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Physical-chemical analysis of failures in lame-femoral prostheses of ASTM F-138 austenitic stainless steel

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Abstract – Thousands of revision surgeries of femoral total arthroplasty conduced in Brazil may be related to low durability of implants. This study researched material's characteristics through physical-chemical analysis trying to correlate the causes of early replacement to of lack of conformity of the chemical composition or presence of undesirable phases in the material. Tests were performed with scanning electron microscopy and microanalysis by EDS and X-ray diffraction. The results showed that the problems presented are associated to phenomena of carbides' precipitation and martensite generated by heat treatment or by the manufacturing process.

Being subjected to extreme conditions under the action of complex mechanical loads in protein environment and in the presence of highly corrosive salt ions, the lame-femoral prostheses should be made of excellent corrosion-resistant materials and good mechanical performance [(1)]. The high wear may result in release of metal ions or even particles, causing the premature failure of these biomaterials, which can generate serious damage to health of the patient.

This study aimed to correlate the chemical characteristics of the biomaterials studied with the early replacement of lame-femoral prostheses of ASTM F-138 austenitic stainless steel in *Sistema Único de Saúde (SUS)'*s patients in Brazil. Tests were performed by scanning electron microscopy (SEM) with microanalysis by EDS and X-ray diffraction (XRD). The results showed that the problems presented are associated to the phenomena of carbides' precipitation (chromium migration to grain contour), causing a loss of chemical stability in physiological environment, i.e. high risk of wear mechanism and possible shedding of debris from the prostheses. This phenomenon is intensified when the Cr amount drops to less 9% within the grain or when the formation of martensite or macles in grains. The XRD spectra indicated the presence of significant martensite, probably induced during the mechanical conformation and the heat treatment applied to the material. Both phenomena cause loss of corrosion resistance due to the chromium depletion in the steel matrix (ASTM F-138 after use) or appearance of gradients mechanical/biological parameters (physical properties) over the material[(2)].

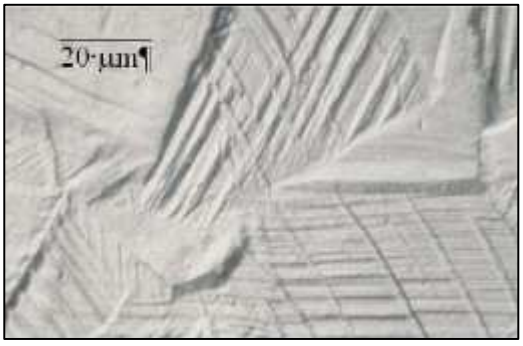

Figure 1: SEM micrography of the sample attacked steel ASTM F-138 showing the effect of deformation on the microstructure during the manufacture.

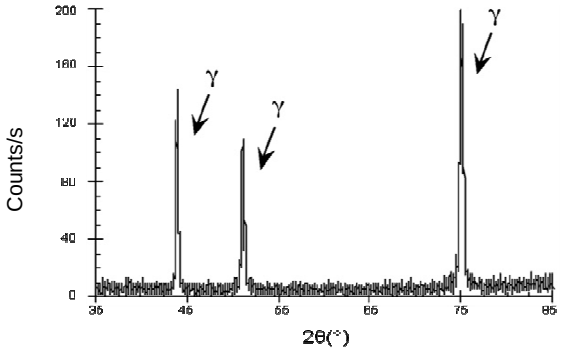

Figure 2: Typical XDR prostheses of ASTM F-138 austenitic stainless steel.

References

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