

Restorative Dentistry Issue (Removable Prosthodontics, Fixed Prosthodontics, Endodontics, Dental Biomaterials, Operative Dentistry)

7-1-2018

Stresses Induced By Integrated and' Nonintegrated Extracoronar Semi-Precision Attachments For Maxillary Distal Extension Bases

Ahmed Al-Okl

Assistant Professor of Removable Prosthodontics Faculty of Dental Medicine, Al Azhar University, (Asuit branch) Egypt

Mahmoud Al Samahy

Professor of Removable Prosthodontics. Oral and Maxillofacial Prosthodontic. Dep. Faculty of Dentistry, King Abdulaziz University. Jeddah, KSA. Professor of Prosthodontics Faculty of Dentistry, Alexandria University. Egypt.

Hatem Amin

Professor of Removable Prosthodontic. Oral and Maxillofacial Prosthodontics Department, Faculty of Dentistry, King Abdulaziz University. Jeddah, KSA. Professor of Prosthodontics Cairo university. Egypt.

U Khashaba

Department OF Mechanical Engineering, Faculty of Engineering, King Abdulaziz University. Jeddah 21589, KSA. Mechanical design and production Engineering Department, Faculty of Engineering, Zagazig University. Follow this and additional works at: <https://azjd.researchcommons.org/journal>



Part of the [Other Dentistry Commons](#)

How to Cite This Article

Al-Okl, Ahmed; Al Samahy, Mahmoud; Amin, Hatem; and Khashaba, U (2018) "Stresses Induced By Integrated and' Nonintegrated Extracoronar Semi-Precision Attachments For Maxillary Distal Extension Bases," *Al-Azhar Journal of Dentistry*. Vol. 5: Iss. 3, Article 9.

DOI: <https://doi.org/10.21608/adjg.2018.17195>

This Original Study is brought to you for free and open access by Al-Azhar Journal of Dentistry. It has been accepted for inclusion in Al-Azhar Journal of Dentistry by an authorized editor of Al-Azhar Journal of Dentistry. For more information, please contact yasmeenmahdy@yahoo.com.



Stresses Induced By Integrated and' Nonintegrated Extracoronar Semi-Precision Attachments For Maxillary Distal Extension Bases

Ahmed B. El-Okil⁽¹⁾, Mahmoud EL Samahy⁽²⁾, Hatem K. El Din Amin⁽³⁾ and U. A. Khashaba⁽⁴⁾

Codex : 34/1807

azhardentj@azhar.edu.eg

<http://adjg.journals.ekb.eg>

ABSTRACT

Purpose: The aim of the present study is to compare the stresses induces on the splinted abutments by two different reciprocation designs in conjunction with extra-coronar semi-precision attachments retained removable partial denture (RPD) using strain gauge analysis.

Material and methods: For this study, two RPD designs were made A, and B. representing maxillary bilateral distal extension edentulous area. The two abutments, canine and first bicuspid was fixed splinted on both sides with porcelain facing crowns. For design (A) an extra coronal attachment with integrated interlock was used at the distal aspect of the splinted first bicuspid and canine. For design (B) a parallel interlock extra coronal attachment was used with a conventional lingual bracing arm. A strain gauge was used for this study to measure the micro-strain induced on the apical and lateral sides of the canine and first-bicuspid abutments.

Results: SPSS software program was used in the statistical analysis of the results. The results revealed that maximum stresses induced at the apex of the canine and first-bicuspid abutments were in case of design (B). While no significant difference between the two designs when the lateral load was applied

Conclusion: A more favorable stress applied on the canine and bicuspid obtained with integrated interlock attachment.

KEYWORDS

*Stress analysis,
extracoronar semi-precision
attachments,
Removable partial denture,
strain gauge*

1. Associate Professor of Removable Prosthodontics. Oral and Maxillofacial Prosthodontic. Dep. Faculty of Dentistry, King Abdulaziz University. Jeddah, KSA. Assistant Professor of Removable Prosthodontics Faculty of Dental Medicine, Al Azhar University, (Asuit branch) Egypt
2. Professor of Removable Prosthodontics. Oral and Maxillofacial Prosthodontic. Dep. Faculty of Dentistry, King Abdulaziz University. Jeddah, KSA. Professor of Prosthodontics Faculty of Dentistry, Alexandria University. Egypt.
3. Professor of Removable Prosthodontic. Oral and Maxillofacial Prosthodontics Department, Faculty of Dentistry, King Abdulaziz University. Jeddah, KSA. Professor of Prosthodontics Cairo university. Egypt.
4. Department OF Mechanical Engineering, Faculty of Engineering, King Abdulaziz University. Jeddah 21589, KSA. Mechanical design and production Engineering Department, Faculty of Engineering, Zagazig University.

