The Influence of Clip Material and Cross Sections of the Bar Framework Associated with Vertical Misfit on Stress Distribution in Implant-Retained Overdentures

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Purpose: The aim was to evaluate the stress concentration caused by different cross sections of bar frameworks and clip materials used to retain overdentures. ***Materials and Methods:*** Three-dimensional models of a severely resorbed arch, an overdenture retained by two implants, and a bar-clip attachment system were made. A total of twelve models were made according to the cross section of the bar framework (round, oval, or Hader), clip material (gold or plastic), and presence of misfit. A vertical misfit of 100 µm between the implant and the bar framework was made on the right implant. Finite element models were obtained by importing the solid model into mechanical simulation software. The base of the mandible was set to be the fixed support, and a pressure of 100 MPa was applied to the right mandibular first molar. The analysis was made by means of von Mises stress for the prosthetic components and microstrain to the bone tissue. ***Results:*** Round bars led to lower values of stress in the clip and prosthetic screw of the ill-fitted component and lower microstrain values in the peri-implant bone tissue. The lowest values of stress in the bar were observed in the Hader groups. Plastic clips reduced the stress concentration in all structures compared with gold clips. ***Conclusion:*** The clip material and the cross section of the bar framework influenced the stress distribution in overdentures retained by a bar-clip system presenting vertical misfit. *Int J Prosthodont 2014;27:26–32. doi: 10.11607/ijp.3627*

The treatment of edentulous patients with conventional complete dentures is considered a modality that provides esthetics, function, and satisfaction at low cost.[1,2] However, the rehabilitation of patients with severe alveolar bone resorption presents some clinical management challenges in terms of how to provide adequate support, stability, and retention,[3] especially in the mandible. The placement of two interforaminal implants in the anterior region of the mandible to retain an overdenture is an effective choice to overcome these problems.[4,5] Treatment with overdentures has been considered by many authors to be the first option in terms of treatment for edentulous patients,[6,7] providing a considerable increase in stability, retention, masticatory function, patient satisfaction, and survival rates of the implant.[8,9]

The commercially available retaining systems for overdentures are ball attachments, magnetic attachments, bar attachment, telescopic crowns, and locator attachments.[5,10,11] The use of bar attachments can bring some biomechanical advantages due to the splinting of the implants, allowing better stress distribution and the possibility of overcoming excessive divergence in the inclination of the implants. It also provides higher levels of comfort and long-term stability.[12,13] However, there is an absence of studies verifying the influence of the cross section of the bar frameworks on the biomechanics of the overdenture during function. Another important factor when using bar-clip attachments is the type of clip. Traditionally, metallic and plastic clips have been used. There has been extensive discussion in reference to the retaining potential and the loss of retention force over time of these structures, but the level of stress caused by these structures has not yet been evaluated.

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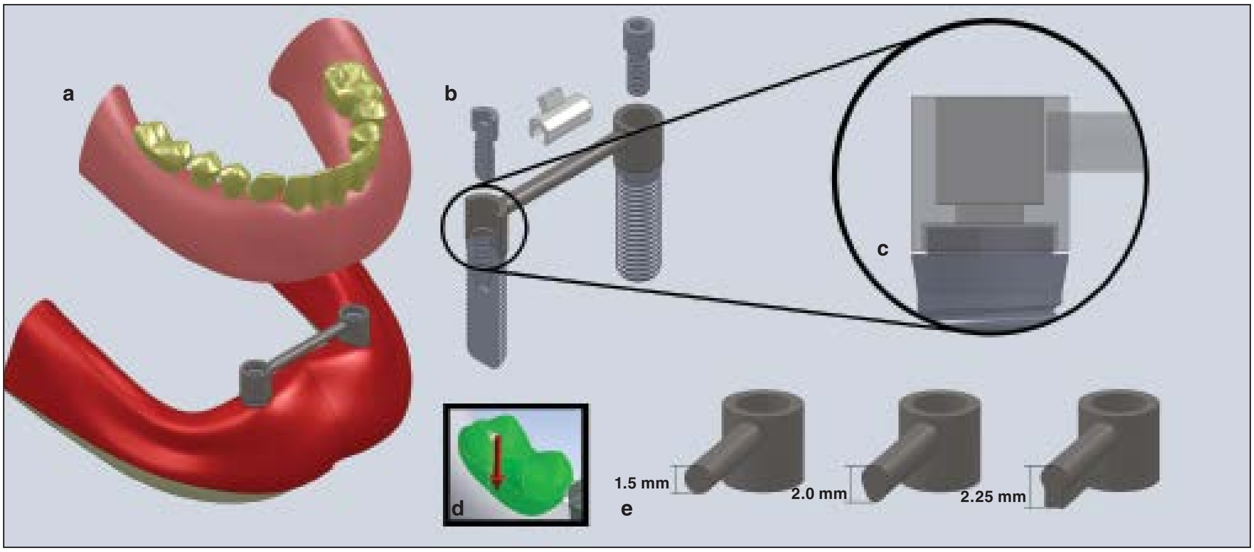


