

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

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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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6 metal-on-metal type including in all seven AWRF cases; three cases were revised to ceramic-on-
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14 **Introduction**

15 Metal on metal hip resurfacing arthroplasty (HRA) has shown mixed results: while some
16 surgeons have shown excellent medium to long-term results, others have not been so successful
17 [1-7]. The technique of hip resurfacing is significantly different from stemmed total hip
18 arthroplasty (THA) and a long learning curve exists for this new method [2]. While many failure
19 mechanisms are similar to those of THR, some of the failure modes are distinctly different, such
20 as femoral neck fracture [8]. As we learn more about this new technique, we are also learning
21 how to prevent some of these failures and improve the outcome of HRA. This is demonstrated by
22 our latest results that show a 97.4% survivorship at 5 years with 1000 uncemented HRA [3].

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

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

36 [12, 13]. And, laboratory simulation has demonstrated that acetabular components placed too
37 steeply results in edge loading and a much higher wear rate [11, 14].

38 Bone preservation of HRA theoretically would make revision surgery less complicated. However,
39 this has only been shown for isolated femoral revisions [15]. On the other hand, revision of
40 AWRF has had a poor outcome due to poor clinical score, muscle damage, instability and even
41 nerve injury [10, 16]. Extensive debridement and change to non-metal bearing implants has been
42 recommended, but the outcome of this recommendation has been poor [10]. Because we believe
43 that the causative problem in AWRF is acetabular component malposition (leading to edge
44 loading, excessive wear and metallic overload of the tissues) rather than metal allergy; we
45 pursued an alternative strategy to revise these: limited debridement combined with repositioning
46 a new large metal bearing acetabular component. There are two possible options to accomplish
47 this goal; isolated acetabular revision and revision of both components to a new large bearing
48 THA. However, when the femoral resurfacing component is retained (as in isolated acetabular
49 revision), it is not known whether the wear scar on the femoral component will be tolerated.

50 When a THR construct is used, the head can be changed but one has to be confident that the
51 trunion design of the new THR is adequate. We realize that there is now great controversy in
52 using any large metal bearing in combination with a femoral stem, because a higher failure rate
53 due to trunion corrosion has been reported with many of these constructs. Many of our revisions
54 were done before this became known. But we have not encountered any trunion failures with
55 either the Corin or Biomet designs that we used. Also, Lavigne has shown significantly lower ion
56 release using the unique Biomet Magnum trunion design [17]. Therefore, we believe this design
57 gives us the best combination of hip stability and trunion stability. We have only revised to a
58 non-metal smaller bearing if acetabular fixation cannot be achieved with a large metal bearing or

59 when the diagnosis of AWRF is not clear and we suspect severe allergy may be the cause of
60 failure. This is rare in our experience.

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

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

76

77 **Materials and Methods**

78 Institutional Review Board approval was obtained for the present study. Between May 2001 and
79 August 2011, a single surgeon (T.P.G.) performed 2497 (*1815 in male vs. 682 in female; 72.7%*
80 *vs. 27.3%*) metal-on-metal HRA cases in 2060 patients (minimum 2-year follow-up) including
81 those performed in his learning curve of this surgical technique [2]. Three different implants

82 were utilized in the entire group: Hybrid Corin Cormet 2000 (Corin, Cirencester, UK) in 373
83 cases from March 2001 to March 2005; Hybrid Biomet Recap (Biomet, Warsaw, Indiana) HRA
84 in 740 cases from November 2004 to August 2008; and uncemented Biomet Recap in 1384 from
85 March 2007 to August 2011. 87 of these 2497 cases (3.5%) were revised at the time of this study.
86 Of these 87 revisions, 67 (77%) cases were revised by the same surgeon, while the remainder
87 were revised elsewhere. 59 (88%) of these 67 revision cases have reached their minimal two-
88 year follow up, only one of them was lost to follow-up at time of this study. Therefore , 58 cases
89 formed the current study group. The causes for revision of HRA were listed in Table 1. The
90 primary causes for revision were acetabular component loosening, femoral neck fracture,
91 femoral component loosening, and adverse wear related failure (AWRF). The demographics for
92 the study group are listed in Table 2. Women had significantly higher failure rate than men. (30/
93 682 vs. 28/1815; 4.4% vs. 1.5%) ($P<0.001$). The underlying causes for this appears to be a
94 higher incidence of dysplasia in young women and the fact that smaller bearing sizes are
95 required in women [19, 20].