INTRODUCTION

Rehabilitation of a partially distal extension base(s) is the main challenge for the prosthodontist. Implant-retained is an option but sometimes not possible due to insufficient bone or patients preference¹⁻³.

Numerous studies had conducted to test the effect of distal extension partial dentures on both abutments and residual alveolar ridge^{4,5}.

Attachment provides an important psychological and mechanical union in treating patients. Extracronal attachments may be useful for treating class I, class II and bounded partially edentulous patients when comparing with clasp assemblies, they provide more esthetics and retention⁶.

Several methods were used to control stresses occurred with semi-precision or precision attachments with distal extension base(s) including splinted abutment teeth, stability of denture base, broad tissue coverage, resilient design of the prostheses, occlusal harmony, loading techniques and shimming⁷. Shohet⁸ compared the greatest destructed forces on abutment with rigid design and other resilient retainers.

Resilient extracoronral attachments do not always supply suitable support and bracing because of their resilient nature. Therefore, they require specially designed bracing arms on surveyed crowns. Besides, they increase unfavorable cantilever forces on the abutment teeth⁹. During function, a lever action is developed at the most distal portion of the removable partial denture (RPD). The more downward force on the RPD, the greater tipping action on the abutment tooth, which suggests a stress breaking action incorporated into the design to control the stress on the periodontal attachment of the abutment tooth¹⁰.

The palatal surface of the splinted crowns should have preparations for the bracing arm prolonged to the proximal area to secure tooth support, stability and indirect retention and transmit forces along the long axis of the tooth¹¹ and minimizing wear of key or keyway during insertion¹². Making a groove for

the free end arm will aid retention and resist, any tendency to distort the attachment in mesio-distal direction⁹. Also, using of bracing arm is a best way of overcoming the length of the attachment.

Saito et al,¹³ showed in their study that the attachment denture with a lingual stabilizing arm produced more stress to the abutment teeth.

A strain gauge is a device attached to the object by a suitable adhesive to record its deformation when subjected to stress. As the object is deformed, the gauge deformed, causing its electrical resistance to change.¹⁴⁻¹⁷

A strain gauge can be widely applied in dental research ,it can be used alone to assess in vivo and in vitro stress in prostheses, implants, and teeth^{18,19}, other authors use the strain gauge technique with photoelasticity or FEM techniques²⁰⁻²³. It can guide further research and clinical studies by predicting some disadvantages and streamlining clinical time.²⁴

The aim of this study is to compare the stresses induces on the splinted abutments by two different reciprocation designs in conjunction with extracoronral semi-precision attachments retained removable partial denture (RPD).

MATERIAL AND METHODS

For this study a typodont* model was used. Preparations for crowns were performed on the maxillary canines and first bicuspid on both sides (Fig.1)

The roots were surrounded by 1-mm thickness addition- type silicone** layers to simulate periodontal ligament. The edentulous ridge was covered with 2-mm thickness silicone impression material to simulate resiliency of the mucosa.

The typodont model was duplicated with a reversible hydrocolloid material and poured in improved dental stone.

On the resulting cast, the wax pattern of the splinted crowns of the canine and first bicuspid on both sides was constructed as one single unit with

* *DPS Model UK U 13 www.kavo.comMat.N2/NO O.623.1921*

** *Silicon impression material, Zhermack, 45021 Badia Poletine (Rovigo0, Italy*

the adaptation of the plastic castable matrix of the attachments. One cast received extracoronally semi-precision attachment with integrated interlock on both sides (design A), while parallel interlock (design B) was done on the other cast with lingual bracing arm, on both sides also (Fig. 2, 3).

