*Title Page (with full author details)

OUTCOMES AFTER REVISION OF METAL-ON-METAL HIP RESURFACING ARTHROPLASTY

THOMAS P. GROSS, MD
FEI LIU, PHD

MIDLANDS ORTHOPAEDICS, P.A.
COLUMBIA, SC, USA

Send Correspondence To:

Fei Liu, PhD
Midlands Orthopaedics, P.A.
1910 Blanding St
Columbia, SC, USA 29201
Phone: (803) 331-6894
Fax: (803) 933-6339
Email: feilresearch@gmail.com
or grossortho@yahoo.com

*Abstract (125 Words Maximum)

ABSTRACT:

We report the results of 58 hip resurfacing arthroplasties (HRA) revised by a single surgeon with an average of 5.2±2.6 years follow-up. The four most common causes for revision were acetabular component loosening, femoral neck fracture , femoral component loosening, and adverse wear related failure (AWRF). In 95% of cases (55/58), the revision bearing was a large metal-on-metal type including in all seven AWRF cases; three cases were revised to ceramic-on-polyethylene. There were two repeat revisions due to acetabular component loosening. Revision of AWRF had an excellent outcome using limited debridement and a stable large metal bearing placed in the correct position. The only problematic group was the one revised for acetabular loosening in which 2/16 (6%) required repeat revision for failure of acetabular fixation.

Key Words: Hip Revision; Hip Resurfacing; Metal-on-Metal; Acetabular Position; Hip Arthroplasty; Adverse Wear Failure

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Introduction

Metal on metal hip resurfacing arthroplasty (HRA) has shown mixed results: while some surgeons have shown excellent medium to long-term results, others have not been so successful [1-7]. The technique of hip resurfacing is significantly different from stemmed total hip arthroplasty (THA) and a long learning curve exists for this new method [2]. While many failure mechanisms are similar to those of THR, some of the failure modes are distinctly different, such as femoral neck fracture [8]. As we learn more about this new technique, we are also learning how to prevent some of these failures and improve the outcome of HRA. This is demonstrated by our latest results that show a 97.4% survivorship at 5 years with 1000 uncemented HRA [3].

Recall of two major implant systems of HRA, the DePuy ASR and the Zimmer Durom as well as reports of a high rate of pseudotumors from the Nuffield Orthopaedic Center, University of Oxford using non-recalled implants led to a rapid loss of popularity of hip resurfacing [9]. Because of an initial lack of understanding of the cause of these pseudotumors, some speculated that they were caused by metal allergy. Poor outcomes reported for revision of AWRF cases from the same group has further contributed to loss of popularity of metal bearings [10]. It now appears that most “pseudotumors” may be actually cases of inflammatory tissue response to excessive wear debris rather than metal allergy; we therefore call these adverse wear related failures (AWRF) [11].

Koen DeSmet was the first to elucidate this problem of metalosis due to malpositioned acetabular components in 2008 [12]. Our results have confirmed his initial insight [11]. Other clinical studies have also shown that malpositioned acetabular components result in higher blood ion levels, soft tissue inflammation seen on CT or MRI and metalosis seen at the time of revision

[12, 13]. And, laboratory simulation has demonstrated that acetabular components placed too steeply results in edge loading and a much higher wear rate [11, 14].

Bone preservation of HRA theoretically would make revision surgery less complicated. However, this has only been shown for isolated femoral revisions [15]. On the other hand, revision of AWRF has had a poor outcome due to poor clinical score, muscle damage, instability and even nerve injury [10, 16]. Extensive debridement and change to non-metal bearing implants has been recommended, but the outcome of this recommendation has been poor [10]. Because we believe that the causative problem in AWRF is acetabular component malposition (leading to edge loading, excessive wear and metallic overload of the tissues) rather than metal allergy; we pursued an alternative strategy to revise these: limited debridement combined with repositioning a new large metal bearing acetabular component. There are two possible options to accomplish this goal; isolated acetabular revision and revision of both components to a new large bearing THA. However, when the femoral resurfacing component is retained (as in isolated acetabular revision), it is not known whether the wear scar on the femoral component will be tolerated. When a THR construct is used, the head can be changed but one has to be confident that the trunion design of the new THR is adequate. We realize that there is now great controversy in using any large metal bearing in combination with a femoral stem, because a higher failure rate due to trunion corrosion has been reported with many of these constructs. Many of our revisions were done before this became known. But we have not encountered any trunion failures with either the Corin or Biomet designs that we used. Also, Lavigne has shown significantly lower ion release using the unique Biomet Magnum trunion design [17]. Therefore, we believe this design gives us the best combination of hip stability and trunion stability. We have only revised to a non-metal smaller bearing if acetabular fixation cannot be achieved with a large metal bearing or when the diagnosis of AWRF is not clear and we suspect severe allergy may be the cause of failure. This is rare in our experience.