Fig 1 **(a)** The three-dimensional model used in this study. **(b)** Dental implant and prosthetic screw configuration. **(c)** Vertical misfit representation. **(d)** Pressure location and direction applied on the right mandibular first molar. **(e)** Different cross sections of the bar framework.

An important factor in terms of the success of implant-supported or -retained rehabilitations is the passive fit. The absence of passive fit might cause biologic and mechanical complications in the system, such as bone loss and failure of the prosthetic components.[14] Despite these complications, the various steps of prosthetic fabrication inevitably lead to some alterations, making the presence of a certain level of misfit a clinical reality. Thus, the presence of misfit must be considered when any type of evaluation is made. It was observed in a previous study that vertical misfits of 150 μm are clinically acceptable.[15]

A numeric analysis carried out via finite element models can be used to evaluate the stresses in all of the structures of implant prostheses, overcoming some methodologic and ethical restrictions of other experimental methods. This methodology provides accurate and reliable information about the biomechanical efficiency of the system.[16,17] Thus, the aim of this study was to evaluate the stress distribution of different types of bar attachments and clip materials used to retain overdentures. The null hypotheses were that *(1)* different cross sections of the bar framework and *(2)* different clip materials do not influence the stress distribution in the peri-implant bone tissue and prosthetic components.

Materials and Methods

Three-dimensional (3D) finite element models reproducing a mandibular overdenture retained by bar-clip attachments seated on a severely resorbed arch with two cylindric titanium implants (4.0-mm diameter × 11-mm length, Nobel Biocare) in the anterior region with different configurations were made using specific 3D modeling software (SolidWorks). A total of 12 models were made according to the cross section of the bar framework (round, oval, or Hader), material of the clip (gold or plastic), and presence of misfit, as follows: G1 = 100-μm misfit, round bar, and gold clip; G2 = 100-μm misfit, round bar, and plastic clip; G3 = 100-μm misfit, oval bar, and gold clip; G4 = 100-μm misfit, oval bar, and plastic clip; G5 = 100-μm misfit, Hader bar, and gold clip; G6 = 100-μm misfit, Hader bar, and plastic clip, G7 = fitted framework, round bar, and gold clip; G8 = fitted framework, round bar, and plastic clip; G9 = fitted framework, oval bar, and gold clip; G10 = fitted framework, oval bar, and plastic clip; G11 = fitted framework, Hader bar, and gold clip; and G12 = fitted framework, Hader bar, and plastic clip.

The denture base presented an intimate contact with the soft tissue, representing a recently made overdenture. The vertical misfit (100 μm) was made between the right implant and the bar framework (Fig 1).

