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The effect of attachment types and implant level on the stress distribution in a mandibular overdenture: a 3D Finite Element Analysis

O efeito dos tipos de sistemas de retenção e nível dos implantes na distribuição de tensões em overdentures mandibulares: Análise por Elementos Finitos 3D

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ABSTRACT

Objective: The objective of this study was to evaluate the stress distribution in bone-surrounding implants placed in different levels in a mandibular overdenture. **Material and Methods:** A Computerized Tomography (CT) scan of an edentulous mandible was used to generate the models. Two implants with an internal connection were placed perpendicular to the occlusal plane in the Canine sites of the mandible. The implant in the left side was placed 1mm higher than the other side. Dolder bar and ball attachments were designed. Loading was performed by clenching the teeth with reconstruction of the muscles. In the anterior loading condition, force was applied to the central incisors and in the posterior loading conditions, it was applied to the molars and premolars. Then the Maximum Principal Stresses in the peri implant bone was evaluated with finite element analysis. **Results:** In both models, the highest stress values were recorded in the cortical bone surrounding the higher implant except in the ball model with unilateral load application on the right side (64.7 MPa). In almost all loading conditions the stress value differences in models with bar and ball attachments were low. Only in the anterior loading condition, the stress magnitude was higher in two implants of the ball model (60.5 MPa in the left side and 21 MPa in the right side) compared to the bar model (54.5 MPa in the left side and 17.5 MPa in the right side). **Conclusion:** The stress concentration did not affected considerably by the attachment system. High stress values were found adjacent the implant with a higher level. To reduce the amount of stress, bilateral balance occlusion should be considered.

KEYWORDS

Stress; Finite element analysis; Overdenture; Dental implants.

RESUMO

Objetivo: O objetivo deste estudo foi avaliar a distribuição de tensões em tecido ósseo ao redor de implantes instalados em diferentes níveis em uma Overdenture mandibular. **Material e Métodos:** Uma tomografia computadorizada (TC) de uma mandíbula edêntula foi usada para gerar os modelos. Dois implantes de conexão interna foram instalados perpendicularmente ao plano oclusal na região de caninos inferiores. O implante do lado esquerdo foi instalado 1mm acima do que do lado direito. A barra Dolder e o pilar tipo bola foram projetados. A carga foi realizada apertando os dentes com reconstrução dos músculos. Na condição de carga anterior, a força foi aplicada nos incisivos centrais e nas condições de carga posterior, foi aplicada nos molares e pré-molares. Em seguida, as Tensões Máximas Principais no osso periimplantar foram avaliadas com análise de elementos finitos. **Resultados:** Em ambos os modelos, os maiores valores de tensão foram registrados ao redor do osso cortical ao redor do implante superior, exceto no modelo tipo bola com aplicação de carga unilateral no lado direito (64,7 MPa). Em quase todas as condições de carregamento, as diferenças nos valores de tensão nos modelos com fixações de barra e tipo bola foram baixas. Apenas na condição de carregamento anterior, a magnitude da tensão foi maior em dois implantes do modelo tipo bola (60,5 MPa no lado esquerdo e 21 MPa no lado direito) em relação ao modelo barra (54,5 MPa no lado esquerdo e 17,5 MPa no lado direito). **Conclusão:** A concentração de tensão não foi afetada considerando o sistema de retenção. Maiores valores de tensão foram encontrados adjacentes ao implante com um nível mais alto. Para reduzir a quantidade de tensão, a oclusão bilateral balanceada deve ser considerada.

PALAVRAS-CHAVE

Tensão; Análise de elementos finitos; Overdenture; Implantes dentários.

INTRODUCTION

Conventional dentures may cause some difficulties for their users due to a lack of support and stability. Patients' chewing ability is heavily affected by their disadvantages [1]. To solve this issue, implant-supported overdentures were introduced. It is yet one of the most effective treatments for edentulous patients [2]. One of the treatment plans is using an overdenture supported by two implants (two-implant overdentures). These types of overdentures are cost beneficial and have a great outcome for edentulous patients [3]. To improve the stability of overdentures, many attachment systems have been introduced such as ball, locator, bar, magnet, and various options which increase the masticatory efficiency and satisfaction [4].

The type of attachments used to hold the overdentures must be wisely selected by the professionals [5]. The goal is to reduce the amount of stress at the site of the implants and also distribute the stress equally between two implants. Placing the implants at an equal level plays an important role to achieve this goal [6].

