Metal Ions and Oxidative Stress Markers in Patients Following Metal-on-Metal Hip Resurfacings

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INTRODUCTION

Hip resurfacing continues to be a successful alternative to conventional total hip replacement in young patients with osteoarthritis. The metal on metal bearings in surface arthroplasty are associated with long periods of elevated ion circulation [1-3]. Given that hip resurfacing is generally reserved for young patients, it is essential to understand the systemic effect and clinical relevance of raised serum cobalt (Co), chromium (Cr) and molybdenum (Mo) levels. Implant size and orientation have been shown to increase circulating metal ions following hip resurfacing. However, little is known regarding the effect of different surgical variables on the concentration of metal ions in the blood of patients with resurfacings. The biological response to metal alloys is also poorly understood and can result in cellular toxicity [4,5], metal hypersensitivity [6-8], and chromosomal changes in vitro [9].

We measured different operative variables to determine their effect on the concentration of metal ions in the blood of patients after hip resurfacing. We also correlated the level of metal ions to the concentration of plasma oxidative stress biomarkers (total antioxidants, peroxides, and nitrated proteins) to assess the systemic effect of increased ions and the potential for oxidative stress damage.

METHODS

A total of 74 patients (61 Men and 13 Women) with complete data were prospectively followed after unilateral surface arthroplasty. The mean age at the time of surgery was 53 years (range, 38-73 years). Patients were followed at regular intervals and the data was collected at 1 year, 2 years, and latest follow-up. The average follow-up was 32 months (range, 24-54 months). Osteoarthritis was the main diagnosis in all the patients except for one who presented with hip dysplasia. The clinical outcomes were measured using the Harris Hip Score (HHS) and the University of California Los Angeles (UCLA) activity score. Institutional review board and informed consent were obtained for the purpose of this study.

The clinical and radiographic parameters consisted of component size and orientation, severity of osteoarthritis, evidence of loosening and heterotopic ossification. The levels of Co, Cr, and Mo ions were measured by inductively coupled plasma-mass spectrometry (ICP-MS). The ion levels were then correlated to the concentration of oxidative stress markers (total anti-oxidants, peroxides, and nitrated proteins) in the serum of patients. Whole blood was chosen because it is believed that certain metal elements, such as Cr, have an affinity for and can accumulate in red blood cells.

RESULTS

Both the HHS and UCLA outcome measures improved significantly compared to pre-operative scores. A larger head diameter and a larger cup diameter of the resurfacing resulted in lower levels of Co and Cr in blood of patients. However, the acetabular inclination, stem-shaft angle, and the version angle had no significant effect on the levels of Co, Cr and Mo. There was also no correlation between the concentration of metal ions and the level of plasma oxidative stress markers.

Figure 1: Increasing levels of Co and Cr levels following hip resurfacing.

DISCUSSION

CoCr particles are known to be toxic and result in reversible chromosomal changes. Co+ ions have been shown to be more efficient in inducing macrophage apoptosis than Cr+ ions. The pre-treatment of cells with cellular antioxidants decreased the toxicity Co particles, suggesting a role for reactive oxygen species (ROS) in the toxic mechanism of Co. The formation of ROS eventually results in increased DNA, lipid, and protein oxidation with subsequent cell and tissue damage. Metal ions can be deleterious to circulating cells. It is, therefore, imperative to understand the biological reactivity of metal particles and ions given the increasing popularity of metal bearings in young patients undergoing resurfacing.

The results of our study have shown that a larger head diameter and a larger cup diameter significantly decreased cobalt and chromium ion levels in blood of patients with hip surface arthroplasty. However, the acetabular inclination and stem-shaft angle had no effect on the concentration of metal ions. The increased production of metal ions did not change concentration of total antioxidants, peroxides, or nitrated proteins.

REFERENCES