When we advocate for a limited debridement we should be clear that we are not implying that a small incision should necessarily be used. In fact, less experienced surgeons should always use a large incision to be sure that adequate visualization occurs. We recommend that most (not all) of the debris should be peeled off of the muscle. There is usually a thick debris-laden membrane that can be removed without damaging the underlying muscle. Small amounts of debris close to vital nerves or vessel can be left in place. If 90% of the debris is removed, this is enough. A tumor operation is not the correct approach. The acetabular component is always malpositioned in these cases. We advocate placing a new component in the correct position if residual bone quality is adequate to allow stable primary fixation. Correct position is according to our previously published guidelines (RAIL- relative acetabular inclination limit) based on bearing size and measured on standing pelvis x-ray [18].

The purpose of this paper is to review our results with revision of HRA with minimum two-year follow-up. We also wanted to determine which failure modes were more problematic to revise. In particular, we were interested in the outcome of revision for AWRF using an approach that is quite different than what has led to poor outcomes in past reports.

Materials and Methods

Institutional Review Board approval was obtained for the present study. Between May 2001 and August 2011, a single surgeon (T.P.G.) performed 2497 (*1815 in male vs. 682 in female; 72.7% vs. 27.3%*) metal-on-metal HRA cases in 2060 patients (minimum 2-year follow-up) including those performed in his learning curve of this surgical technique [2]. Three different implants were utilized in the entire group: Hybrid Corin Cormet 2000 (Corin, Cirencester, UK) in 373 cases from March 2001 to March 2005; Hybrid Biomet Recap (Biomet, Warsaw, Indiana) HRA in 740 cases from November 2004 to August 2008; and uncemented Biomet Recap in 1384 from March 2007 to August 2011. 87 of these 2497 cases (3.5%) were revised at the time of this study. Of these 87 revisions, 67 (77%) cases were revised by the same surgeon, while the remainder were revised elsewhere. 59 (88%) of these 67 revision cases have reached their minimal two-year follow up, only one of them was lost to follow-up at time of this study. Therefore，58 cases formed the current study group. The causes for revision of HRA were listed in Table 1. The primary causes for revision were acetabular component loosening, femoral neck fracture, femoral component loosening, and adverse wear related failure (AWRF). The demographics for the study group are listed in Table 2. Women had significantly higher failure rate than men. *(30/ 682 vs.* 28/*1815; 4.4% vs. 1.5%) (P<0.001)*. The underlying causes for this appears to be a higher incidence of dysplasia in young women and the fact that smaller bearing sizes are required in women [19, 20].

We define AWRF as an inflammatory reaction around hip implants caused the presence of wear debris [11]. In metal-on-metal bearings, the debris is cobalt-chrome particles. The preoperative triad of elevated blood ion levels, a steep acetabular inclination angle (AIA), and a fluid collection on three-dimensional imaging is confirmed by a grey metalosis at the time of revision. As is the case with other causes of joint replacement failure, there may be multiple combined reasons for failure. Infection must always be ruled out. Loose implants can cause inflammatory reactions and some metalosis due to backside wear debris.

For the revision, a minimally invasive posterior approach was used combined with a comprehensive blood management protocol and multimodal pain management program.

Perioperative data was listed in Table 3. In most revisions, there was at most minimal metalosis and soft tissue inflammation. In infections, there was the greatest inflammation. Small amounts of metalosis and occasionally hematoma were typically seen around loose acetabular components. Larger amounts of metalosis and inflammation were seen around well fixed malpositioned components failed due to AWRF. Femoral neck fractures were accompanied by hematoma. Femoral osteonecrosis and loosening had minimal reaction.