Misch [7] has been suggested that splinting the implants with the bar attachment reduces the loading forces specifically when the implants placed at the same occlusal height, at an equal distance from the midline, and in a similar angulation. Sometimes due to unequal alveolar resorption in different regions of the mandible the implants can't be fixed accurately and as a consequence, the implants won't be placed at an even level [8].

As the stress on the bone surrounding the implant is one of the main reasons for implant treatment failure, evaluating the factors which affect the stress values is an important task. It has been suggested that splinting the implants will reduce the stress levels on the peri-implant bone [9].

It is not possible to determine the stress values in overdentures clinically. Finite Element Analysis (FEA) is a reliable and approved method and has numerous advantages. By using this method, the stress distribution in 3D models can be analyzed color-coded and numerically [10-12].

There are many studies comparing bar and ball type attachments regarding stress distribution around two implants [5,13,14]. But there have been a few data regarding the comparison of these two types of attachments in the situations that the implants aren't at the same height. Therefore this study was designed to compare the bar and ball attachments regarding the stress distribution around the implants with different levels using FEA and 3D models.

METHODS AND MATERIALS

Computerized Tomography (CT) imaging was used to remodel the mandible. All of the CT scan data with 1mm sections and the data obtained from MIMICS software (Materialise Interactive Medical Image Control System; Materialise, version 21, Leuven, Belgium) were imported into Solidworks software (version 28, Dassault systemes solidworks corp, MA, United States) for remodeling purposes. The implant model was created using Solidworks software. ITI implants (Straumann, Switzerland, 10×4.1 mm) were used. The bone level implants were placed perpendicular to the occlusal plane on the left and right Canine sites of the mandible with an internal connection. The implant in the left side was 1mm higher than the implant on the right.

The tickness of the cortical (about 2 mm) was recorded using CT scan imaging. The mucous membrane was designed with a width of 2mm.

Two models were created (Figure 1). In the first model, Dolder bar attachment was used. The attachment height was 3.25 mm and the maximum thickness was 2.25 mm. In the second model, ball attachments were used with a height of 3.4 mm. For placing the denture on the tissue, plastic clips were used for the bar model. Titanium housings with golden capsules were used for the ball model. All of the materials in this study were considered isotropic and linearly elastic. The osseointegration between implants and the bone was considered 100%. Denture movement on the implant was considered smoothly and without any frictions. After defining the boundary conditions and physical properties of the materials (Table I), the meshing process was started and the models were divided into the elements (Figure 2).

Loading was performed by reconstruction of the muscles (Figure 3). Medial pterygoid, Masseter, and Temporalis muscles were modeled by COSMOSWorks software (version 12.1., Dassualt systemes solidworks corp, MA, United States). The weight factor multiplied by the scaling factor determines the amount of muscle force in the activity. The anatomical properties and the forces of the muscles were obtained from the literature [20] (Table II).

Different types of loads were applied to the models. The anterior load were applied on midline. This was done to simulate the food cutting process. Posterior bilateral load was applied on molars and premolars on both sides. To achieve the unilateral posterior loading condition, the force was applied on the left and right molars and premolars separately.

The number of elements was 468472 for the ball attachment model and 482426 for the bar model. The number of nodes was 746557 for the ball attachment model and 752654 for the bar model. The elements were parabolic & tetrahedral solid. The size of the elements was set to be 1.5 mm.

The Von Misses graph as an indicator of the stress was exported both color-coded and

