An Investigation of Metal Ion Release in Total Hips, Hip resurfacing and Total Knee Replacements

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Aim: In the mid 21st Century McKee and Watson-Farrar [1] adopted a metal-on-metal (MoM) bearing for the total hip replacement (THR) and Ring [2] later followed the same concept with his initial design. However, by the mid-1970s, Charnley’s technique [3] for low-friction arthroplasty of the hip had taken hold and MoM had been all but rejected in favour of using metal-on-polyethylene bearings. The appeal of resistance to wear conferred by MoM bearings compared with metal-on-polyethylene [4] has encouraged a trend towards the re-introduction of the MoM bearing couple. Recently, the emergence of abnormal soft-tissue reactions to MoM THR and hip resurfacing have been reported [5-9]. The deposition of cobalt-chrome wear particles in peri-prosthetic tissues induces a number of inflammatory changes including necrosis [10]. Periprosthetic soft-tissue lesions have been described in the literature as metallosis, aseptic lymphocytic vasculitis-associated lesions (ALVAL), adverse reaction to metal debris (ARMD) and pseudotumours [9, 11-13]. The analysis of retrieved implant-derived debris from joint capsules has shown that the most common metal was chromium (Cr), present in the form of Cr(III) phosphate; the analysis showed no variance between the level of blood metal ions [14]. These metal ions may have arisen from corrosion, wear, or a combination of the two. No evidence of Cr(VI) in the tissues was found [15]. Edge loading due to implant malposition and shallow acetabular components are thought to cause a failure of lubrication and to contribute to excessive wear and increased metal ion release [16]. Reports in relation to the Articular Surface Replacement implant (ASR; DePuy, Leeds, UK), data suggests that tissue destruction is not dose dependent and may, in part, be caused by a true vasculitis [17]. An important note is that Willett et al [12] described the histological features of ALVAL in non-MoM bearing designs as well. Other reports in the literature also show ALVAL is associated with a variety of causes of failure and this may suggest that it is a physiological response to metal wear debris, which occurs to some degree in all implanted metal femoral components [10, 18].

Methods: Following human ethics approval, 200 patients were enrolled in this single surgeon randomised controlled study. The treatment groups were total knee replacement (TKR) (n=100), hip resurfacing (HR) (n=50) and total hip replacement (THR) (n=50). Serum cobalt (Co) and chromium (Cr) ion levels were taken preoperatively for baseline measurement then at 6 month, 1 year and 2 years postoperatively. Clinical and radiological functional outcomes were also collected and additional daily dietary considerations were taken into account for blood Co & Cr test results.

Results: A preliminary observation of the data was performed in Excel to investigate the release trend of the metal ions (Figs 1 & 2).

Discussion: All patient metal ion levels were in the safe range. Whilst there are other reported studies comparing the effect of head diameter of MoM bearings on systemic release of metal ions, this is the first paper to compare MoM hip bearings with TKR bearings. An important point is that there was no difference between the release of Cr levels for the TKR and THR at the 2 year time-point. The trend of metal ion release is similar for all implants. However, THR deviates from HR at the 12 month time-point for Co levels. This paper demonstrates that surgical technique plays an important role in metal ion release and the long term integrity of a MoM bearing.

Significance: The significance of this paper is that it will inform the clinician that if a joint is replaced with a CoCr implant, metal ion will be released. However, if the implant is positioned correctly the metal ion release is minimal.

References:

Figure 1

Figure 2

The data was checked for normality using a Q-Q plot and analysed using a MANOVA with a Tukey HSD test. Initially there is a significant difference (p<0.05) between TKR and THR and a highly significant difference (p=0.001) between TKR and HR for the 6 month Cr ion levels. There is a highly significant difference (p<0.001) between TKR and HR and THR for the 6 month Co levels. At the 1 year time-point there is no difference between the TKR and THR for Cr levels. However, there is a significant difference (p<0.05) between TKR and HR for Cr levels at the 1 year time-point. Again there is a highly significant difference (p<0.001) between TKR, THR and HR for Co levels at 1 year. At the 2 year time-point there is no difference (p>0.05) between the TKR and THR for Cr levels. However, there is still a highly significant difference (p<0.001) between TKR, THR and HR for Co levels at 2 years. There was no significant difference detected between THR and HR (p>0.05) for both Co and Cr levels at all time-points.