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Metal Ion Levels Post Primary Unilateral Exeter Total Hip Arthroplasty

Please note that:

1) All authors have participated in the research

2) The article has not been submitted elsewhere

3) Institutional review board approval and informed consent have been received

4) In relation to this study the authors have no conflicts of interest or financial declarations

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METAL ION LEVELS POST PRIMARY UNILATERAL EXETER TOTAL HIP ARTHROPLASTY

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ABSTRACT

BACKGROUND: Metal ion release is common following total hip arthroplasty, yet postoperative levels have not been defined for most stems currently used in clinical practice.

AIM: To assess metal ion release in the serum of patients with well functioning unilateral Exeter V40 primary total hip arthroplasties one year after surgery.

METHODS: Whole blood chromium and serum cobalt levels were measured in 20 patients following primary total hip arthroplasty with the Exeter V40 stem and a variety of acetabular components one year after surgery.

RESULTS: Whole blood chromium levels were within the normal range (10-100 nmol/L), with a single mild elevation of serum cobalt (normal < 20 nmol/L).

CONCLUSION: In well functioning primary unilateral total hip arthroplasty using the Exeter V40 stem with a variety of acetabular components one year post surgery, whole blood chromium levels are normal and serum cobalt elevations are rare and mild.

KEY WORDS: arthroplasty; hip; cobalt; chromium; ions; bone cements

INTRODUCTION

The release of metal ions following the implantation of a metallic device has been a well recognized phenomenon in orthopaedics for over fifty years now. (1-3) Various studies have shown raised levels of metal ions including titanium, nickel, cobalt and chromium in serum, blood clot and urine samples after implantation with alloys containing these metals. (4-6) Furthermore, a range of prosthetic devices have been implicated, including intramedullary nails and more commonly acetabular shells, femoral stems and femoral heads used in total hip arthroplasty. (6, 7)

In recent times, many studies have focused on metal ion release after total hip arthroplasty/resurfacing using metal on metal bearings, finding significantly elevated levels of cobalt and chromium. (7-11) However, metal ion release is not isolated to metal on metal bearings alone, with studies also showing elevated ion levels in conventional metal on polyethylene bearings as well, although to a much lesser extent. (4, 12-15) Various reasons have been provided explaining these elevated levels, with causes such as loosening and taper wear at either the neck-stem or head-neck interface being implicated. (12, 16-18)

There is as yet no accepted definition as to the so-called “normal” levels of metal ions following conventional total hip arthroplasty. Much variation exists in the timing, methods of testing used to detect metal ions levels and the types of prosthesis/fixation method involved. However, there is a consensus that the blood cobalt and chromium levels of patients with well-functioning metal on metal implants are approximately 34 nmol/L and 38.5 nmol/L, respectively. [19] The

expert advisory group of the Medicine and Healthcare Products Regulatory Agency (UK) has recommended monitoring of patients with metal ion levels greater than 119 nmol/L for cobalt and 134.5 nmol/L for chromium. [20] Adverse local tissue reactions have been correlated with mean serum cobalt levels of 162 nmol/L while pseudotumour formation has been reported at mean serum cobalt levels of 50.75 nmol/L. [16,18]

The Exeter V40 System (Stryker Orthopedics, Mahwah, NJ) which utilizes a modular design with separate femoral head and femoral stem components is currently the most commonly used cemented femoral system for total hip arthroplasty in Australia. (19) There are currently no studies that have examined metal ion release following the use of the Exeter V40 System for total hip arthroplasty. This study aimed to assess metal ion release in the serum of patients with well functioning unilateral Exeter V40 primary total hip arthroplasties one year after surgery to determine if metal ions are elevated.

MATERIALS AND METHODS

Patients for this study were recruited over a 10-month period from November 2011 until August 2012. Institutional review board approval was obtained. The recruitment was performed at routine one-year postoperative outpatient reviews. The inclusion criteria for this study were (1) one year post primary unilateral Exeter V40 total hip replacement (cemented femoral component with cemented or uncemented acetabular component), (2) no prosthesis or metalwork elsewhere, (3) Harris Hip Score > 80 and no signs/symptoms of infection, (4) no radiographical signs of loosening, (5) no

significant systemic diseases affecting metal metabolism (including chronic renal failure with eGFR < 30) and (6) no chronic exposure to metal ions (eg occupational). The aim of this study was not to make comparisons between groups thus a control group was not selected, and power calculations were not performed. An initial sample size of 20 patients was set.

