EGYPTIAN DENTAL JOURNAL
www.eda-egypt.org
VOL. 68, 2643:2649, JULY, 2022
PRINT ISSN 0070-9484 • ONLINE ISSN 2090-2360
FIXED PROSTHODONTICS AND DENTAL MATERIALS
Submit Date : 11-04-2022 • Accept Date : 19-04-2022 • Available online: 30-06-2022 • DOI : 10.21608/edj.2022.132628.2066

A STRESS ANALYSIS STUDY OF TWO DIFFERENT DESIGNS FOR UNILATERAL DISTAL EXTENSION BASE PARTIAL DENTURES RETAINED BY EXTRACORONAL ATTACHMENT. AN INVITRO STUDY

Nagla Nassouhy*

ABSTRACT

Objectives: This study was conducted to compare the strains transmitted to the edentulous ridge with two different designs of unilateral removable prostheses using an extracoronal attachment; the unilateral removable partial denture and the unilateral removable porcelain fused to metal bridge.

Materials and Methods: An epoxy resin model with a unilateral distal extension base was prepared to receive a fixed porcelain fused to metal bridge carrying an extracoronal attachment. A unilateral removable partial denture (group I) and a unilateral porcelain fused to metal bridge (group II) were constructed using conventional casting and processing techniques and connected to the extracoronal attachment. Strain gauge was attached to the crest of the edentulous ridge beneath the area of the first molar and loads were applied to each prosthesis separately using a universal testing machine at the beginning of the test (baseline) and after 2000 insertion and removal cycles. Data was collected and statistically analyzed.

Results: A statistically significant difference was found in each group between the mean strain values at baseline and after 2000 insertion and removal cycles. The mean strain values were higher in group II than group I both at baseline and after 2000 insertion and removal cycles, but the difference was not statistically significant.

Conclusions: The unilateral removable porcelain fused to metal attachment retained bridge transfers comparable strains to the edentulous ridge as the unilateral removable attachment retained partial denture. The nylon cap needs to be frequently replaced to avoid excessive strains on the edentulous ridge.

KEYWORDS: Distal extension base, extracoronal attachment, stress analysis, unilateral partial denture, unilateral bridge.

* Associate Professor, Department of Prosthodontics, Faculty of Dentistry, Cairo University, New Giza University

INTRODUCTION

Distal extension base cases have always been a challenge in prosthodontics due to the absence of a posterior abutment which prevents the use of a fixed restoration. The difference in compressibility between the mucosa overlying the edentulous ridge and the periodontium of the abutment teeth results in overloading the supporting structures and bone resorption when a removable partial denture is used [1–4]. The fabrication of an implant restoration can solve these problems. However, it might not be applicable in all situations due to limitations such as quality and quantity of available bone as well as the patient's financial capabilities [5–8].

Precision attachments have proven to be a successful treatment option especially in unilateral distal extension base cases [9,10]. They provide a functional as well as an esthetic restoration, while maintaining the health of the supporting structures and reducing some of the problems associated with conventional removable partial dentures [11–13]. These prostheses allow for esthetic partial dentures without metal clasp display that are often a major objection of many patients [14–17].

An attachment is essentially composed of a male part (patrix) and a female counterpart (matrix). One part is incorporated within the partial denture, and the other part is attached to the cast bridge covering the abutments. The two parts become engaged, providing retention and stabilization to the denture during function and rest while being highly esthetic and appealing to the patient [3,11].

The unilateral design for removable partial dentures for class II Kennedy cases is claimed to be more acceptable to patients than the bilateral design due to its simplicity and decreased tissue coverage which is more comfortable during speech and mastication. The attachments used for these cases need to incorporate a resilient element to act as a stress breaker to dissipate the potentially damaging forces that can be transmitted to the abutments during function [15,16,18,19].

Another approach for using attachments in class II Kennedy cases is the removable bridge, which resembles the conventional fixed bridge in form and material, but is connected to the abutments through the attachment matrix incorporated within the bridge allowing it to be removed and seated like an attachment partial denture. The bridge is constructed of porcelain fused to metal, and has no denture base or flanges extending over the edentulous ridge, while maintaining a point contact on the ridge by the pontics. Advantages of this approach include decreased tissue coverage with no denture base or flanges which enhances patient comfort and acceptance of the prosthesis due to its close resemblance to fixed restorations [20,21].

