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CASE REPORT

Correlation between inclination of the acetabular component and metal ion levels in metal on metal hip resurfacing / replacement

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Abstract:

Aim:

Metal wear particles and metal ions are released from large diameter metal-on-metal (MoM) hip articulations possibly resulting in local soft tissue toxicity. Periprosthetic osteolysis from biological response to particulate wear debris results in implant loosening and failure.
Our aim was to determine whether steeply inclined acetabular components give rise to
higher metal ion concentrations.

Patients and methods:

Between April 2003 and June 2006, 22 patients had large diameter MoM THA or hip resurfacings by a single Surgeon.12 male and 10 female patients. Average age was 56
years (44 - 69 years).
Patients were divided into 2 groups. Group A, acetabular inclination angle > 45 degrees
(n=14) and Group B with an angle <45 degrees(n=8). Acetabular cup inclination was measured using standard pelvic AP radiograph. Blood chromium(Cr) and serum cobalt
(Co) were measured at an average follow up of 3.2 years (2.4 to 5 years).

Results:

Mean blood Cr level in Group A (236 nM/L) was significantly higher
(p = 0.04*) than Group B (124 nM/L).Mean serum Co level in Group A
(387 nM/L) was significantly higher (p = 0.02*) than Group B (177 nM/L).

Conclusion:

Elevated metal ion levels in the blood is not a good thing as the long term systemic consequences are not known and predict a poor outcome.
Recent literature suggests acetabular component positio influences bearing wear contributing to metal ion release after MoM hip replacement. Our findings indicate that
acetabular components with inclination angle >45 degrees produce significantly higher
metal ion concentrations leading to a poor result.

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Introduction

Metal-on-metal resurfacing hip replacement (1-3) is becoming an increasingly common
alternative to total hip replacement, particularly in younger patients.(4-8) It preserves femoral bone,has a lesser risk of dislocation and better wear characteristics than metal on polyethylene.(2,6)The early to mid-term published results have been encouraging. (4,9-12) There are, however, a number of concerns about the metal-on-metal bearing. Although its wear rate is low,(13) it still releases metal particles and ions into the body,(14,15) particularly cobalt and chromium since most metal on-metal bearings are made of a cobalt chromium alloy (CoCr). The diameter of a hip resurfacing bearing is more than that of most THR components and theoretically, if the lubrication conditions are not ideal, may increase the amount of metal ions released.(16) Several studies have reported increased serum concentrations of both Co and Cr after resurfacing/ hip replacement.(16-22) The long-term consequences of increased levels of these ions in the body are not known. High concentrationsof Co and Cr are toxic and are known to interfere with anumber of biological functions.(23-25) Willert et al (26) have described a soft tissuereaction

thought to be related to metalsensitivity in patients with a metal-on-metal THR. There have also been recent reports of soft-tissue reactions with resurfacing/ Hip replacement.(27,28) In the light of these concerns, it is important to examine factors which may influence the release of metal ions after resurfacing hip replacement. It has been reported that the position of the acetabular component will influence the bearing wear of a resurfacing/ hip replacement.(29) Further, it has been observed that large amounts of metallosis are found during the revision of steeply-inclined acetabular components.(30,31) The relationship between wear and inclination angle in THR was examined by Brodner et al(17) who showed that there was considerable variation in the measurements of metal ions, but no clear relationship between the abduction angle and the level of metal ions. The relationship between level of activity and the concentration of metal ions was studied by Heisel et al(19) but no correlation was found between acute changes in activity level and the concentration of metal ions. Our aims in this study was to determine whether a steeply-inclined acetabular component would give rise to a higher concentration of metal ions

Patients and Methods

Between April 2003 and June 2006, 22 patients had large diameter MoM THA or hip resurfacings by a single Surgeon.12 male and 10 female patients. Average age was 56 years (44 - 69 years).Patients were divided into 2 groups. Group A, acetabular inclination angle > 45 degrees(n=14) and Group B with an angle <45 degrees(n=8). Acetabular cup inclination was measured using standard pelvic AP radiograph. Blood chromium(Cr) and serum cobalt (Co) were measured at an average follow up of 3.2 years (2.4 to 5 years).These patients did not have any other metal implants at the time of measurement. The reason for the minimum one-year post-operative sample time was to avoid the confounding factor of higher levels of wear during the run-in period.(13,18)

