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Research Article

COMPARATIVE EVALUATION OF THE EFFECT OF THREE DIFFERENT ATTACHMENT SYSTEMS ON STRESS DISTRIBUTION PATTERNS IN TWO IMPLANT SUPPORTED MAXILLARY OVERDENTURE: A 3D FINITE ELEMENT ANALYSIS

Gade Jaykumar Rambhau., Khodaskar Neha Arun., Agrawal SonamVinod., GadeVandana Jaykumar and Lahoti Krishna kumar

Department of Prosthodontics Swargiya Dadasaheb Kalmegh Smruti Dental College And Hospital, Hingna, Nagpur

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A B S T R A C T

Purpose: To evaluate and compare the stress distribution patterns on two implant supported maxillary overdenture with three different attachment systems using a 3D finite element analysis.
Material and methods: The 3D finite element models were prepared using maxillary two implant supported overdenture models with implants placed in canine regions bilaterally. Total three models using three different attachment systems namely Ball, Hader Bar and Locator attachments were used in this study. All the models were loaded bilaterally with an incremental vertical load from 0-100N at increments of 0, 20, 40, 60, 80 and 100N.
Results: In cortical bone the maximum von-mises stress of around 12.5 MPa is observed for Bar attachment design and the minimum von-mises stress of around 9.57 MPa is observed for Locator attachment design. In the cancellous bone the maximum von-mises stress of around 3.26 MPa is observed for Ball attachment design and the minimum von-mises stress of around 3.1 MPa is observed for Bar attachment design.
Conclusion: within the limitations of the study it was observed that in cortical bone maximum Von Mises stresses were observed for bar attachments and minimum for locator attachments. In cancellous bone maximum Von Mises stresses were observed for ball attachments and minimum for bar attachments.

INTRODUCTION

Implant retained overdenture are alternative treatment options because of their relative simplicity, minimal invasiveness and affordability especially for patients presenting persistent problems with conventional complete dentures. They are supported, retainedand stabilized by both implants and mucosa, therefore it requires fewer implant than fixed implant prosthesis. Palatal coverage and proper extension of the overdenture is necessary to transmit the loads to primary load bearing area in maxilla. Applications of attachments improve the retention of implant retained overdentures. If not chosen properly they transmit the horizontal or vertical load to supporting implants which may result in marginal bone resorption, periodontal bone loss, pressure necrosis and failure of osseointegration. So, stress around dental implant is analysed using several methods including Photoelasticity, Finite Element Analysis [1], Strain gauges [2] on bony surfaces. The advantages of Finite Element Analysis include accurate representing, complex geometries, easy model modification and representation of the internal stress [1].

Corresponding author:* **Gade JaykumarRambhau
Department of Prosthodontics Swargiya Dadasaheb Kalmegh Smruti Dental College And Hospital, Hingna, Nagpur

Ideally 4-6 implants are indicated for maxillary implant supported overdentures[3]. Many patients may not be able to proceed with an ideal treatment plan due to concerns related to overall health and healing capacity or simply financial constraints. Thus two implant supported overdenture in maxilla appear to be better alternative.

Unlike, mandibular two implant supported overdenture there is very less documentation about maxillary two implant supported overdenture with different attachment systems. Thus aim of this study was to evaluate and compare the stress distribution patterns on two implant supported maxillary overdenture with three different attachment systems using a 3D finite element analysis. The objectives of study were: i) To evaluate stress distribution patterns of the two implant supported maxillary overdenture with Ball, Bar and locator attachments. ii) To compare the stress distribution patterns obtained with three different attachment systems.

MATERIALS AND METHODS

Construction of finite element models

A CT scan of maxilla was utilised to model the bone by plotting the key points on the graph and generating identical key points on the ANSYS 12.1 Software [4] .The three 3 D finite element maxillary two implant supported overdenture models with implants placed in canine regions bilaterally having three different attachment systems namely, Ball, Bar and Locator attachments were used in this study. These models were labelled as A, B, C respectively. (fig 1,2,3)