96 We define AWRF as an inflammatory reaction around hip implants caused the presence of wear
97 debris [11]. In metal-on-metal bearings, the debris is cobalt-chrome particles. The preoperative
98 triad of elevated blood ion levels, a steep acetabular inclination angle (AIA), and a fluid
99 collection on three-dimensional imaging is confirmed by a grey metalosis at the time of revision.

100 As is the case with other causes of joint replacement failure, there may be multiple combined
101 reasons for failure. Infection must always be ruled out. Loose implants can cause inflammatory
102 reactions and some metalosis due to backside wear debris.

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

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

111 Femoral revision was uncomplicated. In isolated femoral revisions, the neck was trimmed and an
112 uncemented primary femoral stem and head were implanted. The head was of the same brand
113 and matched the bearing size of the acetabular component. In Corin cases, the C-fit stem was
114 used; in Biomet cases, the Mallory, Taperloc and Taperloc microplasty stems were used. We
115 encountered no femoral ingrowth or trunion failures with these designs; therefore, no further
116 analysis was performed. In isolated acetabular revisions, revision was more difficult. Limited
117 enhanced fixation options exist for resurfacing acetabular components. Typically, thicker walled
118 components with spikes were used. In some cases, fixation was not possible without moving to a
119 larger bearing size; therefore, femoral revision was then required at the time of revision. In
120 AWRP cases , a thick grey membrane containing the metalosis could always be carefully peeled

121 from the remaining soft tissues leaving muscle groups and even the hip capsule intact and
122 undamaged. Even lesions tracking into the pelvis along the psoas could be peeled out through the
123 hip joint. Our goal was to remove 90% of the metallic load, but not to perform a tumor operation.
124 Whenever possible, we reconstructed with another large metal bearing in a more horizontal
125 position if adequate acetabular fixation could be achieved.

126

127 **Results**

Revision Of Metal-On-Metal Hip Resurfacing

128 Kaplan-Meier survival rate of the entire revision cohort was 96.6% at five years (31/58 have
129 reached their five year follow-up.) using failure of any component for any reason as the end
130 point. The mean follow-up after the HRA revision was 5.2 ± 2.6 years (2-11.4 years). The average
131 Harris hip score was 92 ± 14 (range: 45 to 100) at the latest follow-up. The mean UCLA activity
132 score was 6 ± 2 (range: 2 to 10).

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

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

151 recurrent dislocation (12.5%, 2/16) were in this group. There was no significant difference found
152 between the other groups.

153 Without including the seven AWRF cases, the metal ion results at minimal two-year follow-up
154 were available for 35 cases. The average Co level was 2.5 ± 2.0 ug/L (range: 0-6.8) and the Cr
155 level was 1.6 ± 1.2 ug/L (range: 0-3.8). Clinical data are listed in Table 3 for the entire group. All
156 revision cases had three intraoperative cultures taken. These were negative except in the three
157 cases that were revised for infection. All seven cases revised for AWRF had extensive grey
158 metalosis seen in surgery. There was no significant metalosis seen in the remainder. A cell saver
159 was used in 30 cases with an average of 167 ± 154 ml (range: 45-800) blood returned. The
160 surgical data is listed in Table 5.

161 In eight cases that might have been classified as pseudotumors by others, there were seven cases
162 that satisfied our criteria for AWRF with ion levels elevated above 10ug/L, AIA > 50° on
163 standing pelvis radiographs and a fluid collection/mass on three dimensional scanning;
164 confirmed by the finding of metalosis at the time of revision surgery. There was one case with
165 suspected allergy that had an extensive inflammatory mass, ion levels below 10ug/L and no
166 metalosis. Detailed information of the seven AWRF were previously reported [11]. All AWRF
167 cases and the possible allergy case had 3 negative intraoperative cultures. All the AWRF cases
168 were revised to another large metal bearing with improved acetabular component position. In 4/7
169 (57%) only the acetabular component was revised. There were no complications in the AWRF
170 group. There were no sciatic palsies, no dislocations, no transfusions, no permanent limp, and no
171 recurrent inflammatory lesions. Ion levels improved in all patients and CT scans at 3-12 months
172 postop showed absence of fluid collection or mass in all the cases. 5/7 cases of AWRF had a

173 metal on metal hip bearing on the opposite side, which continued to function well, and had no
174 fluid collection on 3-dimensional scanning.