Research has been done on the effect of these two different designs on the abutments, however, their effect on the edentulous ridge has not been sufficiently studied. This article was done to compare the effect of these two different designs and materials (the removable partial denture and the removable porcelain bridge) retained by an extra-coronal attachment on the strains transmitted to the residual ridge in Kennedy Class II cases.

MATERIALS AND METHODS

Fabrication of the epoxy model

An epoxy resin model with a unilateral distal extension base was fabricated for this study with the second premolar as the last standing abutment. The first and second premolars were prepared to receive a fixed, full-coverage porcelain fused to metal bridge to which the extra-coronal attachment was to be connected. The abutment teeth were prepared, and then the model was duplicated using addition silicon (Replisil 22 N addition curing duplicating silicone, Germany) into an extra hard dental stone cast on which the wax patterns (Renfert grey wax, Germany) for the crowns of the two abutments were fabricated as one unit.

A dental surveyor was used to carve a ledge on the lingual surface of the wax pattern of the bridge. The patrix part of the extra-coronal attachment (RK-1, Bursa, Turkey) was then attached to the wax pattern using blue casting wax. The paralleling mandrel of the surveyor was used to ensure proper placement of the attachment. A space of 2 mm was allowed between the attachment and the ridge.

The entire assembly was then cast in the conventional manner in cobalt chromium alloy. Porcelain was added to the bridge and fired, and the prosthesis was cemented on the abutments of the epoxy resin model using glass ionomer (Medifil, Promedica, Germany) (fig. 1a). Then, the steps of fabricating the two different prostheses were commenced.

Group I (the unilateral removable partial denture)

A unilateral removable partial denture with a metal framework was constructed in in this group. First, the space beneath the patrix of the attachment was blocked with utility wax, and impression was made of the resin model using addition silicon to produce a cast with extra hard dental stone. The cast was then blocked out and duplicated into a refractory cast in the manner followed conventionally during metallic partial denture framework fabrication.

During fabricating the wax pattern (Wax patterns, Bego, Bremen, Germany) of the framework, it was made to extend and cover the lingual ledges of the fixed bridge to act as a side plate for bracing and stabilization of the denture. The matrix of the attachment was attached to the wax pattern of the framework in proper position in relation to its patrix. Conventional casting techniques were carried out to obtain the metal framework. The framework was then tried on the epoxy resin model and complete seating was verified. The remaining steps of partial denture construction was then continued to obtain the final unilateral removable partial denture with proper teeth set-up and an accurately fitting denture base fabricated from heat cured polymethyl methacrylate adapting and extending to cover supporting structures of the edentulous ridge. (fig. 1b).

The denture was checked on the epoxy model for proper fit and adaptation of the denture base and the plastic cap was inserted in its place within the matrix using the plastic positioner tool provided by the manufacturer.

Group II (the unilateral removable porcelain fused to metal bridge)

The second design in this study was a removable porcelain-fused-to-metal two-unit bridge without an acrylic resin denture base extending over the edentulous ridge and with only a point contact between the pontic and the ridge.

During the wax pattern step of fabricating the removable bridge, the matrix of the attachment was placed on the patrix and attached to the wax pattern of the removable bridge. The removable bridge was then cast in the conventional casting manner followed by the addition and firing of porcelain (fig 1c). The plastic cap was inserted in its place within the bridge as with group I.

Strain gauge installation and loading of the prostheses

The strain gauge (KFGS-2N-120-C1-11L1M2R, Kyowa electronic instruments co., Japan) was placed on the crest of the ridge of the epoxy model at the location of the first molar tooth. The strain gauge was fixed in position with cyanoacrylate adhesive and its wire was secured in place with self-cure acrylic resin.

A universal testing machine (Lloyd LR5K Test Machine, Ltd, UK) was used to apply a vertical static load ranging from 0-100 N on the first molar tooth of the two prostheses. A notch was made in the first molar tooth to allow for the seating of the loading tip of the universal loading machine.