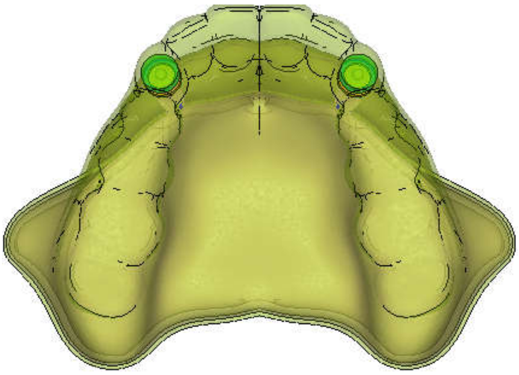


Figure 1 Model A-Ball Attachments

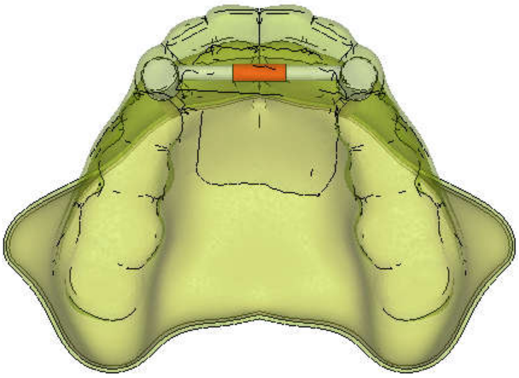


Figure 2 Model B- Bar Attachment

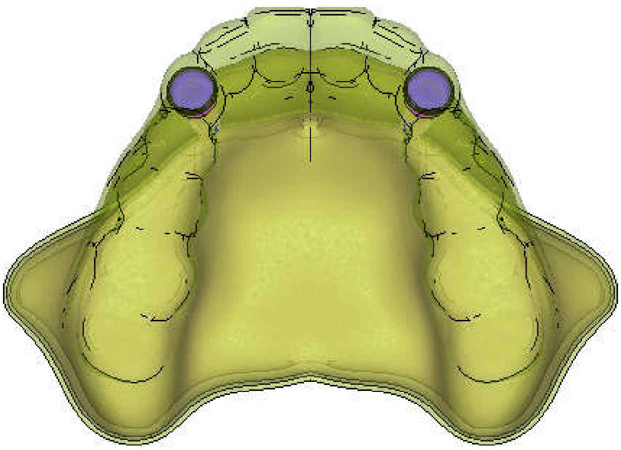


Figure 3 Model C- Locator Attachments

An implant having 3.75mm diameter and length 11.5mm (Noble Biocare) was modelled. The surface of simulated implant was threaded having thread pitch 0.4mm and inner diameter of implant was 2.25mm.

The ball attachment modelled was 2.25mm in diameter with cuff height 1mm and overall length of 3mm for model A. The silicon O-ring attachment had an inner radius of 1.25mm and outer radius of 2mm.

The bar attachment modelled was 25mm in length for the model B. The locator attachment modelled was 3.86mm in diameter with cuff height 1.78mm and overall length 3.81mm for the model C.

The mucosa was modelled on the cortical bone having thickness of 2mm all over. An overdenture having acrylic denture base and acrylic teeth was modelled over the implants with attachments on all three models. All these materials that were utilised in this model were regarded as homogeneous isotropic and linearly elastic.

Meshing of the models

A CT scan of a completely edentulous patient was procured and then only region of interest (maxilla) was considered and then converted the dicom data into geometric models using reverse engineering technique

The reverse engineering includes scanning the models, measuring the length, diameter and other features using standard measuring instruments and scanning machines. The Geometric modeling was done using "Rapid form" software (3D Systems Geometric, Korea). A"Hypermesh" meshing software (Hypermesh 13.0 Altair Engineering Inc.Hypermesh, America) was used for mesing of the geometric models of the edentulous maxilla, overdenture and implant abutment system. In hypermesh the individual parts like soft bone, hard bone, implant, attachment mucosa and denture were then discriticised and assembled. These meshed models are called finite element models and it consists of nodes and element data. Total no. of nodes and elements are listed in the table 1.

Table 1 Nodes and Elements

Part	No. of Nodes	No. Of elements
Cortical Bone	23966	75184
Cancellous bone	35551	139992
Mucosa	21394	63519
Implant	19956	79504
Ball attachment	5212	17832
Denture Cap	1654	5426
Rubber	740	1830
Clip	530	1398
Bar Attachment	3728	11631
Locator Attachment	4254	15934
Denture	28122	91744

Loading procedure

The three meshed models A, B and C were afflicted by incremental loading force from 0-100 N at interval of 0,20,40,60,80 and 100 for all three attachments.

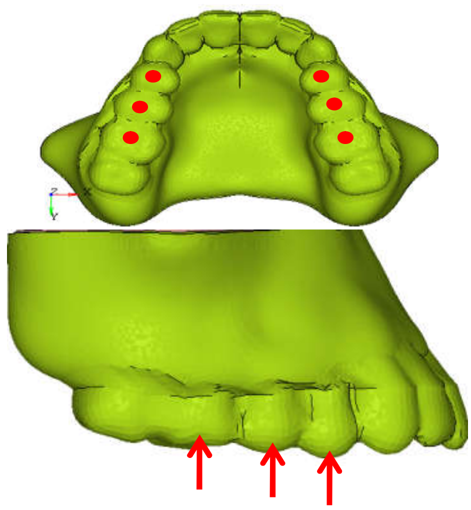


Figure 4 bilateral load in vertical direction (load varied from 0,20,40,60,80 and 100N)

The loading was done bilaterally in the region of first premolar, second premolar and first molar region (fig 4).