Femoral revision was uncomplicated. In isolated femoral revisions, the neck was trimmed and an uncemented primary femoral stem and head were implanted. The head was of the same brand and matched the bearing size of the acetabular component. In Corin cases, the C-fit stem was used; in Biomet cases, the Mallory, Taperloc and Taperloc microplasty stems were used. We encountered no femoral ingrowth or trunion failures with these designs; therefore, no further analysis was performed. In isolated acetabular revisions, revision was more difficult. Limited enhanced fixation options exist for resurfacing acetabular components. Typically, thicker walled components with spikes were used. In some cases, fixation was not possible without moving to a larger bearing size; therefore, femoral revision was then required at the time of revision. In AWRF cases，a thick grey membrane containing the metalosis could always be carefully peeled from the remaining soft tissues leaving muscle groups and even the hip capsule intact and undamaged. Even lesions tracking into the pelvis along the psoas could be peeled out through the hip joint. Our goal was to remove 90% of the metallic load, but not to perform a tumor operation. Whenever possible, we reconstructed with another large metal bearing in a more horizontal position if adequate acetabular fixation could be achieved.

Results

Kaplan-Meier survival rate of the entire revision cohort was 96.6% at five years (31/58 have reached their five year follow-up.) using failure of any component for any reason as the end point. The mean follow-up after the HRA revision was 5.2±2.6 years (2-11.4 years). The average Harris hip score was 92±14 (range: 45 to100) at the latest follow-up. The mean UCLA activity score was 6±2 (range: 2 to 10).

There were two failures in this study; both were due to failures of acetabular ingrowth into the revision component. The first was in a woman who had HRA for OA. The acetabular porous coating debonded causing component (Corin Cormet 2000) loosening 6.5 years after the primary HRA; isolated acetabular revision was performed with a flanged cup, which failed bone ingrowth. The patient was finally successfully revised to an uncemented THA with a standard porous cup with screws. The HHS score was 83 three years after the repeat revision. The second failure was in a woman who had HRA for dysplasia. The acetabular component (hybrid Biomet Recap) failed 5 months after the primary HRA; isolated acetabular revision was performed with a flanged cup, which failed bone ingrowth. The patient was finally successfully revised to a 36mm ceramic-on-polyethelene THA. Two further complications occurred after the second revision. Two years later a low energy pelvic fracture occurred which healed without treatment. Three dislocations occurred treated with closed reduction.

No patients died. In addition to the two complications described above, there were other two complications identified. There was another case of recurrent dislocation treated with closed reduction. There was one superficial wound breakdown at four months without deep infection that resolved after debridement. There were no sciatic nerve palsies, thromboembolic events or significant medical complications. The only group that suffered significant complications was the group revised for acetabular loosening. Both failures (12.5%, 2/16) and both cases with recurrent dislocation (12.5%, 2/16) were in this group. There was no significant difference found between the other groups.

Without including the seven AWRF cases, the metal ion results at minimal two-year follow-up were available for 35 cases. The average Co level was 2.5±2.0 ug/L (range: 0-6.8) and the Cr level was 1.6±1.2 ug/L (range: 0-3.8). Clinical data are listed in Table3 for the entire group. All revision cases had three intraoperative cultures taken. These were negative except in the three cases that were revised for infection. All seven cases revised for AWRF had extensive grey metalosis seen in surgery. There was no significant metalosis seen in the remainder. A cell saver was used in 30 cases with an average of 167±154 ml (range: 45-800) blood returned. The surgical data is listed in Table 5.

In eight cases that might have been classified as pseudotumors by others, there were seven cases that satisfied our criteria for AWRF with ion levels elevated above 10ug/L, AIA > 50° on standing pelvis radiographs and a fluid collection/mass on three dimensional scanning; confirmed by the finding of metalosis at the time of revision surgery. There was one case with suspected allergy that had an extensive inflammatory mass, ion levels below 10ug/L and no metalosis. Detailed information of the seven AWRF were previously reported [11]. All AWRF cases and the possible allergy case had 3 negative intraoperative cultures. All the AWRF cases were revised to another large metal bearing with improved acetabular component position. In 4/7 (57%) only the acetabular component was revised. There were no complications in the AWRF group. There were no sciatic palsies, no dislocations, no transfusions, no permanent limp, and no recurrent inflammatory lesions. Ion levels improved in all patients and CT scans at 3-12 months postop showed absence of fluid collection or mass in all the cases. 5/7 cases of AWRF had a metal on metal hip bearing on the opposite side, which continued to function well, and had no fluid collection on 3-dimensional scanning.

