A COMBINED MACRO- AND MICROSCOPIC 3D MODEL OF THE FRACTURE PROGRESS AT AN IMPLANT-POLYMER INTERFACE DURING REMOVAL TORQUE EVALUATION

Kohei Murase[1,2], Patrik Stenlund[2,3], Jukka Lausmaa[2,3], Anders Palmquist[2,4]

[1] Dept. of Intelligent Mechanical Engineering, School of Engineering, Kinki University, Japan; [2] BIOMATCELL VINN Excellence Center of Biomaterials and Cell Therapy, Sweden; [3] Chemistry, Materials and Surfaces, SP Technical Research Inst. of Sweden, Sweden; [4] Dept. of Biomaterials, Inst. of Clinical Sciences, Sahlgrenska Academy at University of Gothenburg, Sweden

Introduction

Even though several attempts to explain the complex mechanical mechanisms of implant stability and osseointegration have been made, unidentified mechanisms still exist. The literature is focused on relating surface roughness to bone healing and osseointegration [Le Guehennec, 2007], [Shalabi, 2006], [Wennerberg, 2009]. Identifying the influence of specific factors on the implant stability is very difficult due to biological variation at the implant site and the large number of potential factors. The application of finite element analysis (FEA) in implant dentistry is regarded as one of the most suitable tools for analysis of the mechanisms of the geometrical complex bone implant systems [Geng, 2001].

The aim of this study was to increase the understanding of the mechanics controlling implant stability. By combining a macro and a micro FEA model the interfacial fracture mechanisms of removal torque experiments were simulated and further validated by an experimental model system of Ti cylinders embedded in thermosetting polymer in order to eliminate the biological variation.

Materials and methods

FEA was used to study the fracture mechanisms at an implant-polymer interface during removal torque evaluation. The simulated system was validated using an equivalent removal torque experimental model system set up. Acid etching (AE) where used to modify the surface roughness of experimental machined Ti cylinders. These where then spin coated with a wax based anti-adhesion coating. Characterization of the surface topography was done by optical profilometry and scanning electron microscopy. An epoxy thermosetting polymer EP 986 (Altropol, Germany), was used as embedding material for the cylinders.

Results

Surface roughness parameters of the AE cylinders measured; S_a: 858.2 ± 54.3 (nm), S_{dr}: 42.3 ± 6.4 (%), S_{dq}: 46.5 ± 2.3 (deg). The macro model FEA displayed an exponential stress distribution at the cylinder-polymer interface, presented in Fig. 1. Interfacial polymer fractures occurred as the polymer strength was exceeded, as seen in Fig. 2.

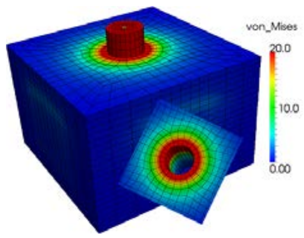

Figure 1: Macro model equivalent stress distribution around the cylinder implant modeled in EP 986 at a rotation of 1.1 degree.

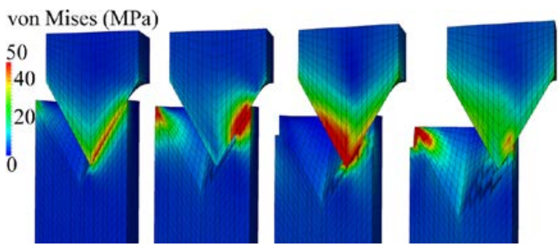

Figure 2: Micro model stress distribution and polymer (lower part) fractures at different stages of the implant (upper part) displacement.

Discussion

By combining the macro and micro FEA models the trends in the removal torque plots could be explained by the polymer properties and the fracture progress.

References

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