RESULTS

The 3D models of maxillary two implant supported overdenture with three different attachment systems of the maxilla comprising of cortical bone and cancellous bone was constructed. The vertical force ranging from 0-100N was applied to the first premolar, second premolar and first molar area in increments 0,10,40,60,80 and 100N. The stresses generated in both type of bone as well as implants with attachments were assessed.

Following models were studied

Model A: Two implant supported maxillary overdenture with ball attachment.

Model B: Two implant supported maxillary overdenture with bar attachment.

Model C: Two implant supported maxillary overdenture with locator attachment.

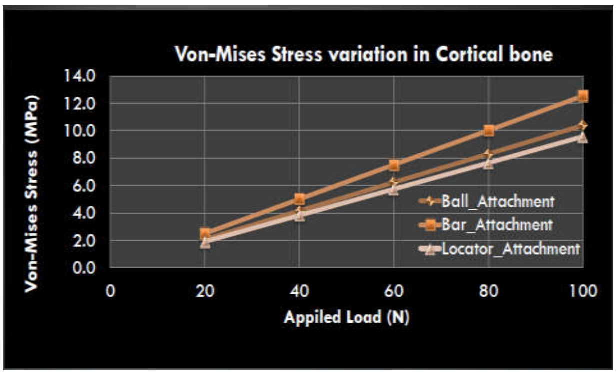
The material properties of various materials used in the model were taken from the literature [5,6](table 2).

Table 2 Mechanical properties of the materials

STRUCTURAL ELEMENT	POISSON'S RATIO	YOUNG'S MODULUS	REFERENCES
Cortical Bone	0.3	13700	Barbier et al
Cancellous Bone	0.3	1370	Barbier et al
Mucosa	0.37	1	Menicucci et al
Acrylic Resin	0.35	3000	Tanino et al
Acrylic Tooth	0.35	3000	Tanino et al
Titanium	0.3	135000	Brunski et al
Co-Cr Alloy	0.33	218000	Caglar et al
Stainless Steel	0.31	19000	Barao et al
Plastic Clip	0.28	3000	Manufacturer
O' Ring Rubber	0.45	5	Chun et al
Nylon Cap	0.45	5	Chun et al

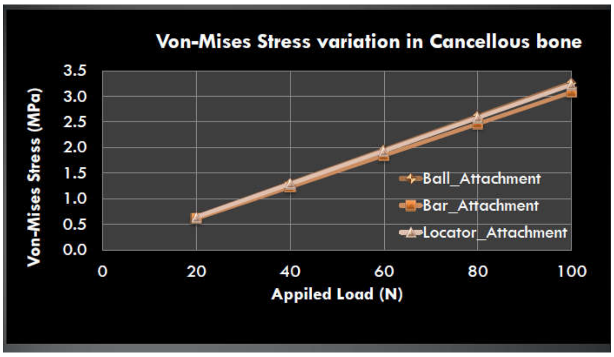
The Von-mises stresses and their distribution at the bone level and implant level was obtained through a finite element software and the data was in the form of colour coded graph. The stress graph had gradation of colour from red to blue, red colour indicated the highest stress area whereas blue was the lowest stress area.

Graph 1 shows that in cortical bone the maximum von-mises stress of around 12.5 MPa is observed for Bar attachment design and the minimum von-mises stress of around 9.57 MPa is observed for Locator attachment design.



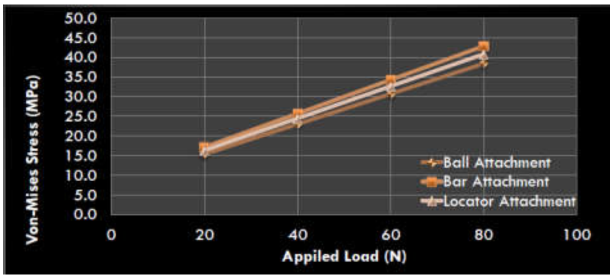
Graph 1 Von Mises Stresses in Cortical Bone

Graph 2 shows that in cancellous the maximum von-mises stress of around 3.26 MPa is observed for Ball attachment design and the minimum von-mises stress of around 3.1 MPa is observed for Bar attachment design.