Discussion:

The outcome of revision for HRA was excellent with a 96.6% survivorship five years after revision. The recurrent dislocation rate was 3.4% (2/58). Although this series is small, these results are comparable to those of primary THA and primary HRA [2, 3, 21]. Our results also suggested that the failure rate of primary HRA improved over time probably due to improved implant design and surgical technique (Table 4). Using the uncemented femoral component, late femoral component loosening has not been seen in the last 979 cases 92-5 year follow-up); with improvement of postoperative management rather than patient selection, femoral neck fractures have been reduced to from 1.2% for the first 500 cases to 0.6% for the last 1497 cases; using a trispike cup in cases with acetabular wall defects, we have shown the acetabular component loosening is significantly reduced [19].

Acetabular revisions had a higher failure rate because supplemental fixation options are limited in HRA. Revisions for AWRF were uncomplicated. This is contrary to previously published results. The fact that inflammatory reactions resolved after revision to another correctly positioned metal bearing and the fact that 5/7 cases had another metal bearing in the opposite hip without reaction confirms our hypothesis that AWRF are caused by acetabular component malposition creating edge loading *rather* than by allergy to metals. When we performed a limited debridement and revised with another large metal bearing placed correctly, the problem resolved and complications were avoided. Our results are significantly better than those reported for extensive debridement and conversion to smaller bearing THR.

Currently, most attention in HRA is focused on adverse wear failures (AWRF) and failures of acetabular component ingrowth. There have been two implant recalls related to problems with implant design that resulted in a high rate these problems. The Zimmer Durom hip system was found to suffer from a high rate of acetabular ingrowth failure [7], while the DePuy ASR system suffered from both excessive ingrowth failures and a high rate of AWRF [6, 22].

Our rate of AWRF is relatively low at 1% in 10 years [11]. Comparatively, the reported range is from 1-4% with non-recalled implants. With the Depuy ASR system, the rate of AWRF was much higher [22, 23]. The cause of AWRF has now been amply demonstrated to be due to malposition and/or too shallow a design of the acetabular component leading to an abnormally high wear rate caused by edge loading. Furthermore, we have published a robust guideline (RAIL: relative acetabular inclination limit) for placement of acetabular components to avoid AWRF [18].

Even the Oxford Group, which initially published that acetabular component malposition was not the cause of pseudotumors and instead invoked allergy as a possible cause, now in their most recent publication, has found that edge loading is seen in most of these cases. Edge loading has been shown to be associated with a high implant wear rate by others and is caused by acetabular component malposition [14].

Even though the incidence of AWRF is low in most series [11], the highly publicized terrible outcomes of revision for AWRF [10] and the legalities surrounding metal bearing failure with two implant recalls have made many surgeons nervous about using these implants. A general impression among surgeons that “all metal bearings are bad” and that failures are random have taken hold. Frequently, the cause of failure is not accurately diagnosed, but a revision is performed for “metal problems”. The problem with the DePuy ASR implant was that there were many cases of acetabular ingrowth failure as well as many AWRF with this system. There were likely many cases with both diagnoses. In these cases, it was difficult to make one specific diagnosis; therefore it is understandable that accurate diagnoses were often not possible for DePuy ASR failures. In our experience with the Corin and Biomet cases this is not true. From our previously published series as well as in this current report, it is clear that in most cases an accurate diagnosis can be made preoperatively and confirmed by surgical findings. We had only one case of unexplained swelling resulting in the diagnosis of exclusion of "metal allergy".

Although some have speculated that pseudotumors are caused by metal allergy, we have found no compelling evidence that allergy plays an important role in clinical failures. When we previously investigated our failures due to inflammatory reactions, all cases had high ion levels, steep inclination angles, and metalosis found at revision. They were in fact caused by excessive wear due to edge loading [11, 18]. There were no unexplained inflammatory reactions in which we needed to invoke allergy as a cause. For the first time, in this series, we have found one case that we suspect may have been due to metal allergy (diagnosis of exclusion). There was an extensive inflammatory reaction with negative cultures and without elevated ion levels, or metalosis. Therefore, we believe that metal allergy remains a rare diagnosis of exclusion for failed metal bearing implants. However, we do not deny that severe inflammatory reactions to metal debris occur. We describe our management of seven of these cases in the current study. What we disagree with is the commonly held notion that these severe inflammatory reactions are allergic responses. The success of our management strategy supports, but is not adequate to prove, our hypothesis that these inflammatory reactions are caused by inflammatory response to metallic debris overload. It is uncertain whether this lymphocyte reactivity to metal debris is etiologically linked to poor implant performance [24].