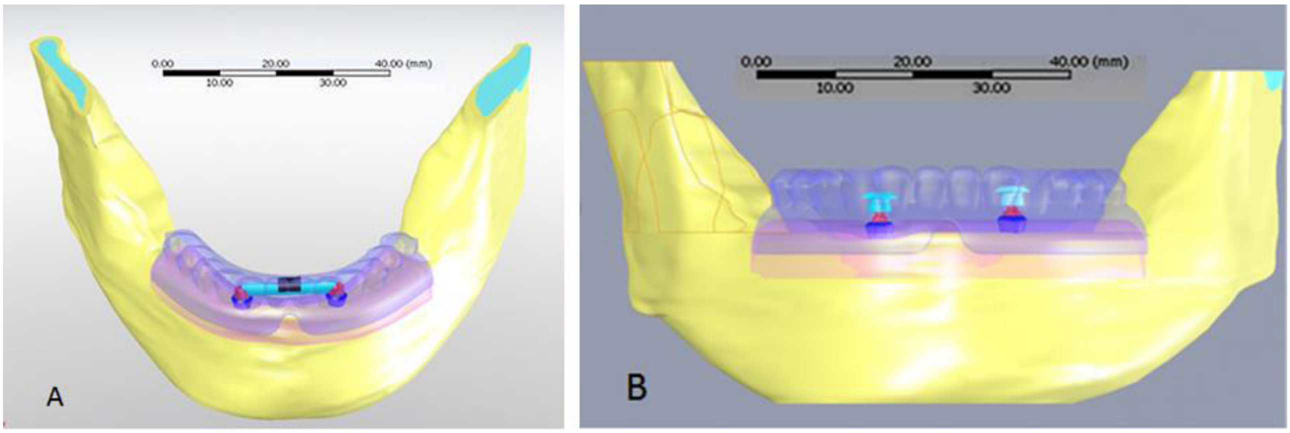

Figure 1 - 3D models of the (A) bar and (B) ball attachments.

Table I - Physical properties of the materials

Materials	Elastic modulus (MPa)	Poisson ratio	Reference
Acrylic resin	3000	0.35	[6]
Cortical bone	13700	0.3	[2]
Trabecular bone	1370	0.3	[2]
Mucosa	680	0.45	[6]
Ball abutment and metallic cap	114000	0.3	[2]
Implant	110000	0.33	[15]
Bar	218000	0.33	[16], [17]
Clips	3000	0.28	[18]
Lamella retention insert	97000	0.42	[19]

numerical to analyze the stress values in the peri-implant bone.

RESULTS

In both models, the highest stress was recorded around the cortical bone which was near the implants (especially in their distal region) (Figures 4-5). Except in one condition (unilateral loading on the right side with ball attachments), all of the loading trials resulted in higher stress levels on the higher implant which was in the left side of the mandible (Table III).

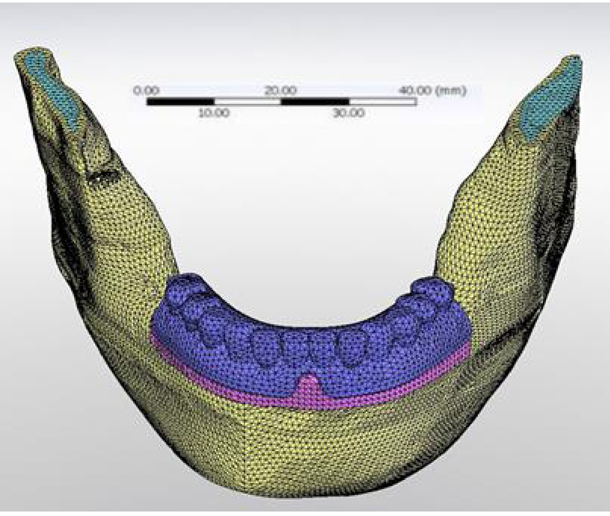

Figure 2 - Meshing process.

By anterior load application in both bar and ball models, the higher implant (left) experienced more stress in the ball model which was 10% higher in comparison to the model with the bar attachment (54.5 MPa in the bar model, 60.5 MPa in the ball model). Under anterior loading conditions, the amount of stress around the left implants was about 3 times higher than the right implant in both models. Under bilateral posterior loading conditions, the amount of stress recorded for the bar model was 16.4 MPa (in the cortical bone adjacent to the left implant) and 13.9 MPa (in the right side). The stress values in the model with ball attachments were 15.8 MPa (in the cortical bone adjacent to the left implant) and 14.7 MPa (on the right side). The left side peri-implant bone exhibited a higher amount of stress values in both models, especially in the bar attachment model. In this type of loading the amount of stress was lower compared to other loading conditions.

Under unilateral Loading conditions on the left side, the cortical bone surrounding the left implant showed a higher amount of stress values in both ball and bar models (165 MPa for the bar model and 169 MPa for the ball model). The cortical bone adjacent to the right implant