The removable partial denture was fully seated on the epoxy model and load was applied gradually

from 0-100 N with a speed of 100 mm/s. Strains were measured at the beginning of the test (baseline), and then the prosthesis was removed and seated 2000 times, then the second strain measurements were taken. Each of the two measurements was repeated 20 times. Microstrains were recorded during load application by the computer connected to the universal testing machine using a specialized software (Nexegen ver.4.3 material testing software, Ametek, China) to collect and present the readings. The testing steps were repeated in the same manner for the removable porcelain fused to metal bridge (fig 2).

Collection of data and statistical analysis

The mean and standard deviation values were calculated for each group in each test. Data was explored for normality using Kolmogorov-Smirnov and Shapiro-Wilk tests. Data showed parametric (normal) distribution. Paired sample t-test was used to compare between two groups in related samples. Independent sample t-test was used to compare between groups in non-related samples. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

RESULTS

The results of this study showed that there was a statistically significant difference between strain values at the baseline and those after 2000 insertion and removal cycles in both groups where ($p<0.001$). The highest mean value was found in the baseline readings, while the least mean value was found after 2000 cycles in both groups (table 1, fig 3).

The results also showed that the mean strain values were higher in group II (removable bridge) more than group I (removable partial denture) at both the baseline readings and after 2000 cycles. However, this difference was found to be statistically non-significant (table 1, fig 3).

Fig. (1) (a,b,c)

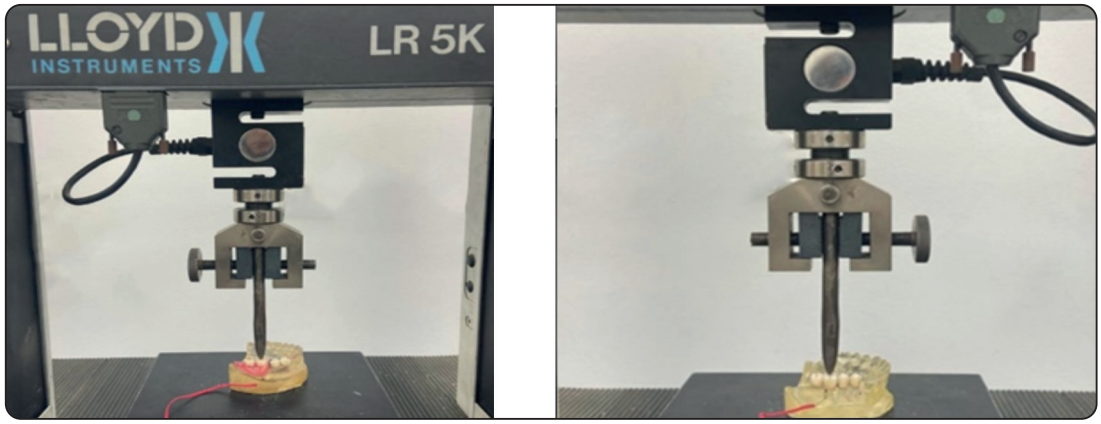

Fig. (2)

TABLE (1): The mean, standard deviation (SD) values of strain of different groups

Variables	Strain				p-value
	Group I Removable partial denture		Group II Removable bridge		
	Mean	SD	Mean	SD	
Baseline	25.71	5.34	32.86	8.59	**0.086ns**
After 2000 cycles	55.71	8.59	61.43	5.56	**0.074ns**
p-value	**<0.001***		**<0.001***		

; significant (p<0.05) ***ns; non-significant (p>0.05)***

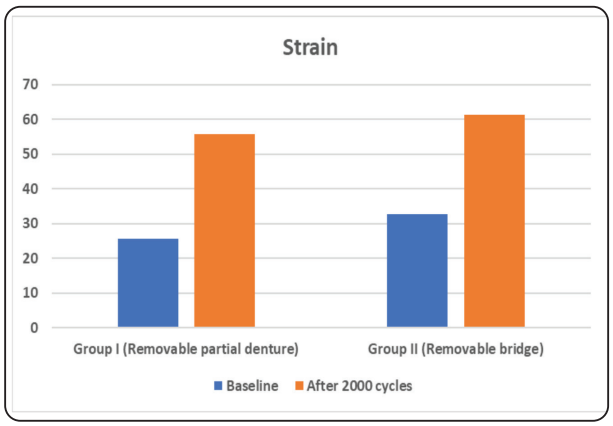

Fig. (3) Bar chart showing strains in groups I and II at baseline and after 2000 cycles