Several reports have indicated that revision of HRA is less complicated and more successful than revision of primary stemmed THR [15]. While this seems to be true when only the femoral component is revised, it has not been the case with revision of HRA for AWRF [10, 16]. The main complications with revision for AWRF appear to be instability (16-19%) and nerve injury (0-19%). Extensive debridement has been recommended for these cases, because of the fear that allergy is a causative factor. Changing to implants that do not contain cobalt chromium or nickel has been advocated. Extensive debridement likely leads to the high rate of nerve injury. Extensive debridement combined with mechanically compromised smaller bearings lead to instability.

In DeSmet’s series [16] of 42 revised HRAs, cause of revision also did not influence the outcome of revision. Mean Harris hip score was 90/100. Mean follow-up was 2.7 years (1-7.3). 64% of failures were due to acetabular malposition. 29% had metalosis, 17% had osteolysis. Overall 4/42 cases (10%) required a second revision. When the femoral or acetabular component was revised alone, retaining the large metal bearing, the rate of complications was low. In 12 patients revised for acetabular malposition, extensive metalosis was seen requiring “extensive soft tissue resection”. In 25 /42 cases a revision to a smaller ceramic-ceramic bearing THR was performed. 20% of these had a complication and 16% of these suffered dislocations. A single experienced resurfacing surgeon performed all revisions with a mean time between primary and revision surgery of 2.2 years (0.1- 6.3).

In the Oxford series [10] of 53 revisions of HRA, 16 were revised for AWRF (pseudotumors). The clinical outcome in this group was significantly worse than for revisions for other causes or for a matched group of primary THR. The mean Oxford hip score was 21/48 (4-41). Mean follow-up was 3 years (0.8-7.2). There were 3/16 (19%) femoral nerve injuries, 3/16 (19%)

recurrent dislocations, 1/16 (6%) femoral artery injury, and 2/16 (13%) loose acetabular components. 75% of patients required transfusion. Major complications were seen in 50% and 5/16 (31%) required repeat revisions). 13 different surgeons performed the revisions with a mean time from primary surgery to revision of 1.59 years (0.01-6.69).

In contrast, we had excellent clinical outcome in or 58 HRA revisions including our AWRF revisions. The AWRF revisions required no transfusions, and suffered no complications, specifically no dislocations, nerve injuries or loose components. A single surgeon performed all revisions with a mean time between primary and revision surgery of 2.8±2.8 years (range: 0-8.5). The time between primary HRA and revision was similar in all 3 series; therefore it is not likely that one report dealt with more severe longstanding AWRF than any other group.

In conclusion we find:

- Outcome of revision HRA for all causes is similar to those published primary THA or HRA studies.
- Hip resurfacings revised for AWRF have an excellent outcome if a limited debridement is carried out and large metal bearings are correctly placed.
- Retention of a well-fixed worn femoral component seems to be well tolerated.
- Femoral fractures or necrosis do not occur if the femoral resurfacing component is retained.
- Revision for acetabular fixation is the most difficult because limited supplemental fixation options exist for large metal bearings.

- Metal allergy remains a rare diagnosis of exclusion in cases of inflammatory reactions around implants.

References:

