Long-term outcomes of patients undergoing uncemented or cemented arthroplasty revision following metal-on-metal total hip arthroplasty failure: A retrospective observational study with a mean follow-up of 7 years

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Abstract

Background

A high rate of complications due to metal-on-metal (MoM) revisions has been relatively commonly documented. The purpose of this retrospective study was to compare the long-term outcomes of patients who had undergone uncemented or cemented total hip arthroplasty (THA) revision for prior primary MoM THA failure.

Methods

Data from 234 patients (234 hips) who underwent uncemented or cemented THA (UTHA or CTHA) for prior primary MoM THA failure during 2007 - 2018 were retrospectively analysed. Follow-up occurred 3 months, 6 months, 1 year, 2 years, and then every 1 year after conversion. The mean follow-up time was 84.15 months (range, 67 - 101 months). The primary endpoint was the modified Harris Hip Score (HHS). The secondary endpoint was the major orthopaedic complication rate.

Results

The HHS demonstrated statistically greater differences in the CTHA group than in the UTHA group 12 months after conversion. From the 12th month after conversion to the final follow-up, CTHA yielded better functional outcomes than UTHA. There were significant differences in the rates of re-revision, aseptic loosening, and periprosthetic fracture between the groups (10.3% for UTHA vs 2.5% for CTHA, $p = 0.015$; 16.3% for UTHA vs 5.9% for CTHA, $p = 0.011$; and 12.0% for UTHA vs 4.2% for CTHA, $p = 0.045$, respectively).

Conclusion

In the setting of revision for primary MoM THA failure, we found definite evidence of the superiority of CTHA over UTHA in terms of improving functional outcomes and decreasing the major orthopaedic complication rate.

Background

Bearing surfaces provided by metal-on-metal total hip arthroplasty (MoM THA) became increasingly prevalent, particularly in the context of an ageing population, in earlier decades[1, 2]. In recent years, however, the use of MoM THA has sharply declined due to the reported low 10-year survivorship and high failure rates that are associated with a host of issues (i.e., adverse reactions to metal debris [ARMDs], aseptic loosening, and infection)[3, 4]. Failure after MoM THA is well recognised, is due to various reasons, and frequently requires revision intervention[5]. Among predominantly active individuals, failure that occurs secondary to MoM wear tends to be a concern[6]. Although MoM bearings have fallen out of favour as a result, orthopaedists continue to struggle with this issue of revision burden[7]. Poor bone stock may be attributed to the substantial bone and soft tissue destruction caused by ARMD that is

powerfully implicated in the pathophysiology of MoM THA failure, contributing to the substantially high revision rate as well as the rapid time-to-failure[8].

This escalated MoM THA-related failure rate may also contribute to the increase in the use of UTHA or CTHA[8, 9]. A limited number of studies have assessed complications due to the conversion of MoM THA to the use of uncemented or cemented femoral components (UTHA or CTHA)[3]. Interest in CTHA has increased over the last decade, with several studies showing higher HHSs with fewer orthopaedic complications for CTHA than for UTHA, while others have demonstrated no significant differences between the two[5]. Furthermore, there remain concerns that longer-term outcomes of UTHA may not be as robust as those of CTHA regarding reduced revision rates[8, 10]. Additionally, the highly selected features of the studied patient data are common in the published literature[11, 12]. Consequently, the findings in those studies could not be referred to as valid.

To date, no definitive consensus exists on the long-term outcomes of conversion from primary MoM THA revision to UTHA or CTHA due to any cause[11]. Furthermore, given the lack of literature and in order to gain a better understanding of these types of conversion, we performed a retrospective study to assess the long-term outcomes of conversion from primary MoM THA to UTHA or CTHA.

