Comparison of Complications Following Revision of Metal-on-Metal Versus Metal-on-Polyethylene Total Hip Arthroplasty

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abstract

The aim of this study was to examine the clinical characteristics of patients who required revision and the rate of early complications after revision for metal-on-metal total hip arthroplasty (MOM THA) and metal-on-polyethylene total hip arthroplasty (MOP THA). Matched cohorts were selected by retrospective review from a single-center database of revision THAs for failed MOM and MOP THAs from 2010 to 2014. A total of 140 hips in 140 patients comprised the study population; 39 revisions were performed for failed MOM THAs (MOM group), and 101 revisions were performed for failed MOP THAs (MOP group). Data included patient demographics, reason for revision, type of revision procedure, any complication within 90 days after surgery, admission type, and discharge disposition. Primary diagnosis, time from primary THA to revision, operative time, blood loss, and length of stay were reviewed. The analysis showed the time from the index primary procedure to first revision was earlier \((P=.01)\) in the MOM group despite no significant intergroup differences in age, gender, primary diagnosis, or body mass index. Surgical morbidity, as indicated by operative time, blood loss, and length of stay, was lower in the MOM group. The stem was retained more often in the MOM group. There was no significant difference between the groups in overall complication rate. These findings indicate that when performed at an earlier time period before extensive soft tissue reaction to metal ions, revision following MOM THA is not associated with an increased complication rate compared with revision following MOP THA. [Orthopedics. 2017; 40(1):e164-e169.]

Modern metal-on-metal total hip arthroplasty (MOM THA) was introduced into clinical practice with expectations for better range of motion by virtue of the availability of larger head sizes and less implant wear compared with metal-on-polyethylene total hip arthroplasty (MOP THA). However, in subsequent years after the expanded use of metal-on-metal bearings, clinical studies as well as national implant registry data have indicated a higher rate of revision associated with the use of metal bearings, particularly large diameter metal-on-metal bearings. Pain, adverse tissue reaction to metal debris (ARMD), and elevated serum metal ion levels have all been implicated as reasons for revision. Consequently, the use of MOM THA has declined in current practice, and some types of MOM THA either have been recalled or are no longer available in many countries worldwide.\(^1\)\(^-\)\(^6\)

As the number of failed MOM THA increases, revision THA following MOM THA has become a unique clinical challenge and has been highlighted in studies reporting the outcome after revision of MOM THA. Munro et al\(^7\) examined the average 25-month results after revision MOM THA and found that a major postop-
operative complication was experienced in 12 of 32 hips, with a high dislocation rate of 28%. Grammatopolous et al. reported that pseudotumor was identified in 30% of revisions for MOM THA. After examining the outcome of revision of failed MOM THA caused by pseudotumor or revision for other factors, they reported that the outcome of revision for patients with pseudotumor was particularly unfavorable, with a major complication rate of 50%. Based on the results of these previous clinical studies, the outcome of revision for failed MOM THA is potentially inferior to that of revision for non-MOM THA. However, clinical experience with this specific category of revision and publication of results in the orthopedic literature is not robust. As a result, it is unclear what unique variables might influence the outcome of revision procedures for failed MOM THA.

The specific aim of the current study was to examine the clinical characteristics of patients indicated for revision and the rate of early complications after revision for a matched cohort of MOM THA vs MOP THA. It was hypothesized that the complication rate for revision after failed MOM THA would be higher than for revision after conventional MOP THA.

**Materials and Methods**

Using a clinical database (University of California San Francisco [UCSF] arthroplasty patient outcome database), a retrospective review was conducted of 463 consecutive revision THAs performed between 2010 and 2014. Patients who underwent first-time revision of either MOM or MOP THA were included in the review. Patients who underwent revision for infection and those who underwent primary THA with use of a non–cross-linked polyethylene liner or MOM resurfacing THA were excluded to allow comparison of metal bearings with polyethylene currently in clinical use. A total of 140 hips in 140 patients were included in the study.

