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Heavy Metal: Perspectives on the Controversy Surrounding Metal-on-Metal Hip Implants

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Metal-on-metal hip implants have recently attracted considerable negative attention in the press on account of their high failure rates and complications in surrounding tissue caused by implant wear and subsequent wear particle formation. Hundreds of thousands of people around the world who have undergone hip replacement surgical procedures using these implants stand to be affected both medically and financially. In this short note, we briefly examine the issues relating to metal-on-metal hip implant function and explain how research on these issues is helping us to develop implants that are far more suitable for *in vivo* environments.

Recent news reports highlighting the serious doubts that have been cast on the efficacy of metal-on-metal implants for use as hip prostheses are not altogether surprising, given the trends observed in research findings involving such implants in recent years [1]. To explain the issue in question, hip replacements are required when the hip joint is no longer able to function for several reasons, the most common of which are age-related osteoarthritis or fractures of the hip. The materials used to manufacture these implants include metals such as titanium and stainless steel, ceramics such as zirconia, and polymers such as ultra high molecular weight polyethylene. The term *metal-on-metal* refers to the materials that form the two components of a total hip replacement (the femoral head and acetabular cup, which link together to form a *ball-and-socket* joint).

The choice of such strong and highly stiff materials is partially linked to the biomechanics of the hip joint – and thereby linked to the choice we as a species made to become bipedal and break ranks from the rest of the animal kingdom millions of years ago. The forces arising from our bipedal gait mean that even when we do nothing other than stand still, the hip joint is subjected to a minimum force approximately equal to four times our body weight [2]. It has long been considered that the only available materials that can withstand such forces without immediately cracking under the burden, so to speak, are the ones mentioned above (and this is especially so for the metals), which is why they have been the materials of choice in hip implants for so many years.

But are the metals and metal alloys used to make these implants really able to withstand the forces associated with everyday activities such as walking, playing contact sports, or kneeling to pray? Once a hip prosthesis has been fitted inside a patient's hip following a surgical procedure known as a *hip arthroplasty* [3], the ideal scenario would be for patients to get back to their daily activities and forget all about the presence of this alien object inside their bodies – forever! Alas, hip implants, and particularly metal-on-metal ones, simply do not work that way. Activities such as walking or jumping or kneeling exert tremendous forces on our hip joints and consequently on the implants themselves. To illustrate this point, imagine using all your strength to grind a pestle against an empty mortar, and carrying out this exercise not just for a few minutes but for years on end with only a few hours' break in between each grinding run. At some distant point in time, the surfaces of both mortar and pestle will begin to wear away and release small particles of their constituent materials and at another distant point in time, you risk breaking either mortar or pestle or both.

The exact same scenario transpires in the case of these implants. As they begin to wear, metal-on-metal hip implants release significant quantities of tiny metallic particles into the surrounding environment, which in this case happens to comprise the bone tissue enveloping the implant. The body perceives these particles *floating* around inside and initiates a number of processes broadly termed as *foreign body reactions* to try and isolate this implant from the surrounding tissues. However, the particles themselves can undergo further wear, release metal ions at various concentrations, and potentially affect the surrounding bone in a process called *osteolysis*, which causes bone tissues adjoining the implant to break down so that the implant doesn't fit into its designated space quite as snugly as it should [4]. The end result of all these activities is that the body ends up not accepting the implant entirely, both implant and the tissues surrounding it undergo undesirable changes, the implant undergoes loosening and/or failure and ultimately has to be replaced.

The fact that this issue has cropped up now after hundreds of thousands of people the world over have already undergone hip replacement surgery with metal-on-metal implants owes a good deal to common human folly as aptly explained by the oft-used idiom: shoot first and ask questions later. But it also points to a gratifying trend towards actually beginning to ask some very pertinent questions about the sort of materials we select to put into

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our bodies in the first place. To put things into historical perspective, implants, whether for medical or aesthetic purposes, are as old as civilization itself – ear piercings have been recorded in mummified remains of ice men from Austria dating back more than 5000 years [5].

For the longest time, implant material selection has been a trial-and-error process based on the properties of the material itself, and scant attention has been paid to how the body's cells, tissue and organs react to the presence of such materials in their midst. To illustrate with a rather risqué but instantly recognisable example, the efficacy of breast implants made of industrial-grade silicon has been called into serious question, courtesy of the recent PIP implant scandal. However, use of this polymeric material pales in comparison to the efforts of nineteenth-century researchers working to develop the perfect breast implant, who experimented with diverse but even more highly ill-advised materials such as glass balls, ox cartilage and gutta-percha (an inelastic natural latex produced from the sap of certain tropical trees) [6].

The point to note here is that it is only recently that researchers are beginning to truly understand that the interactions between implants of various material compositions and the cells, tissues and organs surrounding them have an integral role in determining the success of implants in fulfilling their functions over a long-term period – this is also known as *biocompatibility.* Simply put, if your cells don't like what an implant is made of, the implant will perform less well and the chances of implant failure increase. The earlier that researchers, regulatory bodies, corporations, governments and the general public take this simple truth to heart, the less likely that such issues experienced by those with metal-on-metal implants or the breast augmentation implants will occur. Thankfully our understanding of fundamental human tissue–material interactions is improving by the day and this can only lead to improved synthetic and natural material implants for use in biomedical applications.

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