

ABSTRACT

Background: Osseointegrated titanium implants are routinely used in clinical dentistry as anchorage units for dental prostheses. Although the overall clinical results are good, there are clinical situations when an optimized implant healing is desirable, for instance in order to shorten healing periods and to allow immediate loading.

Aims: The present work was undertaken to study the influence of some micro- and macroscopical surface modifications on the integration and stability of titanium implants in bone. In addition, the aim was also to study the influence of a bone growth factor and autogenous bone grafts on implant healing in bone defects.

Materials & Methods: The thesis is based on five experimental studies using a total of 12 mongrel dogs and 39 New Zealand White rabbits. In total, 327 screw-shaped implants were evaluated with histology and biomechanical tests. The implants had either a turned surface or had been treated with anodic oxidation to create a porous surface structure (microscopic modification). A groove with various sizes was added to one thread flank of oxidized implants (macroscopic modification) for comparison with implants without a groove. Ground sections of the intact bone-titanium interface were prepared for light microscopy and quantitative morphometry. A micro-CT technique was used for 3D visualisation of the bone in relation to the implant surface. Implant stability was measured with removal torque (RTQ) tests and resonance frequency analysis (RFA) measurements.

Results: Turned and oxidized implants were placed in the dog mandible with circumferential defects which were filled with dog BMP+ carrier, carrier alone, autogenous bone chips or nothing. No differences in histological response and implant stability were seen between the different materials and controls after 4 and 12 weeks of healing. However, oxidized implants showed a stronger bone tissue response and were significantly more stable than turned implants after 4 weeks. A rabbit study demonstrated direct bone formation at the surface of oxidized but not turned implants after 7, 14 and 28 days. A darkly stained layer became populated with osteoblasts which produced osteoid towards the implant surface whilst turned implants seemed to be integrated by approximation of bone from the surrounding bone and marrow tissues. In paper III, an increased resistance to RTQ was seen for oxidized implants with a 110 µm wide and 70 µm deep groove as compared with control implants without a groove after 6 weeks of healing. This was not observed for 200 µm wide grooves. Histology showed an affinity of bone formation to the grooves. Paper IV evaluated the influence of three different groove sizes on implant stability as measured with RTQ and RFA. The results confirmed that 110 µm grooves resulted in better stability than implants with 80 µm or 160 µm wide or no grooves. Histology of RTQ specimens revealed an increased incidence of bone fracture at the entrance of the groove as opposed to a separation at the bone-implant interface with decreased groove width. Bone formation had an affinity to the grooves which increased with decreased groove width. In paper V, bone formation was seen to occur more frequently in grooves than on opposing flank surfaces after 7, 14 and 28 days of healing in implant sites with small bone volumes.

Conclusions: The present thesis shows that both micro- and macroscopical surface modifications have positive influences on the bone tissue response and stability of titanium implants. It is suggested that this is due to a combination of (i) contact osteogenesis as stimulated by the microtopography and (ii) guided bone formation as stimulated by the macrotopography, which resulted in an improved mechanical interlocking between bone and implant surface.

Keywords: titanium, dental implants, surface modification, bone tissue, biomechanics, BMP,

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ON THE INFLUENCE OF MICRO- AND MACROSCOPIC SURFACE MODIFICATIONS ON BONE INTEGRATION OF TITANIUM IMPLANTS

AKADEMISK AVHANDLING

Som för avläggande av medicine doktorsexamen vid Göteborgs Universitet kommer att offentligens försvaras i Föreläsningssalen, Avd Biomaterialvetenskap, Medicinaregatan 8B, fredagen den 1 september 2006 kl. 13.00 av

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- I. Salata LA, Miranda Burgos P, Rasmusson L, Novaes Jr AB, Papalexiou V, Dahlin C, Sennerby L. Osseointegration of oxidized and turned implants in circumferential bone defects with and without adjunctive therapies. An experimental study on BMP-2 and autogenous bone graft in the dog mandible. *Submitted*
- II. Miranda-Burgos P, Rasmusson L, Meirelles L, Sennerby L. Early bone tissue responses to oxidized and turned titanium implants in the rabbit tibia. *Submitted*
- III. Hall J, Miranda-Burgos P, Sennerby L. Stimulation of directed bone growth at oxidized titanium implants by macroscopic grooves. An in vivo study. *Clinical Implant Dentistry and Related Research 2005;7(suppl 1):76-82*
- IV. Miranda-Burgos P, Sennerby L, Meirelles L, Hall J. Influence of groove width on affinity for bone formation and stability of grooved oxidized screw-shaped titanium implants. A biomechanical and histological study in the rabbit. *Submitted*
- V. Miranda-Burgos P, Schupbach P, Hall J, Sennerby L. Early bone formation at grooved oxidized titanium implants. A descriptive light microscopic and micro-CT study in the rabbit. *In manuscript*