All surgeries were performed by one of the two senior authors (RC, HE) at two separate institutions. The Exeter V40 femoral components inserted in all patients utilized an identical stainless steel alloy (Orthinox Stainless Steel – Chromium 19.5-22%, Nickel 9-11%, Manganese 2-4.25%, Molybdenum 2-3%, Niobium 0.25-0.8%, Silicon 0.75%, Copper 0.25%, Phosphorus 0.025%, Sulphur 0.01%, Iron for balance) for both the stem and head components. A modern cementing technique was the method of fixation in all cases. No limit on head size was defined, with the choice based on intraoperative factors such as stability and patient age.

The choice of acetabular component was based on surgeon preference. Thus, a range of components were used including the Exeter X3 Rimfit Cup (Stryker Orthopedics, Mahwah, NJ) in cemented fixation and the Fixa (Adler Ortho, Cormano, MI), Procotyl (Wright Medical Technology, Arlington, TN) and Trident (Stryker Orthopedics, Mahwah, NJ) components in uncemented fixation, all made from a titanium alloy (Ti6Al4V – Aluminum 5.5-6.5%, Vanadium 3.5-4.5%, Titanium for balance). Highly cross-linked ultra-high molecular weight polyethylene was used as the acetabular bearing surface in all cases.

Blood samples were tested for cobalt and chromium levels by Sullivan Nicolaides Pathology, Queensland. Samples were collected from patients into EDTA trace element vacutainers (Becton Dickinson, Franklin Lakes, NJ) using a stainless steel needle at a collection centre and transported to the laboratory at ambient temperature for analysis. Whole blood chromium was analysed first and plasma cobalt performed afterwards. Samples were diluted 1 in 20 with diluent and distilled water using a Starlet Robot (Hamilton Robotics, Reno, NV) by directly sampling from the barcoded EDTA trace element tube after thorough mixing. The diluted samples were vortexed and transferred to an Agilent 7500CE inductively coupled plasma mass spectrometer (ICPMS) equipped with Octopole reaction cells (Agilent Technologies, Santa Clara, CA) for analysis. Helium gas was used in the reaction cell for both chromium and cobalt analysis to reduce interference from polyatomic species formed in the plasma. The ICPMS counts for each analyte were processed using the Agilent 7500CE software. A calibration graph was constructed using the counts obtained from the ICPMS expressed as a ratio to the internal standard counts for each analytical run and specimen type. Quality control samples were run every 20 samples and their acceptability was checked. The patient sample results were calculated from the calibration graphs, and downloaded to the laboratory computer for authorization. Sullivan Nicolaides Pathology defined levels of <20 nmol/L for cobalt and 10-100 nmol/L for chromium as normal for an Australian population using the method of testing mentioned above. These “normal” levels are similar to the levels detected in the control and preoperative groups of other studies. (4, 5, 7, 8, 12, 13)

RESULTS

The final group of 20 patients consisted of 9 hybrid (4 Fixa (Adler Ortho, Cormano, MI); 4 Procotyl (Wright Medical Technology, Arlington TN); 1 Trident (Stryker Orthopedics, Mahwah, NJ) and 11 cemented (Exeter X3 Rimfit (Stryker Orthopedics, Mahwah, NJ)) total hip arthroplasties. There were 5 28mm, 8 32mm and 7 36mm heads used. Table 1 demonstrates the basic demographics, operative details and cobalt/chromium levels for all patients. The mean age at surgery was 70.6 years (SD 10.5) and the mean time of follow-up was 13.6 months (SD 1.4, range 11-17). The only abnormal result has been highlighted in bold. This slightly elevated result was not investigated further but the patient will continue to be followed up.

DISCUSSION

The results of this study show that at one year in well functioning primary unilateral total hip arthroplasty patients with an Exeter V40 stem and a variety of acetabular components, whole blood chromium levels are within the normal range. Mild elevation of serum cobalt was only seen in one case.

