Investigation of Chemical State and Distribution of Metal Ions in Tissues around an Bio-medical Implant

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1. Introduction

Our previous studies showed that the bio-medical implants release metallic elements during the long periods of times while inserted in the human body. The chemical interactions between the tissues and surface of the implants, and the mechanical friction of implants are considered to be responsible for the release of metals into the human tissues.

The aim of the present project is to use the focused beam from a synchrotron radiation source to measure the distribution of the major elements of a matrix of the human tissues and also the distribution of the trace elements (Fe, Cr, Ti etc.) incorporated into the matrix. For this purpose X-ray fluorescence spectroscopy was used. Furthermore, X-ray absorption fine structure analysis (XAFS) was used to determine the chemical state of the released materials. The preliminary results of the investigation using BL39XU in SPing8 are presented in this report.

2. Clinical Background

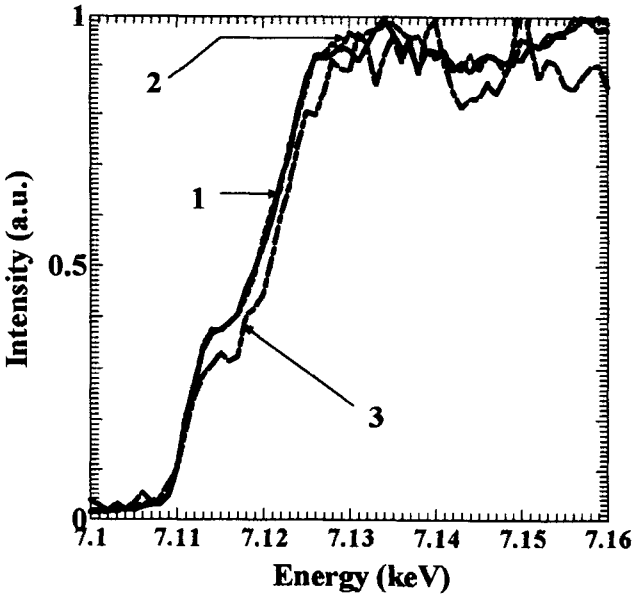
The specimens, which are investigated in this paper, are from a systematic follow-up of patients with total hip joints. The first 100 consecutive entirely hydroxy-apatite (HAp) coated hip arthroplasties in 86 patients between 32 to 73 years of age (average age 56.2 years) and female-male ratio 75/25 were followed-up prospectively for 6 to 8 years.

3. Material and Method

The specimens (9 sections from different parts around a total hip joint system) are from the case of one female patient, 55 years of age and with a diagnosed arthrosis. The implant consisted of a stem and a metal backing made of Ti-6Al-4V, an implant head made of stainless steel, and a polyethylene (PE) cup. Both the stem and the metal backing had a plasma-sprayed HAp surface coating with a thickness of 155 microns. Accelerating PE wear was diagnosed, leading to re-operation 5.4 years after insertion.

4. Results and Conclusions

SRXRF and XAFS analysis demonstrated the presence of different metals, such as Ti, Fe, and Cr in different chemical states. The SR-XRF spectra show presence of metallic elements in the soft tissues, which can be well related to the clinical observation of frictions between the two metals used in the prosthesis.



The spectra of iron in three different points in tissues around a retrieved implant. The curves 1 and 2 correspond to the points where the particles from stainless steel are dominantly present in the tissues, with high concentration. The curve 3 corresponds to a point with low concentration of metallic elements. The chemical state is remarkably different from that of Fe in stainless steel.

The application of micro beam synchrotron radiation to the detection of metal ions, mapping of the elements in a wide area in the biological tissues and detailed mapping in a cell or sub-cell scale, make it possible to further investigate the interactions of the accumulated elements in the cells and its consequence in the normal functioning of the cells .