was 77 years (42 to 89) with 59 males and 90 females.

The indications for revision were aseptic loosening in 113 hips, recurrent instability in 29, peri-prosthetic fracture in 11 and sepsis in two. In all, 117 revisions included both the acetabular and femoral components while 38 involved revision of the acetabular component only. The DM component consists of a stainless steel outer shell with a highly polished inner surface that articulates with a mobile, ultra-high molecular-weight polyethylene (UHMWPE) liner. This in turn articulates with the femoral head, which remains mobile yet 'captured' within the liner.

The outer shell is anatomically shaped. It has superior and posterior lips as well as anterior and inferior 'cut-outs' (Fig. 2). The design is intended to reduce impingement with the psoas and soft tissues as well as to eliminate dislocation of the liner from the shell. The opening diameter of the polyethylene liner is smaller than that of the femoral head such that a compression instrument is required to force the head into the liner. This discrepancy prevents dislocation of the head from the liner, yet enables full movement within it. The opening of the liner is chamfered, so that a smooth articulation, when required, can take place between the neck of the femoral component and the liner.

The outer metal shell has a press-fit option (hydroxyapatite plasma-sprayed onto a titanium coating) as well as a cemented option. The cemented option has a cross-hatched pattern grooved into the stainless steel to aid cement/ prosthesis mechanical interlock. The size of the femoral head was 28 mm in every femoral revision in our series although a 22 mm head option was also available.

Cementless acetabular components were implanted in 122 hips and the cemented version in 33. We used cementless implants where there was a contained defect in which a stable fit could be achieved. These implants do not have the option of screw fixation as the inner surface of the shell is highly polished and articulates with the mobile polyethylene liner. Where adequate press-fit could not be achieved, impaction grafting with morcellised fresh frozen allograft from donor femoral heads was used to reconstruct the acetabulum and a cementless implant used (Fig. 3). In hips where fixation remained a concern, or where the defect was uncontained, a cemented component was implanted after the acetabulum had been reconstructed using morcellised

Fig. 4

Radiograph of a 67-year-old female patient at two years after revision total hip replacement using a double mobility component cemented into a cage bone graft construct.

Fig. 5

Radiograph of an 82-year-old male patient with advanced dementia showing a dislocation at eight weeks after revision; note that the liner has dislocated from the outer shell whilst remaining engaged on the modular femoral head.

and/or fresh bulk frozen allograft with a reinforcing acetabular cage (Gap; Smith & Nephew, Memphis, Tennessee) (Fig. 4).

All operations were undertaken by the senior author (THAM) using a posterolateral approach.

Three authors (NLV, RGM, THAM) undertook review of the medical records and assessment of the patients. Clinical and radiological evaluations were performed at six weeks, three months, six months, one year and annually thereafter. Radiographs were assessed for loosening in the three zones as described by DeLee and Charnley[36] by three authors (NLV, RGM, THAM). All patients completed Oxford hip score (OHS) questionnaires[37] at each visit unless they were unable to do so as a result of cognitive impairment. For those who were unable to attend the clinic, telephone interviews were performed in order to ascertain the OHS and whether there had been any problems with the hip that had been dealt with at another hospital.

Statistical analysis. This was performed using Microsoft Excel with Analyse-it software package (Microsoft, Leeds, United Kingdom). Parametric OHS data were compared using the two sample *t*-test. A p-value < 0.05 was considered statistically significant throughout. Survivorship of the hips was studied using the Kaplan-Meier method with calculation of 95% confidence intervals (CI).

Results

The mean follow-up was 42 months (18 to 68). During the study period, five patients died and seven were lost to final follow-up, leaving data on 143 hips in 137 patients available for analysis. Of these, dislocation occurred in three hips (2.1%, three patients) within six weeks of surgery and one of these dislocated again a year later (Fig. 5). In all four instances, the patients made an uncomplicated recovery following successful closed reduction and four weeks of bed rest.

Of the three patients with dislocation, the initial indication for revision was instability in two patients and periprosthetic fracture in the third. Intra-operatively it was noted that all three patients had severely attenuated abductor musculature. In all three hips the polyethylene liner dislocated from the metal shell with the metal head remaining within the liner (Fig. 5). We had no cases of intra-prosthetic dislocation, in which the head separates from the polyethylene liner. With dislocation considered the endpoint for failure, Kaplan-Meier analysis showed the rate of survival at five years was 98.1% (95% CI 93.3 to 100; numbers at risk at 0, 1, 2, 3, 4 and 5 years were 155, 152, 104, 74 and 27, respectively). With a subgroup analysis of the 29 hips revised for instability, and with dislocation (two of 29) being considered the endpoint for failure, Kaplan-Meier analysis showed survival at five years in this subset to be 93.1% (95% CI 78.1 to 100; numbers at risk at 0, 1, 2, 3, 4 and 5 years were 27, 27, 27, 20, 15 and 9, respectively). We had no cases of recurrent dislocation requiring further revision surgery.

