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Metal ion levels comparison: Metal-on-metal hip resurfacing vs total hip arthroplasty in patients requiring revision surgery

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1. Introduction

In 2018, we are now well aware of both the complications and the implications of revision surgery in metal-on-metal (MoM) hips. There were over 60,000 metal-on-metal hips implanted in the United Kingdom. We are dealing with these failures and the revisions which are causing a huge drain on the National Health Service in the United Kingdom. The initial perceived advantages of preserving bone stock and improved stability (due to the increase jump distance) has been overshadowed by the generation of metal ions. The increased levels of both cobalt and chromium levels in these patients have led to adverse reactions to metal debris (ARMD) and the formation of pseudo-tumours (as shown in Fig. 1). This eventually leads to aseptic loosening and failure of the implant.

In the large diameter resurfacing bearings it is postulated that the primary wear occurs at the articulating surface. In the arthroplasty group, in addition to wear at the articular surface there is also wear that occurs at the trunnion due to corrosion. The modularity increases the number of metal ions generated, specifically Cobalt, at the taper junction. This was also reported in a study specifically looking at metal ions generated at the head-neck-taper junction.[1]

Larger heads were initially introduced in total hip arthroplasty in order to deal with the risk of dislocation and also to give patients a greater arc of movement. Head size has been implicated as a source of failure in metal-on-metal hips. Langton et al.[2] highlighted excess wear in the articular surface replacement. This was especially higher in the ASR implants which underwent 'edge loading' as a result of the smaller area of coverage between the acetabular and femoral components. Shimmin et al.[3] in their study reported that the smaller head size ($\leq$44 mm) components had a five time higher risk of failure than the larger head sizes ($\geq$55 mm). They believed that this was due to the fact that the larger head sizes were more forgiving of mal-alignment resulting in less edge-loading. This caused less wear particle generation and ARMD.

However, Garbuz et al.[4] in their study compared large head THA patients with hip resurfacing. They found that there were higher levels of cobalt and chromium ions generated in the large head THA group as opposed to the resurfacing group. He recommended that we avoid using large head THA. This was using the Durom system. Currently there is no role for the large head metal-on-metal THA.

The Medical and Health Regulation Agency (MHRA) has recommended that all patients who have undergone a MoM hip are followed up locally to undergo an annual review of their blood metal ion levels. It is recommended that patients with metal ion levels of more than 7 parts per billion (ppb) are monitored closely for ARMD. A high-risk group of patients were identified by the MHRA in 2017, as women that have undergone a resurfacing procedure, men who have had resurfacings with small femoral heads ($\leq$48 mm) and any stemmed replacements with femoral heads $\geq$36 mm. These patients require annual follow up even if asymptomatic.

Our study follows up 890 patients that underwent a resurfacing or arthroplasty between the years of 2009 and 2014. In our follow-up of 3–9 years we found that 110 of these patients required a revision procedure. We specifically analysed this subgroup of patients that underwent a revision procedure. The primary aim of the study was to assess the difference in metal ions generated between the arthroplasty group (36 mm MoM Pinnacle - Corail THA system) and resurfacing group (ASR, Birmingham & Cormet Hip Resurfacing). These patients were all symptomatic patients that had either high metal ion levels or MRI scans revealing ARMD. It was postulated that the total hip arthroplasty group will have more metal ions generated as a result of both wear particles generated at the articular surface and the trunnion.

2. Materials and methods

As mentioned earlier, every Trust has to maintain a database of all patients that underwent a Metal on Metal hip replacement. In my local Trust, there were over 600 patients that had undergone a hip replacement with this type of bearing surface. This large series of patients who underwent a revision procedure for a MoM implant locally was reviewed retrospectively from the senior author's database. There were 110 patients that were identified that underwent a revision procedure for failed MoM hip. The database was then used to extract basic demographic information regarding the patients. These were mapped on

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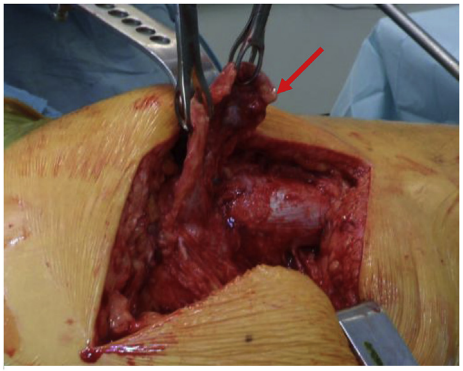

Fig. 1. Intra-operative picture showing a PSEUDOTUMOUR.

an Excel spreadsheet. No personal confidential information was extracted. iLab software used to collect each patient's blood results was used to extract serum cobalt and chromium levels prior to patients undergoing a revision operation. Patients with renal failure or the Metsul resurfacing prosthesis were excluded. Patients that underwent the Pinnacle THA were compared against those that underwent the Birmingham/Cormet or ASR Resurfacing.

