Insert Poster Number

The influence of crestal bone loss and bone graft replacement on the stress distribution around dental implants : A finite element analysis

Topic: Poster Presentation

Abstract

Background:
The prosthesis supported by osseointegrated implants has become a basic part of restorative therapy for both completely and partially edentulous patients.Various studies have shown that the stability of implant is related to the biomechanical properties of the bone surrounding. Time-dependent marginal bone loss around implants is still unavoidable and could jeopardize implant stability and the supported prosthesis.Because the finite element method is an effective analysis tool, it has been used in a variety of biomechanical studies regarding dental implantation.

Aim:
The aim of this study was to investigate the biomechanical effects of grafts and stres distribution in the bone surrounding an implant placed in mandibula premolar region based on the finite element method.

Methods:
A 3-dimensional finite element model of a mandibula premolar section of bone was used in this study.The standard threaded implant, anatomy of the crestal cortical bone and cancellous bone with the vestibule bone defects around dental implant neck and augmentated bone with kinds of grafts were represented in the 3-dimensional finite element models. A dental implant of 4.1 mm diameter and 10 mm length and for the defects around implant neck depth of 2 mm, 4 mm and 6 mm were chosen. Axially 300N and laterally 100N of forces were considered and the stresses developed in the supporting structures were analyzed.

Results:
According to our resuls the stress was highest in the cortical bone, lower in the grafted bone, and lowest in the cancellous bone which is a parallel outcome with the literature. Stresses produced with off-axial loads were higher in the cortical and grafted bones and lower in the cancellous bone compared with axial loads .

Conclusions and clinical implications:
Findings in our study suggest that the type of loading affects the load distribution more than the variations in bone, and native bone is the primary supporting structure.

Background and Aim

In recent years, with the progress in dental implant surface characteristics and the establishment of surgical methods, implant-supported restoration has been recognized as a reliable treatment. Treatment with dental implants has the ability to maintain the alveolar ridge over time, which is known to resorb in height and width after extraction of teeth. The crestal bone around dental implants may act as a fulcrum point for lever action when a force (bending moment) is applied, indicating that peri-implant tissues could be more susceptible to crestal bone loss by applying force. Although bone loss around implants is reported as a complication when it progresses uncontrolled, resorption does not always lead to implant loss, but may be the result of biomechanical adaptation to stress. To regenerate bone of sufficient quality and quantity for the installation of dental implants, autologous bone is considered to be the gold standard grafting material. But the disadvantages involved with harvesting autologous bone and the general limited availability, synthetic bone substitution materials is another choice. For problems involving complicated geometry, it is very difficult to achieve an analytical solution. Finite element analysis (FEA) is an accepted theoretical technique for obtaining a solution to complex mechanical problems by dividing them into a collection of much smaller inter-related elements.The distribution of forces in peri implant bone has been investigated by finite element analyses in several studies. The aim of this study was to evaluate the stress distribution around dental implants following the graft application procedures into bone defects.

Methods and Materials

The 3-D FEA is considered an appropriate method for investigation of the stress throughout a 3-D structure, and therefore this method was selected for bone and implants stress evaluation in this study. The software SOLIDWORKS (Yenasoft,Ataşehir,İstanbul) was used for preprocessing, finite element analysis, and ANSYS 14.0 () for postprocessing in the study. A main 3-D model of a box shaped mandibula premolar region was designed for testing and analysis. The model consisted of 2 mm cortical bone with cancellous bone inside. By this model 3 bony defects with 1mm width were formed, first one was with 2mm height,second one was with 4mm height and the last one was with 6mm height. In the superstructure the Dental Implant KA had a diameter of 4. 1 mm, length of 10 mm and H2 abutment were chosen for the analysis. Otogenous (G1) and bioglass 45s5 (G2) synthetic graft materials were applicated into the defects formed before. All materials used in the models were considered to be isotropic, homogeneous and linearly elastic.

