Original Article

Midterm results of 36 mm metal-on-metal total hip arthroplasty

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Abstract

Background: Despite the many perceived benefits of metal-on-metal (MoM) articulation in total hip arthroplasty (THA), there have been growing concerns about metallosis and adverse reaction to metal debris (ARMD). Analysis of size 36 mm MoM articulation THAs is presented. These patients were evaluated for patient characteristics, relationship between blood metal ions levels and the inclination as well as the version of acetabular component, cumulative survival probability at final followup and functional outcome at final followup.

Materials and Methods: 288, size 36 mm MoM THAs implanted in 269 patients at our institution from 2004 to 2010 were included in this retrospective study. These patients were assessed clinically for hip symptoms, perioperative complications and causes of revision arthroplasty were analysed. Biochemically, blood cobalt and chromium metal ions level were recorded and measurements of acetabular inclination and version were examined. Radiological evaluation utilizing Metal Artefact Reduction Sequence (MARS) MRI was undertaken and implant cumulative survivorship was evaluated.

Results: The mean followup was 5 years (range 2–7 years), mean age was 73 years and the mean Oxford hip score was 36.9 (range 5–48). Revision arthroplasty was executed in 20 (7.4%) patients, of which 15 patients underwent single-stage revision THA. The causes of revision arthroplasty were: ARMD changes in 6 (2.2%) patients, infection in 5 (1.9%) patients and aseptic loosening in 5 (1.9%) patients. Three (1.1%) patients had their hips revised for instability, 1 (0.3%) for raised blood metal ions levels. The implant cumulative survival rate, with revision for any reason, was 68.9% at 7 years.

Conclusions: Although medium-sized MoM THA with a 36 mm head has a marginally better survivorship at midterm followup, compared to larger size head MoM articulating THA, our findings nonetheless are still worryingly poor in comparison to what has been quoted in the literature. Furthermore, ARMD-related revision remains the predominant cause of failure in this cohort with medium-sized MoM articulation. No correlation was found between blood metal ions levels and the inclination as well as the version of acetabular component.

Key words: Hip arthroplasty, implant survivorship, metal-on-metal articulation, revision, 36 mm head

MeSH terms: Arthroplasty, replacemet, hip, hip prosthesis, hip joint

Introduction

Over the last decade, there has been a massive resurgence in metal-on-metal (MoM) total hip arthroplasty (THA), with an estimated 1 million hips implanted worldwide.[1] This is due to perceived benefits which include: Improved arc of motion, decreased risk of dislocation, lower volumetric wear, and durability of bearing surfaces.[2] However, towards the latter end of the decade, problems have emerged relating to unacceptably high revision rates of large head MoM conventional THRs within 10 years of implantation. This has been evidenced by data from multiple national level hip registry databases.[3-5] The issues pertaining to these poor outcomes include local tissue changes such as acute lymphocytic vasculitis associated lesion, pseudotumor, and metallosis related to implanted

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MoM THA.[6-8] Because of these alarming concerns, the iterations of these MoM bearing surfaces lost favor and were replaced by alternative bearing such as metal-on-ultrahigh molecular weight polyethylene and ceramic on ceramic (CoC) implants.[4]

On the other hand, there are studies suggesting that small size 28 mm MoM articulation THA and large head resurfacing arthroplasty have better outcomes in the midterm in comparison to more conventional larger head MoM THA articulation.[9,10] The Canadian arthroplasty society experience has shown a favorable 5-year survivorship using resurfacing arthroplasty with head sizes of >50 mm in the adult male population.[9] There is still, however, a paucity of information in the literature with respect to outcomes of using an intermediate head size of 36 mm MoM articulation. The determinant of metal debris in large MoM THA is considered due to *trunnionosis* while in small head sizes are related to the type of articular lubrication. It's unclear as to what the mechanism of metal ion debris is in intermediate size articulation, namely 36 mm head. Furthermore, the clinical impact of this is not well understood. We feel that it is important to address this specifically in terms of clinical outcomes such as patient reported outcome measures (PROMS) and implant longevity.

Our study aims therefore to: (1) Assess demographics of patients who underwent size 36 mm articulation MoM THA; (2) examine the relationship between blood metal ions levels and the inclination as well as version of the acetabular component; (3) determine the cumulative survival probability at final clinic followup; and (4) evaluate the functional outcome of these patients at final followup.