Methods

Study population

A retrospective study was performed with an initial study cohort that included 326 patients (326 hips) identified from our joint registration database who underwent UTHA or CTHA revision due to prior primary MoM THA failure from March 2005 to January 2018. The main reasons for revision included ARMD, aseptic loosening, infection, dislocation, and fracture. The inclusion criteria for the study included patients who underwent a conversion procedure from primary MoM THA (Zimmer Biomet, Warsaw, IN) to UTHA or CTHA (femoral component: Stryker Orthopaedics, Mahwah, SM, USA; acetabular component: standard-device, Stryker, Mahwah, New Jersey); all conversion procedures were performed by three experienced orthopaedists (WY, XZ, MZ) via a direct anterior approach, as reported[13]. The main exclusion criteria included patients without an MoM-bearing surface at the time of conversion; patients with inadequate clinical data, active infection, dyskinesia, or bone-related diseases; patients unable to follow instructions; and patients with malignant tumours, injury severity scores (ISSs) ≥ 10 , brain dysfunction due to any cause within 6 months, pulmonary complications (i.e., reintubation), cardiovascular complications (i.e., cardiac arrest, myocardial infarction), renal complications (i.e., insufficiency or failure), vascular cognitive impairment, a history of alcohol and/or drug abuse, a body mass index (BMI) $> 40 \text{ kg/m}^2$, and an American Society of Anesthesiologists (ASA) score of IV or V.

A standard protocol was utilised to obtain clinical and radiographic data. Follow-up occurred 3 months, 6 months, 1 year, 2 years, and then every 1 year after conversion. The primary endpoint was the modified Harris Hip Score (HHS), which has scores ranging from 0 to 100 points, with higher scores representing

better function. The secondary endpoints were the major orthopaedic complication rates. All the patients included underwent conversion to UTHA or CTHA at our medical centre and were assessed individually with the modified HHS at each follow-up. Image data were acquired at these same time points: anteroposterior (AP) radiographs of the pelvis and AP and lateral radiographs of the hip as well as computed tomography (CT) or magnetic resonance imaging (MRI) if necessary. The occurrence of major orthopaedic complications was recorded for each patient during the follow-up.

Based on our criteria, a total of 234 individuals (234 hips) undergoing conversion from primary MoM THA to UTHA or CTHA were identified for the final analysis in the study (UTHA: $n = 116$, mean age, 67.34 ± 6.25 years; CTHA: $n = 118$, mean age, 67.45 ± 6.21 years). The mean time to failure after primary MoM THA was 4.3 years (range, 1.2 - 6.5 years) for UTHA and 4.4 years (range, 1.1 - 6.4 years) for CTHA. At the time of analysis, the mean follow-up time from conversion was 84.12 months (range, 67 - 100 months) for UTHA and 84.23 months (range, 66 - 101 months) for CTHA. A study flow chart is presented in Figure 1, and the baseline data are shown in Table 1.

Statistical analysis

Between-group differences in terms of the baseline data and the main follow-up data were compared. Follow-up was calculated in days from the date of revision/conversion to the date of death or final follow-up, whichever occurred first. Revision was defined as the complete removal of the endoprosthesis. Re-revision was defined as the removal or exchange of any component. Prosthesis loosening and endoprosthesis failure were judged based on prior descriptions[8]. Heterotopic ossification was judged using the Brooker classification system[14]. Continuous data are presented as the means and standard deviations. T-tests were utilised to assess between-group differences if the data were consistent with assumptions regarding the normal distribution and homogeneity of variance. If not, Wilcoxon rank-sum tests were utilised. Categorical data are presented as frequencies and percentages and were compared between groups using Chi-squared tests or Fisher's exact tests, as appropriate. All statistical analyses were performed using SPSS, version 24.0 (IBM, Armonk, NY). A 2-sided p value less than 0.05 was considered significant.

Results

Primary endpoint

The mean HHSs after conversion are shown in Table 2. The mean HHSs in the UTHA and CTHA groups were 79.14 (± 8.12) and 79.28 (± 7.66) 3 months after conversion, 86.65 (± 6.62) and 87.76 (± 7.44) 6 months after conversion, 88.17 (± 7.72) and 91.43 (± 8.52) 12 months after conversion, and 79.18 (± 11.12) and 84.32 (± 10.35) at the final follow-up, respectively. The HHSs demonstrated statistically greater differences in the CTHA group than in the UTHA group 12 months after conversion ($p = 0.031$). From the 12th month after conversion to the final follow-up, CTHA yielded better functional outcomes than UTHA (all $p < 0.05$). Almost 76% of the patients who experienced MoM THA failure and underwent

conversion to UTHA or CTHA had acceptable HHSs at the final follow-up. Differences in HHSs were not significant between the groups 3 months or 6 months after conversion.