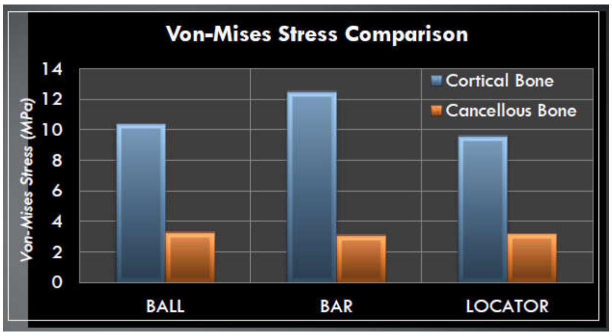
Graph 2 Von Mises Stresses in Cancellous bone

Graph 3 shows that at implant and attachment levelthe maximum von-mises stress of around 43 MPa is observed for Bar attachment design whereas the minimum von-mises stress of around 38 MPa is observed for Ball attachment design.



Graph 3 Von-mises Stress comparison in Implant Attachment Designs

Graph 4 shows that, the max stress in cortical bone is observed for Bar attachment design and minimum stress is observed with locator attachment design.



Graph 4 Von-Mises Stress Comparison between cortical and cancellous bone with different attachment systems.

Also for stresses in cancellous bone its almost same in all three cases. Since the minimum stress is observed on cortical bone with locator attachment design, it is the best design compared to other two designs for the applied load and assumed material properties.

DISCUSSION

An implant supported overdenture is subjected to various types of axial and non axial stresses. The resultant of these forces is transmitted through the superstructure and the attachments to the implants and may lead to concentration of stresses in different parts of implants as well as surrounding bone [7,8,9]. This study was conducted to evaluate stress patterns of maxillary two implant supported overdenture with three different attachments namely Ball, Bar and Locator attachments.

- *Stress Distribution at the Cortical Bone Interface under vertical Loading.* The maximum stress was found concentrated in model B (Hader bar) with vertical loading. The Minimum stress concentration was seen in model C (locator attachment).
- *Stress Distribution at the Cancellous Bone Interface under vertical Loading Conditions.* The maximum stress was found concentrated in model A (Ball attachment) with vertical loading. The minimum stress concentration was seen in model B (Hader Bar).
- *Stress Distribution in the Implant Body under vertical Loading Conditions:*

The maximum von-misesstress were observed for Bar attachment design.

The minimum von-misesstress were observed for Ball attachment design.

The results of this study indicates that stress distribution pattern differ under different bone conditions with different attachment systems.

CONCLUSION

Within the limitations of this study following conclusions were drawn:

1. In cortical bone maximum Von Mises stresses were observed for bar attachments and minimum Von Mises stresses were observed for locator attachments.
2. In cancellous bone maximum Von Mises stresses were observed for ball attachments and minimum Von Mises stresses were observed for bar attachments.

Thus it can be concluded that quality of bone influences the attachment selection.

References

1. Geng JP, Tan KB, Liu GR. Application of finite element analysis in implant dentistry: a review of the literature. *The Journal of prosthetic dentistry*. 2001 Jun 30; 85(6):585-98.
2. Satpathy S, Babu CS, Shetty S, Raj B. Stress distribution patterns of implant supported overdentures-analog versus finite element analysis: A comparative in-vitro study. *The Journal of Indian Prosthodontic Society*. 2015 Jul 1; 15(3):250.
3. Damghani S, Masri R, Driscoll CF, Romberg E. The effect of number and distribution of unsplinted maxillary implants on the load transfer in implant-retained maxillary overdentures: An in vitro study. *The Journal of prosthetic dentistry*. 2012 Jun 30; 107(6):358-65.
4. Kayabaşı O, Yüzbasıoğlu E, Erzincanlı F. Static, dynamic and fatigue behaviors of dental implant using finite element method. *Advances in engineering software.* 2006 Oct 31; 37(10):649-58.
5. Chun Hj, Park Dn, Han Ch, Heo Sj, Heo Ms, Koak JY. Stress distributions in maxillary bone surrounding overdenture implants with different overdenture attachments. *Journal of oral rehabilitation*. 2005 Mar 1; 32(3):193-205.
6. Kim MJ, Hong SO. Finite element analysis on stress distribution of maxillary implant-retained overdentures depending on the Bar attachment design and palatal coverage. *The journal of advanced prosthodontics*. 2016 Apr 1; 8(2):85-93.
7. Eskitascioglu G, Usumez A, Sevimay M, Soykan E, Unsal E. The influence of occlusal loading location on stresses transferred to implant-supported prostheses and supporting bone: a three-dimensional finite element study. *The Journal of prosthetic dentistry*. 2004 Feb 29; 91(2):144-50.
8. Sevimay M, Turhan F, Kiliçarslan MA, Eskitascioglu G. Three-dimensional finite element analysis of the effect of different bone quality on stress distribution in an implant-supported crown. *The Journal of prosthetic dentistry*. 2005 Mar 31; 93(3):227-34.
9. Şahin S, Cehreli MC, Yalçın E. The influence of functional forces on the biomechanics of implant-supported prostheses-a review. *Journal of dentistry*. 2002 Nov 30;30(7):271-82

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