Surgical Variables Affect Metal Ion Levels in Blood of Patients with Articular Surface Replacement

+Antoniou, J; Petit, A; Mwale, F; Zukor DJ; Huk, OL.
Division of Orthopaedic Surgery, McGill University and Lady Davis Institute for Medical Research, Montréal, QC, Canada.
Senior author: janton@orl.mcgill.ca

INTRODUCTION
Like all arthroplasties, the survivorship of hip resurfacing is a function of design, patient, and surgical variables. In recent clinical studies, implant position, stem orientation, and fixation of the femoral component have been associated with disappointing results. Other studies suggest that a valgus orientation decreases the risk of peri-prosthetic femoral neck fracture [for review see 1]. The latter also brings into question the use of an absolute angle for all patients. Obtaining the maximum possible valgus angle, while avoiding notching, may in fact provide the optimum protection from peri-prosthetic femoral neck fractures. On the other hand, due to elevated cobalt (Co) and chromium (Cr) ions in blood of patients with metal-on-metal hip resurfacing, metal ion toxicity, hypersensitivity, and carcinogenicity are also a cause for concern. However, little is known about the effect of surgical variables on the concentration of circulating metal ions. The present study investigated the effect of head diameter, acetabular inclination, and pin-shaft angle on the concentration of Co and Cr in the blood of patients with hip resurfacing.

MATERIALS AND METHODS
From January 2004 to March 2005, all patients with a diagnosis of non-inflammatory degenerative joint disease and having a primary hip resurfacing [ASR®, DePuy Orthopaedics] by one of the three orthopaedic surgeons from our institution were considered for entry in the study. The study was approved by our Institutional Review Board. All laboratory analyses were performed by personnel blinded to the protocol. Patients were assessed at 1 year (86 patients) and 2 years (52 patients) follow-up visits. All patients were doing well at their follow-up visits and no sign of osteolysis was observed on X-rays. Both the acetabular inclination and the pin-shaft angle were measured on X-ray by a blinded observer.

Blood samples were collected into Sarstedt Monovette® tubes for trace metal analysis with 21G needles also specific for trace metal analysis (Sarstedt, Montreál, QC) and kept at -80°C until analysis. Levels of Co, Cr, and Mo were determined by inductively coupled plasma-mass spectrometry (ICP-MS) on a Perkin Elmer SCIEX Elan 6100 DRC at the Geochemical Laboratories of McGill University.

Statistical analyses were performed with StatView (SAS Institute, Cary, NC) using the Z-test for correlation coefficients.

RESULTS
Figure 1 shows that a bigger head diameter tended to decrease the levels of Co and Cr at 1 year post-operatively. However, the correlations were not statistically significant ($R^2 = -0.097; p = 0.35$). Similar results were observed at 2 years post-operatively with $R^2 = -0.039 (p = 0.69)$ and for Cr ($R^2 = 0.049 (p = 0.69)$) and for Co and Cr, respectively.

Figure 2 shows that at 1 year post-operatively, a larger acetabular inclination angle increased the levels of Co ($R^2 = 0.204; p = 0.04$) and Cr ($R^2 = 0.283; p = 0.004$). At 2 years post-operatively, there was statistical correlation between the acetabular inclination and the level of Cr ($R^2 = 0.293; p = 0.035$), but not with the level of Co ($R^2 = 0.118; p = 0.41$).

Figure 3 shows that at 1 year post-operatively, the pin-shaft angle was negatively correlated with the level of Co ($R^2 = -0.313; p = 0.004$) but not with the level of Cr ($R^2 = 0.099; p = 0.38$). At 2 years post-operatively, there was no statistical correlation between the pin-shaft angle and the level of Co ($R^2 = -0.043; p = 0.79$) and Cr ($R^2 = 0.073; p = 0.65$).

DISCUSSION AND CONCLUSION
In the present study, we showed that at 1 year post-operatively a larger head diameter of the resurfacing tended to decrease the levels of Co and Cr in patients with hip resurfacing. Tribology theory and hip simulator studies both indicate a reduction in wear as the bearing diameter increases, given that all other manufacturing parameters are equal. A recent study also suggested that the acetabular component size was inversely correlated to the Cr level at 1 year post-operatively [2]. However, the correlation was very low ($R^2=0.089$) and it should be considered with caution. Metal ions can be generated from surface corrosion as well as from wear particles. Therefore, the concentration of ions in the blood of patients with MM hip implants is multifactorial and not only due to wear of the bearing. The levels of Co and Cr can also be related to patient parameters, such as the rate of clearance of these ions. The results showed that a larger acetabular inclination angle increased the levels of Co and Cr at 1 year post-operatively. This is in agreement with a previous study showing that the angle of the acetabular inclination was significantly associated with increased Co levels ($R^2=0.25; p=0.02$) [2]. This is however contrary to what was observed in patients with metal-on-metal hip arthroplasty where no statistically significant difference was observed in Co or Cr levels between their greatest inclination (55-63°), the intermediate inclination (44-46°), and the smallest inclination (23-37°) groups [3]. These results suggest that the angle of inclination has only a transient effect on the metal ion levels. It is also possible that the effect of acetabular inclination on metal ion levels is different in resurfacing and THA patients.

Several studies suggested that a valgus orientation of hip resurfacing decreases the risk of peri-prosthetic femoral neck fracture [for review see 3]. It also brings into question the use of an absolute angle for all patients. Results of the present study showed that the pin-shaft angle was inversely correlated with the Co level at 1 year post-operatively, suggesting that the valgus orientation is also preferable to decrease ion levels in patients with hip resurfacing.

In conclusion, results showed that the head diameter, the acetabular inclination, and the pin-shaft angle affected the level of metal ions in blood of patients with hip surface replacement. However, longer follow-ups are required to determine conclusively on the effect of surgical variables on the level of metal ions in bone of these patients.

REFERENCES