

IMPLICATIONS OF ORTHOPAEDIC FRETTING CORROSION PARTICLES ON SKELETAL MUSCLE MICROCIRCULATION

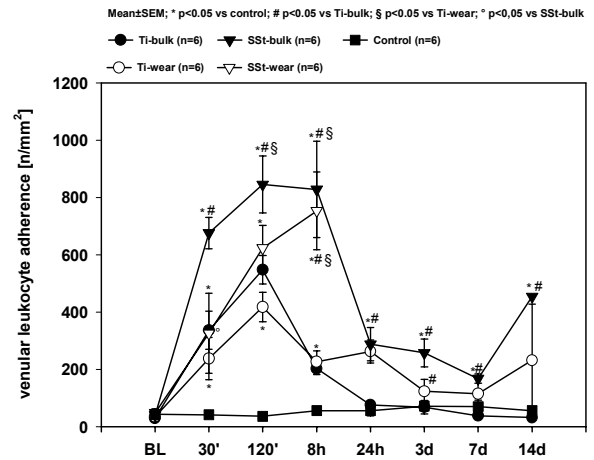
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INTRODUCTION: Particulate corrosion and wear products of metal implants are increasingly becoming regions of interest, due to a cascade of biological and biomechanical events they induce. The impairment of skeletal muscle microcirculation by fretting corrosion particles may have profound consequences. We therefore studied in vivo leukocyte-endothelial cell interaction in skeletal muscle after confrontation with characterized titanium and stainless steel fretting corrosion particles, and compared these results with those of the bulk materials.

METHODS: By use of the hamster dorsal skin fold preparation and intravital fluorescence microscopy, the reaction of capillaries and postcapillary venules of striated muscle were quantitatively assessed for leukocyte-endothelium-interaction before and after implantation of pure titanium (Ti) or stainless steel (SSt) implants against their wear products. 4mm² large plates with a thickness of 0.5mm consisting of either SSt or Ti were used. Fretting wear particles of the above metals were produced in Ringer solution. The generated debris was analysed according to size and shape by means of electron microscopy. Plates and particles, packed into volumes of 2mm³, were applied to six Syrian golden hamsters each. A recovery period of 72h between surgery and start of the experiments was allowed to eliminate the effects of anaesthesia and microsurgery on the vasculature. Leukocytes were stained in vivo with rhodamine-6G (0.1 µmol/kg) and classified according to their interaction with the vascular endothelial lining as adherent, rolling or free flowing cells. After baseline (BL) recording without debris/ plates, microcirculatory analyses were performed at 30min, 120min, 8h, 24h, 3 as well as 7 and 14 days after implantation and compared to six empty control animals.

RESULTS: The production rate for wear particles differed between Ti and SSt. The same particle volume was generated 23-times faster when Ti was worn. The generated Ti-particles were bigger in size, having a diameter of 0.64 ±0.77µm. Their circularity was 0.62 ±0.16. Most of the evaluated SSt-particles were smaller in size with a diameter of 0.17±0.37µm. The circularity of SSt was comparable to Ti: 0.57 ±0.19.



In all groups implantation of bulk and wear products led to an activation of leukocytes with a notable increase of the leukocyte endothelial-cell interaction within the first 120 min, compared to controls. This initial increase was found to be transient in the Ti-plate after 24h, and in the Ti-wear group after 3days (see Figure for adhering leukocytes). SSt-plates and -wear induced a significant massive inflammatory response within the first 8h. After 8 hours, the animals treated with bulk SSt-implants showed signs of recuperation, further evaluation of the animals with SSt-debris was not possible due to massive inflammation and edema of the skin fold chamber.

DISCUSSION & CONCLUSIONS: Using the hamster dorsal skinfold chamber preparation and intravital microscopy, we could demonstrate that stainless steel induces a more pronounced inflammatory answer in contrast to the implant material titanium. However, we were not able to show a general benefit of bulk vs. debris. Overall the study suggests that not only the bulk properties of orthopedic implants but also the microcirculatory implications of inevitable wear debris may play a role in determining biocompatibility and longevity of an implant. The skinfold chamber is a feasible and versatile model for observation of the dynamic process of microvascular response after foreign-body implantation, and offers much perspective.