The primary surgery was MOM THA in 39 patients and MOP THA in 101 patients. In all of the patients who underwent MOP THA, highly cross-linked polyethylene liners were used in the index primary procedure. The primary THA procedures were performed both at UCSF and at outside hospitals. Data including patient demographics, reason for revision, type of revision procedure, surgical variables, any complication within 90 days after surgery, admission type, and discharge disposition were collected. Patient demographic data included age, gender, and body mass index (BMI). Primary diagnosis (osteoarthritis, rheumatoid arthritis, or avascular necrosis), duration of time elapsed from the primary THA to revision, operative time, blood loss, and length of hospital stay were reviewed.

Normally distributed continuous variables were compared using t test, chi-square test, and Fisher exact test. All statistical analyses were performed using SPSS version 22 software (SPSS, Chicago, Illinois).

**Results**

**Patient Demographics**

Patient demographics are presented in Table 1. The time from the index primary surgery until the first revision was shorter (P=.01) in the MOM group than in the MOP group (45.0±17.0 months vs 56.9±43.1 months, respectively). No statistically significant difference was observed for age (P=.06), sex (P=.06), or BMI (P=.07) between the MOM and MOP groups. Preoperative diagnoses for the primary THA included osteoarthritis, rheumatoid arthritis, and avascular necrosis. Distribution of the primary diagnosis was not significantly different between the groups (P=.59). In the MOM group, prosthesis head sizes were 32 mm in 6 patients and greater than or equal to 36 mm in 33 patients.

**Reason for Revision**

The most common reason for revision in the MOM group was pain (41%), followed by ARMD (25.6%) and aseptic component loosening (20.5%). In the MOP group, the predominant reasons for revision were aseptic component loosening (50.5%), dislocation and subluxation (19.8%), and periprosthetic fracture (9.9%). Other causes for failure and revision included component malalignment, component fracture, heterotopic ossification, acetabular wear, and leg-length discrepancy. The incidence of revision due to pain without loosening was significantly higher in the MOM group (P<.001), and the incidence of failure due to aseptic loosening and periprosthetic fracture was significantly higher in the MOM group (P<.001). Adverse tissue reaction to metal debris was observed exclusively in the MOM group, whereas failure caused by periprosthetic fracture, component frac-

**Table 1**

<table>
<thead>
<tr>
<th>Demographic</th>
<th>MOM THA Group (n=39)</th>
<th>MOP THA Group (n=101)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean±SD (range), y</td>
<td>60.3±9.7 (39-81)</td>
<td>63.7±11.8 (33-89)</td>
<td>.06</td>
</tr>
<tr>
<td>Sex, female/male, No.</td>
<td>17/22</td>
<td>63/38</td>
<td>.06</td>
</tr>
<tr>
<td>Primary diagnosis, OA/RA/AVN, No.</td>
<td>38/0/1</td>
<td>92/3/6</td>
<td>.59</td>
</tr>
<tr>
<td>BMI, mean±SD (range), kg/m²</td>
<td>28.3±5.6 (20.1-43.6)</td>
<td>28.3±5.5 (16.4-41.2)</td>
<td>.07</td>
</tr>
<tr>
<td>Time until first revision, mean±SD (range), mo</td>
<td>45.0±17.0 (9-82)</td>
<td>56.9±43.1 (1-155)</td>
<td>.01*</td>
</tr>
</tbody>
</table>

Abbreviations: AVN, avascular necrosis; BMI, body mass index; MOM, metal-on-metal; MOP, metal-on-polyethylene; OA, osteoarthritis; RA, rheumatoid arthritis; THA, total hip arthroplasty.

*Significant difference (P<.05).
Feature Article

A revision procedure, acetabular wear, heterotopic ossification, and leg-length discrepancy were encountered only in the MOP group (Table 2).

