

Influence of occlusal schemes on the stress distribution in upper complete denture in centric and eccentric relation

Abdalbasit A. Fatihallah, B.D.S., M.Sc.⁽¹⁾

ABSTRACT

Background: This study was aimed to identify the sites of maximum stresses in both balanced and lingualized occlusion in centric and eccentric relation

Materials and Methods: Two sets of complete denture constructed and a load of 60 N applied to sites of occlusal contacts so the Von-mises stresses produced from this load applied collected.

Results: Balanced and lingualized occlusal schemes compared in centric and eccentric relation, both mean and standard deviation for the calculated stresses compared at the crest of the ridge, buccal flange and mid-palatal suture.

Conclusion: Both balanced and lingualized occlusion transmit minimal pressure at the mid-palatal suture and with the concentration of stresses at the crest of ridge in centric, while at the working side balanced occlusion produced greater pressure than lingualized scheme and at balancing side vice versa occur.

Keywords: Finite element, three dimensional analysis, complete denture. (J Coll Dentistry 2005; 17(2): 17-20)

INTRODUCTION

The denture stability and the restoration of physiologic function "mastication" is the most important factor to be considered in complete denture construction the arrangement of the denture teeth and the occlusal schemes are important factors in denture stability and function⁽¹⁾

The amount of strains and subsequently the stresses in functioning dentures caused by using various posterior teeth of different occlusal configuration has not been satisfactorily investigated so that many attempts have been made to determined which occlusal form produced the greater stress per unit pressure⁽²⁾

The physiologic condition of the supporting tissue must be maintained in healthy condition which a prime request when constructing an oral prosthesis, the changes which is take place in these tissues might be due to the unequal distribution of functional forces over it.⁽³⁾

There is a great relationship between the width of occlusal table and the pressure produced over the supporting mucosa and even the sites and the number of occlusal contacts⁽⁴⁾

Devan define the denture stability as the forces of occlusion that do not alter substantially the positional relationship of the artificial teeth to the underlying bone. For a denture to be stabilized the interposed mucoperiostium must not be subjected to a state of torque.⁽⁵⁾

Occlusal contacts occurring during voluntary lateral jaw movement vary in regard to location and number these variation are reflected in therapeutic technique through the two well known but apposed concept" Canine protected occlusion and group function occlusion".⁽⁶⁾

Ortman stated that complete denture occlusion is the closure of maxillary and mandibular denture in centric relation and through out the range of functional and non-functional movements of the mandible occlusion must be developed to function efficiently and with least amount of trauma to the underlining supporting tissues.⁽⁷⁾

It's obviously desirable that we should try to reduce the incidence of fatigue failure to a minimum, so that two ways of choice available:

1. There are alternative materials of greater inherent resistance to flexural fatigue.
2. Reduction of the fatigue failure though is to reduce the stress borne by the denture.⁽⁸⁾

Craig stated that FEM stress analysis is valuable for analyzing complex geometries and it can determine stress/strains through out a three dimensional component. In this method a finite number of discrete structural elements are inter connected at finite number of points or nodes, these finite element are formed when the original structure is divided into a number of approximately shaped sections with the section retaining the actual properties of the real materials.⁽⁹⁾

Darber et al conducted a study to examine the stress distribution at the tooth denture base interface of acrylic resin teeth⁽¹⁰⁾

(1) Assistant lecturer, Department of Prosthodontics, College of dentistry university of Baghdad.

Table 1: Material properties used in the FEM.

