Surface Modification of Dental Implants for Craniofacial Applications: Pilot Data from a Preclinical Animal Model

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Abstract

In the context of craniofacial rehabilitation, novel dental implant strategies address critical challenges in osseointegration and biomechanical stability—factors essential to advancing reconstructive outcomes in craniofacial surgery. Dental implants constitute a well-accepted therapeutic treatment of partial or complete edentulism and are vital in craniofacial reconstruction for restoring oral function and aesthetics following trauma, tumor resection, or congenital defects. They also serve as anchors for extraoral prostheses—such as ears, noses, and orbital devices—enhancing stability and patient comfort. Different approaches exist regarding the time of dental implants placement and bone quality, the surgical approach applied and their immediate or delayed loading with prosthetic restorations. Osseointegration of dental implants can be compromised under suboptimal conditions—such as overloading, inflammation, or unfavorable biomechanics—as well as in cases of impaired bone healing, presenting a significant challenge for oral surgeons.

In the present study, immediately loaded one-piece dental implants were fabricated with laser printing, coated with minerals and doxycycline (DOX) loaded chitosan and inserted in the mandibles of beagle-dogs and Aachen mini-pigs three months after teeth extractions. All implants were placed by an experienced maxillofacial surgeon. After 8 weeks of healing, the bone along with the implants, were removed to evaluate osseointegration and histological analysis of the soft and hard tissues and histomorphometric analysis of the bone-implant contact (BIC) was performed.

The outcomes suggest that implant performance was influenced by biomechanical challenges, likely related to functional loading during early healing. Although the implant abutments had no occlusal contact, forces from the tongue or mastication may have contributed to micromovements, potentially interfering with early bone integration. Especially in the early stages after implant placement, such loading can cause implant movement which disturbs the process of bone formation. Histological and histomorphometric analysis of the failed implants revealed inflammatory infiltration with macrophages and leukocytes, and soft tissue penetration in the bone to implant interface. However, the surviving implants demonstrated enhanced osseointegration and increased new bone apposition compared to the uncoated control group, indicating that the applied coatings did not adversely affect the osseointegration process.

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