1. Gross TP, Liu F. Current Status of Modern Fully Porous Coated Metal-On-Metal Hip Resurfacing Arthroplasty. J Arthroplasty, 2013
2. Gross TP, Liu F, Webb LA. Clinical outcome of the metal-on-metal hybrid Corin Cormet 2000 hip resurfacing system: an up to 11-year follow-up study. J Arthroplasty 27(4): 533, 2012
3. Gross TP, Liu F. Hip resurfacing with the Biomet Hybrid ReCap-Magnum system: 7-year results. J Arthroplasty 27(9): 1683, 2012
4. Gross TP, Liu F. Metal-on-metal hip resurfacing with an uncemented femoral component. A seven-year follow-up study. J Bone Joint Surg Am 90 Suppl 3: 32, 2008
5. Amstutz HC, Le Duff MJ. Eleven years of experience with metal-on-metal hybrid hip resurfacing: a review of 1000 conserve plus. J Arthroplasty 23(6 Suppl 1): 36, 2008
6. Hug KT, Watters TS, Vail TP, Bolognesi MP. The withdrawn ASR THA and hip resurfacing systems: how have our patients fared over 1 to 6 years? Clin Orthop Relat Res 471(2): 430, 2013
7. Li J, He C, Li D, Zheng W, Liu D, Xu W. Early Failure of the Durom Prosthesis in Metal-on-Metal Hip Resurfacing in Chinese Patients. J Arthroplasty, 2013
8. Mont MA, Schmalzried TP. Modern metal-on-metal hip resurfacing: important observations from the first ten years. J Bone Joint Surg Am 90 Suppl 3: 3, 2008
9. Glyn-Jones S, Pandit H, Kwon YM, Doll H, Gill HS, Murray DW. Risk factors for inflammatory pseudotumour formation following hip resurfacing. J Bone Joint Surg Br 91(12): 1566, 2009
10. Grammatopolous G, Pandit H, Kwon YM, Gundle R, McLardy-Smith P, Beard DJ, Murray DW, Gill HS. Hip resurfacings revised for inflammatory pseudotumour have a poor outcome. J Bone Joint Surg Br 91(8): 1019, 2009
11. Gross TP, Liu F. Incidence of adverse wear reactions in hip resurfacing arthroplasty: a single surgeon series of 2,600 cases. Hip Int 3(23): 250, 2013
12. De Haan R, Pattyn C, Gill HS, Murray DW, Campbell PA, De Smet K. Correlation between inclination of the acetabular component and metal ion levels in metal-on-metal hip resurfacing replacement. J Bone Joint Surg Br 90(10): 1291, 2008
13. Takamura KM, Amstutz HC, Lu Z, Campbell PA, Ebramzadeh E. Wear Analysis of 39 Conserve Plus Metal-on-Metal Hip Resurfacing Retrievals. J Arthroplasty, 2013
14. Williams S, Leslie I, Isaac G, Jin Z, Ingham E, Fisher J. Tribology and wear of metal-on-metal hip prostheses: influence of cup angle and head position. J Bone Joint Surg Am 90 Suppl 3: 111, 2008
15. Ball ST, Le Duff MJ, Amstutz HC. Early results of conversion of a failed femoral component in hip resurfacing arthroplasty. J Bone Joint Surg Am 89(4): 735, 2007
16. De Haan R, Campbell PA, Su EP, De Smet KA. Revision of metal-on-metal resurfacing arthroplasty of the hip: the influence of malpositioning of the components. J Bone Joint Surg Br 90(9): 1158, 2008
17. Lavigne M, Belzile EL, Roy A, Morin F, Amzica T, Vendittoli PA. Comparison of whole-blood metal ion levels in four types of metal-on-metal large-diameter femoral head total hip arthroplasty: the potential influence of the adapter sleeve. J Bone Joint Surg Am 93 Suppl 2: 128, 2011
18. Liu F, Gross TP. A Safe Zone for Acetabular Component Position in Metal-On-Metal Hip Resurfacing Arthroplasty: Winner of the 2012 HAP PAUL Award. J Arthroplasty 28(7): 1224, 2013
19. Gross TP, Liu F. Prevalence of dysplasia as the source of worse outcome in young female patients after hip resurfacing arthroplasty. Int Orthop 36(1): 27, 2012
20. Gross TP, Liu F. Risk factor analysis for early femoral failure in metal-on-metal hip resurfacing arthroplasty: the effect of bone density and body mass index. J Orthop Surg Res 7(1): 1, 2012
21. Huo MH, Parvizi J, Bal BS, Mont MA. What's new in total hip arthroplasty. J Bone Joint Surg Am 91(10): 2522, 2009
22. Langton DJ, Joyce TJ, Jameson SS, Lord J, Van Orsouw M, Holland JP, Nargol AV, De Smet KA. Adverse reaction to metal debris following hip resurfacing: THE INFLUENCE OF COMPONENT TYPE, ORIENTATION AND VOLUMETRIC WEAR. J Bone Joint Surg Br 93(2): 164, 2011
23. Reito A, Puolakka T, Elo P, Pajamaki J, Eskelinen A. High Prevalence of Adverse Reactions to Metal Debris in Small-headed ASR Hips. Clin Orthop Relat Res, 2013
24. Hallab NJ, Anderson S, Caicedo M, Skipor A, Campbell P, Jacobs JJ. Immune responses correlate with serum-metal in metal-on-metal hip arthroplasty. J Arthroplasty 19(8 Suppl 3): 88, 2004

Table 1

Table 1: Detail information about the causes of the failures in the study group.