Materials and Methods

Data were collected retrospectively, in collaboration with research specialist nurses, from our institutional MoM hip arthroplasty database. This database was initiated following the introduction of the Medicines and Healthcare Products Regulatory Agency (MHRA) guidelines.[11] We included all patients with size 36 mm uncemented MoM Pinnacle Shell and Corail Stem THA (Ultamet; DePuy, Leeds, UK) implanted between October 2004 and November 2010 at our institution. Our exclusion criteria included; hip resurfacing arthroplasty, THAs performed for fracture or metastatic disease, revision procedures, THA with bearing surfaces other than MoM, articulation sizes other than 36 mm and patients with <2-year followup.

The primary end point was implant cumulative survivorship. Functional outcomes were measured using the Oxford hip score (OHS). Patients were evaluated for hip symptoms, perioperative complications and causes of revision arthroplasty were analyzed. Blood cobalt and chromium metal ions level were recorded and measurements of acetabular inclination and version were examined. Standardized anteroposterior and cross table lateral (LAT) radiographs of postoperative patients were obtained and digitally recorded on picture archiving and communication system (PACS)(AGFA Health Care, Belgium) PACS software was used to analyze the images and to measure the abduction angle and the version of the acetabular component.

Also, we undertook data collection on metal artefact reduction sequence magnetic resonance imaging (MARS MRI) using MAR sequences with a 1.5T MR scanner (Siemens Symphony; Siemens, Erlangen, Germany) on the cohort of symptomatic patients and in those with elevated metal ion levels. At our institution, followup of these patients was in accordance with the (MHRA) guidelines which recommend that all symptomatic patients with a MoM joint should undergo analysis of blood metal ions and cross-sectional imaging utilizing MARS MRI. The protocol included: Annual followup for the life of the implant, patients are to be investigated at each outpatient followup with clinical and radiographic assessment as well as blood test to measure metal ions. Those patients with blood metal ion levels >7 ppb, which equals to 119 nmol/L cobalt or 134.5 nmol/L chromium, would require a repeat check of metal ion levels at 3 months. Patients who were symptomatic at index followup or those who had raised metal ions levels >7 ppm at consecutive followup (3 months apart) were subjected to MRI scan of the hip and pelvis using MARS protocol. Clinical judgment with respect to revision arthroplasty was considered in the light of the combination of abnormal imaging and biochemical parameters.

Patients who underwent revision arthroplasty had their metal ion levels repeated at 3 months. This is to ensure blood cobalt and chromium levels were improving, as persistent high levels are associated with cardiotoxicity and sudden death.[12]

Those patients who underwent revision arthroplasty, from MoM to metal-on-polyethylene (MoP) articulation, were followed up at 6 weeks, 3 months, 1-year, then 5 years and 10 years. Patients with normalized blood metal ion levels and more than 80 years of age were discharged from followup clinic.

Statistical analysis

Statistical analysis was carried out using the Statistical Package for Social Sciences (SPSS) PASW statistics version 18.0 (SPSS Inc., Chicago, Illinois, USA). Parametric tests were used for normal data and nonparameteric tests for nonnormally distributed data, and significance was set at $P \leq 0.05$. The Kaplan–Meier predicted survival method was used to generate survival curves with 95% confidence intervals (CIs) and to determine predicted cumulative survival at 7 years.

Results

Cases were identified from an original cohort of 480 patients who underwent MoM articulation THR. Of those, 360 hips were size 36 mm MoM THA. Seventy two patients were excluded due to missing data and loss to followup, leaving a final cohort of 288 hips in 269 patients. The mean age in the study is 73 years (range 37–92 years) and female gender was more prevalent than male patients (141 vs. 128) [Table 1].