Secondary endpoint

There were 83 major orthopaedic complications in 116 UTHA patients versus 47 in 118 CTHA patients. Of the 83 UTHA-related orthopaedic complications, 12 (10.3%) involved re-revision, 19 (16.3%) were associated with aseptic loosening, 14 (12.0%) involved periprosthetic fractures, and 6 (5.1%) involved unbearable hip pain. Of the 47 CTHA-related orthopaedic complications, 3 (2.5%) involved re-revision, 7 (5.9%) were associated with aseptic loosening, 5 (4.2%) involved periprosthetic fractures, and 8 (6.7%) involved intolerable hip pain (Table 3). The between-group difference in the re-revision rate was significant at the last follow-up (10.3% for UTHA vs 2.5% for CTHA, $p = 0.015$). Almost 82.1% of the cases of re-revision for UTHAs were attributed to aseptic loosening compared to 73.5% of the cases of re-revisions for CTHAs ($p = 0.034$).

Discussion

The current findings provide evidence that the revision of primary MoM THA failure using CTHA results in superior long-term clinical outcomes compared with the use of UTHA. To our knowledge, this is the largest study regarding outcomes due to conversion after MoM THA failure.

Complications of MoM THA related to ARMD can result in significant bone and soft tissue destruction as well as increased metal ion levels, especially cobalt and chromium, potentially increasing the risk of implant failure and posing a challenge for future revision[8, 5]. Metal ions can inhibit osteoblast gene expression, and they have a negative impact on osteoblast cell number and activity[3, 7, 15]. Hence, this could ultimately result in bone ingrowth failure in the uncemented components utilised during the conversion to UTHA after MoM THA failure[15]. The results of MoM THA revision have revealed high rates of orthopaedic complications due to aseptic loosening, deep infection, and dislocation[3]. In the 2018 National Joint Registry Annual Report, the 14-year cumulative probability of revision was 22.2% for uncemented stemmed MoM THA[16]. Additionally, in the 2018 Australian Orthopaedic Association's Annual Report, the 15-year cumulative probability of revision was 29.6%[16]. Whether increases in hip stability exist following MoM THA revision has become one of the key indicators[8, 17, 18]. Hip stability following conversion to CTHA is superior to that following conversion to UTHA owing to the instability of the bone and uncemented components[8]. There is often macroscopic damage or bone defects at the time of UTHA re-revision[15]. The cause of bone defects has been shown to be associated with malposition and a design that is too shallow for the acetabular component, resulting in atypically elevated wear triggered by edge loading[19, 1]. A prior study showed a high rate of aseptic loosening of the femur component after UTHA re-revision due to MoM THA failure[5]. Failure due to aseptic loosening occurs more frequently with UTHA re-revision than with CTHA re-revision[20]. The most appropriate re-revision intervention to decrease the high rate of aseptic loosening tends to be a matter of ongoing

debate[8]. Perhaps there is an effective solution when both the femoral and acetabular components are well ingrown.