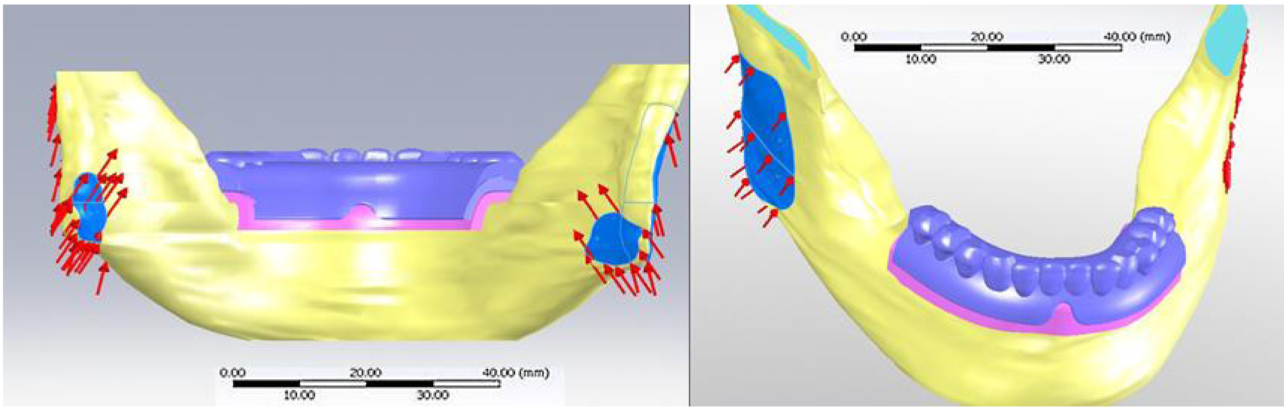

Figure 3 - Modeling of the muscles.

Table II - The forces of the muscles (weight factor and scaling factor)

	Weight factor (Newton)	Scaling factor			
		Anterior clenching		Posterior clenching	
		Right	Left	Right	Left
Superficial masseter	190.4	0.40	0.40	1.00	1.00
Deep masseter	81.6	0.26	0.26	1.00	1.00
Medial pterygoid	174.8	0.78	0.78	0.76	0.76

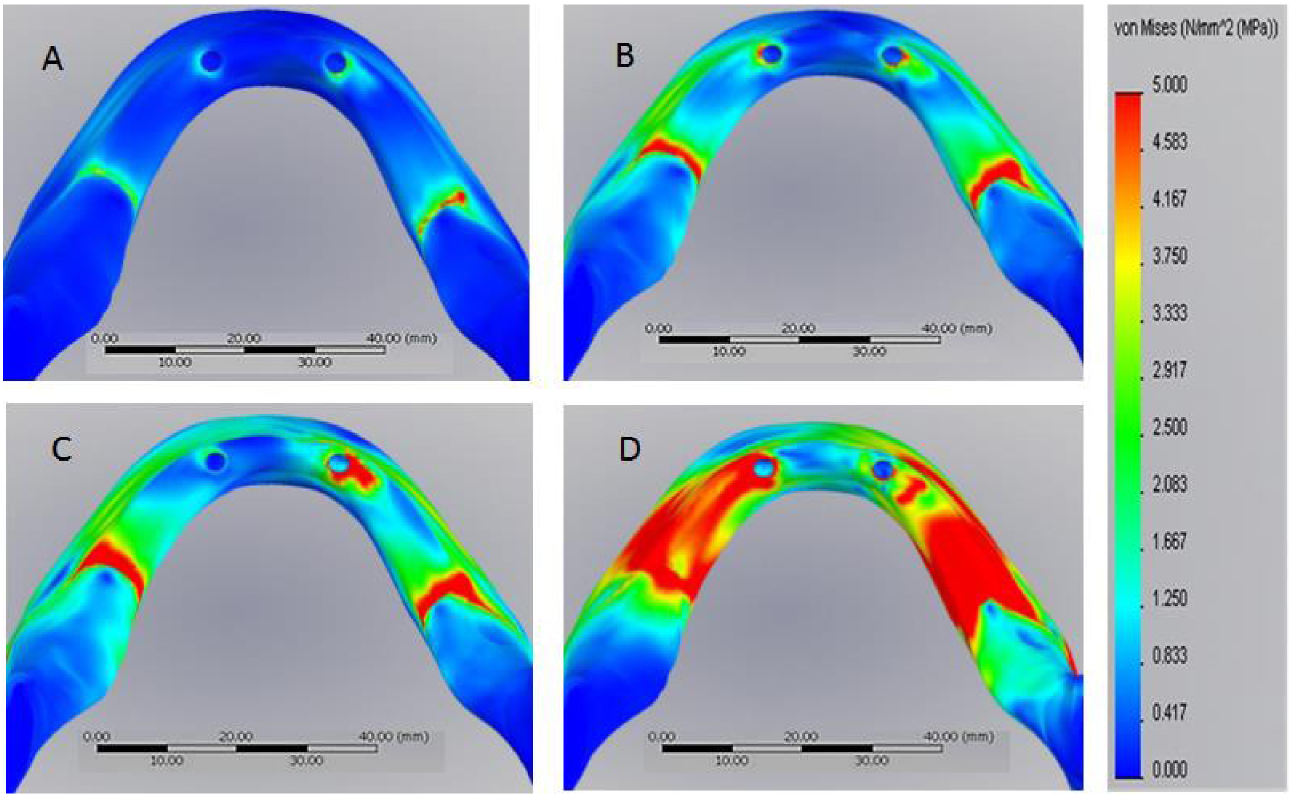

Figure 4 - Stress values in the Ball model (A) bilateral loading (B) anterior loading (C) unilateral loading on the right side (D) unilateral loading on the left side.