After waxing up the copings of the crowns, the male part of each abutment was aligned to its respective crown using a Milling Machine * with paralleling mandrel. The matrix (male part) should be mounted parallel to the path of insertion, over the center of the residual alveolar ridge.

For design (B) a step (ledge) was prepared in the lingual surface of the waxed-up crown on the first bicuspid to accommodate a conventional bracing arm and an occlusal rest seat was created to receive a metallic extension from the lingual bracing arm.

The wax pattern of the crowns was casted, the porcelain facing was constructed and the crowns were temporary cemented ** to the prepared abutments. Then the removable partial denture was designed and casted with cobalt chromium alloy. The yellow plastic female component (matrix) was placed in the metal frame work (Fig. 4).

The following two RPD designs were used in this study.

Design (A): An extra coronal attachment with integrated interlock (Vario-Stud-Snap) *** was used at the distal aspect of the splinted first bicuspid and canine (Fig. 5).

Design (B): An extra coronal attachment with parallel interlock (Patix sg) *** was used at the distal aspect of the splinted first bicuspid and canine with a conventional lingual bracing arm (Fig. 6).



Fig. (1) Typodont model with prepared teeth

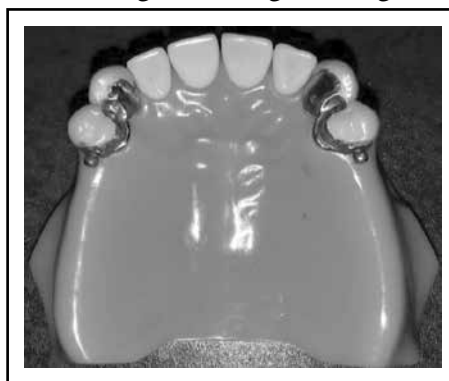


Fig. (3) The porcelain crowns with parallel interlock attachment.



Fig. (2) The porcelain crowns with integrated interlock attachment.

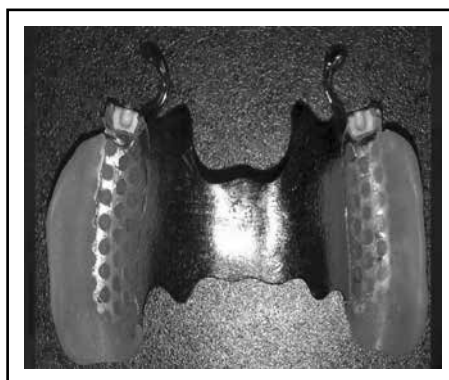


Fig. (4) Matrix was placed in the metal frame work.

*Bredent company, GmbH & CoG. Weissenhorner Str.2.89250 Senden. Germany.

** Cavex temporary cement BV, 852 RW Haarlem (Holland)

*** Bredent company, GmbH & CoG. Weissenhorner Str.2.89250 Senden. Germany.

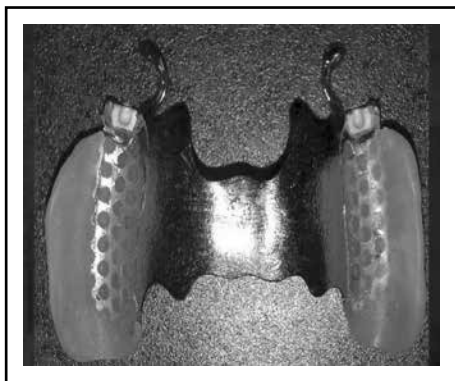


Fig. (5) Metallic RPD without bracing arm

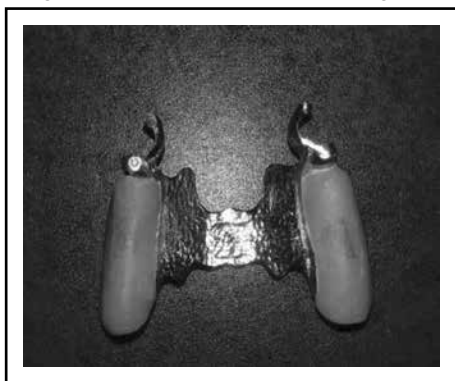


Fig. (6) Metallic RPD with a lingual bracing arm

The root surfaces of the abutment were prepared on the model which receives strain gauges. Two holes were drilled in the model corresponding with the root surface on the abutment teeth which permit wires of strain gauges to pass through the model. Two channels were made at each hole to permit lead wire cable of strain gauges to pass out of the model without tension; the wire was secured with adhesive. Strain gauges were oriented parallel to the long axis of each abutment and were held in their sites using Teflon sheets supported with gauges. An insulation coat was applied to the outer surface of the strain gauges for protection.

