A FINITE ELEMENT ASSESSMENT OF STRESS DELIVERY AT IMPLANT BONE BOUNDARY IN PLATFORM SWITCHED SHORT DENTAL IMPLANTS

Running title: 3D FEM study on platform switched implants

Authors

1. **Dr. Sangamesh Gurunath Fulari,**
Associate Professor, Department of Orthodontics and Dentofacial Orthopaedics, Bharati Vidyapeeth (Deemed to be University) Dental College & Hospital, Sangli, Maharashtra, India

2. **Dr. Yashika Bali,**
Associate Professor, Department of Prosthodontics and Crown & Bridge, Swami Vivekanand Subharti University, Subharti Dental College & Hospital, Meerut, UP, India

3. **Dr. Benny Budhwar,**
Ex Senior Lecturer, Department of Orthodontics and Dentofacial Orthopaedics, Bhojia Dental College, Baddi, HP, India

4. **Dr. Rishibha Bhardwaj,** ***(Corresponding author)***
Associate Professor, Department of Orthodontics, School of Dental Sciences, Sharda University, Greater Noida, UP.

5. **Dr. Rupamalini SN,**
Assistant Professor/Senior Lecturer, Department of Periodontics, MR Ambedkar Dental College and Hospital, Bangalore, Karnataka, India

6. **Dr. Manav Ahuja,**
Private Practitioner, Department of Oral Maxillofacial Surgery, Gurgaon, Haryana, India

7. **Dr. Swati Chhabra**
Associate Professor, Department of Conservative dentistry and Endodontics, MM College of dental sciences and research, Maharishi Markandeshwar (Deemed to be university), Mullana, Ambala, Haryana, India

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Abstract

***Aims*:** To assess the stress distribution when placing short platform switched dental implants at various depths in the equicrestal and subcrestal regions.

***Materials and method*:** A three-dimensional finite element model (FEM) was used to model the mandibular posterior molar area, using consistently thick 1.5 mm cortical bone with an inner core of cancellous bone. The study's implants had proportions of 5 mm in length, 4.5 mm in diameter, and 3.5 mm for the abutments. For a realistic simulation, 100 N of force was applied in both axial and oblique (15° and 30°) directions. Ansys Workbench produced each and every model. Both cancellous and cortical bone are evaluated for Von Mises stress at different depths. 10 noded tetrahedron elements with three degrees of freedom per node are used to interpret translations on the x, y, and z axes.

***Results*:** In FEM simulations, all 5 positions of platform switched short osseointegrated implants showed varying stress-based biomechanical behaviour depending on the geometry of the bone, the direction of the applied force, and the depth of the implant placement.

***Conclusions*:** Axial forces were less harmful than oblique forces. The cortical and cancellous bone experienced less stress as a result of the placement of subcrestal implants.

Keywords

Eqicrestal, finite element analysis, platform switch, short dental implants

Introduction

As a natural alternative to dentures, dental implants have a significant positive impact on a person's general health. A site-related issue gives a serious intimidation to implant placement and failure among the many circumstances that could favour implant failure. As an alternative to standard implants, short dental implants can be used for procedures that call for sinus lifting or bone augmentation due to insufficient bone volume or density. Any implant less than 8 mm in length is referred to as a short dental implant in the current lexicon. [1]

In vitro finite element model (FEM) design aids in the clear comprehension of ideas for clinical applications involving any animals or people, while also providing data on stress and strain in bone and implant structures. [1]

Investigations into the connection involving peri-implant bone remodelling, implant loading and design, have been conducted using a variety of techniques, including models, strain gauges, and finite element analysis (FEA). The research of the biomechanics of the implant and around bone, in addition prediction of the outcome of implant systems in a variety of practical conditions, have benefited greatly from FEA, which takes into account the experimental restrictions. [2]

An important factor affecting the primary stability of implants is the feature of the bone and the cortical bone thickness (CBT). In distributing stress or strain, CBT is crucial. [1]

A key factor in the long-standing development and longavity of dental implants is crestal bone loss. In the past, a number of researchers have noted crestal bone loss of 1-1.5 mm in the first year and 0.1 mm in the following years due to various factors. Oral implants must have adequate bone volume and density to be successful. When using osseointegrated dental implants for edentulous patients, practitioners repeatedly run into anatomic disparity in the premolar and molar areas, one of which is the maxillary sinus. The design of the implant is one of the main factors affecting its primary stability and capacity to withstand loads during or after osseointegration. The primary stability of a dental implant is influenced by the implant's design, the procedure used to place it, and the bone characteristics of the implant site. [2]

The benefits of platform switching with Morse taper dental implant joints include maintaining the soft tissue profile, lessening bone loss, and, eventually, lowering the incidence and frequency of marginal periimplantitis linked to the implant-abutment platform. [2]

The goal of the current study was to determine how stress would be distributed when short platform switched dental implants were placed equicrestally and subcrestally at different depths.