**Table 2**

<table>
<thead>
<tr>
<th>Reason for Failure</th>
<th>MOM THA Group (n=39)</th>
<th>MOP THA Group (n=101)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aseptic component loosening/lysis</td>
<td>8 (20.5%)</td>
<td>51 (50.5%)</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Periprosthetic fracture</td>
<td>0 (0%)</td>
<td>10 (9.9%)</td>
<td>.023*</td>
</tr>
<tr>
<td>Pain</td>
<td>16 (41.0%)</td>
<td>5 (5.0%)</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Component malalignment</td>
<td>1 (1.9%)</td>
<td>1 (1.0%)</td>
<td>1</td>
</tr>
<tr>
<td>ARMD</td>
<td>10 (25.6%)</td>
<td>0 (0%)</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Dislocation/subluxation</td>
<td>4 (10.3%)</td>
<td>20 (19.8%)</td>
<td>.088</td>
</tr>
<tr>
<td>Component fracture</td>
<td>0 (0%)</td>
<td>4 (4.0%)</td>
<td>.311</td>
</tr>
<tr>
<td>Acetabular wear</td>
<td>0 (0%)</td>
<td>5 (5.0%)</td>
<td>.275</td>
</tr>
<tr>
<td>Heterotopic ossification</td>
<td>0 (0%)</td>
<td>2 (2.0%)</td>
<td>.387</td>
</tr>
<tr>
<td>LLD</td>
<td>0 (0%)</td>
<td>1 (1.0%)</td>
<td>.583</td>
</tr>
<tr>
<td>Other</td>
<td>0 (0%)</td>
<td>3 (3.0%)</td>
<td>.568</td>
</tr>
</tbody>
</table>

Abbreviations: ARMD, adverse tissue reaction to metal debris; LLD, leg-length discrepancy; MOM, metal-on-metal; MOP, metal-on-polyethylene; THA, total hip arthroplasty.

*Significant difference (P<.05).

**Table 3**

<table>
<thead>
<tr>
<th>Variable</th>
<th>MOM THA Group (n=39)</th>
<th>MOP THA Group (n=101)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of revision, No.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cup/stem</td>
<td>2 (5.1%)</td>
<td>19 (18.9%)</td>
<td></td>
</tr>
<tr>
<td>Cup</td>
<td>36 (92.3%)</td>
<td>47 (46.5%)</td>
<td></td>
</tr>
<tr>
<td>Stem</td>
<td>1 (2.6%)</td>
<td>14 (13.9%)</td>
<td></td>
</tr>
<tr>
<td>Head/liner</td>
<td>0 (0%)</td>
<td>21 (20.8%)</td>
<td></td>
</tr>
<tr>
<td>Operative time, mean±SD (range), min</td>
<td>102.2±31.8 (59-212)</td>
<td>139.9±56.0 (39-298)</td>
<td>&lt;.001*</td>
</tr>
<tr>
<td>Blood loss, mean±SD (range), g</td>
<td>360.3±224.2 (150-1100)</td>
<td>594.5±600.2 (50-4000)</td>
<td>.008*</td>
</tr>
</tbody>
</table>

Abbreviations: MOM, metal-on-metal; MOP, metal-on-polyethylene; THA, total hip arthroplasty.

*Significant difference (P<.05).

**Revision Procedure**

For the revision procedure, a posterior approach was used in all cases, and a bearing surface of metal or ceramic on highly cross-linked polyethylene implant was used for all cases, except for 1 case in which the femoral component was revised and the MOM bearing was left in place. Revisions were divided into 4 categories: both cup and stem revision (cup/stem); cup revision with only the acetabular cup component revised excluding liner exchange alone (cup); stem revision with stem and head exchanged (stem); and head, liner, or both head and liner revision, with both acetabular cup and femoral stem component retained (head/liner) (Table 3). In both the MOM and MOP groups, cup revision alone was the most predominant type (92.3% and 46.5%, respectively). Cup/stem, stem, and head/liner revisions were performed more frequently in the MOP group (P<.001). An extended trochanteric osteotomy was performed in 1 of the 3 MOM THAs (33.3%) and in 15 of the 33 MOP THAs (45.5%) that required stem removal.