The metal ion levels found in this study are reassuringly low compared to a number of other studies that have been performed assessing metal ion release following hip arthroplasty surgery. The majority of these studies focus on metal on metal joint arthroplasty/resurfacing procedures, with metal on polyethylene bearings acting as a control. (7-11, 13-15) Only a few studies have concentrated on metal ion release following conventional metal on polyethylene total hip arthroplasty alone. Bartolozzi et al analysed serum and urine chromium levels in

the early (<30 days) postoperative period after cemented total hip arthroplasty, finding elevated levels in both samples types. An older femoral prosthesis was used in this study though, and the exact metal composition of the alloy used was not discussed. (4) Jacobs et al analysed serum and urine chromium concentrations, as well as serum cobalt, titanium and vanadium over a longer period (36 months), finding elevated levels throughout. (12) However, most patients in their study underwent uncemented femoral stem fixation and alloy metal composition was once again not discussed. Other related studies have assessed metal ions other than cobalt and chromium, such as titanium, aluminum and vanadium, almost consistently finding elevated levels. (12, 15, 20)

The mild elevation in serum cobalt found in one patient is unlikely to be related to the prostheses that were inserted, considering none of the alloys used contained any cobalt. A more likely explanation is the fact that cobalt is absorbed primarily via the gastrointestinal system, and thus various dietary factors can act to cause minor variations in serum cobalt levels, such as the one seen in this single patient. (21, 22)

The effect of chromium and cobalt ions on the human body is still under investigation. Nevertheless, hypersensitivity reactions, local soft tissue toxicity, bone loss, cardiac, endocrine and neurological symptoms have all been attributed to elevated levels of cobalt and chromium after total hip arthroplasty. (16, 18, 23) There is also evidence of harmful consequences from other fields, with reports of cardiomyopathy due to cobalt exposure in alcoholic cobaltism and industrial poisoning. (24) Although, the exact level and duration of metal ion

exposure required for a pathologic response is still difficult to determine, as well as the exact nature of this response, and further research needs to be undertaken to clarify this link further. (25)

This study concentrated on a single prosthesis of interest in order to minimise confounding factors where others have reported on several prostheses. (7, 10, 14, 15, 26) The aim of this study was not to make a comparison, but to provide a baseline to define so called “normal” levels in this specific population, which has not been previously investigated. The single time point for collection (one year postoperative) may arguably be a weakness of this study, but previous research has shown that steady state levels of metal ions are reached at approximately one year postoperative. (7, 8)

CONCLUSION

The results of this study show that in well functioning primary unilateral total hip arthroplasty using the Exeter V40 stem with a variety of acetabular components, at one year post surgery, whole blood chromium levels are within the normal range. Elevation of serum cobalt is rare, and if present, levels are only slightly elevated. These levels are reassuring considering the widespread use of the Exeter V40 System.

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Table 1: Basic demographics, operative details and cobalt/chromium levels for all patients.

Patient	Age	Time from Surgery (months)	Cobalt (nmol/L)	Chromium (nmol/L)	Head Size (mm)	Acetabular Component
1	83	15	<2	<10L	32	Stryker X3 Rimfit
2	74	13	3	<10L	32	Stryker X3 Rimfit
3	64	14	<2	<10L	32	Stryker X3 Rimfit
4	66	12	4	10	28	Stryker X3 Rimfit
5	76	15	<2	14	32	Stryker X3 Rimfit
6	71	12	<2	<10L	32	Stryker X3 Rimfit
7	75	15	**27**	<10L	28	Stryker X3 Rimfit
8	72	15	7	<10L	32	Stryker X3 Rimfit
9	56	17	3	<10L	28	Stryker X3 Rimfit
10	61	13	5	<10L	28	Stryker X3 Rimfit
11	53	14	<2	<10L	28	Stryker X3 Rimfit
12	73	11	5	29	36	Adler Fixa
13	66	12	<2	<10L	36	Adler Fixa
14	75	13	4	<10L	36	Adler Fixa
15	90	14	6	<10L	32	Adler Fixa
16	54	13	2	<10L	36	Wright Procotyl
17	77	12	3	<10L	36	Wright Procotyl
18	82	14	3	<10L	36	Wright Procotyl
19	85	14	3	<10L	36	Wright Procotyl
20	59	13	4	<10L	32	Stryker Trident

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