DESIGN DEVELOPMENT OF AN ENDOSSEOUS DENTAL IMPLANT

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1. Introduction

This study explores the hypothesis that through redesign, dental implant prosthesis can be developed to substantially reduce stress shielding and alleviate masticatory loads effects. The description of the development of a new prosthesis designed to treat this problem through new fixation geometry was based on the static loading and finite element analysis. Therefore, a mathematical model has been achieved to understand the behavior of stress and its distribution along the implant/bone surfaces by comparing three structurally similar yet morphologically different types of implant, threaded cylindrical implant and spherical-lobe implant (solid-lobar implant) and hollow-lobar implant, Figure 1.

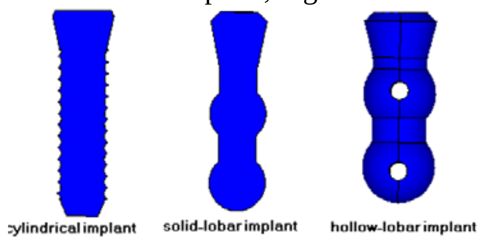

Figure 1: The geometry of models.

2. Geometry Modeling and Materials

The ANSYS Finite Element Package was used. The resulting 3-D model volumes were discredited using 8-node explicit brick elements. The bone-implant interface was considered fully bonded. Axisymmetric FE models are constructed for all implant-abutment-bone systems.

The implants and abutments are modeled as Ti6Al4V with linear-elastic, isotropic and homogenous properties. The cortical bone is modeled as 3 mm thick layers, with an elastic modulus of 14 GPa and Poisson's ratio of 0.3, surrounding the trabecular bone of a 17 mm thick layer, with an elastic modulus of 1.37 GPa and Poisson's ratio of 0.31.

3. Loading and Restraints

Three types of loads were applied to the abutment, vertical force (FV = 2500 N) and lateral (FL = 500 N) loads applied on the vertical axis of the implant, and bending moments (M = 4000 N.mm) [1]. Inferior border of the bone block was fixed in order not to occure any possible movements [2].

4. Results

4.1. The effect of geometry parameters upon stress distribution in the implant

High stresses were recorded in the neck area of all models. However, the stress concentration was shown greater in the cylindrical model than any other one, since the highest stress localized at the cervical margin and at the first threads of the implant. This stresses localization could cause stress shielding and eventually implant losing. On the other hand, the hollow lobar model showed a favorable stress distribution than any other model under three different loads conditions.

4.2. The stress distributions at mandibular bone

The highest von Mises stress under vertical load was observed at the bottom of the implant in all models, however its ratio was much lower than in the cortical bone whereas the highest von Misce stresses were occurred near the cortical plates on the buccal and lingual sides under lateral loading.

5. Conclusion

Based on our analysis and discarding the models with higher values of implant stresses, entering the new design parameter (solid-lobar implant) i.e., low stress in retaining implants, into our selection process, shows a good compromise between the stress shielding and mechanical performance of the dental implant prosthesis according to the finite element analysis results.

References

[1] Bozkaya *et al*, J Prosthet Dent, 92:523-530, 2004.

[2] Kim *et al*, KAID 12**(1):** 23-40, 1992.