Materials	Elastic Modulus (MPa)	Poisson Ratio	Density (kg/m^3)
G1	14,000	0.3	0.0018
G2	35,000	0.3	0.0027
Titanium	110,000	0.3	0.0045
Cortical bone	14,000	0.3	0.0022
Cancellous bone	3,000	0.3	0.0001

Table 1: Material properties

The implant, the abutment, the bone and graft materials are assumed to be bounded and the mesh was generated (Figure 1). Forces of 300 N and 100 N were separately applied axially (AX) and buccolingually (BL), respectively, to the center of the abutment of totally 6 different FE model and the von Mises stresses (equivalent [EQV] stresses) in the structure were calculated (Figure 2).

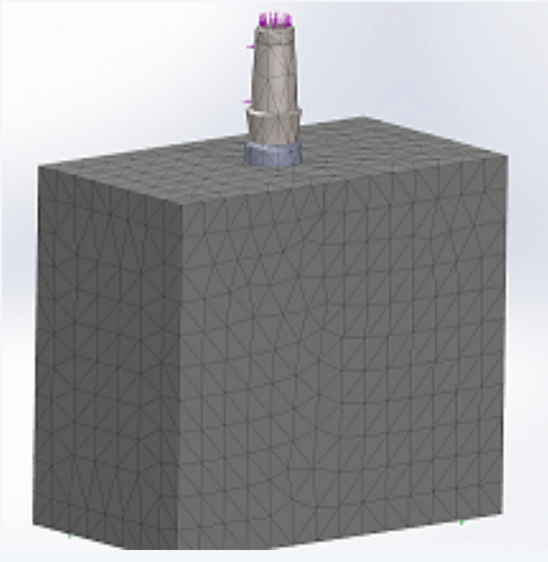

Figure 1:The mesh form of the superstructure

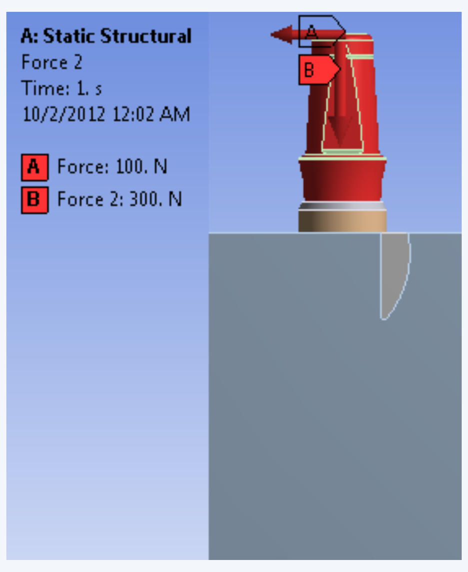

Figure2:Forces and directions

Results

In all of the six models maximum von Misses stresses occured on the side where the horizontal force applied on the abutment and the implant neck. While G1 and G2 showed similar stress values with the bone, G2 showed higher values comparing G1 (Table 2). Stress values showed an increase while defect depth increased.

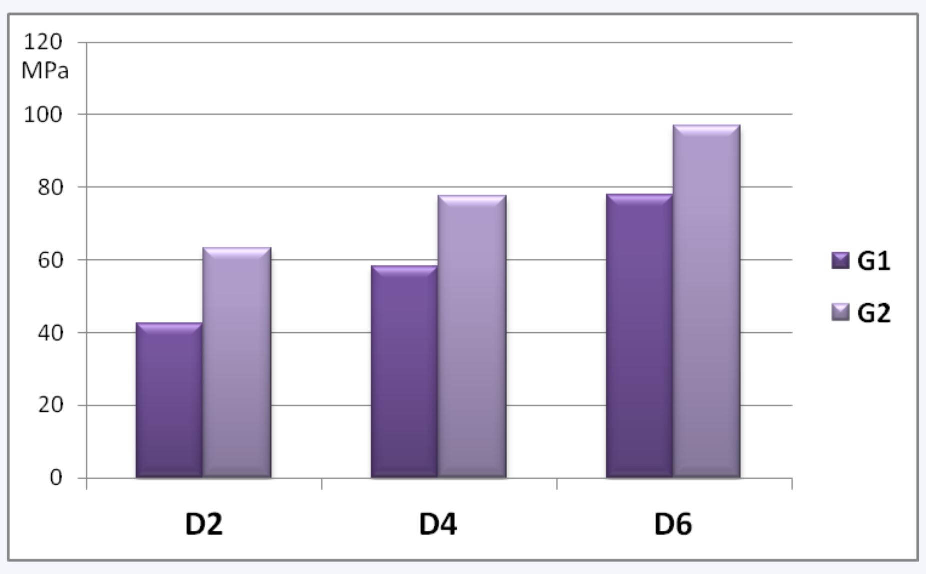

Table 2: Comparison of the stresses occured on graft materials G1 for the otogenous,G2 for the bioglass 45S5

Moreover, since defect depth increased, the area of the stresses occured on the implant and abutment expanded, however the intensity of the stresses showed a decrease (Figure3,4).