Patients underwent blood metal ions analysis as per MHRA national guidelines. Blood metal ion levels were elevated >7 ppb in 18 (6%) patients, 83% of those were cobalt ions only. However, cobalt levels improved to acceptable threshold in 6/18 (33%) patients and in 8/18 (44%) patients. Cobalt ion levels improved at a mean of (4.5 standard deviation 1.7) year. The mean acetabular component abduction angle was 45° (range 32–66°) and mean version was 7.4° (range −15–40°). No correlation was observed between blood metal ions levels and acetabular cup inclination ($P < 0.074$), cup version ($P < 0.057$) or patients' hip symptoms ($P < 0.405$). However, statistically significant correlation was noted between acetabular cup inclination and patients' symptoms ($P < 0.017$) for those patients with high abduction angles >45°.

Revision hip arthroplasty was undertaken in a total of 20 hips (7.4%) [Table 2]. The most common cause of failure was revision for adverse reaction to metal debris (ARMD) (2.2%), of which two-thirds were symptomatic, followed by aseptic loosening of arthroplasty components (1.9%) and infection (1.9%). Four patients experienced a combination of symptomatic hips with elevated metal ions and pseudotumors. One patient had revision arthroplasty for elevated blood metal ions; we also noted an intraoperative metallosis. MARS MRI findings for this patient were negative but clinically reported trochanteric pain and clicking hip motion. Dislocation was found to be a cause of implant failure in 3 (1.1%) patients, one with irreducible dislocated THA and the other patient who experienced recurrent dislocation. One of these patients had an intraoperative finding of metallosis at the time of revision surgery. Pseudotumor formation had equal distribution in both gender groups (1.1% each group). However, male patients had a higher rate of aseptic loosening (1.1% vs. 0.7%), infection (1.1% vs. 0.7%), instability (1.1% vs. 0%), and metallosis (0.7% vs. 0%). The statistical significance of these findings could not be calculated owing to small observed revision numbers [Table 3].

Table 1: Demographic profile of the study group

Characteristics	Number
Metal on metal (including resurfacing arthroplasty)	480
Metal on metal 36 mm THA	360
Metal on metal 36 mm THA completed data	288
Patients completed data	269
Male gender (%)	128 (44)
Female gender (%)	141 (56)
Mean age years (range)	73 (37-92)
Mean followup years (range)	5 (2-7)

THA=Total hip arthroplasty

Table 2: Mode of failure along with gender distribution

Reasons for revision	Total hips *n* (%)	Hips in male patients	Hips in female patients
Aseptic loosening	5 (25)	3	2
Infection	5 (25)	3	2
ARMD	6 (30)	3	3
Raised blood metal ions levels	1 (5)	1	0
Dislocation	3 (15)	3	0
Total revision	20	13	7

ARMD=Adverse reaction to metal debris

Patients underwent single-stage revision arthroplasty for aseptic loosening, ARMD changes and instability. The acetabular shell was revised as indicated to uncemented component with the exchange of bearing surfaces to either hard on hard like CoC or hard on soft bearings such as MoP or ceramic on polyethylene. Ceramic bearings were favored in patients younger than 65 years of age. The femoral stem was revised in cases of aseptic loosening and in patients with ARMD changes that impacted on stem fixation after resection of these abnormal tissues. Loose femoral stems components were explanted and revised for either uncemented or cemented femoral components. Uncemented stems were implanted in younger patients and those with Dorr A and B type femur. However, well-implanted and well fixed femoral stems with no taper changes were retained. Five patients underwent revision for infection using a two stage procedure. The first stage procedure included explantation of the components (removal of acetabular and femoral components) with thorough debridement. Multiple samples were obtained for microbiological analysis followed by placement of an antibiotic loaded cement spacer followed by subsequent targeted antibiotics therapy for 6 weeks. Once infection was deemed to be eradicated, the second stage procedure involving removal of the cement spacer and implantation