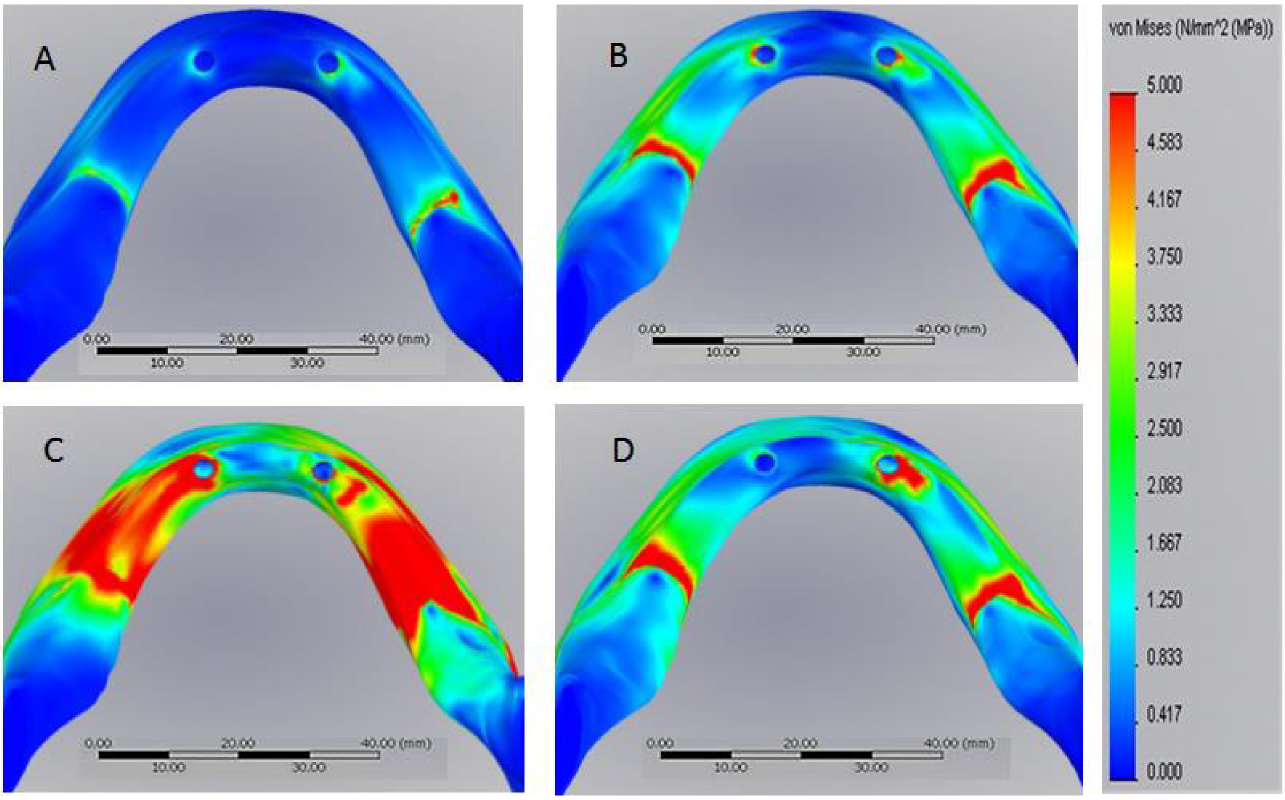

Figure 5 - Stress values in the Bar model (A) bilateral loading (B) anterior loading (C) unilateral loading on the left side (D) unilateral loading on the right side.

exhibited lower stress concentration but the peak pressure was relatively high in both models (60 MPa for the bar model and 59 MPa for the ball model).

Table III - Maximum stress values (MPa) with bar and ball attachments

		Anterior loading	Posterior bilateral loading	Unilateral loading on the right side	Unilateral loading on the left side
Bar attachment	Right implant	17.5	13.90	44.70	60.25
	Left implant	54.50	16.40	52.80	165
Ball attachment	Right implant	21	14.7	64.7	59
	Left implant	60.5	15.8	50	168

By unilateral loading application on the right side in the model with ball attachments, the right peri-implant bone showed greater stress values compared to the left side (64.7 against 50 MPa) but in the model, with the bar attachment, the cortical bone adjacent to the left implant exhibited a higher amount of stress concentration (44.7 MPa in the right side and 52.8 MPa in the left side) compared to the right implant in both models.