Finite element models were obtained by importing the solid model into mechanical simulation software (Ansys Workbench 11, Ansys). The total number of elements generated in the finite element models are presented in Table 1. The shape of the element was tetrahedral with 10 nodes, and the mean edge length of the element was 0.5 mm. Stability of the model was

Table 1 Three-Dimensional Model Specifications

	Elements	Nodes
G1 and G2	253,999	451,367
G3 and G4	254,245	451,796
G5 and G6	254,270	451,924
G7 and G8	451,342	253,974
G9 and G10	451,845	254,272
G11 and G12	451,602	254,074

Table 2 Materials Used

Material	Young's modulus (GPa)	Poisson ratio
Cortical bone	13.7	0.30
Cancellous bone	1.37	0.30
Mucosa	0.34	0.45
Titanium (implant)	110	0.33
Titanium (screws)	110	0.28
Cobalt-chromium	218	0.33
Gold clip (type IV gold alloy)	80	0.33
Plastic clip	3	0.28
Acrylic resin	2.94	0.30
Artificial teeth	1.96	0.30

Table 3 Microstrain Values (με) in Peri-implant Bone Tissue

	Clip material	Cross section of the bar framework		
		Round	Oval	Hader
100-μm misfit groups				
Left implant	Gold	459.7	483.2	488.7
	Plastic	365.5	378.7	383.6
Right implant (ill-fitted)	Gold	562.0	581.3	585.7
	Plastic	443.2	455.8	457.2
Fitted framework groups				
Left implant	Gold	450.8	479.6	490.6
	Plastic	358.2	374.9	384.2
Right implant	Gold	703.5	686.3	634.4
	Plastic	570.3	556.2	520.7

checked, and particular attention was paid to the refinement of the mesh resulting from the convergence tests at the bone-implant interface.

Displacement constraint conditions were applied to the base of the mandible, and pressure (100 MPa) was applied to the right mandibular first molar, which was on the same side as the misfit, to simulate the act of masticatory function. The analysis was made using von Mises stress for the prosthetic components and microstrain (με) to the bone tissue along the principal axes. Data were produced numerically, color coded, and compared among the models. All materials used were considered to be isotropic, homogenous, and linearly elastic. The contact between the different materials was considered to be 100% and bonded. The elastic properties used were taken from the literature (Table 2).[18,19]

Results

The microstrain values observed in the peri-implant bone tissue are shown in Table 3. The round bar caused an important reduction in microstrain in peri-implant bone tissue when compared with the oval and Hader bars, with an exception for the right peri-implant bone of the fitted framework groups, where the Hader bar presented the lowest values of microstrain (gold clip: 634.4 με; plastic clip: 520.7 με). The clip material also had an important influence on microstrain values. Plastic clips caused less microstrain in the peri-implant bone tissue than gold ones. The microstrain was concentrated in the cortical bone corresponding with the cervical part of both implants. However, the peri-implant bone tissue of the right implant presented the highest strain concentrations (Fig 2).

When the influence of the cross section of the bar framework was verified in the prosthetic screws, it was observed that the right prosthetic screws of the ill-fitted groups combined with the round bar presented lower values of stress compared with the oval and Hader bars (Fig 3). However, in the groups with a fitted framework, the situation was inverted. In the left prosthetic screw, the round bar presented higher stress values compared with the other cross sections of the bar framework for both fitted and ill-fitted framework groups. In regard to the clip material, the plastic clips presented lower values of stress in the prosthetic screws compared with gold clips. The right prosthetic screw of the ill-fitted groups presented higher stress values than the prosthetic screw of the fitted groups.

When the stress distribution in the bar itself was evaluated, the Hader bar presented the lowest stress values, with an exception for the fitted group with plastic clips, where the oval bar presented the lowest value (19.6 MPa). The use of gold clips led to more stress concentration than plastic clips.

