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Original Article

Comparison of metal ion levels in patients with hip resurfacing versus total hip arthroplasty

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ABSTRACT

Mechanical wear at the articular surface and corrosive processes at modular junctions, such as the trunnion, are responsible for metal ions production. We retrospectively reviewed 64 patients who underwent THA with a metal on metal bearing surface and 34 patients with hip Resurfacing. Metal ion measurements, six-week post-op radiographs, and functional scores were included in the analysis. Cobalt ion levels were significantly elevated in THA patients, 2.95 μg/L as compared to resurfacing patients, (2.95 versus 1.30 μg/L, $p < 0.0005$). Chromium levels were not significantly different between THA patients and resurfacing patients (1.05 versus 1.00 μg/L, $p = 0.529$).

1. Introduction

While metal on metal hip replacement had been attempted in the past, this bearing surface enjoyed another wave of popularity relatively recently which has since faded. There are notable advantages to this bearing construct that include allowing for a larger head size and potentially more durable bearing surface. With larger heads there are reduced dislocation rates, a greater jump distance of the femoral head, and a greater head-to-neck ratio that reduces impingement and increases range of motion.[1–4]

However, these devices have also been associated with increased local and systemic metal ion levels,[5] in some cases resulting in adverse local tissue reactions and pseudotumor formation.[6–8] Metal ion generation with these implants has been attributed to multiple sources, with wear at the articulation initially believed to be the predominate source. However, the trunnion of modular THA implants (Fig. 1) is increasingly being recognized as a source of metal ions (Fig. 2), seen even in more conventional metal on polyethylene bearing surfaces.[9–13] Corrosion mechanisms have been proposed, but there are still no definitive answers. It is generally accepted that a combination of mechanical forces strip away the protective passive oxide layer on the metal surface, which exposes the underlying susceptible alloy to electrochemical reactions with the acidic synovial fluid.[14,15] It is theorized that the mechanical forces are due to micromotion from an imperfect union at the metal-to-metal junction of the taper, which is complemented with torqueing forces by the femoral head.[15] This concept explains the metal ion generation in some modular THA implants and the potential effect of head size on these ion levels.[16]

The purpose of this study was to compare metal ion levels, revision rates, and functional outcomes in patients with either conventional metal on metal THA or hip resurfacing, in constructs utilizing identical acetabular components, and similar femoral implants. We hypothesized that metal on metal hip total hip replacements would have higher ions levels than hip resurfacings as a result of metal ion generation at the trunion.

2. Materials and methods

A consecutive series of patients undergoing THA or hip resurfacing between October 2006 through April 2012 were retrospectively reviewed following IRB approval. Patients lacking metal ion measurements, follow-up less than one year post-operatively, THA implants other than DePuy Corail, or a diagnosis of renal disease were excluded. Patients with bilateral hip implants of any design were also excluded. A minimum of 1-year follow up was required to avoid the run-in period found in hip implants, which is characterized by elevated metal ion levels during the 1st year, which stabilize thereafter.[17,18] There were 273 arthroplasty patients with 306 hip implants and of these, 98 patients met the inclusion criteria. Of the patients that were excluded, 63 were due to lack of ion measurements, 7 were due to presence of renal disease, 11 for only having ion measurements within one year of the index procedure, 39 had THA implants other than DePuy Corail, and 55

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Fig. 1. Anteroposterior radiograph of a DePuy Corail THA implant. These implants feature modularity between the femoral stem and head components to allow for better implant sizing to the patient intraoperatively. The trunnion is the continuation of the thin metal component, which is functioning as the femoral neck in this radiograph, into the body of the femoral head.

Fig. 2. Intraoperative photo of revision arthroplasty due to metal complications related to trunnion corrosion. Note the black deposits on the trunnion surface that are characteristic of corrosion.

had bilateral hip implants.