At the time of the revision procedure, a head diameter of more than 36 mm was used in 9 of 39 hips (23.1%) in the MOM group and in 17 of 101 hips (16.9%) in the MOP group. A head diameter of either 32 mm or 36 mm was used in 21 of 39 hips (53.1%) in the MOM group and in 66 of 101 hips (65.3%) in the MOP group. A head diameter of less than 32 mm was used in 9 of 39 hips (23.1%) in the MOM group and in 18 of 101 hips (17.8%) in the MOP group. The intergroup difference in head size was not statistically significant.

**Surgical Variables**

The mean operative time was 102.2±31.8 minutes (range, 59-212 minutes) in the MOM group and 139.9±56.0 minutes (range, 39-298 minutes) in the MOP group, with significantly longer surgical time required for the MOP group (P<.001). The mean blood loss also was significantly greater (P=0.008) in the MOP group (594.5±600.2 g) compared with the MOM group (360.3±224.2 g). Because surgical complexity depends on the type of revision, the MOM and MOP groups were analyzed according to the 4 revision type subgroups: cup/stem, stem alone, and head/liner alone. However, in the MOM group, the number of cup/stem, stem, and head/liner revisions were 2, 1, and 0, respectively (Table 3). Thus, meaningful comparison was feasible only for...
the cup alone type. The comparison was specifically made for this revision type between the 2 groups (n, 36 for the MOM group and 47 for the MOP group). The mean operative time for the cup alone procedure was 102.5±32.3 minutes (range, 59-212 minutes) and 129.1±46.6 minutes (range, 54-298 minutes) for the MOM and MOP groups, respectively (P=.003). The mean blood loss was 347.2±194.2 g (range, 150-1000 g) and 508.5±399.6 g (range, 150-2000 g) for the MOM and MOP groups, respectively (P=.13). The length of stay was 1.55 days (range 1.0-9.0 days) compared with 3.5±1.5 days (P=.02). Consequently, in the cases revised with a cup alone procedure, both surgical time and intraoperative blood loss were significantly greater in the MOP group.

### Postoperative Complications

Early postoperative complications were defined as complications encountered within 90 days following the revision procedure. These complications included deep venous thrombosis and pulmonary embolism, infection, dislocation, sciatic and peroneal nerve palsy, periprosthetic fracture, and mechanical failure, as well as medical complications such as myocardial infarction, cardiac dysrhythmia, and renal failure. Mechanical failure included component loosening, component malalignment, and other mechanical complications (Table 4) leading to revision.

Overall complication rates were 20.5% for the MOM group and 29.7% for the MOP group, with no significant differences demonstrated between the groups (P=.299). The most frequently encountered complication was mechanical failure in both groups (12.8% and 18.8% for MOM and MOP groups, respectively). Symptomatic deep venous thrombosis and pulmonary embolism were not experienced in either group. No early infection was encountered in the MOM group, whereas 3 of 101 hips (3%) became infected in the MOP group. Dislocation occurred in 1 hip (2.6%) in the MOM group and 5 hips (5%) in the MOP group. Periprosthetic fracture occurred in 1 hip (2.6%) in the MOM group and 9 hips (8.9%) in the MOP group. Recurrent ARMD was not observed during this early time frame. No patient in this study population had either sciatic or peroneal nerve palsy. Medical complications occurred within 90 days in 4 patients (10.3%) in the MOM group and 4 patients (4%) in the MOP group. No patient in the MOM group experienced renal failure during the early postoperative period, whereas 3 patients (3%) in the MOP group suffered from postoperative renal dysfunction. No significant intergroup difference was demonstrated in the rate of any complication.

### Admission Type and Discharge Disposition

Two percent of the patients in the MOM group were classified as emergency or urgent admissions. The rate of urgent or emergency admissions in the MOP group was 16% (P=.13). The length of stay was shorter in the MOM group (3.1±0.9 days) compared with the MOP group (3.5±1.5 days) (P=.02). With regard to discharge disposition, 78% of the patients in the MOM group were discharged to home health or home self-care. In the MOP group, 49% of the patients were discharged to home health or home self-care, and 47% were discharged to a skilled nursing facility or inpatient rehabilitation (Figure).