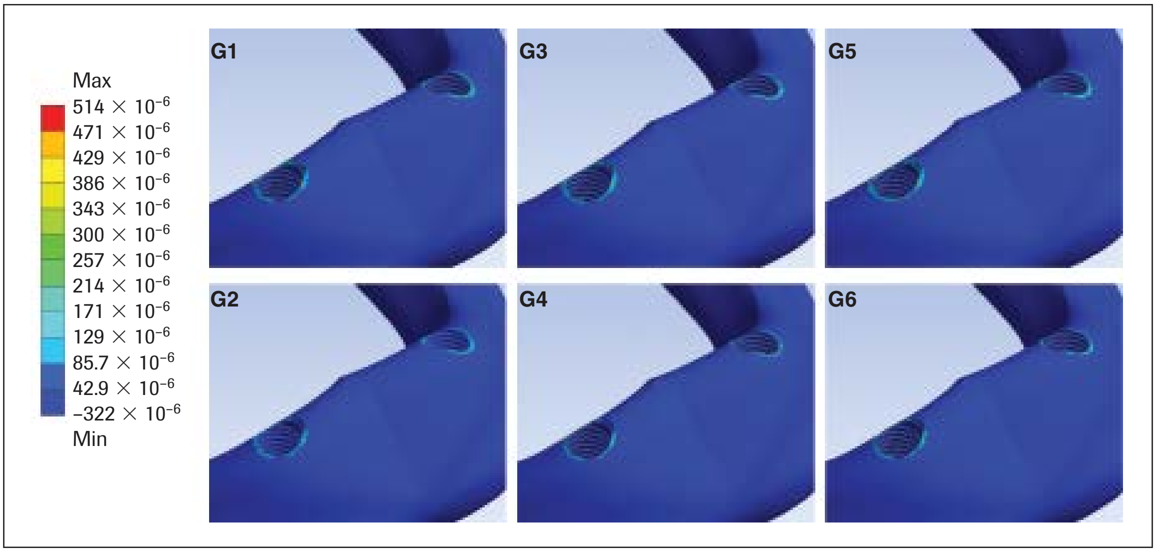
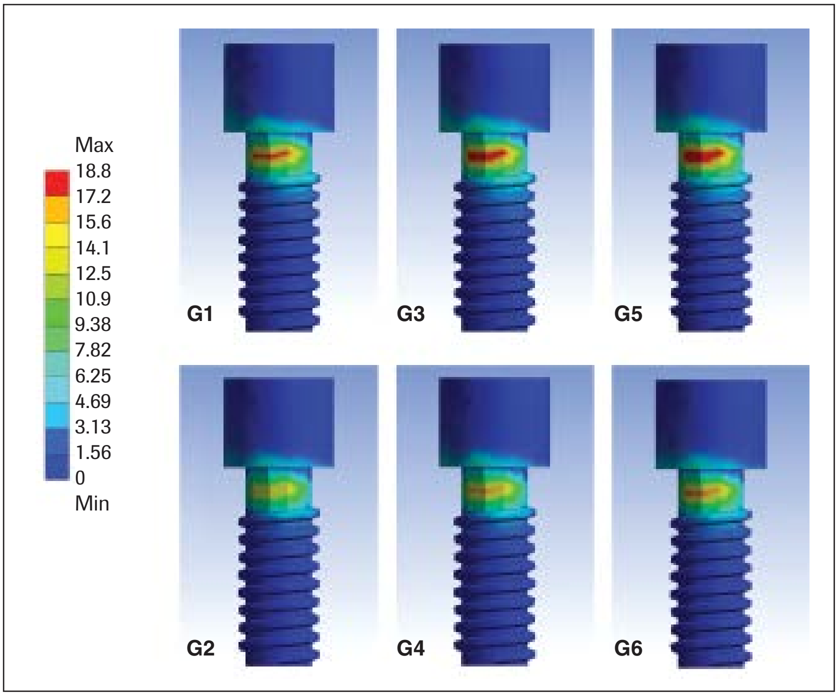


Fig 2 Microstrain values in the peri-implant bone tissues in the groups presenting vertical misfit. G1 = round bar and gold clip; G2 = round bar and plastic clip; G3 = oval bar and gold clip; G4 = oval bar and plastic clip; G5 = Hader bar and gold clip; G6 = Hader bar and plastic clip.