The compressive properties were characterized using computer controlled universal testing machine*. The (apical or lateral) strain gauge was

attached to the silicon periodontal ligaments at portion of the canine and first bicuspid. The used strain gauges is foil type** with 2 gauge factor, 120 W gauge resistance, 5x1.8 mm² gauge dimensions and 9x3.5 mm² backing dimensions.

The strain gauges were wired with coaxial cables to minimize the signal interference noise. The compression tests were performed at constant cross-head speed of 0.5 mm/min (= 50 N), the load was applied at 15 mm distal to the first bicuspid representing the position of the first molar. The strain gauges were connected to PC via 4-channel data acquisition*** to monitor and record the strains during the compression tests. The PC of the testing machine draw and record the load-displacement/time of the test specimen, while the other PC draw and record the time-strain relationship (Fig. 7).

The data was collected, tabulated and statistically analyzed using SPSS software program.

RESULTS

Figures (8& 9) show the mean of micro-strain values around the two abutments teeth.

The micro-strain value at the apical portion of the canine for design- B was found to be more than those of design- A under the compressive load. This values was found to be significant according to (t-test), (p=0.0010).

On the other hand the difference was not statistically significant at the apical portion of the bicuspid abutments in design A and B (p=0.4103).

There was no significant difference between the mean values of micro-strain in the canine and first bicuspid abutments in the two designs when the lateral load was applied, the p= (0.1387) and (0.5234) respectively.

* Instron model 8872 kN.