Materials and Methods

The oral implantology department conducted this study. A 3 dimentional FEM was used to model the mandibular posterior molar region, using consistently thick 1.5 mm cortical bone with an inner core of cancellous bone. The study's implants had proportions of 5 mm in length, 4.5 mm in diameter, and 3.5 mm for the abutments. For a realistic simulation, 100 N of force was applied in both axial and oblique (15° and 30°) directions. Ansys Workbench produced each and every model. Both cancellous and cortical bone are evaluated for Von Mises stress at different depths. 10 noded tetrahedron elements with three degrees of freedom per node are used to interpret translations on the x, y, and z axes. Materials that are homogeneous, linearly elastic, and isotropic were used to build the model. elastic characteristics found in the literature are listed in table 2.

These finite element analysis studies model the mandibular posterior region using fixed boundary conditions. The application of force and control is the boundary condition. The external oblique line buccally to the mylohyoid ridge lingually was the node on the muscle attachment where the boundary conditions were constrained. [1]

An ideal fit between the implant and bone was assumed by the FEM to be present at the bone implant interface. Every model depicts the osseointegrated and loaded state.

Results

In von Mises stress measurement for 0.5 mm subcrestal implants, cortical bone showed greater stress in an oblique direction (30c). Low-stress values are visible with subcrestal implant placement for cancellous bone. Implants positioned 1.5 mm subcrestally showed the lowest stress at (0 c), followed by a rise in stress oblique forces at (30 c). Cancellous bone exhibits maximum stress in an oblique direction (30c), similar to cortical bone, for subcrestal implants. Regardless of the angulation of the force, cortical bone showed the greater stress concentration at 2 mm subcrestally, with the highest in an oblique direction. Regardless of the angulation of the load, cortical bone underwent the least stress and cancellous bone underwent the most stress at the equicrestal position. However, in the subcreasatal position, the cortical bone experiences the most stress at the 0.5 mm subcrestal position and the least at the 1.5 mm subcrestal position for the cancellous bone. [Table 1].

Table 2 indicates the mechanical properties for cortical bone, cancellous bone and titanium.

Table 1: Under a vertical and oblique load of 100 N, the average von Mises stress produced in the cortical and cancellous bone

Angulations of force	**Cortical Bone Cancellous Bone**					**Cortical Bone Cancellous Bone**				
	Equicrestal	0.5mm	1mm	1.5mm	2 mm	Equicrestal	0.5 mm	1 mm	1.5 mm	2 mm
0c	5.11	8.08	6.67	6.47	6.78	2.45	2.21	2.07	1.86	2.14
15c	8.56	18.24	16.43	17.17	17.16	3.12	2.47	2.36	2.25	2.68

30c	12.04	29.25	24.12	28.43	26.32	3.43	2.68	2.85	2.54	3.08

Table 2: Mechanical properties for bone and titanium used in study

Material	**Young's Modules (MPa)**	**Poisson's Ratio**
Cortical bone	13.600(GPa)	0.28
Cancellous bone	1.12(GPa)	0.28
Pure Titanium	110000 (MPa)	0.31
Titanium alloy	113000 (MPa)	0.29

Discussion

we discovered that, oblique forces were more harmful than axial forces,. The cortical and cancellous bone experienced less stress as a result of the placement of subcrestal implants.

Specifically where bone meets the implant is where mechanical stress is distributed. The percentage of bone contact in cortical bone is considerably higher compared to cancellous bone. The bone around the implant neck is under the most strain.[2]

Short platform switched dental implants were used to place equicrestal and subcrestal implants at various depths, and Manchala et al. analysed the pattern of stress distribution. They came to the conclusion that oblique forces were worse than axial forces. [1]

According to Ellendula et al findings, sub-crestal (1-2mm) placement of a Morse taper and a platform-switched implant is advised for long-term success because cortical bone around the equi-crestal implant had the highest levels of von Mises stresses. [2]

Platform switching and narrower abutment platforms can be combined thanks to an internally stable design. Clinical studies have demonstrated that platform-switching abutments increase the available space for the growth and maintenance of soft tissues while also reducing marginal bone loss. [3]

In relation to dental implant joints, Jokstad et al. discussed the development of internal connections that led to better aesthetic outcomes and mechanical stability. [4] The peri-implant bone level is one of the factors considered when determining whether dental implants are successful. It is necessary to maintain the health of the interdental papillae and gingival margins. [5]

In line with earlier studies, the present study showed that cortical bone experienced the maximum peak stress and the least in the trabecular region.[1,6,7]

Abutment fractures, loose abutments, and porcelain veneering fractures were complications with prosthetics. [8] Dentate participants had higher bone density than edentulous participants. [9] Additional research is required to confirm the finding.

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