Materials	Young's modulus (MPa)	Poisson's ratio	Authors
Tooth	2.65×10^3	0.35	Craig (9)
Acrylic resin denture base	2.65×10^3	0.35	Craig (9)
Mucosa	7.5	0.45	Larabee(14)

debonding from the denture base. They found that when load was applied to upper incisors the maximum tensile stresses were concentrated within the body of the tooth & not at the tooth denture base interface and calculated stresses at the interface was relatively low, and Darber et al found that irrespective to the type of acrylic resin used, the maximum tensile stresses were found at the palatal aspect of the interface.⁽¹¹⁾

MATERIALS AND METHODS

The samples consist of two groups of upper complete dentures; the first group represents the balanced occlusal schemes while the second group represents the lingualized occlusal schemes. The model was drawn on a grid paper after sectioning of the original upper denture mesial and distal to the upper first molar so that a section was made crossing the palate to the other side of the denture then the following steps take place:

1. The mesial and distal area of the denture base were drawn on a grid paper with its exact dimensions through super imposition of them on the grid paper, x and y coordinate system obtained for a specific key points to both mesial and distal areas of the denture base.
2. The distance between the mesial and distal area of the denture base block section obtained by the means of Vernier which represent the Z-value in space that change the model from two dimensional to three dimensional model.
3. The mesial and distal areas were joined at their key points by lines then the lines converted to areas and the areas converted to volumes which represent the denture base.

4. Modeling of the tooth was made by the aid of Vernier through obtaining the real dimension with the selection of specific key points.
5. the mucosal thickness under the denture was supposed to be 1.5mm⁽¹⁾
6. The model "tooth, denture base and mucosa" glued together in order to act as one unit through ANSYS options when applying the boundary conditions.

Materials properties used in this FEM are shown in Table 1 and the element used is a 3-dimensional brick shape element.

The Load was applied to the upper posterior teeth According to the site of contacts with the opposing artificial lower posterior teeth in centric and eccentric relation, the load applied to each set equal to 60 N (Figure 1,2,3 and 4)^(12,13)

The maximum principle stresses obtained at a specific selected node, which located at the crest of the ridge, buccal flange and the mid palatal suture.



Figure 1: The site of occlusal contact in balanced occlusion in centric relation

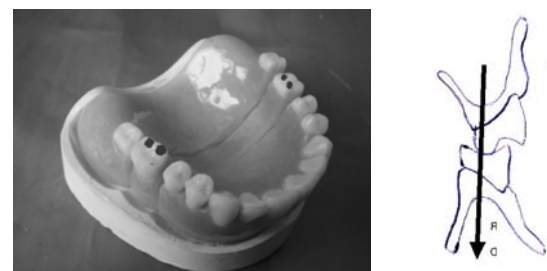


Figure 2: The site of occlusal contact in lingualized occlusion in centric relation

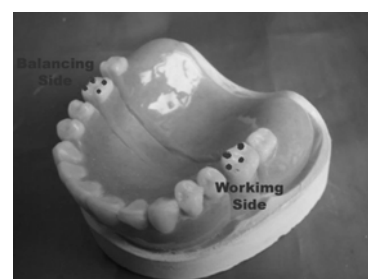


Figure 3: The site of occlusal contact in Balanced occlusion in eccentric relation

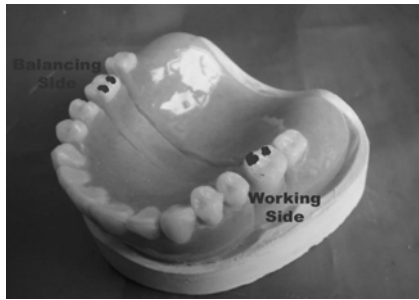


Figure 4: Represents the site of occlusal contact in lingualized occlusion in eccentric relation

RESULTS

Comparing stresses generated at centric occlusion in balanced and lingualized occlusal schemes:

Examination of the results obtained from the FEM through applying Von mises theory of failure and obtains the stresses at specific selected nodes located at the crest of the ridge, mid-palatal suture and buccal flange, results shows that the highest stress values at the crest of the ridge "15.371 KPa, 0.961 KPa in balanced and lingualized occlusal schemes respectively". Table 2,3; Fig. 5,6

Table 2: Values of stress including mean for balanced occlusion (KPa)