175

176 **Discussion:**

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

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

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

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

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

213 Even though the incidence of AWRF is low in most series [11], the highly publicized terrible
214 outcomes of revision for AWRF [10] and the legalities surrounding metal bearing failure with
215 two implant recalls have made many surgeons nervous about using these implants. A general
216 impression among surgeons that “all metal bearings are bad” and that failures are random have
217 taken hold. Frequently, the cause of failure is not accurately diagnosed, but a revision is
218 performed for “metal problems”. The problem with the DePuy ASR implant was that there were

219 many cases of acetabular ingrowth failure as well as many AWRP with this system. There were
220 likely many cases with both diagnoses. In these cases, it was difficult to make one specific
221 diagnosis; therefore it is understandable that accurate diagnoses were often not possible for
222 DePuy ASR failures. In our experience with the Corin and Biomet cases this is not true. From
223 our previously published series as well as in this current report, it is clear that in most cases an
224 accurate diagnosis can be made preoperatively and confirmed by surgical findings. We had only
225 one case of unexplained swelling resulting in the diagnosis of exclusion of “metal allergy”.

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

Revision Of Metal-On-Metal Hip Resurfacing

242 Several reports have indicated that revision of HRA is less complicated and more successful than
243 revision of primary stemmed THR [15]. While this seems to be true when only the femoral
244 component is revised, it has not been the case with revision of HRA for AWRP [10, 16]. The
245 main complications with revision for AWRP appear to be instability (16-19%) and nerve injury
246 (0-19%). Extensive debridement has been recommended for these cases, because of the fear that
247 allergy is a causative factor. Changing to implants that do not contain cobalt chromium or nickel
248 has been advocated. Extensive debridement likely leads to the high rate of nerve injury.
249 Extensive debridement combined with mechanically compromised smaller bearings lead to
250 instability.

251 In DeSmet's series [16] of 42 revised HRAs, cause of revision also did not influence the
252 outcome of revision. Mean Harris hip score was 90/100. Mean follow-up was 2.7 years (1-7.3).
253 64% of failures were due to acetabular malposition. 29% had metallosis, 17% had osteolysis.
254 Overall 4/42 cases (10%) required a second revision. When the femoral or acetabular component
255 was revised alone, retaining the large metal bearing, the rate of complications was low. In 12
256 patients revised for acetabular malposition, extensive metallosis was seen requiring "extensive
257 soft tissue resection". In 25 /42 cases a revision to a smaller ceramic-ceramic bearing THR was
258 performed. 20% of these had a complication and 16% of these suffered dislocations. A single
259 experienced resurfacing surgeon performed all revisions with a mean time between primary and
260 revision surgery of 2.2 years (0.1- 6.3).

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

Revision Of Metal-On-Metal Hip Resurfacing

265 recurrent dislocations, 1/16 (6%) femoral artery injury, and 2/16 (13%) loose acetabular
266 components. 75% of patients required transfusion. Major complications were seen in 50% and
267 5/16 (31%) required repeat revisions). 13 different surgeons performed the revisions with a mean
268 time from primary surgery to revision of 1.59 years (0.01-6.69).

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

275

276 In conclusion we find:

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

- 286
- Metal allergy remains a rare diagnosis of exclusion in cases of inflammatory reactions
- 287
- around implants.