While there have been continued advancements in prosthetic materials, the risks associated with conversion from MoM THA to UTHA or CTHA remain a substantial concern[15, 8, 3]. However, the obtainable literature on the outcomes of this type of conversion is lacking and contradictory[21, 4, 22]. A growing but still extremely limited body of literature has described the role of UTHA or CTHA revision in the setting of prior MoM THA failure and has demonstrated significant differences in clinical outcomes, although all the studies are limited by small sample sizes and/or short-term follow-up periods[3, 13, 8]. Undeniably, invasive revision procedures are associated with a high rate of orthopaedic complications[8]. However, we failed to detect noteworthy distinctions regarding the rates of major orthopaedic complications 12 months after conversion. Concerns have existed regarding whether these two types of conversion have substantial differences in long-term outcomes, including orthopaedic complication rates[8, 18, 3]. In 2002, Sierra et al.[23] identified 132 cases of conversion from MoM arthroplasties to UTHA and reported a high rate of major orthopaedic complications (45%), including a 13% aseptic loosening rate and a 9% dislocation rate, which were all higher than the rates found in this current study. In 2009, Eswaramoorthy et al.[24] reported on 76 patients who underwent conversion from MoM arthroplasties to UTHA. Similar to the findings observed in the current study of failed MoM THA treatment, both aseptic loosening and periprosthetic fracture were the primary orthopaedic complications due to conversion. They also described a high rate of major orthopaedic complications (24%), mainly attributable to a high rate of aseptic loosening (20%). Then, Taheriazam et al.[25] assessed outcomes in 138 patients who were treated via conversion from MoM THA to CTHA and showed a major orthopaedic complication rate of 16% at the 2-year follow-up, including a 16% aseptic loosening rate. Based on a similar premise, Stryker et al.[26] reported on 114 cases of conversion from MoM THA to CTHA and showed a major orthopaedic complication rate of 18%, with a re-revision rate of 7%, primarily attributable to aseptic loosening (14%) and deep infection (6%).

Femoral aseptic loosening, especially in young, active patients, was a common factor for re-revision after conversion in the current study, which was also found by others assessing UTHA or CTHA revisions. CTHA has been developed in an effort to improve the fusion of cement and bone tissue and has become conventional for MoM THA revision failure[3, 13]. Short-term or midterm results of CTHA conversion following MoM THA failure have revealed extremely low rates of major orthopaedic complications, especially aseptic loosening[20, 5]. Rahman et al.[5] reported on 20 patients who experienced MoM THA failure and who underwent conversion using CTHA; few patients were found to have aseptic loosening.

This current analysis also reveals that the reason for conversion has a prevailing impact on the outcomes of conversion. With modern THA and surgical techniques, conversion due to an indication of MoM wear has low rates of re-revision, regardless of the use of UTHA or CTHA for conversion, whereas conversion due to conventional periprosthetic fracture tends to be associated with a higher rate of re-revision. It is imperative that these facts are understood by orthopaedists and patients prior to conversion.

It should be acknowledged that there are limitations in this study. First, selection bias appears to be unavoidable due to the exclusion of a number of patients. Second, this retrospective observational study was susceptible to errors in recording differences in comorbidities and orthopaedic complications, which may have created unaccounted confounding variables and may have resulted in a diminished power to draw convincing conclusions. Attempts were made to allow for more than a few confounding variables; nevertheless, we believe that this analysis is inadequate. Third, we failed to include data on metal ion concentrations as well as information about high- and low-volume orthopaedists. Despite these limitations, we believe that the margin of error is tolerable in the current setting because of the relatively large sample size.

Conclusions

The long-term results reported in this study support a growing body of evidence that conversion to CTHA due to primary MoM THA failure is associated with more significant improvements in modified HHSs as well as lower major orthopaedic complication rates than conversion to UTHA.

Abbreviations

UTHA: uncemented total hip arthroplasty; CTHA: cemented total hip arthroplasty; MoM THA: metal-on-metal total hip arthroplasty; ARMD: adverse reaction to metal debris; BMD: bone mineral density; ISS: injury severity score; BMI: body mass index; ASA: American Society of Anesthesiologists; HHS: Harris hip score; AP: antero-posterior; CT: computed tomography; MRI: magnetic resonance imaging; SD: Standard deviation.

Declarations

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Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author upon reasonable request.

Authors' contributions

WC performed the data collection and analysis and participated in manuscript writing. SM, JL, and BC performed the database setup and statistical analysis. MZ, XZ, WY, and GH performed the operations. MZ and XZ participated in the study design and coordination and helped to draft the manuscript. All authors have read and approved the final manuscript.