		Mean	Std
	Centric Occlusion		
	Crest of Ridge	21.138	2.831
	Mid-palatal Suture	0.0205	0.006
	Buccal Flange	15.371	1.702
Eccentric Occlusion	Ridge Crest Working	21.138	2.831
	Ridge Crest Balancing	11.702	1.127
	Mid-palatal Suture	0.0113	0.005
	Buccal Flange Working	15.371	1.702
	Buccal Flange Balancing	17.882	2.495

Table 3: Values of stress including mean for lingualized occlusion (KPa)

		Mean	Std
	Centric Occlusion		
	Crest of Ridge	14.03	1.395
	Mid-palatal Suture	0.054	0.001
	Buccal Flange	0.861	0.159
Eccentric Occlusion	Ridge Crest Working	9.004	1.966
	Ridge Crest Balancing	12.49	1.511
	Mid-palatal Suture	0.136	0.016
	Buccal Flange Working	11.43	2.710
	Buccal Flange Balancing	5.988	0.489

Comparing stresses generated at eccentric occlusion in balanced and lingualized occlusal schemes.

Generally speaking for both working and balancing side, the mean stress values in the lingualized occlusal scheme much less than those generated in the balanced occlusal scheme. While for mid-palatal suture no considerable changes takes place. (Table 2,3; Figure7, 8)

DISCUSSION

Comparing stresses generated at centric occlusion in balanced and lingualized occlusal schemes:

The stresses generated in lingualized occlusal scheme are considerably less than those generated in balanced occlusal scheme, this may be due to number of occlusal contact reduced so that there is only a one centric stopper between upper and lower antagonist teeth in case of lingualized occlusion." this is in agreement with Ohgori et al ⁽¹⁾ who conducted a study to show the influence of occlusal schemes on the pressure distribution under a complete denture by comparing fully balanced and lingualized occlusion using pressure transducer attached to simulated dentures. (Figure 5,6)

No changes take place at the mid-palatal suture when comparing the values of stresses in both occlusal schemes (Table 2 and 3).

When comparing stresses in lingualized and balanced occlusal schemes generated at eccentric occlusion:

Table 2 and 3 show that stresses generated at the mid-palatal suture reduced in fully balanced occlusion than that in lingualized occlusal schemes due to the fact that:

1. The position of the upper posterior teeth is rather tilted buccally than centered over the ridge crest so that the buccolingual position of the posterior teeth will affect the stress distribution and consequently the stress reaching the midline of the denture.
2. The site of occlusal contacts, in that only the palatal cusp of the upper posterior teeth contact the fossa and central groove of the lower posterior teeth.

Stresses generated at the working side at the crest of the ridge and buccal flange for balancing occlusion seems to be more than that for the lingualized occlusal scheme due to the number of occlusal contact increased. For the

balancing side at the crest of the ridge vice versa occur, while at the buccal flange the

same results take place this is may be due to the sites of occlusal contacts differ. Fig. 7,8

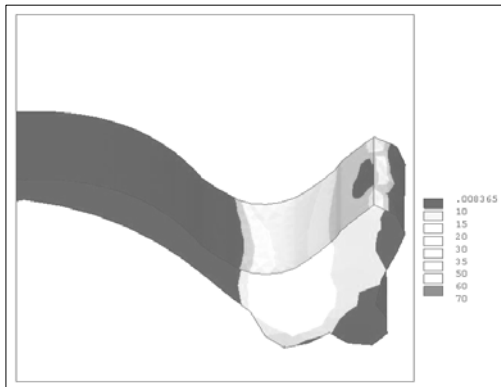


Figure 5: Three-dimensional model represents stress contours in balanced occlusal scheme at centric occlusion. (KPa)

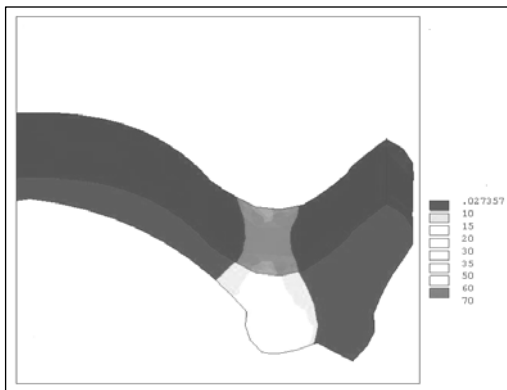


Figure 6: Three-dimensional model represents stress contours in lingualized occlusal scheme at centric occlusion. (KPa)