** model RS 632-180

***model 9237 NI

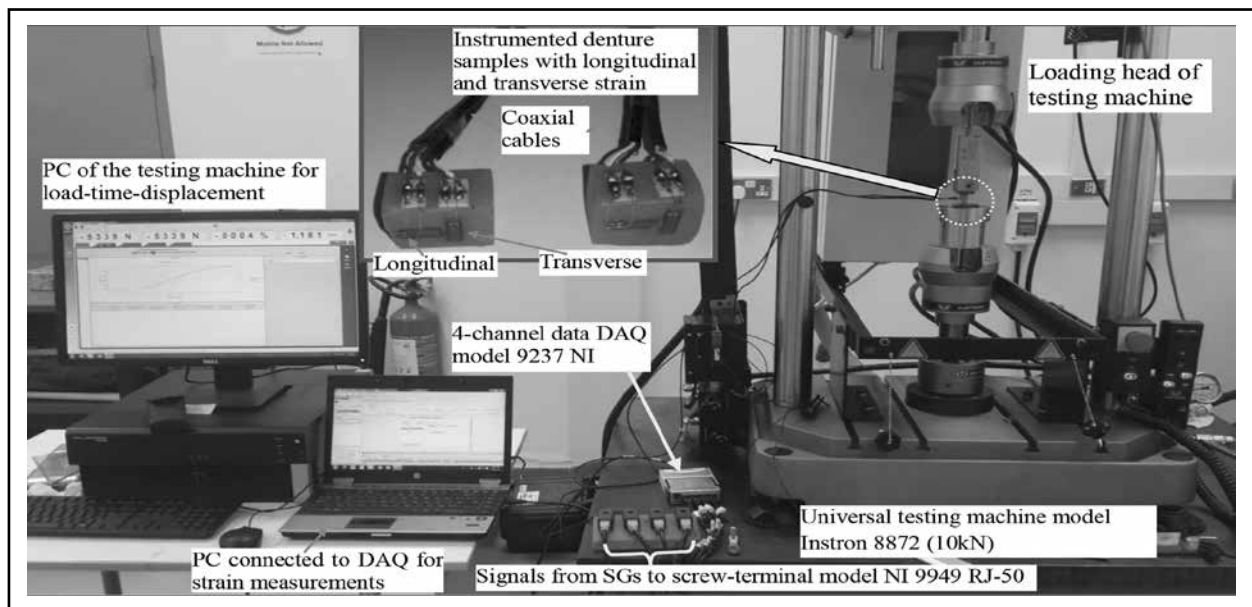


Fig. (7) Experimental setup

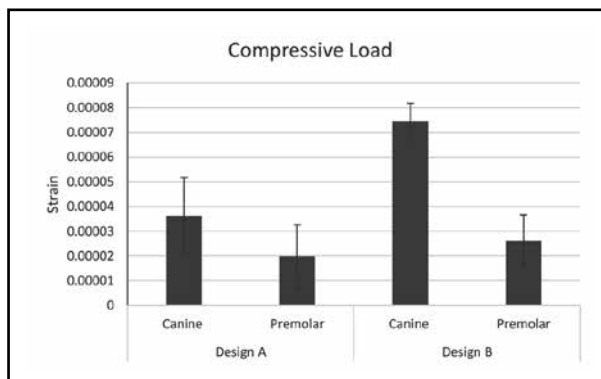


Fig. (8) The micro-strain measurements at the apex of the abutments under the two different designs.

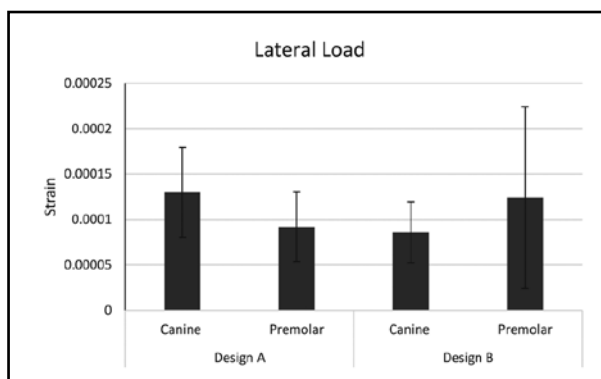


Fig. (9) The micro-strain measurements at the lateral side of the abutments under the two different designs.

DISCUSSION

Posterior distal extension partial denture bases present a number of design challenges, particularly is the distribution of forces to remaining alveolar ridges and teeth to provide function and comfort.^{25,26}

Understanding the difference in nature and behavior of the tissues supporting RPD is critical for long term success of the prosthesis. These differences multiplied by the function, create major stresses on the tooth-tissue prostheses.²⁷ so, it is necessary for an attachment used in conjunction with RPD to be in proper design of reciprocation to reduce the lateral load to which the abutment is subjected.⁵

The aim of this study was done to compare the effect of two different designs of reciprocation in conjunction with extra coronal semi-precision attachment retained regarding the response of compressive and lateral loads applied on the maxillary distal extension bases.

In this study we suggest the use of extracoronol resilient attachment retained RPD in maxillary distal extension ridges, which is agreed with some authors^{28,29} but with certain limitations to avoid excessive torque applied to the most distal abutment.

Moreover, extracoronaral attachments are castable attachment with plastic retentive portion. With its elasticity, it is possible to control flexure and construct a resilient and shock absorbing prostheses,³⁰ so providing less torque to the abutment teeth.³¹

Fixed splinting of adjacent abutment teeth is an important factor when attachment retainers are used for an extension removable partial denture.³² So, in every attachment designed RPD case especially the distal extension prostheses require a minimum of two splinted abutment on either side placed in crowns in order to aid in distributing the forces.³³ In this study, canine and first premolars at each side were splinted anterior to edentulous span to aid in better distribution of stresses.

From the results of this study, the configuration of integrated interlock attachment applied less compressive load on the canine and bicuspsids, with no significant difference regarding the bicuspsids between the two designs, which probably due to the neighboring stress breaking effect of the attachment and favorable less compressive forces on the canine. This result is in agreement with Saito et al,¹³ who found that attachment denture to which a lingual stabilizing arm had been added produced more stress on the abutment teeth than without a stabilizing arm. It seems reasonable to assume that with lingual stabilizing arm, there was more rigidity inducing more stresses.