Ethics approval and consent to participate

This study was approved by the Medical Ethics Committee (The First Affiliated Hospital, Sun Yat-sen University), and an exemption from informed consent was obtained from our responsible Investigational Ethics Review Board.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Tables

Table 1 Patient demographics and outcomes

Variable	UTHA ^a (n=116)	CTHA ^b (n=118)	<i>p</i> -value
Sex, M/F	52/64	53/65	0.409 ^c
Age, years	67.34±6.25	67.45±6.21	0.142 ^d
BMI, kg/m ²	28.23±7.32	28.15±7.22	0.261 ^d
BMD	-3.47±0.26	-3.48±0.42	0.132 ^d
Side, left/right	56/60	57/61	0.277 ^c
Interval to failure after primary MoM THA (years)	4.3(1.2 - 6.5)	4.4(1.1 -6.4)	0.331 ^d
Comorbidities, n%			0.402 ^e
Hypertension	61(52.5)	69(58.4)	
Diabetes mellitus	32(27.5)	28(23.7)	
Hypertension and Diabetes mellitus	23(20.0)	21(17.9)	
Mechanism of injury, n%			0.780 ^e
Traffic-related injury	26(22.4)	28(23.7)	
Injury by falling	51(43.9)	46(38.9)	
Tamp injury	39(33.7)	44(37.4)	
ASA Index, n%			0.920 ^e
I	22(18.9)	24(20.3)	
II	64(55.1)	63(53.3)	
III	30(26.0)	31(26.4)	
Preoperative HHS	56.33±17.36	56.43±16.92	0.164 ^d
Follow-up period (months)	84.12±16.62	84.23±17.49	0.214 ^d

UTHA^a: uncemented total hip arthroplasty; CTHA^b: cemented total hip arthroplasty;

^cAnalysed using the chi-square test; ^dAnalysed using an independent-samples t-test;

^eAnalysed using the Mann-Whitney test. BMI: body mass index; BMD: bone mineral density; MoM THA: metal-on-metal total hip arthroplasty; ASA: American Society of Anesthesiologists; HHS: Harris hip score.

Table 2 Long-term follow-up: functional outcomes

HHS, month after conversion	UTHA ^a (n=116)	CTHA ^b (n=118)	p-value
3	79.14±8.12	79.28±7.66	0.212
6	86.65±6.62	87.76±7.44	0.181
12	88.17±7.72	91.43±8.52	0.031*
24	88.72±7.35	90.47±7.75	0.036*
36	87.14±8.43	89.43±8.27	0.027*
48	87.56±9.42	88.77±9.72	0.025*
60	86.32±9.68	87.73±11.25	0.014*
72	82.29±10.16	85.71±10.12	0.011*
84	79.78±11.65	84.72±11.82	0.000*
Final follow-up	79.18±11.12	84.32±10.35	0.000*

**Statistically significant values.*

UTHA^a: uncemented total hip arthroplasty; CTHA^b: cemented total hip arthroplasty.

Table 3 Long-term follow-up: prosthesis-related complications

Variable, n%	UTHA ^a (n=116)	CTHA ^b (n=118)	p-value
Re-revision	12(10.3)	3(2.5)	0.015*
Aseptic loosening	19(16.3)	7(5.9)	0.011*
Periprosthetic fracture	14(12.0)	5(4.2)	0.045*
Dislocation	10(8.6)	4(3.3)	0.092
Femur shaft fracture	3(2.5)	3(2.5)	0.983
Deep infection	3(2.5)	8(6.7)	0.130
Unbearable hip pain	6(5.1)	8(6.7)	0.604
Lower limb shortening (>1.5 cm)	5(4.3)	2(1.6)	0.240
Heterotopic ossification	11(9.4)	7(5.9)	0.308

**Statistically significant values.*

UTHA^a: uncemented total hip arthroplasty; CTHA^b: cemented total hip arthroplasty.

Figures

Figure 1

Flow diagram demonstrating methods for identification and exclusion of studies compare the long-term outcomes of patients who had undergone an uncemented or cemented total hip arthroplasty (THA) revision for prior failed primary metal-on-metal total hip arthroplasty (MoM THA).