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Original Article

Effects of Implant Design and Occlusal Loading on Bone Remodeling in Implant Supported Single Crown: A Finite Element Study

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Abstract

Objectives: This study explores the preliminary understanding of the biomechanics with respect to the effect of implant design and occlusal loading location on the mandibular bone remodeling of implant supported single crown.

Methods: Three different implant designs (standard, short, and mini implant) with different occlusal loadings including non-occlusal contact (area loaded) and occlusal contact (center and 2-mm offsets horizontally loaded) were used to explore the stresses and strains transferred from the ceramic crown to the peri-implant bone throughthe implant. A 200 N loading was applied at the center of the crown. A strain energy density obtained from a three-dimensional finite element analysis was used as the mechanical stimuli to drive cortical and cancellous bone remodeling over the first 12 months after implant placement.

Results: Different occlusal loading location had a significant effect on bone remodeling responses in terms of the change in the average peri-implant bone density and overall stress/strain distributions. The 2 mm-horizontally offsets loading presented the largest stresses, strains, strain energy density, bone density, compared with the other occlusal loading locations. Under the 2-mm horizontally offsets loading, the greatest remodeling rate was achieved in mini implant, followed by standard and short implant. In mini implant, an average peri-implant bone density in cortical was 1.94 g/cm3 and in cancellous bone was 1.14 g/cm3 after 12 months of bone remodeling. The remodeling rate was rapidly high in the first to the second month of loading and continuously decreased until 12 months.

Conclusions: Within the limitations of this study, The occlusal loading location appeared to play important role than the implant design. An increased occlusal loading offset affected bone remodeling activities. A mini implant had the fastest remodeling process when compared with the short and standard implants, resulting in more bone density and strength in the first few months of an implant healing time. However, the mini implant also had the highest stress at bone-implant contact that may decrease primary implant stability.

Keywords: bone remodeling, implant biomechanics, implant design, loading location, mini implant