### DISCUSSION

This study demonstrates that patients in the MOM revision group presented earlier for revision after the index primary procedure but did not have a higher level of perioperative complexity or postoperative complications compared with patients in the MOP group. Although a large number of patients in the MOM cohort demonstrated adverse reaction to metal debris, there were no cases of large or catastrophic muscle and soft tissue necrosis in this series.

In the MOM group, the majority of the revisions (36 of 39 hips) were for the cup alone, whereas in the MOP group (n=101) the type of revisions were 19 cup/stem, 47 cup alone, 14 stem alone, and 21 head/liner. Three of the 39 MOM THAs (7.7%) and 33 of the 101 MOP THAs (32.7%) required stem removal. Not surprisingly, operative time was longer and blood loss was greater in hips undergoing cup/stem

### Table 4

<table>
<thead>
<tr>
<th>Complication</th>
<th>MOM THA Group (n=39)</th>
<th>MOP THA Group (n=101)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>DVT/PE</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>Infection</td>
<td>0 (0%)</td>
<td>3 (3.0%)</td>
<td>.43</td>
</tr>
<tr>
<td>Dislocation</td>
<td>1 (2.6%)</td>
<td>5 (5.0%)</td>
<td>.34</td>
</tr>
<tr>
<td>Sciatic/peroneal nerve palsy</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>ARMD</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>Periprosthetic fracture</td>
<td>1 (2.6%)</td>
<td>9 (8.9%)</td>
<td>.11</td>
</tr>
<tr>
<td>Mechanical failure</td>
<td>5 (12.8%)</td>
<td>19 (18.8%)</td>
<td>.53</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>0 (0%)</td>
<td>0 (0%)</td>
<td></td>
</tr>
<tr>
<td>Cardiac dysrhythmia</td>
<td>4 (10.3%)</td>
<td>4 (4.0%)</td>
<td>.24</td>
</tr>
<tr>
<td>Renal failure</td>
<td>0 (0%)</td>
<td>3 (3.0%)</td>
<td>.55</td>
</tr>
</tbody>
</table>