The samples were obtained using an intravenous catheter. After the catheter had been introduced, the metal needle was withdrawn and the first 5 ml of blood were discarded to avoid possible contamination from the needle. A second 5 ml were collected using a vaccum tube.Blood levels of Co and serum levels of Cr were measured using inductive-coupled plasma mass spectrometry.The value of 45° was chosen based on the previous work of Brodneret al (17) who reported higher levels of metal ions in patients with an abduction angle greater than 45°.

Statistical analysis.

All statistical analyses were performed using Sigma plot software . The level of significance was set at $p \leq 0.05$.

Results

Mean blood Cr level in Group A (236 nM/L) was significantly higher (p = 0.04*) than Group B (124 nM/L).Mean serum Co level in Group A 387 nM/L) was significantly higher (p = 0.02*) than Group B (177 nM/L).

Discussion

Our findings indicate that steeply-inclined acetabular resurfacing components give rise to higher concentrations of metal ions. The reason for a very high concentration of metal ions in some cases may be edge-loading which causes marked localized wear (30) and gives rise to elevated levels of ions. (32) The more steeply-inclined the acetabular component, the more likely the occurrence of edge-loading. What is not clear from the literature is the relationship between the level of metal ion and complications. It is clear, however, that a soft-tissue reaction to large quantities of particulate debris can result in fluid or mass formation with subsequent destruction of soft tissues (19,28,33) as well as bone resorption leading to loosening of the implant or fracture of the femoral neck.(28) Our findings are in agreement with those of the present literature (34,35) who reported that inclination of the cup are related to the level of metal ions for patients implanted with the resurfacing/ hip replacement.The positioning of the acetabular component seems to be much more critical in metal-on-metal resurfacing hip replacement than in conventional THR. This is in part because the acetabular component has a low profile to avoid impingement on the femoral neck, and in part because the wear associated with edge-loading has much more serious consequences.Edge-loading of metal-on-metal devices can disrupt the fluid film lubrication mechanism,(37) resulting in inadequate lubrication and increased wear.(38) Surgeons must therefore take great care to avoid edge-loading. This principle also applies to metal-on-metal THRs of larger diameter. The achievement of correct acetabular orientation isdifficult for a number of reasons.(36,39) First, the position of the pelvis on the operating table is poorly defined and may alter. It is often very different from that perceived by the surgeon. Secondly, when the surgeon implants the acetabular component the estimate of its position relative to the patient is usually made by eye.This is likely to introduce errors. Thirdly, the appearance of the acetabulum at operation differs from that measured on the post-operative radiographs. When implanting the acetabular component, the surgeon considers the degree of opening to be the angle between the axis of the acetabular component and the sagittal plane, and anteversion the angle between the axis of the component and

the coronal plane. When measuring acetabular inclination on radiographs, the angle between the axis of the acetabular component and the transverse plane is projected on to and measured in the coronal plane. Since the angles are measured in different ways they are profoundly different. If there is no acetabular component anteversion then that measured by the surgeon and that on the radiograph are the same, but as the anteversion increases the inclination measured on radiograph also increases, even though the inclination at surgery does not. At resurfacing, surgeons tend to antevert the acetabular component substantially to prevent impingement, and this will therefore appreciably increase the inclination of this component. In our study we have shown that high wear is very likely to occur in metal-on-metal resurfacings if the acetabular components are implanted steeply. The clinical message, therefore, is that surgeons should be to ensure that these are never implanted more than 45° open. In order to achieve this, surgeons should probably aim to implant them less than 45° open. There is a need for improvement in instrumentation and possibly navigation in order to assist surgeons to achieve this aim.(40)

Conclusion:

Elevated metal ion levels in the blood is not a good thing as the long term systemic consequences are not known and predict a poor outcome.
Recent literature suggests acetabular component position influences bearing wear contributing to metal ion release after MoM hip replacement. Our findings indicate that
acetabular components with inclination angle >45 degrees produce significantly higher
metal ion concentrations leading to a poor result.

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