Research Article

JRAD Journal of Research and Advancement in Dentistry

J Res Adv Dent 2018; 7:3:243-246.

Evaluation of Stress Distribution of Four Immediate Loading Implant Designs

Rohit Singh[1] Supriya Singh[2*] Revati Singh[3] Vaibhav Kamal[4] Jazib Nazeer[5] Sachin Sinha[6]

[1]Lecturer, Department of Prosthodontics, Patna Dental College and Hospital, Patna, Bihar, India.
[2]MDS, Department of Oral Medicine and Radiology, Private Consultant, Patna, Bihar, India.
[3]Senior Resident, Department of Dentistry, Patna Medical College and Hospital, Patna, Bihar, India.
[4]Senior Lecturer, Department of Pedodontics, B. R Ambedkar Dental College, Patna, Bihar, India.
[5]Lecturer, Department of Oral Pathology, Patna Dental College and Hospital, Patna, Bihar, India.
[6]Reader, Department of Periodontology, Awadh Dental College and Hospital, Jamshedpur, Jharkhand, India.

ABSTRACT

Background: In an edentulous patient, continuous alveolar bone resorption takes place eventually resulting in an impaired denture bearing area. The effect will be a decrease of denture stability and retention. The mandibular immediate loaded implant supported overdenture has gained significant psychological acceptance by the patients due to its relative simplicity, minimal invasiveness, cost effectiveness and because they can be immediately loaded.

Aim: A comparative analysis of stress distribution of four immediate loading implant designs in the edentulous mandible when simulated load is applied with an overdenture in three densities of Cancellous bone using three dimensional Finite Element Study.

Method: In this study a three dimensional finite element analysis was planned, to observe the stress distribution of four immediate loading implants designs in the edentulous mandible, when simulated masticatory load was applied with an overdenture using three densities of Cancellous bone. The implants used for the study were: 1.Implant of 15mm length, 1.8mm diameter with a reverse buttress thread design (Mini Dental Implant). 2.Implant of 15mm length, 3mm diameter with a box type of thread design (Maximus OS Implant). 3. Implant of 13mm length, 2.5mm diameter with a 'V' type of thread design (TRI Dental Implant). 4.Implant of 15mm length, 4.5mm diameter with a groovy type of thread design (Nobel Replace Select Implant).

Conclusion: It was found that the stress induced by all the implants tested were below the limit above which failure of the implant would take place.

Keywords: Immediate loading, Implant supported overdenture, Mandible, Stress.

INTRODUCTION

In an edentulous patient, continuous alveolar bone resorption takes place eventually resulting in an impaired denture bearing area. The effect will be a decrease of the denture stability and retention. Implant dentistry presents a viable and effective treatment alternative for many edentulous patients complaining of lack of retention in their mandibular dentures. When an implant supported overdenture is used the maximum biting force increases to almost double than that of conventional dentures [1]. Patient satisfaction is also increased.

In recent times, the mandibular immediate loaded implant supported overdenture has gained significant psychological acceptance by the patients due to its relative simplicity, minimal invasiveness, cost effectiveness and because they can be immediately loaded.

Received: Nov. 11, 2017: **Accepted**: Dec. 22, 2017
*Correspondence **Dr. Supriya Singh.**
Department of Oral Medicine and Radiology, Private Consultant, Patna, Bihar, India.
Email: Not Disclosed

MATERIALS AND METHOD

Finite Element analysis has been established as a very useful tool in understanding and evaluating the stresses in a system like bone implant interface. The basic concept of the Finite Element Analysis can be explained as follows. A continuum i.e. problem domain is divided into non-overlapping elements. This is called discretization of a domain. It is achieved by replacing the continuum by a set of key points called nodes, which when properly connected, form the elements. The collection of nodes and elements form the Finite Element Mesh. When loaded displacement of the nodes is used to calculate the stress at that point. The results can be viewed in the form of a color coded diagram which helps in visualizing the stress pattern [2,8].

The four implants used for comparison were

1. Implant of 15mm length, 1.8mm diameter with a reverse buttress thread design (Mini Dental Implant from Imtek Sendax).
2. Implant of 15mm length, 3mm diameter with a box type of thread design (Maximus OS Implant from Biohorizons).
3. Implant of 13mm length, 2.5mm diameter with a 'V' type of thread design (TRI Dental Implant from Lifecare Products).
4. Implant of 15mm length, 4.5mm diameter with a groovy type of thread design (Nobel Replace Select Implant from Nobel Biocare).

Three bone densities were considered for the study. Depending on the bone density, the following types of Cancellous bone were considered for the study.

1. Type A- Maximum Cancellous Bone Density into which an implant can be placed
2. Type B- Intermediate Cancellous Bone Density
3. Type C- Minimal Cancellous Bone Density into which an implant can be placed [3].

The software used in the study was Ansys Version 8 University Intermediate. A Finite Element Model of the mandible with four implants in the interforaminal region was created. This model was split in two symmetrical halves through the midline and static masticatory load of 325N was applied on the premolar and molar region to simulate actual biting conditions[3,4,8]. This gave the force acting on the mesial and distal implant.