DISCUSSION

Based on the Misch [7] suggestion, the implant placed in a higher level in the overdenture will be the main support and the rotation axis of the overdentures thus it will receive more occlusal load. In this study in almost every type of loadings, the higher implant showed more stress values compared to the lower one (except under the right side loading condition with ball attachments). The ability of the bar attachment to reduce the stress values between two implants wasn't considerable and a significant reduction in the magnitude of stress values on the higher implant in the bar model was not noticed compared to the ball model.

Only in the anterior loading condition the amount of stress around both implants was lower in the model with bar attachment compared to the model with ball attachments (almost 10%).

Multiple studies compared splinted and non-splinted attachments, some found better stress distribution with a bar attachment [9]. However some studies found no significant differences between these two types of attachments [21,22]. The reason for these contradictory results may be due to different loading conditions and the materials used in the attachments.

In this study, the plastic matrix was used for the bar attachment and a Golden capsule with a titanium cap was used for ball attachments. In a study by Alvarez-Arenal et al. [4], it was found that attachment material is related to the amount of transferred stress. Daas et al. [23] reported that the amount of stress was based on the resiliency of the attachment. The clipping part of the bar can't rotate freely because of the friction and has low resiliency so as a result a larger amount of stress was transferred to the implant [24].

Bar attachment was not efficient in distributing the stress between the implants. In the left unilateral loading condition in both models with bar and ball attachments stress distribution was the same and almost 75% of the stress values transferred to the higher implant and in other conditions almost 54% of the stress values transferred to the higher implant. In the bilateral posterior loading condition, the difference between stress values in the cortical bone surrounding the implants was lower than in other loading conditions. This finding was similar to the study of Unsal et al. [25]. The stress distribution pattern in the cases of bilateral loading was more evenly, so it could be recommended to consider bilateral balanced occlusion in overdentures [2,25].

Unilateral loads adjacent to the higher implant lead to severe stress concentration in the cortical bone surrounding this implant. Because the higher implant was approximate to the loading site and acted as a fulcrum, more stress values were observed [4]. Although the existence of a 1mm difference in implant heights, the stress values in the left unilateral loading condition in the higher implant were very severe (almost 3 times more than other conditions and 10 times more than posterior bilateral loading condition). So it could be recommended to adjust the bone level by surgical procedure before the implant insertion and place the implants at the same level.

In the model with ball attachments in the right unilateral loading condition, more stress values were found in the lower implant because in this condition due to proximity of the lower implant to the place of the load application, it acts as a fulcrum and the prosthesis rotated and separated from the opposite side. Also, lower stress values were found in the higher implant.

In the model with the bar attachment, two implants and the bar act as a single unit so in right unilateral loading condition more stress values were found in the higher implant.

In a study by Ozan et al. [6] in 2015, ball and locator attachments at different height levels were evaluated. It was demonstrated that stress values decreased in the model with 3 mm height differences in comparison to the control group. They concluded that an increase of bone height and decrease of crown height, reduce the level arm effect. In our study, one implant was placed 1 mm lower than the adjacent implant. Lamella retention insert and clips were considered in the models in order to achieve more accurate results, which were not used in the study mentioned above. Attachment types and positions of implants were different in these two studies.

In a study by Unsal et al. [25] in 2019, mandibular overdentures with different bone heights and attachment types were analyzed. In the presence of loading, more stress values were found in the cortical bone of the models with unilateral bone resorption than models with the same bone height on each side. They also found that in unilateral loading conditions, the crestal bone adjacent to the implant on the ipsilateral side showed maximum stress which is similar to the result of our study.

Khurana et al. [26] in 2018, evaluated ball and locator attachments of varying heights in a mandibular overdenture. They found more stress values in the models with an increased collar height of the attachment system and the ipsilateral side of load application showed higher stress in comparison to the contralateral side.

In this study based on the previous studies, 2 mm thickness was considered for the soft tissue [13,27]. The alveolar bone was considered homogenous and linearly elastic [25]. Osseointegration was considered 100% although it may not occur in clinical situations and this leads to a reduction in stress values in the bone surrounding the implants [25]. In this study bone was modeled as an isotropic and homogenous material, however it has a complex and heterogenous structure [26]. Thus, because of fundamental differences in the nature of the clinical and laboratory conditions it must be clinically examined and approved.