Variables	***Number***	***Incidence of failures***	***Time (revision) after primary surgery (yr)***	***Treatment***
Modes of Failure	***58***	***100%***	—	—
Acetabular Loosening	*16*	*28%*	*2.9±2.7 (range:0.2-8.2)*	*Acetabular revision: 13* *Total revision: 3*
Femoral Neck Fracture	*16*	*28%*	*0.2±0.1 (range:0-0.6)*	*Femoral revision: 16*
Late Femoral Loosening (after 2 year)	*11*	*19%*	*5.9±2.0 (range:3.3-8.5)*	*Femoral revision: 9* *Total revision: 2*
Adverse Wear	*7*	*12%*	*4.6±1.9 (range:2.4-7.1)*	*Acetabular revision: 4* *Total revision: 3*
Early Femoral Head Collapse (Osteonecrosis) (before 2 year)	*4*	*7%*	*1.3±0.4 (range:0.8-1.8)*	*Femoral revision:3* *Total revision: 1*
Deep Infection	*3*	*5%*	*1.9±0.5 (range:1.3-2.3)*	*Total revision: 3*
Significant groin pain	*1*	*5%*	*8.4*	*Total revision: 1*

Table 2

Table 2: Summary of the primary surgery in the study group.

Variables	*Number*	*Percentage*
# of Cases	*58*	——
In women	*30*	*51.7%*
In men	*28*	*48.3%*
# of Patients	*55*	——
Female	*29*	*52.7%*
Male	*26*	*47.3%*
Deceased	*0*	——
Diagnosis		
Osteoarthritis	*33*	*56.9%*
Dysplasia	*11*	*19.0%*
Avascular Necrosis	*6*	*10.3%*
Post-trauma	*3*	*5.2%*
Others	*5*	*8.6%*
Implant Brand(primary surgery)		
Cemented Corin	*24*	*41.4%*
Cemented Biomet	*17*	*29.3%*
Uncemented Biomet	*17*	*29.3%*
	Average	***Range***
Age at primary surgery (yr)	*50±11*	*12-65*
Time (revision) after primary surgery (yr)	*2.8±2.8*	*0-8.5*
Femoral component size (mm)	*49±5*	*40-58*
BMI (kg/m^2)	*28±5*	*19-51*
T-score	*-1±1*	*-2- 2.3*

Table 3: Summary of the clinical outcomes for the revision HRA cases in the study group.

Variables	***Average***	***Range***
Intraoperative		
*ASA score**	*2±1*	*1-3*
Length of Incision (in)	*5±4*	*4-30*
Operation Time (min)	*114±39*	*65-206*
Estimated Blood Loss (mL)	*362±338*	*50-1600*
Hospital Stay (days)	*2±1*	*1-4*
Postoperative		
Clinical Data		
HHS score	*92±14*	*45-100*
UCLA Activity Score	*6±2*	*2-10*
VAS Pain: Regular Days	*1±2*	*0-6*
VAS Pain: Worst Days	*2±3*	*0-10*
Radiographic Data		
Acetabular inclination angle (°)	*40±7*	*27-54*
	Number	***Percentage***
Radiolucency	*0*	*0%*
Osteolysis	*0*	*0%*

Table 4

Table 4: Summary of the causes for the revision HRA grouped by every 500 cases (including all 87 failure cases：acetabular loosening: 24; femoral neck fracture: 19; late femoral loosening: 15; adverse wear: 8; early femoral head collapse: 5; others: 16 not listed here).