Table 3: Analysis of patients who underwent revision THA

Patients	Gender	Indications for revision	Single stage/ two-stage	Revision of acetabular cup	Revision of bearing	Revision of femoral stem
Case 1	Male	Aseptic loosening	Single stage	Yes (uncemented cup)	MoP†	No
Case 2	Male	Aseptic loosening	Single stage	No (well fixed)	CoC	Yes (revised to cemented stem)
Case 3	Male	Aseptic loosening	Single stage	No (liner exchange UHMWPE)	MoP† UHMWPE	Yes (revision to cemented stem)
Case 4	Female	Aseptic loosening	Single stage	No (liner exchange UHMWPE)	MoP† UHMWPE	Yes (revised to cemented stem)
Case 5	Female	Aseptic loosening	Single stage	No (liner exchange UHMWPE)	Ceramic on UHMWPE	Yes (revised to cemented stem)
Case 6	Male	Infection*	Two-stage	Second stage Yes (uncemented cup)	MoP†	Yes (uncemented stem)
Case 7	Male	Infection*	Two-stage	Second stage Yes (uncemented cup)	MoP†	Yes (cemented stem)
Case 8	Male	Infection*	Two-stage	Second stage Yes (uncemented cup)	MoP†	Yes (uncemented stem)
Case 9	Female	Infection*	Two-stage	Second stage Yes (uncemented cup, constrained liner)	MoP†	Yes (cemented stem)
Case 10	Female	Infection*	Two-stage	Second stage Yes (uncemented cup)	MoP†	Yes (cemented stem)
Case 11	Male	ARMD	Single stage	Yes (uncemented cup, lipped polyethylene liner)	MoP†	Yes (soft tissue changes, uncemented stem)
Case 12	Male	ARMD	Single stage	Yes (uncemented cup)	CoC	Yes (soft tissue changes, uncemented stem)
Case 13	Male	ARMD	Single stage	No (liner exchange to constrained UHMWPE)	Ceramic on UHMWPE	Yes (uncemented stem, granulomatous tissue resected from trochanter and bone allograft secured)
Case 14	Female	ARMD	Single stage	No (liner exchange to polyethylene constrained liner)	MoP†	No (well-fixed, taper not worn. Anterolateral greater trochanter bone defect treated with allograft)
Case 15	Female	ARMD	Single stage	No (exchange of liner to UHMWPE)	Ceramic on UHMWPE liner	No
Case 16	Female	ARMD	Single stage	No (exchange of liner to UHMWPE)	Ceramic on UHMWPE liner	Yes (extended trochanteric osteotomy, uncemented revision stem)
Case 17	Male	Raised blood metal ions level	Single stage	Yes (revision to trabecular metal cup uncemented)	MoP†	No (stem well-fixed and grossly intact taper, capsular tissue metallosis observed intraoperatively)
Case 18	Male	Instability	Single stage	Yes (uncemented cup and constrained polyethylene)	Ceramic on polyethylene	No
Case 19	Male	Instability	Single stage	Yes (uncemented cup and lipped polyethylene	MoP†	No
Case 20	Male	Instability	Single stage	Yes (uncemented cup and constrained polyethylene)	Ceramic on polyethylene	No (intraoperative tissue metallosis observed)

†MoP=Metal-on-polyethylene, THA=Total hip arthroplasty, ARMD=Adverse reaction to metal debris, CoC=Ceramic on ceramic

of uncemented acetabular shell and either a cemented or an uncemented femoral stem, depending on femoral canal type, and a MoP bearing THA was undertaken.

Using revision for all causes of failure as the endpoint, Kaplan–Meier survival analysis showed a cumulative implant survival of 68.9% at 7 years (95% CI 66 – 70)) [Figure 1].

The functional outcome for these patients was assessed using OHS. The assessment scores were those at the latest followup or last assessment prior to revision. The mean OHS in all patients was 36.9 (range 7–48) after the primary procedure. The mean male OHS is 38.94 and mean female OHS was 35.59. The mean OHS in 20 patients who underwent revision surgery was 32.21 while those that were not revised at final followup was had a mean OHS of 36.93. Subgroup analysis of revision cohort due to ARMD related pathology had even lower mean OHS at 28. In revision patients without MRI-based evidence of an ARMD, the mean OHS was 23 and in those with MARS MRI based evidence of ARMD it was 19. Fifteen patients had an OHS at last followup 20 or less, and 16 of these patients had MRI based evidence of an ARMS.