Fig 3 Von Mises stress (MPa) distribution in the right prosthetic screw of the ill-fitted groups. G1 = round bar and gold clip; G2 = round bar and plastic clip; G3 = oval bar and gold clip; G4 = oval bar and plastic clip; G5 = Hader bar and gold clip; G6 = Hader bar and plastic clip.



The Hader bar presented the most unfavorable stress distribution in the clips, mainly when combined with gold clips. When plastic clips were evaluated, the values of stress were approximately three times lower than for gold clips.

All values of stress in the prosthetic screws, bar frameworks, and clips are presented in Table 4.

Table 4 Maximum Values of von Mises Stress (MPa) in the Prosthetic Components

Structure	Clip material	Cross section of the bar framework: Round	Oval	Hader
100-μm misfit groups				
Bar framework	Gold	27.7	26.6	23.0
	Plastic	22.8	21.5	20.3
Left screw	Gold	5.3	4.4	4.8
	Plastic	5.1	4.1	4.7
Right screw (ill-fitted)	Gold	18.6	20.5	21.8
	Plastic	15.8	17.4	18.2
Clip	Gold	11.7	12.5	15.1
	Plastic	4.0	4.4	5.6
Fitted framework groups				
Bar framework	Gold	28.9	25.1	24.6
	Plastic	22.3	19.6	20.2
Left screw	Gold	4.8	1.9	2.2
	Plastic	4.8	1.5	1.8
Right screw	Gold	5.0	3.0	3.6
	Plastic	4.6	2.2	2.6
Clip	Gold	12.5	13.0	15.0
	Plastic	4.3	4.4	5.8

Discussion

The results reveal the relevant influence of the cross section of the bar framework on stress and microstrain distribution in the prosthetic components and peri-implant bone tissue, respectively. Thus, the first null hypothesis (different cross sections of the bar framework do not influence the stress distribution in the peri-implant bone tissue and prosthetic components) was rejected. The use of round bars showed important reductions in the strains in the peri-implant bone tissue, with an exception for the right peri-implant region of the fitted framework groups. Also, the stresses in the right prosthetic screw of the ill-fitted framework groups and in the clip, which could be explained by its lower cross-sectional area compared with the other groups, allowing for higher deformation of the bar, proliferated less stress on the other structures. Previous reports also pointed out that round bars are more favorable in reference to retaining overdentures because they allow more rotational movements than other cross sections of bar frameworks and are also related to fewer fractures and complications.[5,10] However, when round bars were evaluated, the prosthetic screw of the fitted components (left prosthetic screw of the fitted and ill-fitted groups and the right prosthetic screw of the fitted framework groups) showed an increase in stress values that could indicate better biomechanical behavior attributed to the dissipation of the stresses throughout the entire system.

When the bar frameworks were evaluated, the Hader bar presented the lowest stress values with an exception for the fitted group with plastic clips, which can be attributed to its substantial stiffness due to its larger volume. Although stiffness is important in the resistance of the bar, it does not appear to influence the adjacent structures, as the bone tissue, clip, and prosthetic screw of the ill-fitted component presented an increase in stress when stiffer bars were evaluated. This result is in agreement with previous studies that evaluated the influence of vertical misfit in overdentures retained by a bar-clip system.[20,21] It is important to highlight the fact that the aforementioned studies evaluated the static stresses in peri-implant bone tissue and prosthetic components that simulated a displacement in the ill-fitted component until it suited the implant, assuming that screw tightening can compensate for the vertical misfit. The authors of the present study do not believe that screw tightening can compensate for the misfit. Therefore, the prosthetic screw was tightened to the bar framework without altering the vertical misfit, and a load was applied to the prosthesis to simulate the masticatory function of an overdenture retained by an ill-fitted bar framework.

