THE MECHANOBIOLOGY OF TISSUE DIFFERENTIATION AROUND IMMEDIATELY LOADED IMPLANTS: A BONE CHAMBER EXPERIMENT

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INTRODUCTION

Today there is a growing tendency towards immediate or early loading of oral implants. To asses the role of mechanical factors in the healing process around the implants, a combined study, involving both animal experiments and numerical simulations, was performed.

METHODS

A repeated sampling bone chamber (fig. 1) was developed to investigate the influence of mechanical parameters on tissue differentiation around loaded implants. The inner chamber can be harvested and replaced with another chamber, which enables to investigate several experimental conditions within the same site. In this way, variability due to site-specific and species-specific influences can be eliminated. At the same time, a mechanically isolated environment is created.

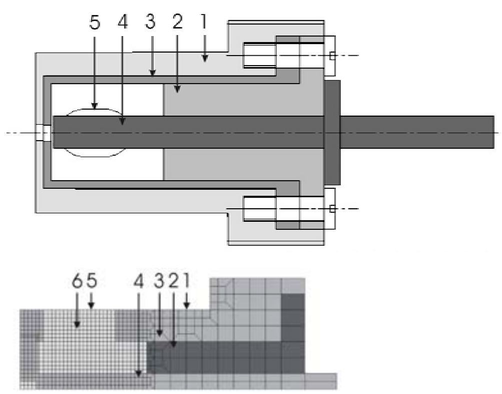

Figure 1: Assembly drawing (upper) and FE model (lower) of the bone chamber. Outer bone chamber (1, ∅ = 1 cm), teflon bearing (2), inner bone chamber (3), test implant (4), perforations (5) and tissue (6).

The animal study was conducted on a group of ten New Zealand white rabbits. During six weeks the implants were dynamically loaded (800 cycles, 1 Hz) twice a week. Four consecutive experiments, corresponding to four displacement amplitudes (0 µm = control, 30, 60 and 90 µm), were performed for every rabbit. These loading conditions were randomized in time to eliminate time-dependent influences. After every experiment, the inner chamber was harvested, the tissue was fixated, sectioned and stained.

2D finite element models were created of the tissue inside the bone chamber (fig. 1). The connections between tissues and chamber were modeled by applying appropriate boundary conditions. Loading of the implants was simulated in accordance with the experiments.

Two mechanoregulatory models were implemented to simulate tissue differentiation in the chamber: the model developed by Prendergast *et al* (1997) and the model developed by Claes *et al* (1999). The models differ in the assumed constitutive behavior of the tissues (biphasic versus uniphasic) and in the nature of the mechanical stimulus (maximal distortional strain and relative fluid velocity versus hydrostatic stress and principal strain).

RESULTS AND DISCUSSION

Simulations for mechanical conditions tested in pilot studies indicate that both models lead to reasonable qualitative results. However, quantitative differences in predicted differentiation patterns were obtained for both models. Moreover, sensitivity analyses show that the assumed constitutive behavior of the tissues has a considerable influence on the outcome of the simulations.

The histological data for the four different loading conditions described here are currently being analyzed and will allow us to perform a more quantitative validation of the models.

REFERENCES

Prendergast *et al*, J Biomech 30(6):539-548, 1997.
Claes *et al*, J Biomech 32(3):255-266, 1999.

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