No significant difference was found by applying lateral load either on the canines or bicuspsids between the two designs. This is due to the shear distributor within the confines of the integrated interlock attachment itself that directs leverage along the long axis of the tooth eliminating the need for RPD component of reciprocation. This result is consistent with those of Wang *et al*,³⁴ who stated that the integrated interlock can counteract the lateral force which has the greatest effect on the terminal abutment in distal extension base RPDs with universal hinge attachment.

Moreover, the extracoronaral attachment reduces the lever arm in relation to the root length as it places the support for RPD closer to bony support of abutment teeth.

Fixed splinting of abutment teeth for attachment retained RPD provides increased resistance only to antero-posterior forces, and the RPD anchored on both sides of the arch can provide cross arch stabilization to forces operating in a buccolingual direction.³⁵ This support the results of this study that the lingual bracing arm is not mandatory for reciprocation in attachment retained RPD. Furthermore, integrated interlock design (design A) can afford the required reciprocal effect.

CONCLUSIONS

With the limitations of this study, we can conclude that

A more favorable stress applied on the canine and bicuspsids obtained with integrated interlock attachment.

The configuration of the integrated interlock attachment provides a nearly equal reciprocation effects as the parallel interlock attachment

The strategic position of the canine with parallel interlock attachment design withstand the higher compressive forces.

REFERENCES

1. Emiel AM, Hegazy SA. Modified rotation joint connection unite versus double Aker clasp used for bracing of maxillary unilateral free end removable partial dentures (in vitro analysis of stresses on principles abutments and edentulous ridge). J Am Sci 2010; 6:109- 14.
2. Burns DR, Ward JE. A review of attachments for removable partial denture design: Part 1. Classification and selection. Int J Prosth 1990; 3: 98- 102.
3. Burns DR, Ward JE: A review of attachments for removable partial denture design: Part 2.. Treatment planning and attachment selection. Int J Prosth 1990; 3: 169- 74.
4. De Van MM: The nature of partial denture foundation; suggestion for its preservation. J Prosthet Dent 1952; 2: 210-8.