The second hypothesis (different clip materials do not influence the stress distribution in the peri-implant bone tissue and prosthetic components) was also rejected since the results showed that the use of a plastic clip is more favorable to reduce the stresses in all structures. This design assumes less elastic modulus than gold clips, a higher deformation, and as a consequence less stress on the other structures. Although less retention is related to plastic clips compared with metal ones, it is important to assume that the retention system does not have to provide excessive retention to the denture due to excessive tensional forces that can harm the peri-implant bone during its removal.[22] The literature is also favorable to the use of plastic clips in terms of retention provided, also they are less favorable to loss of retention force over time.[23,24] Overall, a successful clinical performance of the plastic clips was observed in a recent controlled clinical trial carried out by Bayer et al.[22]

The presence of an ill-fitting component was responsible for an increase of stress in the prosthetic screws. However, the groups with fitted frameworks (G7 to G12) presented the highest values of microstrain in the peri-implant bone tissue next to the right implant. A possible explanation is the fact that the bar framework in the ill-fitted groups does not make contact with the implant and, consequently, does not dissipate the stresses in this region, causing an increase in stress in other prosthetic components rather than the peri-implant bone tissue. The relationship of the vertical misfit and mechanical complications, such as screw loosening, has been established by a previous study.[25] Biologic complications caused by the presence of misfit were observed in the peri-implant bone tissue, bone loss being one of them. Loads induce strains in the bone, and the modeling and remodeling stimuli are dependent on strain magnitude, frequency, and rate.[26] According to Frost´s Mechanostatic Theory,[27] to maintain adequate bone conditions, the microstrains transferred to this structure must not exceed 3,000 $\mu\varepsilon$. Also, Frost's theory suggests that the absence of microstrain would cause bone resorption due to disuse (50 to 100 $\mu\varepsilon$). The microstrain values in the peri-implant bone tissue in the present study, even for the groups presenting vertical misfit, ranged from 358 to 703 $\mu\varepsilon$, which is within the limits of tolerance established to maintain adequate biologic conditions. However, the clinical significance of the findings should be made with caution and validated by different methods.

Despite the fact that finite element analysis provides accurate and reliable information about the biomechanical efficiency of a system,[16,17] some limitations should be mentioned. The structures of the models were considered homogenous, isotropic, and linearly elastic, which is different from living tissues. Also, complete adhesion was considered between the different materials, which may influence the stress and strain distribution. Nonlinear frictional contacts allow minor displacements between the structures and provide excellent simulation results; however, many studies have been conducted by assuming 100% bonded contact between the structures with reasonable results.[16–19,28,29]

Although the importance of preload on resisting separation forces induced during occlusal loading is accepted,[30] in this study, the prosthetic screws were considered to be bonded to the framework and internal implant threads, assuming 100% efficiency of preload (the parts of the model would not get separated), which should be considered a limitation compared with a clinical situation in which screw loosening is a common complication.[31]

The pursuit of passive fit and of designs and materials that can reduce stress and strain induction in peri-implant bone tissue and prosthetic components should always be considered by professionals. Further investigations should evaluate the application of load in both sides of the prosthesis during mastication, the preload on prosthetic screws, and the use of nonlinear finite element analysis to verify the factors that influence failures in overdenture rehabilitations.

Conclusions

Within the limitations of this finite element analysis study, it can be concluded that the presence of vertical misfit caused an increase in stress values in the prosthetic screws of the ill-fitted component compared with the fitted frameworks.

Round bars presented the most favorable biomechanical behavior for ill-fitted frameworks, inducing less microstrain on peri-implant tissue and less stress on the clip and prosthetic screw of the ill-fitted component. The use of plastic clips reduced the stress concentration on all structures compared with gold clips.

Acknowledgments

This study is a part of the postdoctoral research of the first author. The authors reported no conflicts of interest related to this study.