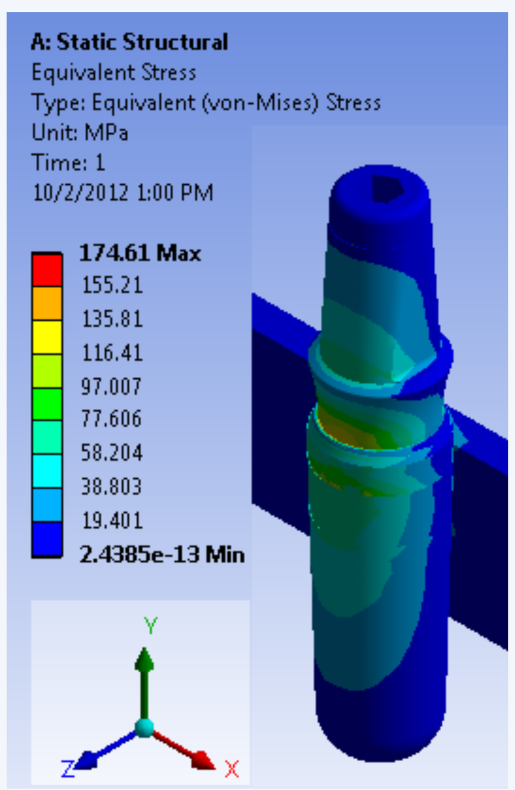

Figure 3: The equivalent stress values for the model had a defect of 6mm depth and graft bioglass.

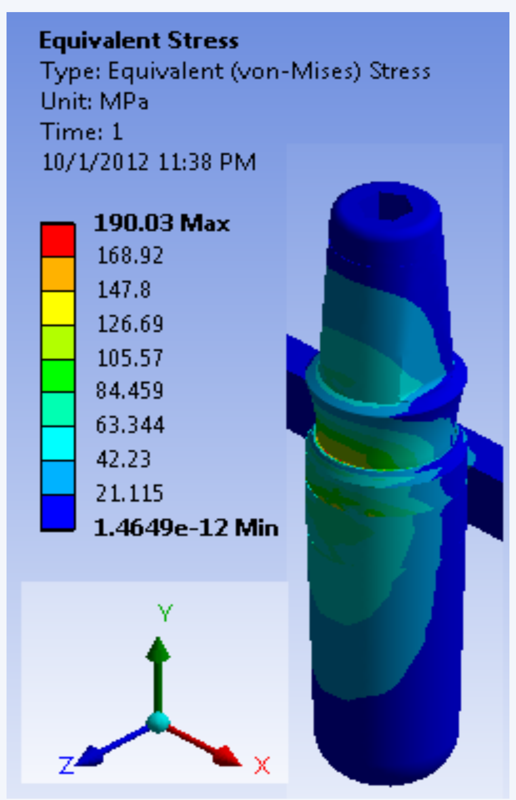

Figure 4: The equivalent stress values for the model had a defect of 2mm depth and graft bioglass.

According to our resuls the stress was highest in the cortical bone, lower in the grafted bone and lowest in the cancellous bone. As we expected G2-bioglass showed higher stress values while G1-otogenous bone graft showed similar values with the bone. Stresses produced with off-axial loads were higher in the cortical and grafted bones and lower in the cancellous bone compared with axial loads .

Conclusions

We can figure out that the type of loading affects the load distribution more than the variations in bone, and native bone is the primary supporting structure. But as bone resorption progresses, the increasing stresses of the cancellous bone and implant under lateral load may raise the risk of failure. While deciding the type of the grafting procedure this comparison of otogenous graft and bioglass may highlight the importance of otogenous bone grafts.

References

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