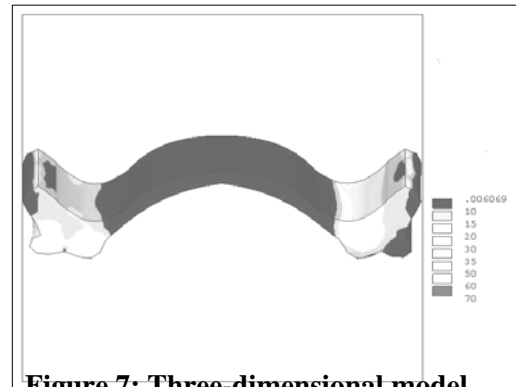


Figure 7: Three-dimensional model represents stress contours in balanced occlusal scheme at eccentric occlusion. (KPa)

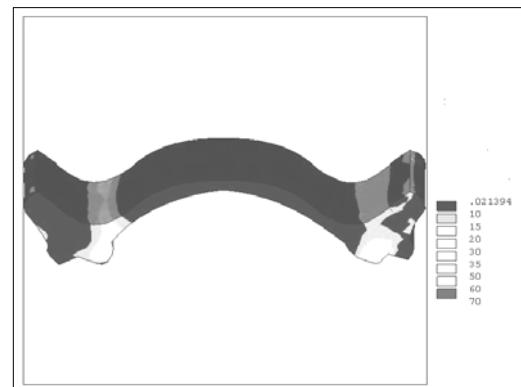


Figure 8: Three-dimensional model represents stress contours in lingualized occlusal scheme at eccentric occlusion. (KPa)

REFERENCES

- Ohguri T, Kawano F, Ichikawa T, Matsumoto N. Occlusal scheme and pressure under complete denture. The International Journal of Prosthodontics 1999; 12(4): 353-8.
- Kelsey CR, Coplostz, Schoonmarker M. The effect of occlusal forms on pressure and bending during mastication with complete denture. J Prosth Dent 1976; 55 (2): 312.
- Lambrech JR, Kydd WL. A functional stress analysis of the maxillary complete denture base. J Prosth Dent 1962; 12(5): 865-72.
- Roedema WH. Occlusal table width and pressure under denture. J Prosth Dent 1976; 36:24-34.
- Devan MM. The concept of neotrocentric occlusion as related to denture stability. JADA 1954; 48: 165-8.
- Woda A, Vegneron P, Douglas K. Non functional and functional occlusal contact. A review of literature. J Prosth Dent 1979; 42(3): 335-41.
- Ortman HR. Role of occlusion in complete denture prosthetic. J Prosth Dent 1971; 27(1): 121-37.
- Johnson W. A study of stress distribution in complete upper denture. The dental practitioner 1965; 15(31): 374-6.
- Craig R. Restorative dental material. 10th ed. Mosby St. Louis 1997: 59-103.
- Darber UR, Huggett R, Harrison A, William K. The tooth denture base bond stress analysis using FEM. Eur Dent J 1993; 1(3): 117-20.
- Darber UR, Huggett R, Harrison A, William K. Finite element analysis of stress distribution at the tooth denture base interface of acrylic resin teeth debonding from denture base. J Prosth Dent 1995; 74(6): 591-4.
- Rahn AO, Heartwell CM. Textbook of complete denture. Ed 5 Philadelphia, Lea and Febiger, 1993.
- Boucher. CO. Swenson's complete denture. Ed 6 St. Louis, C.V. Mosby co. 1970: 567.
- Larrabee W, Glat J. A finite element method of skin deformation. Laryngoscope 1986; 96:413-19.