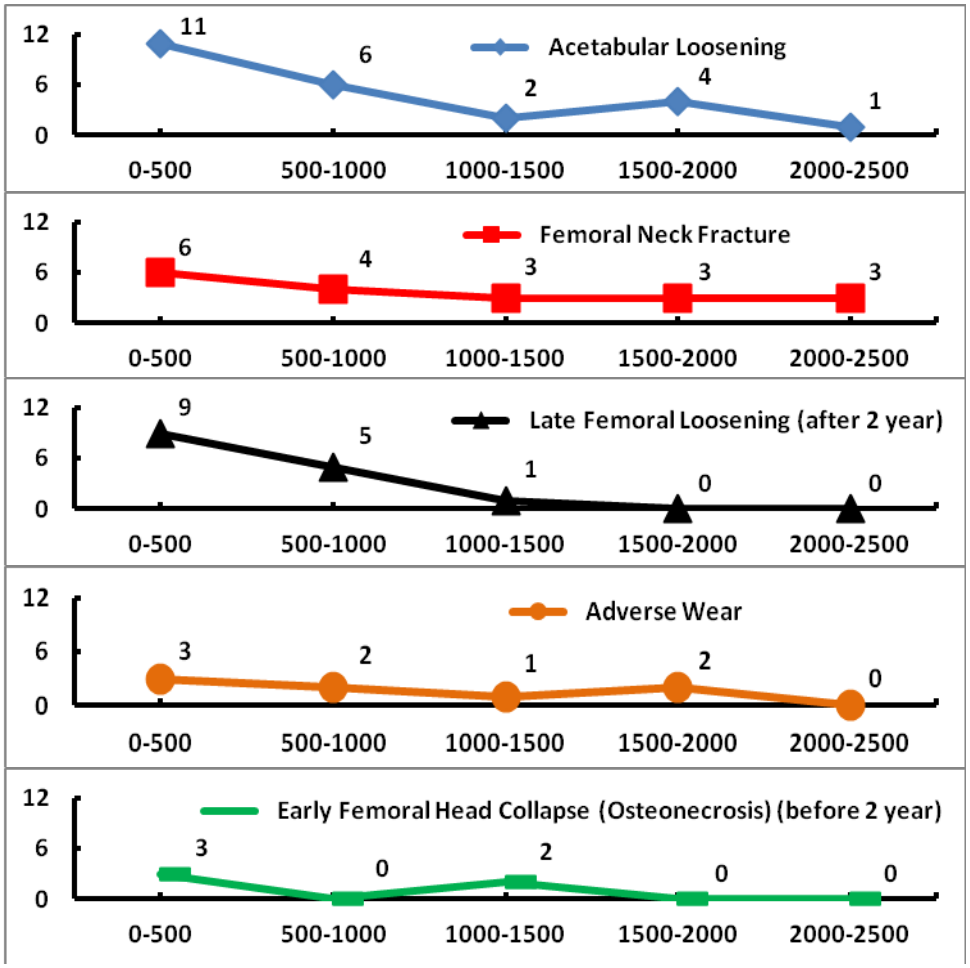

Table 5

Table 5: Summary of the surgical details grouped by modes of failures and revised components in the study group.

Grouped by Modes of Failure	***Number (total 58)***	***Length of Incision (in)***	***Estimated Blood Loss (mL)***	***Operation Time (min)***	***ASA Score***	***Hospital Stay (days)***
Acetabular Loosening	*16*	*5.3±1.5*	*476.3±452.1*	*140.4±44.6*	*1.8±0.7*	*1.6±0.9*
Femoral Neck Fracture	*16*	*4.3±0.8*	*286.7±162*	*83.9±11.8*	*1.9±0.5*	*2.5±0.8*
Late Femoral Loosening (after 2 year)	*11*	*4.5±1*	*222.7±155.5*	*100.7±17.3*	*1.6±0.5*	*1.8±0.5*
Adverse Wear	*7*	*4.9±0.7*	*271.4±89.5*	*122.3±16.8*	*1.7±0.5*	*1.2±0.4*
Early Femoral Head Collapse (Osteonecrosis) (before 2 year)	*4*	*4.0±0*	*262.5±75*	*97.3±18*	*2±0*	*1.5±0.7*
Deep Infection	*3*	*13.3±14.5*	*1066.7±503.3*	*202.5±4.9*	—	—
Significant groin pain	*1*	*4*	*100*	*103*	*2*	*1*
Grouped by Revised Component	***Number (total 58)***	***Length of Incision (in)***	***Estimated Blood Loss (mL)***	***Operation Time (min)***	***ASA Score***	***Hospital Stay (days)***
Acetabular Component Only	*17*	*5.4±1.4*	*432.1±440.6*	*136.4.4±40.9*	*1.6±0.5*	*1.4±0.7*
Femoral Component Only	*28*	*4.2±0.7*	*238.9±138.2*	*88.7±14.2*	*1.9±0.5*	*2.2±0.8*
Both	*13*	*6.7±7.1*	*525.0±404.9*	*139.3±41.0*	*1.9±0.6*	*1.5±0.6*