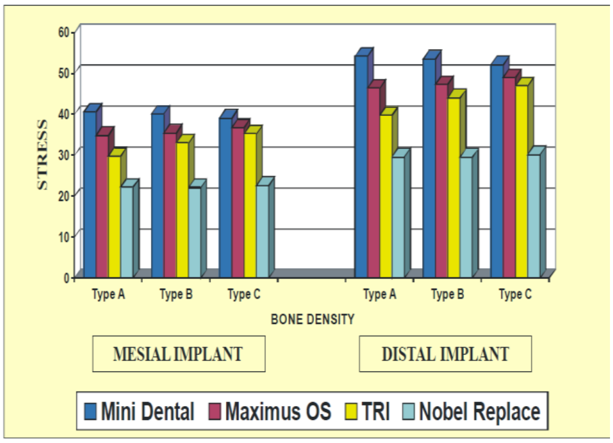
Finite Element models containing the different implants in different densities of bone were created. The material properties were assigned according to the literature and the models were meshed. Loading was done according to the values obtained from above. The results were viewed and analyzed

RESULTS

1. Irrespective of the type of implant and Cancellous bone, the maximum stress concentration was always at the crest of the bone (red zone).
2. As we go apically, the stress reduces.
3. Minimal to no stress was found at the base of the implant (blue zone).
4. Comparatively greater stress was induced by the implant with 15mm length, 1.8mm diameter and a reverse buttress type of thread design (Mini Dental Implant). This was followed by the implant of 15mm length, 3mm diameter and a box type of thread design (Maximus OS). Next was the implant with 13mm length, 2.5mm diameter and a 'V' type of thread design (TRI Dental Implant). The least stress was induced by the implant of 15mm length, 4.5mm diameter and a groovy type of thread design (Nobel Replace Select). (Refer to Table 1 and Graph 1).
5. Stress induced was found to be maximum in 'Type A' Cancellous bone (most dense bone), followed by 'Type B' Cancellous bone and was found to be minimum in 'Type C' Cancellous bone. (Refer to Table 1 and Graph 1).
6. Stress induced caused was more with the distal implant than with the mesial implant.

Table 1: Stress Induced By Different Implant Designs In The Mandible (In Mpa)

Bone Type	Implant	Mini Dental Implant	Maximus OS	TRI Dental Implant	Nobel Replace Select
Cancellous Bone A	Mesial Implant	40.662	34.835	29.806	22.253
	Distal Implant	54.216	46.447	39.742	29.671
Cancellous Bone B	Mesial Implant	40.128	35.474	33.058	22.154
	Distal Implant	53.504	47.299	44.078	29.539
Cancellous Bone C	Mesial Implant	39.081	36.78	35.257	22.674
	Distal Implant	52.108	49.04	47.01	30.233



Graph 1: Stress induced in different desites of bone by different implant designs (In Mpa).

DISCUSSION

Success or failure of an implant is a function of several factors including material sciences, biological and biomechanical aspects. All these factors work together to influence the success or failure of the implant. An implant is designed on the basis of scientific principles and concepts. Today there are a number of implant designs available depending on the different ideologies or clinical situations. A modification in the thread designs has been proved to be important for avoiding the harmful stresses and overloading and hence prevent detrimental effects on the bone implant interface.

Implant supported overdentures provide many advantages like more patient satisfaction and better chewing ability [1,7]. When they are used the maximum biting force increases to almost double than that of conventional dentures [1].

Previously there was a waiting period of a couple of months after placement of implants till the suprastructure could be placed. However patients expected immediate results from their implants and the concept of immediate loading came into the picture. The main objective of immediate loading implants is to give the patient both the implants and the final prosthesis on the same day as the surgery. Immediate loaded implants provide a cost-effective and viable treatment option for patients complaining of loose dentures. In implant dentistry Finite Element Analysis has been established as a reliable method of analyzing the effects of masticatory loads on the alveolar bone [2].

In the study the stress distribution of four immediate loading implant designs was evaluated in three densities of cancellous bone using Finite Element Analysis. It was found that the stress values for all the implants tested were not enough to cause permanent deformation of the bone.

The study has certain limitations namely only the thread geometry and the shape and size of the implant were taken into consideration. Surface roughness and coatings on the implant which could influence stress distribution were not considered. Only static loads were applied while during mastication the loading is of the dynamic type.

In treatment planning, it is necessary to first carefully evaluate the bone width, bone density, economic factors and implant design before deciding which implant design and if two implants or four implants should be placed in the edentulous mandible.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. Raghoebar GM, Meijer HJA, Stegenga B, Vissink A. A randomized clinical prospective clinical trial on the effectiveness of three treatment modalities for patients with lower denture problems. Int J Oral Maxillofac Surg. 2003; 32: 498-503.
2. Geng J. Tan KB, Lui G. Application of finite element analysis in implant dentistry: a review of literature. J Prosthet Dent. 2001; 85: 585-98.
3. Pierrishard L, Hure G, Barquins M, Chappard D. Two dental implants designed for immediate loading a finite element analysis. Int J Oral Maxillofac Implants. 2002;17:353-62.
4. Korioth TW, Johann AR. Influence of mandibular superstructure shape on implant stresses during simulated posterior biting. J Prosthet Dent. 1999; 82: 67-72.
5. Brunski JB, Puleo DA, Nanci A. Biomaterials and biomechanics of oral and maxillofacial implants current status and future developments. International journal of oral and maxillofacial implants. 2000;15:15-45.
6. H.J. Chun, D.N. Park, C.H. Han et al. Stress distributions in maxillary bone surrounding overdenture implants with different overdenture attachments. Journal of Oral Rehabilitation 2005 32; 193–205
7. Behnaz Ebadian, Mahmoud Farzin, Saeid Talebi, Niloufar Khodaeian. Evaluation of stress distribution of implant-retained mandibular overdenture with different vertical restorative spaces: A finite element analysis. Dent Res J (Isfahan). 2012 Nov-Dec; 9(6): 741–747.
8. Caetano CR1, Mesquita MF, Consani RL, Correr-Sobrinho L, Dos Santos MB. Overdenture retaining bar stress distribution: a finite-element analysis. Acta Odontol Scand. 2015 May;73(4):274-9.