THE ROLE OF WEAR PARTICLES IN PROSTHESIS LOOSENING

Donald William Howie
M.B., B.S., F.R.A.C.S.

A thesis submitted for the Degree of Doctor of Philosophy in the University of Adelaide

Department of Pathology
The University of Adelaide
May, 1987
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Loosening of total joint prostheses is often associated with the accumulation of prosthesis wear particles in the surrounding tissues, a macrophage and multinucleate giant cell (MNGC) response, and bone resorption. The studies described in this thesis were undertaken to determine the effects of wear particles, released from the articulating surfaces of prostheses, on cells and tissues, and to investigate the role of wear particles in bone resorption and prosthesis loosening. The investigation was divided into four main sections:

1. Initial studies were performed to determine the type and size of wear particles, and the associated cellular response in human tissues around uninfected total hip arthroplasties. The periprosthetic tissues were examined by light microscopy, transmission electron microscopy (TEM), and energy dispersive X-ray (EDX) microanalysis. The type of cellular response seemed to be related to the number, type, and size of wear particles. A macrophage and MNGC response was common in the presence of large numbers of wear particles. The accumulation of macrophages, which contained large numbers of cytolysosomes, was seen in the presence of particles. Lymphocyte aggregates occasionally were seen in association with metal particles. Polymorphonuclear leucocytes (PMN) were sparse.

2. To determine the effect of wear particles on tissues, an animal model was developed using the intra-articular injection of particles. Light microscopy and TEM examination demonstrated that wear particles similar in size to those seen in human periprosthetic tissues produced a similar tissue response in the rat knee. Cobalt-chrome alloy particles
induced a predominant macrophage infiltrate, necrosis of macrophages, and a transient lymphocytic infiltrate. Aluminium oxide particles and small polyethylene particles also induced a macrophage infiltrate, but little necrosis or lymphocytic infiltrate. Large particles of polyethylene produced aggregation of macrophages and an MNGC infiltrate.

3. Further studies, using a semi-quantitative method of assessment of the tissue response to particles, demonstrated that the number of particles and the extent of the associated macrophage infiltrate changed very little from two weeks to one year following the injection of particles. Further, a greater macrophage infiltrate was seen following injection of a high dose suspension of cobalt-chrome alloy particles compared with a low dose suspension, and a significantly greater macrophage response was seen to cobalt-chrome alloy than to aluminium oxide particles. Thus, the tissue response to particles is related to the persistence of particles in the tissues, the type and amount of particulate material, and, possibly, the degree of cell necrosis induced by particles.

4. The relationship between the tissue response to wear particles and bone resorption was studied using an animal model which involved the injection of wear particles into a rat knee joint adjacent to an acrylic cement plug inserted into the distal femur. In the absence of infection or mechanical causes for loosening, the formation of a connective tissue layer and bone resorption between the cement plug and bone occurred following multiple injections of polyethylene particles.

The results of these investigations indicate that prosthesis wear particles are responsible for a macrophage and MNGC response in the periprosthetic tissues and play a major role in bone resorption and loosening of prostheses.