5. Monteith BD: Management of loading forces on mandibular distal extension prostheses. Part 1: Evaluation of concepts for design. *J Prosthet Dent* 1984; 52: 673- 81
6. El-Charkawi and El- Waked. Effect of splinting on load distribution of extracoronol attachment with distal- extension of prosthesis in vitro. *J Prosthet Dent* 1996; 76:315-20
7. Lee K. Double impression procedure for RPD retained with semi precision attachment, a clinical report. *J Prosthet Dent* 1996; 75:583-7.
8. Shohet N. Relative magnitudes of stress on abutment teeth with different retainers. *J Prosthet Dent* 1969; 49:267-82.
9. Preiskel HW. Precision attachment in prosthodontics. 1& 2. London: Quintessence Publishing Co Ltd, 1995.
10. Waltz ME. Ceka extracoronol attachments. *J Prosthet Dent* 1973; 29:167-71.
11. Andrei OC, Pauna M. Deciding on retention in 1st and IInd class Kennedy edentoulism. *OHDMBSC* 2007; 6:43- 52.
12. Grosso JE, and Miller EL. Removable partial prosthodontic" 3rd ed. St Lous, Blatimore, London, Sydney Toronto, 1991.
13. Saito M, Miura Y, Notani K, Kawasaki T. stress distribution of abutments and base displacement with precision attachment and telescopic crown- retained removable partial dentures. *J Oral Rehabil* 2003; 30:482-7
14. Karl M, Dickinson A, Holst S, Holst A. Biomechanical methods applied in dentistry: a comparative overview of photoelastic examinations, strain gauge measurements, finite element analysis and three-dimensional deformation analysis. *Eur J Prosthodont Restor Dent* 2009; 17:50-7.
15. Goiato MC, Tonella BP, Ribeiro Pdo P, Ferrac, o R, Pellizzer EP. Methods used for assessing stresses in bucco-maxillary prostheses: photoelasticity, finite element technique, and extensometry. *J Craniofac Surg.* 2009; 20:561-4.
16. Naconecy MM, Teixeira ER, Shinkai RS, Frasca LC, Cervieri A. Evaluation of the accuracy of 3 transfer techniques for implant supported prostheses with multiple abutments. *Int J Oral Maxillofac Implants.* 2004; 19:192-8.
17. Cehreli MC, Akkocaoglu A, Comert A, Tekdemir I, Akca K. Human ex vivo bone tissue strains around natural teeth vs. immediate oral implants. *Clin Oral Implants Res.* 2005;16:540-8.
18. Duyck J, Van Oosterwyck H, Sloten JV, De Cooman M, Naert I. Influence of prosthesis material on the loading of implants that support a fixed partial prosthesis: In vivo study. *Clin Impl Dent Relat Res.* 2000; 2:100- 9.
19. Koke U, Wolf A, Lenz P, Gilde H. In vitro investigation of marginal accuracy of implant-supported screw-retained partial dentures. *J Oral Rehabil.* 2004;31:477-82.
20. Fernandes CP, Glantz PJ, Svensson AS, Bergmark A. Reflection photoelasticity: a new method for studies of clinical mechanics in prosthetic dentistry. *Dent Mater.* 2003;19:106-17.
21. Kim WD, Jacobson Z, Nathanson D. In vitro stress analyses of dental implants supporting screw-retained and cement-retained prostheses. *Implant Dent.* 1999;8:141-51.
22. Iplikcioglu H, Akc,a K, C, ehreli MC, Sahin S. Comparison of non-linear finite element stress analysis with in vitro strain gauge measurements on a Morse taper Implant. *Int J Oral Maxillofac Implants,* 2003;18:258-265.
23. Karl M, Winter W, Taylor TD, Heckmann SM. Fixation of 5- unit implant supported fixed partial dentures and resulting bone loading: a finite element assessment based on in vivo strain measurements. *Int J Oral Maxillofac Implants,* 2006; 21:756-62.
24. Aldie' ris Alves Pesqueira, Marcelo Coelho Goiato, Humberto Gennari Filho, Douglas Roberto Monteiro, Daniela Micheline dos Santos, Marcela Filie' Haddad, Eduardo Piza Pellizzer, Use of Stress Analysis Methods to Evaluate the Biomechanics of Oral Rehabilitation With Implants; *Journal of Oral Implantology;* 2014; Vol. XL/ No. Two; 217-228
25. Jain RA, Philip KM, Ariga P. Attachment-retained unilateral distal extension (Kennedy's class II modification 1) cast partial denture. *Int J. Prosth Restor Dent* 2012; 2: 101-7.
26. Navar RM, Campo ML. A new free-end removable partial; denture design. *J. Prosthet dent* 1993; 70: 176-9.
27. Ragghianti MS, Gregghi SL, Lauris JR, Sant'ana AC, Passanezi E. Influence of age, sex, plaque and smoking on periodontal conditions in a population from Baurm, Brazil. *J. Appl Oral Sci* 2004; 12:273-9.
28. Karamely AN. Treatment options for free-end saddle. *J. Prosthet Dent* 2006; 18:124-5.
29. Williamson M. Selection of resilient types of attachments used in removable partial dentures. *British Prosthet J* 2005; 5:125-9.
30. Kapur KK, Deupree R, Dent RJ, Hasse AI. A randomized clinical trial of two basic removable partial denture designs. Part I: Comparison of five year success rates and periodontal health. *J. Prosthet Dent* 1994, 72: 268-82.

31. Koper A. An intracoronar semiprecision retainer for removable partial dentures. The Thompson dowel. J. Prosthet. Dent 1973; 30: 759-68.
32. Kratochvil FJ, Thompson WD, Caputo AA. Photoelastic analysis of stress patterns on teeth and bone with attachment retainers for removable partial dentures. J. Prosthet. Dent 1981; 46: 21-8.
33. Altay OT, Tsolka P, Preiskel HW. Abutment teeth with extracoronar attachments: The effects of splinting on tooth movement. Int J. Prosthodont 1990; 3: 441-8.
34. Wang HY, Zhang YM, Yao D, Chen JH. Effects of rigid and non rigid extracoronar attachments on supporting tissues in extension base partial removable dental prostheses: a non linear finite element study. J. Prosthet. Dent 2011; 105: 338-46.
35. Stewart KL, Rudd KD and Kuebker WA. Clinical removable partial prosthodontics. 2nd ed. Ishiyaku Euro America, Inc. Publisher, 1998.