Resonance Frequency Assessment of Dental Implant Stability with Various Bone Qualities: A Numerical Approach.

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Abstract

Resonance frequency analysis (RFA) has been used by several investigators to assess the boundary conditions of dental implants. The goal of the current study was to determine the vibrating behavior of a dental implant under various surrounding bone conditions. A 3D finite element (FE) model of a cylinder-type titanium implant was developed. In this model, the implant was embedded into a cubic section of bone. The model was first validated using a series of modal testing experiments. The effects of bony conditions on the resonance frequencies of the implant were computed with different bone types and bone densities. Our results show that the resonance frequency of the implant with type III surrounding bone decreased linearly ($r = -0.996$, $P < 0.01$) from 17.9 kHz (without loss in bone density) to 0.6 kHz (90% loss in bone density) when the bone densities were decreased. On the other hand, without bone loss, the highest resonance frequency value (36.1 kHz) was found when the implant was placed into type I surrounding bone. In contrast, the resonance frequency of the implant with type IV bone quality was found to be 9.9 kHz, which is almost four-fold less than that found in the type I model. These results suggest that RFA could serve as a non-invasive diagnostic tool for detecting the stability of dental implants during the healing stages and in subsequent routine follow-up care after treatment.