Radiological loosening of the allograft cage construct was noted in three of the 33 cemented revisions, although the DM component remained secure. One of these became symptomatic and underwent further revision using another

DM component cemented within a new graft and cage construct. There were no radiological signs of loosening in any of the 122 uncemented components, of which 113 were available at final follow-up. Thus the overall rate of further revision was 0.6% at a mean follow-up of 42 months.

Of the 117 hips in which both components were revised, 109 were available at final follow-up. In this group there were three dislocations and one revision. Of the 38 hips where only the acetabular component was revised, there were 34 hips available at final follow up and there were no revisions or dislocations.

Of the 33 hips in which a cemented acetabular component within a graft and cage construct was used, 30 were available at final follow-up; there was one revision for cage failure and no dislocations. Of the 122 hips in which an uncemented component was used, 113 were available at final follow-up; there were no cases of aseptic loosening, but all three dislocations were in this group.

Four patients had a superficial infection and were successfully managed with lavage, debridement and antibiotics. There was only one hip where an organism was isolated; this patient had a washout and change of modular components (head and liner) followed by antibiotics for six weeks with no further infective episodes at final review two years later.

At five years, with revision for failure of the DM component considered the endpoint, Kaplan-Meier analysis showed the rate of survival as 100%. However, with revision of any component as the endpoint, the rate of survival was 99.4% (95% CI 96.7 to 100). Within the subset of those revised using a cemented component within an allograft and cage construct, and with revision of any component being considered the endpoint, the five-year survivorship was 97.1% (95% CI 80.5 to 100). The mean OHS improved from 46.7 (36 to 58) pre-operatively to 19.2 (16 to 35) at final follow-up (*t*-test, $p < 0.001$).

Discussion

Three hips (2%) dislocated in this study of 155 revision THRs using the Saturne Double-Mobility acetabular component. The results are similar to those reported from centres in France using components of the same or similar design in revision THR (1.1% to 5.6%)[28,29,32,34,35] and compare well with those using conventional or constrained acetabular components, with reported rates of dislocation between 7.4% and 25%.[6,8,17,37,38]

Constrained acetabular components incorporate a locking mechanism into the liner that keeps the femoral head in place.[16,21,39,40,41] At the extremes of movement, forces that would otherwise lead to dislocation are transmitted to the locking mechanism and so distributed to the liner-shell and hence the bone-prosthesis interface. Accordingly there is a risk, with repeated loading, of failure of fixation at the interface, leading to loosening or dissociation of components. This is of particular concern where acetabular defects require cage and allograft reconstruction, with a reported rate of failure of 23% at a mean follow-up of 28 months.[17] Studies of constrained liners have shown variable results. Berend et al[25] in a ten-year follow-up of 755 cases reported an overall incidence of dislocation of 17.5%, rising to 29% in those revised for recurrent instability, and the rate of failure was 42%. In smaller cohorts slightly less dramatic results have been reported with rates as low as 6% and survivorship of 95% at ten years in one series.[39] Early mechanical failure in constrained implants is the most common mode of failure and remains a concern, especially as open reduction is almost always required.[42] As such, Lombardi[42] describes them as ‘a necessary evil’ for use only in situations where all other options are exhausted. Other authors only recommend their use after careful consideration or in low-demand patients.[10]

