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Load Transfer along the Bone-Implant Interface and Its Effects on Bone Maintenance

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Abstract

Dental implants provide an attractive alternative to classical prosthodontic techniques in the treatment of edentulism. It has been shown clinically that the bone loss after tooth extraction is reversed by the placement of dental implant, since the first human study reported by Brånemark et al. (1977). The mechanical loads exerted by occlusion are transferred into jawbone through the dental implant, and can potentially affect the bone remodeling according to Wolff's law (Wolff, 1892). Therefore, it is critical to develop a sound understanding of the load transfer mechanism from the implant to the bone. It is equally important, to supply a dental implant with critical chemical and contour features on its surface. If the ideal load transfer characteristics can be identified, it may be possible to improve the osseointegrationA systematic analysis of the load transfer along the bone-implant interface was carried out by using finite element analysis. Various implant systems were designed by changing their contour parameters. Among all design parameters, the diameter, the collar slope, the collar length and the length of the implant were found to be the most influential parameters to the interfacial variations of the normal and shear stresses. Maximum normal and shear stresses were found to occur on the buccal side of the cortical bone, as in many other studies. It was shown that both maximum normal and shear stress values can be reduced by either widening the implant diameter, or increasing the lengths of the collar and body regions. Varying the slope of the collar from negative to positive was found to increase the maximum normal stress, but to reduce the maximum shear stress transferred along the interface. The effects of the external threads were also investigated. It was seen that the general interfacial load transfer behavior doesn't change with

respect to smooth faced implants, but locally the interfacial stresses are elevated around the threads. A bone remodeling algorithm was implemented to analyze the bone maintenance characteristics of smooth faced and threaded implants. This showed poor bone maintenance around smooth faced implants. On the other hand, significant remodeling and densification was predicted around threaded implants. It was shown that the thread tips promote the development of dense bone. Total bone resorption was predicted in the areas between the threads. Similar remodeling phenomenon around implant threads was reported in histologic studies by Schenk &Buser (1998) and Watzak et al. (2005). It appears that adequately high interfacial stresses are introduced by using externally threaded implants. This study contributes to our understanding of the complex problem of load transfer mechanism in the bone-dental implant interface and the subsequent peri-implant bone remodeling. Despite the interesting conclusions drawn from the results, the computational predictions are still limited by the assumptions and simplifications of loading, geometry and material properties made in this study.

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