ANALYSIS OF THE CAUSE OF FAILURE OF TITANIUM ENDOPROSTHESIS

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1. Introduction

The performance of any material on the human body is controlled by two sets of characteristics: biofunctionality and biocompatibility. [1] The selection of materials for medical applications is usually based on a consideration of biocompatibility and suitable mechanical properties.

For the reliable applications of the titanium alloy endoprosthesis in functional medical components, the manufactured parts should be durable not only under static loading but also under cyclic loading. Therefore, the Ti64 alloys, which properties are relatively low modulus, good fatigue strength, formability, machinability, corrosion resistance biocompatibility [2], are most widely used in biomedical replacements, implants, and prosthesis.

Titanium and titanium alloys are widely used in biomedical devices and components, especially as hard tissue replacements as well as in cardiac and cardiovascular applications, because of their desirable properties, such as relatively low modulus, good fatigue strength, formability, machinability, corrosion resistance, and biocompatibility [2]. To judge the significance of a hip joint replacement, the clinical results over 10-20 years must be evaluated. Today, still over half of all hip endoprostheses involves cement fixation. The rest is uncemented, in direct contact with bone [3]. The endoprosthetic of hip joint replacements is currently the most common and successful method in advanced surgery to treat degenerative joint disease, for relieving pain and for correcting deformities [4].

Hip prostheses with a modular neck adapter have been used in orthopedic surgery. Neck modularity of the femoral component of total hip implants is attractive since neck length, anteversion and femur (Fig. 1) offset can be adjusted intraoperatively after implantation of the prosthesis stem. This allows fitting of the prosthesis to the individual anatomical and implantation condition, reducing wear rate, enhancing hip stability, increasing the range of motion and minimizing the risk of dislocation. The disadvantage of this flexibility of such system is an additional interface between the stem and the neck, which bears the risk of micromotions at the interface, resulting in a constant abrasion of the passivation layer and corrosion, especially for titanium alloys [5].

Fig. 1. The X-ray view of the cracked endoprosthesis.

Corrosion prevention in biomaterials has become crucial particularly to overcome inflammation and allergic reactions caused by the biomaterials implants towards the human body. When these metal implants contacted with fluidic environments such as bloodstream and tissue of the body, most of them became mutually highly antagonistic and subsequently promotes corrosion. Biocompatible implants are typically made up of metallic, ceramic, composite and polymers [6].

2. Materials and methodology

Titanium alloys are known for their high sensitivity to fatigue induced by notches.

Accordingly, prosthesis components must be designed in such a way that excessive stress due to construction notches is minimized. For this reason and other design factors, structural testing continues to be mandatory before a product is placed on the market [7].

This contribution deals with the microstructure, microhardness and fatigue behavior of experimental specimens of Ti64 alloy cut from real endoprosthesis. The fatigue test was performed on Vibrophores Amsler 150 HFP Zwick/Roell under three-point bending load at room temperature with a frequency of 65 Hz.

The microhardness was measured using a ZHVμ Vickers hardness tester with a load of 0.5 HV. The spectral analysis was determined by spectrum analyser Bruker.

3. Results

The mechanical properties and microstructure of titanium alloys are strongly dependent on their processing history and heat treatment. The microstructure of sample (Fig.2) was monitored on an optical and electron microscope. The endoprosthesis is composed of two parts- stem and neck, which are placed together. Both are made of titanium alloy but in different ways. The analyze of the cracked endoprosthesis by the light microscope is examining a dendrite structure.

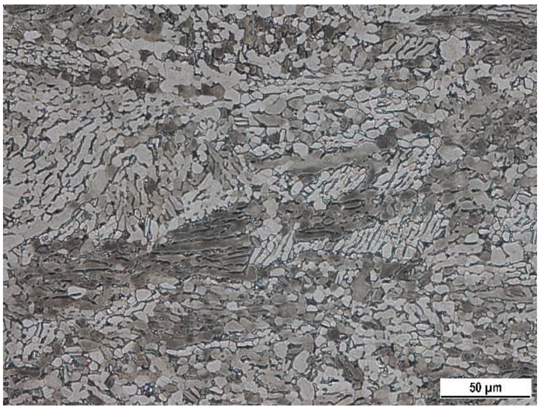

Fig. 2. The microstructure of endoprosthesis with 500x magnification.

4. Conclusions

The microstructure is an essential factor in implant design. It is very important in the role of prematurely failed implants to understand the physical and chemical phenomena at the surface and to minimize corrosion the femoral stem and neck. It is obvious that we need to keep an optimal microstructure regarding corrosion and mechanical properties, which can be controlled through processing parameters and be standardized in the near future. The present study established the surface of microstructures of biomaterials for hip endoprostheses.

Titanium alloys were subjected to thermomechanical and physicochemical processes during their production to obtain additional data for designers and implant producers.

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