The use of large femoral heads (> 32 mm) has been shown to improve stability *in vitro*.[19,22-24,43,44] An increase in the size of the femoral head leads to a corresponding increase in the jump distance and hence a reduction in the risk of dislocation.[45] In addition, an increase in the head-to-neck ratio results in a greater range of movement before impingement occurs with its consequent risk of dislocation.[20,23] Despite this theoretical advantage, improved stability has not necessarily manifested *in vivo*. In a series of 331 dislocations in 10 500 hips, Woo and Morrey[3] found no difference in the rate of dislocation between components with head diameters of 22 mm, 28 mm and 32 mm. In contrast, a review of over 21 000 THRs by Berry et al[46] reported a lower cumulative risk of dislocation with heads of 32 mm diameter compared with those of 22 mm diameter, and these results are reflected in most similar studies investigating the stability of large heads in primary THR.[20,45,47] Despite the concerns raised by some authors,[3,24] the published data tend to indicate that larger head sizes are associated with lower dislocation rates in primary THR. However, studies of their use in revision THR remain sparse.[20,23] In addition, dislocation rates of betweeen 17% and 33% have been reported in the presence of attenuated abductor musculature.[23,24] The improvement in stability that a large head confers comes at a cost in terms of increased frictional torque and thus the potential for increased wear and earlier failure. The space within a hip joint is finite and so, with a larger head diameter, placement of a thinner acetabular component becomes necessary. With the advent of highly crossed-linked polyethylene (XLPE), second generation ceramics and improvements in the manufacture of the surface of metal bearings, the concerns about polyethylene thinness have been addressed to some extent.[48] However, despite the better wear properties of XLPE, large heads still produce significant volumetric wear[49] and are thus at risk of early failure.

The double-mobility concept was developed by Gilles Bousquet in the mid-1970s as an uncemented implant for use in primary THR.[27,29] As a primary component in THR, survivorship in a series of 240 hips at 22 years has been reported to be 74%,[50] and at 15 years in a series of 438 implants to be 97.3%.[51]

Table I. Summary of literature on the double-mobility acetabular component

				Revisions for instability		
Authors	Mean follow-up (mths)	Number of hips	Dislocations (n, %)	Total (n)	Redislocation (n, %)	Re-recurrent dislocation (n)
Current series	42	155	3 (1.9)	29	2 (*6.9*)	1
Leiber-Wackenheim et al[35]	96	59	1 (*1.7*)	59	1 (*1.7*)	0
Hamadouche et al[34]	51	51	2 (*3.9*)	51	2 (*3.9*)	2
Massin and Besnier [52]	54	23	2 (*8.7*)	23	2 (*8.7*)	1
Guyen et al[29]	48	54	3 (*5.6*)	54	3 (*5.6*)	1
Philippot et al[32]	60	163	6 (*3.7*)	26	0 (*0*)	0
Langlais et al[28]	36	88	1 (*1.1*)	5	1 (*20.0*)	1
Leclercq et al[31]	40	13	1 (*7.7*)	13	1 (*7.7*)	0
Levine et al[19]	24	31	2 (6.5)	20	1 (*5.0*)	2
Grigoris et al[18]	50	8	0	8	0	0
Total	50.1	645	21 (*3.2*)	288	13 (*4.5*)	8 (*2.78*)

Their use in revision THR has been reported in nine studies, with mean durations of follow-up ranging from 24 to 96 months, in cohorts varying in size from eight to 163, and reported rates of dislocation of between 0% and 9%.[18,19,28,29,31,32,34,35,52] Within those revised for recurrent dislocation, the incidence of subsequent dislocation has been reported to be between 0% and 20%, although the 20% was reported in a subset of only five patients,[28] with the other larger series reporting rates of up to 9% in between eight and 59 patients (Table I). When early dislocation occurred, authors report that successful closed reduction could always be achieved unless the dislocation was intra-prosthetic. However, except for cases attributable to surgeon error with respect to choice or seating of components (such as size mismatching),[51] intra-prosthetic dislocation was a late complication associated with liner wear.

A summary of ten studies (including this present study) involving 645 revision THRs using DM acetabular components reveals a total of 21 dislocations (3.2%) (Table I). Within this amalgamation, 288 of the revisions were undertaken for recurrent dislocation producing 13 dislocations (4.5%), eight of which went on to dislocate recurrently (2.78%).

There is concern that movement of the large polyethylene liner will generate excessive wear.[33] It has been shown that most of the movement with a 22 mm diameter head occurs at the smaller metal head/polyethylene liner articulation as the frictional torque is lower than that at the articulation between the liner and the metal shell.[27,28,30] It is only during extreme movement that the larger articulation moves. Despite Stulberg's assertion on the reduced wear of double mobility sockets,[53] published data on wear properties of DM components is lacking. However, retrieval studies undertaken by Adam, Farizon and Fessy[54] indicate that even when wear on both concave and convex surfaces was taken into consideration, the dual articulation was not associated with increased wear when compared with conventional metal-on-polyethylene bearings.

We acknowledge the limitations of this study due to its retrospective nature and limited follow-up. As such, at this stage we are unable to comment on long term survivorship within our series. Nevertheless our data suggest the double-mobility acetabular component offers a satisfactory mid-term outcome in patients undergoing revision THR. Of the 29 hips revised for instability, further dislocation occurred in only two patients, neither of whom went on to dislocate repeatedly.

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