References

1. Bellini D, Dos Santos MB, De Paula Prisco Da Cunha V, Marchini L. Patients' expectations and satisfaction of complete denture therapy and correlation with locus of control. J Oral Rehabil 2009;36:682–686.
2. Carlsson GE, Omar R. The future of complete dentures in oral rehabilitation. A critical review. J Oral Rehabil 2010;37:143–156.
3. Zarb GA, Bolender CL. Prosthodontic Treatment for Edentulous Patients: Complete Dentures and Implant-Supported Prostheses, ed 12. Oxford: Elsevier, 2006.
4. Naert I, Quirynen M, Theuniers G, van Steenberghe D. Prosthetic aspects of osseointegrated fixtures supporting overdentures. A 4-year report. J Prosthet Dent 1991;65:671–680.
5. Ha SR, Kim SH, Song SI, Hong ST, Kim GY. Implant-supported overdenture with prefabricated bar attachment system in mandibular edentulous patient. J Adv Prosthodont 2012;4:254–258.
6. Feine JS, Carlsson GE, Awad MA, et al. The McGill consensus statement on overdentures. Mandibular two-implant overdentures as first choice standard of care for edentulous patients. Montreal, Quebec, May 24–25, 2002. Int J Oral Maxillofac Implants 2002;17:601–602.
7. Thomason JM. The use of mandibular implant-retained overdentures improve patient satisfaction and quality of life. J Evid Based Dent Pract 2010;10:61–63.
8. Awad MA, Lund JP, Dufresne E, Feine JS. Comparing the efficacy of mandibular implant-retained overdentures and conventional dentures among middle-aged edentulous patients: Satisfaction and functional assessment. Int J Prosthodont 2003;16:117–122.
9. Awad MA, Lund JP, Shapiro SH, et al. Oral health status and treatment satisfaction with mandibular implant overdentures and conventional dentures: A randomized clinical trial in a senior population. Int J Prosthodont 2003;16:390–396.