Discussion

In this study we used size 36 mm MoM THA, no correlations were observed between blood metal ions levels and acetabular cup inclination ($P < 0.074$) or cup version

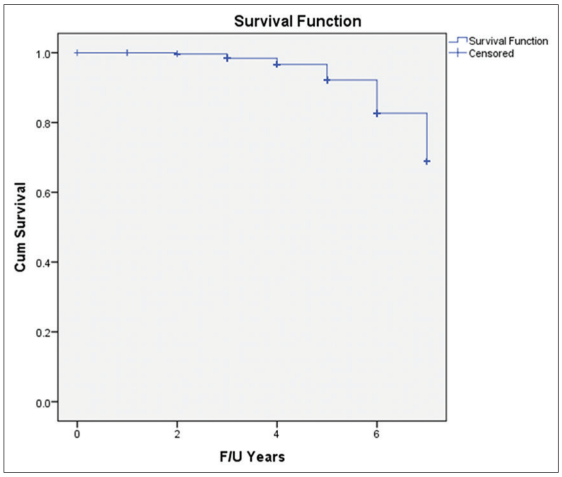

Figure 1: Kaplan–Meier 7-year survival curve showing implant survival of size 36 mm head metal-on-metal articulation total hip arthroplasty

($P < 0.057$) and the cumulative implant survivorship of 68.9% at 7 years was observed with moderate to good OHS with a mean of 36.9. The mean OHS at last assessment before revision arthroplasty was 32.21.

Our mean age in the study was 73 years and a prevalent female gender for 36 mm MoM THR. However, analysis of National Joint Registry (NJR) of England and Wales and Swedish hip registries showed patient characteristics with an average age of 68.7 and 68.4 years, respectively and a predominance of female patients (60% and 58.4%).[4,5] Our mean sample age was slightly higher and this is believed to be related to a single cohort study while the NJR of England and Wales and national Swedish registries reflects analysis of several cohort samples at a national level. Our results, however, are in agreement with a relative predominance of female gender patient.

Acetabular cup inclination and cup version were not statistically significant factors in determining blood metal ion levels in our cohort of patients. However, studies have shown a strong relationship between increased abduction angle of acetabular component and associated greater risk of high concentrations of serum metal ions in MoM hip resurfacing arthroplasty.[13-15] Similar findings were described in MoM hip resurfacing patients with insufficient acetabular cup version, however, the effect of changes in version angle was less prominent than those for inclination angle on whole blood metal ion levels.[16] In the context of large MoM THA, cobalt and chromium levels in whole blood significantly correlated with increased acetabular component inclination angle over 50° and pain scores, albeit no direct correlation was established with acetabular socket version angle or femoral head diameter.[17]

It was difficult to assess combined anteversion based on the regular radiograph. Unfortunately, our followup protocol did not include this parameter. We have addressed the issue of mal alignment and correlation to metal debris by undertaking repeat radiographs measurement on our cohort of a patient of cup inclination angle and its correlation to blood metal ion levels. Furthermore, detailed information like combined version on a standardized X-rays of the pelvis and lateral view of the hip was open to significant measurement error and interobserver variability.[18]

Survivorship at 7 years with revision for any cause was 68.9% [Figure 1]. The total incidence of revision for all reasons was 7.4%. The predominant cause of revision in our cohort was ARMD-related pathology (30%) followed by aseptic loosening (25%). Langton *et al*. series of large head MoM THAs, Kaplan–Meier analysis showed an implant survival of 51.2% at 6 years for the ASR THR cohort as a whole.[19] In their series, however, the minimum femoral component heads size was 40 mm increasing up to 60 mm. The authors implicated trunnionosis as a major determinant of such ARMD related failures. The comparatively higher survivorship in our cohort may be attributable to the smaller head size of 36 mm. Recent analysis of NJR of England and Wales showed implant failure was related to head size, with larger heads MoM articulation failing earlier with a cumulative incidence of revision of 3.2% for size 28 mm and 5.1% for size 52 mm head at 5 years in men aged 60 years. The 5-year revision rates in younger women were 6.1% for 46 mm MoM compared with 1.6% for 28 mm MoP.[20] Similar finding were reported by the Australian Orthopaedic Association National Joint Replacement Registry where larger MoM femoral heads were associated with more than 2 times the rate of revision as that associated with smaller MoM femoral heads (a revision rate of 4.5% for MoM femoral head sizes of <32 mm, and a revision rate of 9.4% for MoM femoral head sizes of >32 mm).[3] Our revision rates are comparable to those reported in national registries and this reflects the normal distribution population of data in MoM THAs. The alarming revision rates for MoM THA reported in these NJRs and major concerns regarding the local and systemic complications related to the effects of metal ions debris, the MoM THA has become an undesirable bearing option. With this in mind, the trends for implanting MoM THA constructs in the United States has also witnessed a significant drop since 2007 and gradually replaced by more favorable ceramic on highly cross-linked polyethylene.[21]