**Abbreviations:** ARMD, adverse tissue reaction to metal debris; DVT, deep venous thrombosis; MOM, metal-on-metal; MOP, metal-on-polyethylene; PE, pulmonary embolism; THA, total hip arthroplasty.
Moreover, occur = .111); however, there were significant
7,8,18
2,5,8,10,15,16
P
= .002) dif
At the peak of usage in
= .001) and blood loss
P
19
- e168
"pseudotumor" specifically experienced
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THA in recent years.
crease in the overall volume of revision
of revision of MOM THA has led to an
high failure rates.
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MOM implants. Ultimately, some MOM
need for regular follow-up with the use of
THA group, 49% of patients were discharged to home health or self-care, and 47% were discharged to a
skilled nursing facility or inpatient rehabilitation. Abbreviations: MOM, metal-on-metal; MOP, metal-on-
polyethylene; THA, total hip arthroplasty.
revision compared with single-component
procedures. However, when both groups
were compared for the same revision type
(cup alone revision), these values were
still larger in the MOP group, suggesting
a higher degree of surgical complexity in
this group (Table 3). The rate of complica-
tions after revision surgery was similar
between the MOM and MOP groups.
In 2008, approximately 35% of THAs
in the United States used a MOM bear-
ing surface. At the peak of usage in
2007, more than 6000 MOM hip resurfac-
ings were performed annually in England
and Wales. In 2010, the United Kingdom
Medicine and Healthcare Products Regu-
latory Agency issued an alert proposing a
need for regular follow-up with the use of
MOM implants. Ultimately, some MOM
hip systems were withdrawn from distri-
bution with concerns for unacceptably
high failure rates. A high volume
of revision of MOM THA has led to an
increase in the overall volume of revision
THA in recent years. Moreover, occurrence of complications such as ARMD or
"pseudotumor" specifically experienced
with a MOM bearing may impact the out-
come of the revision procedure. Revision
of failed MOM THA combined with as-
associated soft tissue damage may pose ex-
treme technical difficulties and additional
challenges.
The initial hypothesis for the current
study was that the complication rates as
well as surgical morbidities would be
higher in the MOM group due to ARMD
associated with soft tissue destruction
and unique complications such as instabil-
ity. Contrary to this hypothesis, findings
demonstrated that operative time, blood
loss, surgical complexity, and length of
hospital stay were greater in the MOP
group. In addition, the rate of complica-
tions in the early postoperative period
(within 90 days) was not significantly
different between the MOM and MOP
groups. One possible explanation for this
finding is that complications of metal bear-
ings were not being seen at the current au-
thors’ institution at an earlier time frame
before extensive soft tissue destruction had
occurred. On the other hand, given that
the current authors’ institution is a refer-
ral center for complex cases, it also may
be true that the cohort of MOP-bearing
revisions represents the “worst case” revi-
sions in this category of patients. Clearly,
the MOM cohort presented with a differ-
ent profile of surgical issues, with the most
relevant being ARMD or local tissue dam-
age that is uniquely attributed to metal ion
reactions. Although this phenomenon has
been reported in MOP hips with a lesser
frequency, it is a common finding in MOM
revisions.
The current study has some limita-
tions. First, the primary THA procedures
in the study population included a mixed
population of patients who underwent
initial surgery both at the current authors’
institution and at outside hospitals using
various implant systems.
Second, there was substantial variabil-
ity in the types and implant systems used
for revision at the discretion of the oper-
ating surgeon. Revision cases with severe
bone loss requiring augments or cup-cage
reconstructions were included in this anal-
ysis. In addition, this study represents the
experience of 3 surgeons, all of whom had
greater than 10 years of specialty practice
in joint reconstruction. Thus, the surgical
indications may not be completely consis-
tent or could potentially vary according
to the operating surgeon. This issue may
induce a bias in patient selection and pro-
duction indication.
A post-hoc analysis among the 3 sur-
geons confirmed that the surgeon may
contribute to the variability in results.
Both mean operative time (98.7 vs 131.2
vs 145.3 minutes, P = .001) and blood loss
(234.5 vs 633.8 vs 581.6 g, P = .002) dif-
fered among the 3 surgeons. However, it is
also apparent that the variability between
surgeons reflected the type and complex-
ity of revisions. The surgical variables
were analyzed by the type of revisions
(cup/stem, cup, stem, and head/liner.)
There were no significant differences
among the 3 surgeons in the MOM group
(P = .111); however, there were significant
differences among the 3 surgeons in the
MOP group (P=0.007). One surgeon trended toward less complex revisions, whereas the other surgeons had a greater number of more complex revisions in the MOM group.

Moreover, the procedure used for revision of MOM THA with taper corrosion at the head-neck junction has changed to some degree during the study period as this entity was recognized during the time course of the study. Although it was unusual in the current series to remove a well-fixed stem due to trunnion corrosion, exchange of a well-fixed femoral stem has been proposed by others.\(^ {20,21}\)

Finally, the current study examined only perioperative complications. Further evaluation of these patient cohorts is mandatory to critically compare the long-term outcomes of revision procedures following MOM and MOP THA. In particular, any long-term consequence of ARMD or elevated serum metal ion level in MOM THA still remains to be completely elucidated.\(^ {22,23}\)

**Conclusion**

The current study compared clinical profiles and short-term complications of revision surgery following MOM and MOP THAs in a referral practice. Surgical morbidity as indicated by operative time, blood loss, and length of hospital stay were lower in the MOM group, but the ability to retain the stem was more frequent. Regarding the rate of postoperative complications, no significant difference was demonstrated between the MOM and MOP groups. Based on the profile of revision cases seen at the current authors’ institution, MOM bearings present with a unique profile of reconstructive challenges and have not provided an advantage in durability or rates of complications after revision surgery. The findings of this study suggest that when performed at an earlier time period before extensive soft tissue destruction, revision following MOM THA is not associated with an increased complication rate compared with revision following MOP THA.

**References**


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