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SIMULATION OF BONE HEALING PROCESSES AROUND DENTAL IMPLANTS DURING THE HEALING PERIOD

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Summary: Objective: The healing process of dental implants after insertion is complex. It was assumed that implant healing is comparable to indirect fracture healing of long bones. Hence, the aim of the present study was to simulate the remodelling process of the bone bed surrounding dental implants, considering different tissue layers until the osseointegrated state is reached.
Methods: The remodelling theory presented by Li et al. [1] was used in our remodelling simulations. A two-dimensional model was created in a bone segment which has 1.0 mm layer of cortical bone surrounding a core of trabecular bone. Three different layers with three different thicknesses were added around the implant in the models. Model 1: Layers of 0.1, 0.2 and 0.3 mm, respectively, of connective tissue (CT) surround the implant. Model 2: Layers of 0.1, 0.2 and 0.3 mm CT, Soft callus (SOC), and intermediate soft callus (MSC) surround the implant. Model 3: Layers of 0.1, 0.2 and 0.3 mm SOC, MSC and stiff callus (SC) surround the implant. A Young's modulus of 20 GPa for cortical bone and 20-1000 MPa for trabecular bone were considered. Different forces (100 N-150 N) were applied on the implant at 20° from its long axis. The model was subjected to a compression pressure with 1.0-5.0 MPa on the lingual and the buccal side to simulate muscle pressure.
Results: Changes in bone density with the different mechanical parameters are presented after 100 and 300 time steps. Comparing the muscle pressure on the model, the bone density reached the maximum value on the cortical bone and outside of the spongious bone at 3 MPa. New bone formation was observed with a layer of 0.1 mm thickness. With a layer of 0.3 mm simulation resulted in bone resorption.
Discussion: A stable region for all remodelling parameters could be determined such that bone density resulted in an equilibrium state with a soft tissue layer of 0.1 mm, which is in accordance with clinical findings. Similar boundary conditions will be applied in future 3D modelling.

References
[1] Li et al., Dent Mater, 23:1073–1078, 2007