CONCLUSION

Based on the limitation of this study, it is possible to conclude that:

1.The difference in the level of implants modified the stress concentration with higher magnitude on the implant at the higher level condition.

2.The attachment system did not affect the stress concentration.

3.In order to reduce the stress concentration, bilateral balanced occlusion should be considered during the prosthesis planning.

Authors' Contributions

SA: designed the study. SN: wrote and edited the manuscript. PA: collected and analyzed data. FTD, FT: critically reviewed the manuscript. All authors read and approved the manuscript.

Conflict of Interest

There is no conflict of interests.

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Regulatory Statement

This study was approved by the Ethics Committee of Qazvin University of Medical Sciences under the code IR.QUMS.REC.1394.469. There is no conflict with ethical considerations.

REFERENCES

1. Paes TJA Jr., Tribst JP, Piva AM, Figueiredo VM, Borges AL, Inagati CM. Influence of fibromucosa height and loading on the stress distribution of a total prosthesis: a finite element analysis. Braz Dent Sci. 2021;24(2):1-7. http://dx.doi.org/10.14295/bds.2021.v24i2.2144.

2. Alvarez-Arenal A, Gonzalez-Gonzalez I, deLlanos-Lanchares H, Brizuela-Velasco A, Martin-Fernandez E, Ellacuria-Echebarria J. Influence of implant positions and occlusal forces on peri-implant bone stress in mandibular two-implant overdentures: a 3-Dimensional Finite Element Analysis. J Oral Implantol. 2017;43(6):419-28. http://dx.doi.org/10.1563/aaid-joi-D-17-00170. PMid:28972823.

3. Ma S, Tawse-Smith A, Thomson WM, Payne AG. Marginal bone loss with mandibular two-implant overdentures using different loading protocols and attachment systems: 10-year outcomes. Int J Prosthodont. 2010;23(4):321-32. PMid:20617220.

4. Alvarez-Arenal A, Gonzalez-Gonzalez I, deLlanos-Lanchares H, Martin-Fernandez E, Brizuela-Velasco A, Ellacuria-Echebarria J. Effect of implant- and occlusal load location on stress distribution in Locator attachments of mandibular overdenture. A finite element study. J Adv Prosthodont. 2017;9(5):371-80. http://dx.doi.org/10.4047/jap.2017.9.5.371. PMid:29142645.

5. Bilhan SA, Baykasoglu C, Bilhan H, Kutay O, Mugan A. Effect of attachment types and number of implants supporting mandibular overdentures on stress distribution: a computed tomography-based 3D finite element analysis. J Biomech. 2015;48(1):130-7. http://dx.doi.org/10.1016/j.jbiomech.2014.10.022. PMid:25443880.

6. Ozan O, Ramoglu S. Effect of implant height differences on different attachment types and peri-implant bone in mandibular two-implant overdentures: 3D Finite Element Study. J Oral Implantol. 2015;41(3):e50-9. http://dx.doi.org/10.1563/AAID-JOI-D-13-00239. PMid:24471769.

7. Misch CE. Dental implant prosthetics. Philadelphia: Elsevier; 2015.

8. Ozyilmaz OY, Aykent F, Ozel GS. Effect of mucosa thicknesses on stress distribution of implant-supported overdentures under unilateral loading: photoelastic analysis. J Appl Biomater Funct Mater. 2019;17(4):2280800019882645. http://dx.doi.org/10.1177/2280800019882645. PMid:31779504.

9. Geramy A, Habibzadeh S. Stress distribution in splinted and unsplinted implant-supported maxillary overdentures: a 3D Finite Element Analysis. Implant Dent. 2018;27(1):56-62. http://dx.doi.org/10.1097/ID.0000000000000708. PMid:29300207.

10. Memari Y, Fattahi P, Fattahi A, Eskandarion S, Rakhshan V. Finite element analysis of stress distribution around short and long implants in mandibular overdenture treatment. Dent Res J. 2020;17(1):25-33. http://dx.doi.org/10.4103/1735-3327.276231. PMid:32055290.

11. Mohamed SE. A finite element analysis of stress distribution in all on four system using different framework materials in the mandible. Egypt Dent J. 2020;66(4): 2423-30.

12. Tribst JP, Piva AM, Rodrigues VA, Borges AL, Nishioka RS. Stress and strain distributions on short implants with two different prosthetic connections–an in vitro and in silico analysis. Braz Dent Sci. 2017;20(3):101-9. http://dx.doi.org/10.14295/bds.2017.v20i3.1433.