We found a somewhat higher rate of infection (1.9%) in our study, although the gender difference was not big and was not possible to perform statistical analysis owing to the low number of events. It is an important question as to whether the local metal debris might be a responsible factor. In this context, it has been reported that metal ions may predispose to infection.[22] Furthermore, there is evidence to suggest that cobalt can impair bacterial phagocytosis.[23] Finally, registry reports have mentioned higher infection rates with MoM THA.[4,5]

It is difficult to establish why certain hips failed due to ARMD changes and others had more obvious reason for revision like aseptic loosening, instability and infection. It has been proposed that a delayed hypersensitivity type reaction can be associated with MoM articulation THA. This triggers the immune system by forming metal ion-protein complex that elicit hypersensitivity responses and subsequent local tissue destruction and ARMD changes.[24,25]

ARMD changes associated with large head MoM implants have been reported in the literature in between 0.5 – 7% at 5 years after surgery.[26-28] The prevalence of pseudotumors around these implants has been estimated to be between 0.3% and 4.0% (mean followup 8 years).[29,30] The Australian Registry estimated the cumulative incidence of revision for metal sensitivity at 9 years to be 1.6% for femoral head sizes >32 mm and 0.1% for femoral head sizes ≤32 mm. In our MoM cohort, ARMD-related tissue changes were seen intraoperatively in six patients and represented 30% of revision cases where pseudotumor formation were identified.[3]

PROMs were reported in this study and OHS provides a better reflection and appreciation of hip functionalities rather than hip arc of movement measurements. Beside the fact that OHS is a validated hip scoring instrument.[31] Although routine preoperative hip arthroplasty recording of PROMS were not performed for our cohort of patients, the overall postoperative mean OHS at final followup was 36.9. In comparison, the mean OHS in patients who underwent revision surgery was expectedly lower at 32.21. In fact, patients who had ARMD related revisions alone had even lower OHS at 28. Our findings are somewhat comparable to the findings of Hosny *et al.*,[32] (2013) who in their retrospective series of large head MoM THAs, showed a mean OHS of those revised for ARMD at final followup to be 23.3. In comparison, OHS for alternative hard bearing surfaces such as CoC has shown much more favorable OHS of 44 at similar midterm followup.[33] Data from the most recent NJR report show a median OHS for MoM THAs following cemented and uncemented procedures to be 41 and 43, respectively. It is, however, difficult to compare these findings to our cohort as the followup periods for these hip scores are 6 months after surgery.[4] Although we recognize that the determinants of functional outcome as measured using OHS are multifactorial including surgeons, implant and patient-related factors, it may be possible that ARMD-related changes may affect musculoskeletal function in both symptomatic and asymptomatic patients with MoM THA consequently translating to poorer functional outcomes reflecting lower OHS.

There are several limitations of the study. Data were collected retrospectively for this study; however, the mechanisms for data collection was robust including institutional personnel trained in data collection. Although we identified large sample size, a proportion of our patients were excluded due to erroneous and missing data. Strict adherence of the MHRA guidelines in terms of assessment of these patients facilitated interpretation of radiographic findings of patients' acetabular components inclination and version angles. However, accurate combined version measurements were precluded because CT scan assessment was not a routine follow up test. Furthermore, we were able to define patient reported outcomes extensively for this group of patients. Finally, it would perhaps have been useful to compare our data with other cohort of varying MoM head sizes.

Conclusion

Our study demonstrates that although intermediate size MoM THA of 36 mm constructs have a marginally better survivorship at midterm followup compared to larger size head MoM articulating THA, the findings nonetheless are still worryingly poor in comparisons to what have been quoted in the literature. Furthermore, ARMD related revision remains the predominant cause of failure in this cohort with intermediate size MoM articulation. Acetabular cup inclination and cup version were not statistically significant factors in determining blood metal ion levels in our cohort of patients of MoM THA.

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Conflicts of interest
There are no conflicts of interest.

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