This consisted 64 total hip arthroplasty patients, of which 39 patients were male and 25 were female. The resurfacing group contained 34 patients, which included 29 males and 5 females. The mean age of patients in the THA group was 70 years (range, 38–93 years old) and the resurfacing group was 60 years (range, 45–76 years old). Median BMI for the THA group was 32.1 kg/m^2 (range, 20.3–60.1 kg/m^2) and the resurfacing group was 30.5 kg/m^2 (range, 17.6–44.0 kg/m^2). The median follow-up interval for metal ion measurements was 3.12 years (range, 1.00–6.27 years) in the THA group, 3.12 years and 4.36 years (range, 1.10–8.27 years) in the BHR group, ($p = 0.017$). Demographic data for each group is summarized in Table 1.

2.1. Surgical procedure

All procedures were performed using the posterior approach by the senior author. Total hip arthroplasty constructs consisted of a Corail stem (Depuy, Warsaw, IN), with a Birmingham femoral head and cup (Smith & Nephew, London, UK) All hip resurfacings were the Birmingham Hip Resurfacing (Smith & Nephew, London, UK).

Table 1
Summary of demographic data between BHR and THA. [a] Independent Samples *t*-test, [b] Mann-Whitney *U* test, [c] Chi-squared test, [d] Fisher's Exact Test.

	BHR ($n = 34$)	THA ($n = 64$)	*p*-value
Mean Age (years)	60 (45–76)	70 (38–93)	< 0.0005[a]
Median BMI (kg/m^2)	30.5 (17.6–44.0)	32.1 (20.3–60.1)	0.550[b]
Sex (males)	85.30% (29/34)	60.90% (39/64)	0.013[c]
Reason for arthroplasty			0.258[d]
Arthrosis	33	53	
Hip Dysplasia	1	2	
Avascular Necrosis	0	6	
Acetabular Fracture	0	1	
Femoral Neck Fracture	0	2	

2.2. Metal ion analysis

Blood samples were drawn from the antecubital fossa and collected in three EDTA containing royal blue-top tubes; the first draw discarded to rinse possible contaminants from the needle. Chromium samples were stored in EDTA royal-blue top tubes and sent to Quest Diagnostics (Valencia, CA) for analysis. Cobalt samples were centrifuged after collection then transferred to a metal free plastic vial and sent to Quest Diagnostics (Chantilly, VA) for analysis. All samples were analyzed using inductively coupled plasma mass spectrometry (ICP/MS). Reference ranges were reported as 0.1–0.4 μg/L for cobalt and ≤1.2 μg/L for chromium. Ion measurements that were below the limit of detection were arbitrarily set to half of the limit of detection. This allowed for inclusion of patients with undetectably levels in the statistical analysis. This method did not affect the findings since these values were reported as medians. Ion levels from the most recent blood draw were included for the statistical analysis with all previous metal ion measurements being excluded.

2.3. Radiographic methods

Anteroposterior radiographs were taken six weeks post-operatively. Acetabular inclination angles were measured using the inter-teardrop line technique; the angle measured between a horizontal line connecting the inferior tip of the teardrops and a line that paralleled the acetabular cup on AP radiographs.[19] Harris Hip Scores (HHS) and Western Ontario & McMaster Universities Index (WOMAC) scores were obtained on routine follow up appointments. Most recent scores were included for analysis.

2.4. Statistics

All statistics were calculated using SPSS 23 (IBM; North Castle, NY). Independent-samples *t*-test was used to compare means of normally distributed data. Medians were compared using the Mann-Whitney *U* test and the Kruskall Wallis H test non-normal data. Normality of data was tested using Q–Q plots and Shapiro-Wilk test. Group associations were analyzed using the X^2 test. Statistical significance was determined with a *p*-value < 0.05.

3. Results

Metal ion levels from most recent blood draw measurements and implant placement data are summarized in Table 2. Median whole blood cobalt levels were significantly higher in the THA group, 2.95 μg/L (range, 0.60–31.90 μg/L), than the BHR group, 1.30 μg/L (range, 0.80–19.60 μg/L), ($p < 0.0005$). There was no significant difference in the median whole blood chromium levels between the THA group, 1.05 μg/L (range, 0.10–9.10 μg/L), and the BHR group, 1.00 μg/L (range, 0.10–10.20 μg/L), ($p = 0.529$). Mean femoral head size was slightly larger in the BHR group, 49.4 mm (range, 42–58 mm), than the