INVESTIGATION OF STRESS-INDUCED IMPLANT FAILURE WITH RESPECT TO PERI-IMPLANT BONE RESORPTION

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Introduction

Endosteal implants represent the most common type of implants used for dental and facial rehabilitation. The stress distribution between prosthesis and peri-implant tissue depends, among others, on the geometrical characteristics of the implant [Yokoyama, 2004], the type of loading [Kayabaşı, 2006], as well as on the surrounding bone quality [Holmes, 1997]. A geometrically accurate FEM model simulating an endosteal implant and the prosthetic superstructure, describing the stress transition of the implant-peri-implant structure and associating these to retrieved fractured parts, will be presented.

Methods

The FEM model introduced in the present paper is demonstrated in Figure 1, both in an exploded and meshed representation. The restored implant geometry (crown, implant screw, abutment and implant) was reverse engineered. The cancellous bone matter was described as a 3 mm thick cylinder surrounding the implant screw, which was embedded 12.16 mm into the edentulous mandibular bone, the screw thread was shaped trapezoid with a 0.58 mm pitch and 0.28 mm deep. The crowns abutment was fixed in the implant at a 7.7 mm length and a 2mm thick abutment distanced the crown from the implant screw.

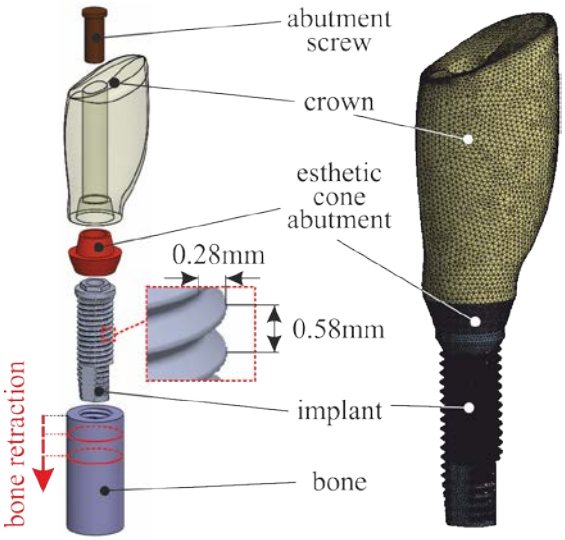

Figure 1: 3D model and meshed geometry.

Results

Figure 2 illustrates the development of the calculated stress fields over a cross section of the endosteal implant as a function of the bone resorption progression, for the worst case scenario of a 225 N horizontal load.

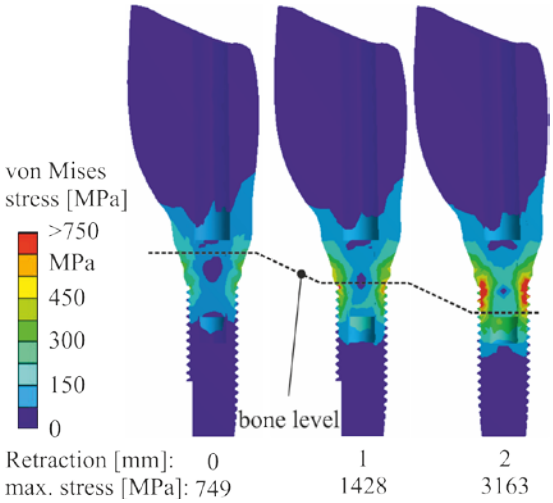

Figure 2: Stress distribution in the implant as a function of the bone resorption.

Discussion

The developing stress fields indicate areas with stress concentrations, which in some cases exceed the expected physiologic limit, a fact that has been reported to lead to bone resorption and remodeling [Inou, 1996]. A closer however look at these stress fields, indicated that these intense phenomena are superficial and rapidly depreciate to normal values just few μm below the implant surface, thus strengthening the hypothesis that implant failure is significantly accelerated in alveolar bone, exhibiting considerable resorption or atrophy.

References

Yokoyama S. *et al*, J Prosthet Dent, 91:234-240, 2004.

Kayabaşı O. *et al*, Adv Eng Softw, 37:649-658, 2006.

Holmes D.C. *et al*, J Oral Implant, 23:104-111, 1997.

Inou N. *et al*, Comp Biomech, 23-42, 1996.