2.1. Patient demographics

There were 105 patients that met the above criteria. Among them, 50 had received a resurfacing prosthesis and 55 a total hip arthroplasty. The mean age of the patients (shown in Fig. 2) in the resurfacing group was 63.12 years (range 40–77 years) and in the THA group was 67.98 years (range 33–86 years). There were 29 females and 21 males in the resurfacing group and 34 females and 21 males in the THA group. The primary cause for undergoing a revision procedure was documented (as seen in Fig. 3 below). Majority of patients were revised for pain and formation of pseudotumour which had been reported on MRI scans.

2.2. Surgical procedure

All procedures were performed by one of the two senior authors. Majority of them were performed using a 'Hardinge approach'. There were only 4 THA's and 2 Resurfacing's which were performed using the 'Posterior approach'. The Birmingham Hip (Smith & Nephew, London, UK), the Cormet (Stryker & Corin) and the Articular Surface Replacement were the resurfacing prosthesis used. The DePuy Corail was the THA implant of choice.

2.3. Metal ion analysis

All blood samples were taken from the ante-cubital fossa with a tourniquet using vacutainer tubes by a phlebotomist in the same Trust.

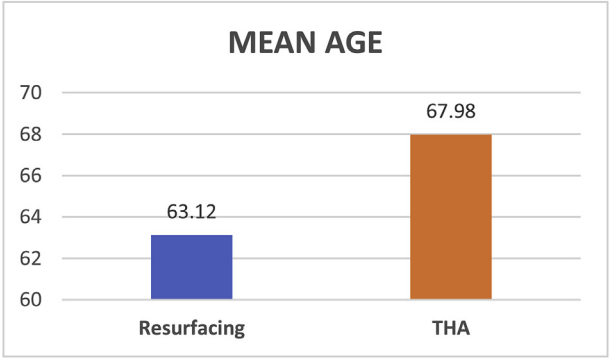

Fig. 2. Mean patient age.

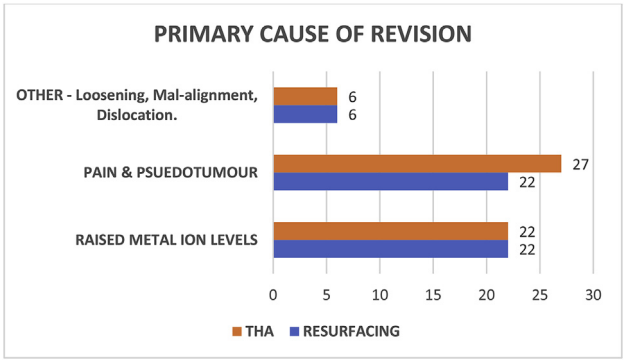

Fig. 3. Cause of revision procedure.

They were analysed using inductively coupled plasma mass spectrometry. This allows a high level of analysis which is extremely sensitive. The cobalt and chromium levels have been expressed in parts per billion (ppb) where 1 ppb is equivalent to 1 μg per litre (ug/L).

2.4. Data and statistics

All the data was collected retrospectively and analysed using Microsoft Excel for Mac and SPSS software. Independent sample t – tests were used to compare means of normal distribution. Statistical significance was determined with a p-value < 0.05 (95% Confidence Interval).

3. Results

The average time between the primary procedure and the revision was 7.13 years (Resurfacing) and 7.01 years (THA) for the two groups. The Pre-Op OHS was 30.06 in the Resurfacing group and 32.00 in the THA group.

We found that the mean Cobalt ions levels in the Resurfacing group and THA group were 28.23 ppb and 24.00 ppb respectively. The Chromium ion levels were 19.67 ppb and 13.24 ppb respectively. Both the Cobalt and Chromium levels were slightly higher in the Resurfacing group as opposed to the THA group. These are shown in Table 1. However, there was no statistically significant difference.

We believed this could be due to the fact that there were 6 ASR's included in the Resurfacing group, which are known to have a higher failure rate as mentioned previously. We then analysed the results after having excluded the ASR's. As expected, the mean Cobalt and Chromium levels came down to 18.29 ppb and 11.39 ppb. These are shown in Table 2 and Fig. 4. However, again there was no statistically significant difference ($p < 0.05$) noted between the two groups.

4. Discussion

There have been a few studies comparing metal ion levels in various prosthesis. However, it has been difficult to explain why some people have extremely high metal ion levels and others do not. There are no reports of our knowledge comparing metal ion level in patients that have required a revision procedure for their metal–on–metal hips. This

Table 1
Metal ion Levels (ppb) - Resurfacing vs THA.

	Type of Prosthesis	N	Mean	Std. Deviation	Std. Error Mean
Cobalt	Resurfacing	50	28.236018	44.2915093	6.2637653
	THA	55	24.004927	29.0656049	3.9192054
Chromium	Resurfacing	50	19.67368	29.583052	4.183675
	THA	55	13.24187	13.363742	1.801967