10. Deslis A, Hasan I, Bourauel C, Bayer S, Stark H, Keilig L. Numerical investigations of the loading behaviour of a prefabricated non-rigid bar system. Ann Anat 2012;194:538–544.
11. Trakas T, Michalakis K, Kang K, Hirayama H. Attachment systems for implant retained overdentures: A literature review. Implant Dent 2006;15:24–34.
12. Ueda T, Kremer U, Katsoulis J, Mericske-Stern R. Long-term results of mandibular implants supporting an overdenture: Implant survival, failures, and crestal bone level changes. Int J Oral Maxillofac Implants 2011;26:365–372.
13. Timmerman R, Stoker GT, Wismeijer D, Oosterveld P, Vermeeren JI, van Waas MA. An eight-year follow-up to a randomized clinical trial of participant satisfaction with three types of mandibular implant-retained overdentures. J Dent Res 2004;83:630–633.
14. Abduo J, Bennani V, Waddell N, Lyons K, Swain M. Assessing the fit of implant fixed prostheses: A critical review. Int J Oral Maxillofac Implants 2010;25:506–515.
15. Jemt T. Failures and complications in 391 consecutively inserted fixed prostheses supported by Branemark implants in edentulous jaws: A study of treatment from the time of prosthesis placement to the first annual checkup. Int J Oral Maxillofac Implants 1991;6:270–276.
16. Bacchi A, Consani RL, Mesquita MF, dos Santos MB. Influence of different mucosal resiliency and denture reline on stress distribution in peri-implant bone tissue during osseointegration. A three-dimensional finite element analysis. Gerodontology 2012;29:e833–e837.
17. Dos Santos MB, Consani RL, Mesquita MF. Influence of different soft liners on stress distribution in peri-implant bone tissue during healing period. A 3-D finite element analysis. J Oral Implantol 2013;39:575–581.
18. Spazzin AO, Dos Santos MB, Sobrinho LC, Consani RL, Mesquita MF. Effects of horizontal misfit and bar framework material on the stress distribution of an overdenture-retaining bar system: A 3D finite element analysis. J Prosthodont 2011;20:517–522.
19. Dos Santos MB, Da Silva Neto JP, Consani RL, Mesquita MF. Three-dimensional finite element analysis of stress distribution in peri-implant bone with relined dentures and different heights of healing caps. J Oral Rehabil 2011;38:691–696.
20. Abreu RT, Spazzin AO, Noritomi PY, Consani RL, Mesquita MF. Influence of material of overdenture-retaining bar with vertical misfit on three-dimensional stress distribution. J Prosthodont 2010;19:425–431.
21. Spazzin AO, Abreu RT, Noritomi PY, Consani RL, Mesquita MF. Evaluation of stress distribution in overdenture-retaining bar with different levels of vertical misfit. J Prosthodont 2011; 20:280–285.
22. Bayer S, Komor N, Kramer A, Albrecht D, Mericske-Stern R, Enkling N. Retention force of plastic clips on implant bars: A randomized controlled trial. Clin Oral Implants Res 2012;23: 1377–1384.
23. Fromentin O, Lassauzay C, Abi Nader S, Feine J, de Albuquerque Junior RF. Testing the retention of attachments for implant overdentures: Validation of an original force measurement system. J Oral Rehabil 2010;37:54–62.
24. Bayer S, Gruner M, Keilig L, et al. Investigation of the wear of prefabricated attachments: An in vitro study of retention forces and fitting tolerances. Quintessence Int 2007;38:e229–e237.
25. Spazzin AO, Henriques GE, de Arruda Nobilo MA, Consani RL, Correr-Sobrinho L, Mesquita MF. Influence of prosthetic screw material on joint stability in passive and non-passive implant-supported dentures. Open Dent J 2009;3:245–249.
26. Halldin A, Jimbo R, Johansson CB, et al. The effect of static bone strain on implant stability and bone remodeling. Bone 2011; 49:783–789.
27. Frost HM. Bone's mechanostat: A 2003 update. Anat Rec A Discov Mol Cell Evol Biol 2003;275:1081–1101.
28. Bacchi A, Consani RL, Mesquita MF, Dos Santos MB. Effect of framework material and vertical misfit on stress distribution in implant-supported partial prosthesis under load application: 3-D finite element analysis. Acta Odontol Scand 2013; 71:1243–1249.
29. dos Santos MB, Bacchi A, Consani RL, Mesquita MF. Influence of thickness and area of reline on the stress distribution in peri-implant bone during the healing period: A three-dimensional finite element analysis. Gen Dent 2012;60:e231–e236.
30. Guda T, Ross TA, Lang LA, Millwater HR. Probabilistic analysis of preload in the abutment screw of a dental implant complex. J Prosthet Dent 2008;100:183–193.
31. Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JY. Clinical complications with implants and implant prostheses. J Prosthet Dent 2003;90:121–132.

Literature Abstract

Multifactorial risk assessment for survival of abutments of removable partial dentures based on practice-based longitudinal study

This study aimed to investigate the survival of removable partial denture (RPD) abutments longitudinally in clinical cases, and to uncover the prognosticating factors that determine survival and tooth loss. One hundred forty seven patients with 236 existing cobalt-chromium dentures were selected from the patient pool of the Department of Removable Prosthodontics of Osaka University Hospital, Japan. A total of 856 RPD abutments and 1,114 nonabutment teeth were included. A Kaplan-Meier survival analysis was used to illustrate the survival of teeth. The analysis revealed a 5-year survival rate of 86.6% for direct abutments, 93.1% for indirect abutments, and 95.8% for nonabutment teeth. Cox's proportional hazard analysis, which was used to investigate associations between each variable and survival time, demonstrated that the survival of the abutment had a significant association with crown-root ratio, root canal treatment, pocket depth, types of abutments, and occlusal support. Thus, the authors conclude that with an understanding of the risk factors present, an evidence-based clinical treatment plan could then be individualized in the planning of an RPD and its abutments.

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