13. Hong HR, Pae A, Kim Y, Paek J, Kim HS, Kwon KR. Effect of implant position, angulation, and attachment height on peri-implant bone stress associated with mandibular two-implant overdentures: a finite element analysis. Int J Oral Maxillofac Implants. 2012;27(5):e69-76. PMid:23057045.

14. Rismanchian M, Dakhilalian M, Bajoghli F, Ghasemi E, Sadr-Eshkevari P. Implant-retained mandibular bar-supported overlay dentures: a finite element stress analysis of four different bar heights. J Oral Implantol. 2012;38(2):133-9. http://dx.doi.org/10.1563/AAID-JOI-D-09-00037.1. PMid:20545552.

15. Shahmiri R, Das R. Finite element analysis of implant-assisted removable partial denture attachment with different matrix designs during bilateral loading. Int J Oral Maxillofac Implants. 2016;31(5):e116-27. http://dx.doi.org/10.11607/jomi.4400. PMid:27632278.

16. Barão VA, Assunção WG, Tabata LF, Delben JA, Gomes EA, Sousa EA, et al. Finite element analysis to compare complete denture and implant-retained overdentures with different attachment systems. J Craniofac Surg. 2009;20(4):1066-71. http://dx.doi.org/10.1097/SCS.0b013e3181abb395. PMid:19553853.

17. Hussein MO. Stress-strain distribution at bone-implant interface of two splinted overdenture systems using 3D finite element analysis. J Adv Prosthodont. 2013;5(3):333-40. http://dx.doi.org/10.4047/jap.2013.5.3.333. PMid:24049576.

18. Assunção WG, Tabata LF, Barão VA, Rocha EP. Comparison of stress distribution between complete denture and implant-retained overdenture-2D FEA. J Oral Rehabil. 2008;35(10):766-74. http://dx.doi.org/10.1111/j.1365-2842.2008.01851.x. PMid:18482352.

19. Shishesaz MO, Ahmadzadeh AS, Baharan AM. Finite element study of three different treatment designs of a mandibular three implant-retained overdenture. Lat Am J Solids Struct. 2016;13(16):3126-44. http://dx.doi.org/10.1590/1679-78253212.

20. Korioth TW, Hannam AG. Deformation of the human mandible during simulated tooth clenching. J Dent Res. 1994;73(1):56-66. http://dx.doi.org/10.1177/00220345940730010801. PMid:8294619.

21. Park JH, Shin SW, Lee JY. Bar versus ball attachments for maxillary four-implant retained overdentures: a randomized controlled trial. Clin Oral Implants Res. 2019;30(11):1076-84. http://dx.doi.org/10.1111/clr.13521. PMid:31385402.

22. Lian M, Zhao K, Wang F, Huang W, Zhang X, Wu Y. Stud vs Bar attachments for maxillary four-implant-supported overdentures: 3- to 9-year results from a retrospective study. Int J Oral Maxillofac Implants. 2019;34(4):936-46. http://dx.doi.org/10.11607/jomi.7224. PMid:30934037.

23. Daas M, Dubois G, Bonnet AS, Lipinski P, Rignon-Bret C. A complete finite element model of a mandibular implant-retained overdenture with two implants: comparison between rigid and resilient attachment configurations. Med Eng Phys. 2008;30(2):218-25. http://dx.doi.org/10.1016/j.medengphy.2007.02.005. PMid:17383925.

24. El-Anwar MI, Mohammed MS. Comparison between two low profile attachments for implant mandibular overdentures. J Genet Eng Biotechnol. 2014;12(1):45-53. http://dx.doi.org/10.1016/j.jgeb.2014.03.006.

25. Unsal GS, Erbasar GNH, Aykent F, Ozyilmaz OY, Ozdogan MS. Evaluation of stress distribution on mandibular implant-supported overdentures with different bone heights and attachment types: a 3D Finite Element Analysis. J Oral Implantol. 2019;45(5):363-70. http://dx.doi.org/10.1563/aaid-joi-D-19-00076. PMid:31536445.

26. Khurana N, Rodrigues S, Shenoy S, Saldanha S, Pai U, Shetty T, et al. A comparative evaluation of stress distribution with two attachment systems of varying heights in a mandibular implant-supported overdenture: a Three-Dimensional Finite Element analysis. J Prosthodont. 2019;28(2):e795-805. http://dx.doi.org/10.1111/jopr.12966. PMid:30191668.

27. Ebadian B, Talebi S, Khodaeian N, Farzin M. Stress analysis of mandibular implant-retained overdenture with independent attachment system: effect of restoration space and attachment height. Gen Dent. 2015;63(1):61-7. PMid:25574722.

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