288

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1 **Table 1:** Detail information about the causes of the failures in the study group.2
3
4
5

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

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

<i>Variables</i>	<i>Number</i>	<i>Percentage</i>
<i># of Cases</i>	58	—
<i>In women</i>	30	51.7%
<i>In men</i>	28	48.3%
<i># of Patients</i>	55	—
<i>Female</i>	29	52.7%
<i>Male</i>	26	47.3%
<i>Deceased</i>	0	—
<i>Diagnosis</i>		
<i>Osteoarthritis</i>	33	56.9%
<i>Dysplasia</i>	11	19.0%
<i>Avascular Necrosis</i>	6	10.3%
<i>Post-trauma</i>	3	5.2%
<i>Others</i>	5	8.6%
<i>Implant Brand(primary surgery)</i>		
<i>Cemented Corin</i>	24	41.4%
<i>Cemented Biomet</i>	17	29.3%
<i>Uncemented Biomet</i>	17	29.3%
	<i>Average</i>	<i>Range</i>
<i>Age at primary surgery (yr)</i>	50±11	12-65
<i>Time (revision) after primary surgery (yr)</i>	2.8±2.8	0-8.5
<i>Femoral component size (mm)</i>	49±5	40-58
<i>BMI (kg/m²)</i>	28±5	19-51
<i>T-score</i>	-1±1	-2- 2.3

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

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

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Revision Of Metal-On-Metal Hip Resurfacing

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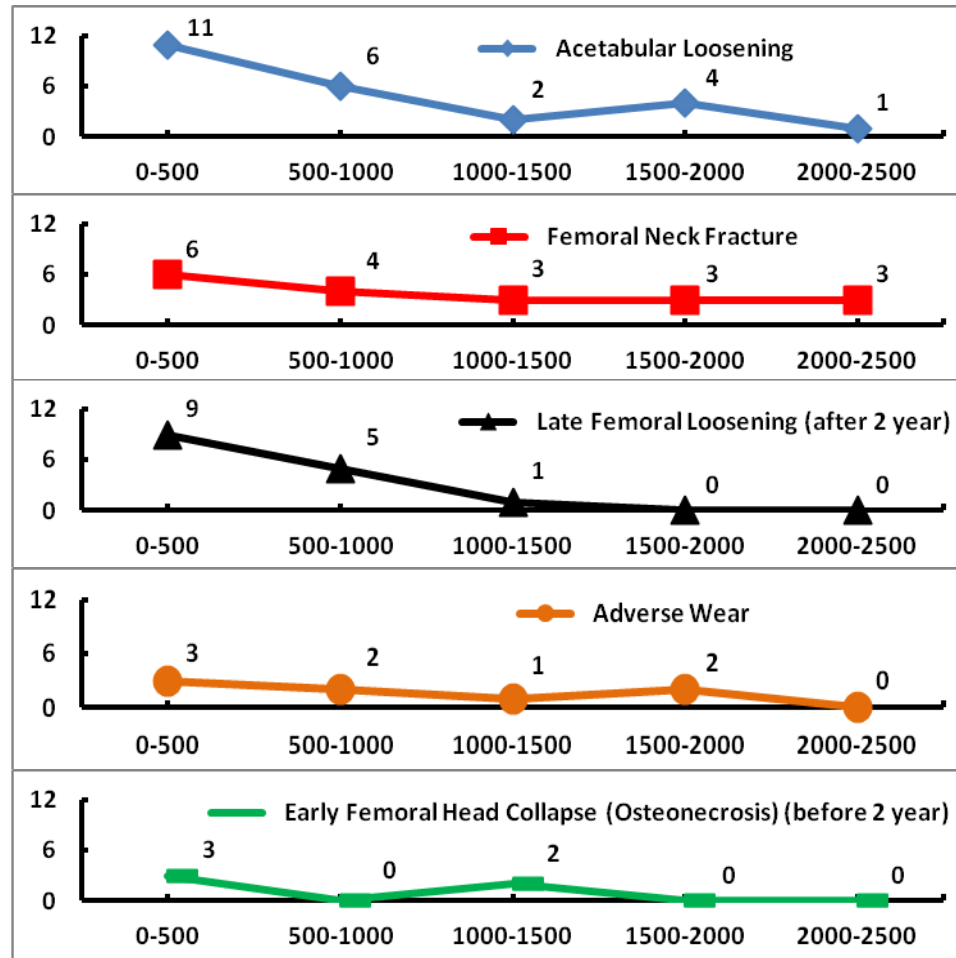


Table 5: Summary of the surgical details grouped by modes of failures and revised components in the study group.

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