DISCUSSION

Attachment retained prostheses have proven to be an effective solution to the unilateral distal extension base cases by providing an esthetic prosthesis that can function effectively while maintaining the health of the supporting structures. Additionally, patients have a general preference to unilateral prostheses more than bilateral prostheses due to their reduced tissue coverage which makes them more acceptable and comfortable during function [22].

The attachment used in this study requires the creation of a ledge on the lingual surface of the fixed bridge covering the abutments to enhance stabilization and bracing of the prostheses and eliminate the need to cross over to the other side of the arch.

There are two designs that can be used with unilateral precision attachments; the unilateral removable partial denture and the unilateral removable porcelain fused to metal bridge. The unilateral removable bridge is a design that is promoted commercially for its lack of denture base coverage and flanges as well as its resemblance to the fixed prosthesis which is usually the first treatment preference for most patients [19,23,24]. On the other hand, the partial denture design is often objectionable to some patients due to the discomfort caused by covering the mucosa by the denture base and flanges and food accumulation beneath the denture base even though it is known for its wider coverage of the edentulous ridge that results in a more favorable stress distribution and preservation of the supporting structures [15,21].

The results of this study showed that the strains transmitted to the edentulous ridge in group II were higher than those transmitted in group I both at baseline and after 2000 insertion and removal cycles. However, this difference was found to be non-significant. This is probably the result of the full extension of the properly adapted denture base over the ridge in group I which allows the distribution of masticatory load over a wider area. Another reason is the more resilient nature of the acrylic resin material of the denture base when compared to the stiffness of the porcelain fused to metal bridge

[3,13,25]. However, the lack of statistical significance between the two groups allows for the possibility of using the unilateral removable bridge as a viable, more acceptable alternative to the removable partial denture since they both transmit comparable stresses to the residual ridge. However, these results are only in regards to the edentulous ridge, and the strains transmitted to the abutments should also be taken into consideration before this decision is made.

The results have also shown a significant increase in the load transmitted to the edentulous ridge in both groups after 2000 insertion and removal cycles. This can be expected as a result of wear of the plastic cap of the attachment after the insertion and removal cycles resulting in loss of retention and movement of the prosthesis over the ridge under loading. The plastic cap also contributes in distributing the load favorably between the abutments and the ridge, and when it undergoes structural changes due to wear and decreased elasticity, more stresses will be transmitted to the ridge [26 27].

CONCLUSIONS

Within the limitations of this study, it can be concluded that the attachment retained unilateral removable bridge can be used with Kennedy class II cases instead of the partial denture design as they both transmit comparable stresses to the edentulous ridge. However, this decision needs further investigations to compare the effect of these two designs on the abutments as well.

Finally, retention plastic caps should be changed frequently to avoid overloading the edentulous ridge due to wear of the caps.

REFERENCES

1. Manderson RD, Wills DJ, Picton DCA. Biomechanics of denture-supporting tissues. Proc 2nd Int Prosthodont Congr 1979; 98–101.
2. J. S. Brudvik. Advanced Removable Partial Dentures,. 1st ed. Chicago, Ill: Quintessence, 1999.
3. Carr A.B., G.P. Mcgivney, D.T. Brown. McCracken's removable partial denture prosthodontics. 11th ed. Mosby Inc, St. Louise, Missouri., 2005.
4. Kern M, Wagner B. Periodontal findings in patients 10 years after insertion of removable partial dentures. J Oral Rehabil 2001; 28: 991–997.
5. Wennerberg A, Albrektsson T. Current challenges in successful rehabilitation with oral implants. Journal of Oral Rehabilitation 2011; 38: 286–294.
6. Gonçalves TMSV, Campos CH, Rodrigues Garcia RCM. Implant retention and support for distal extension partial removable dental prostheses: Satisfaction outcomes. J Prosthet Dent 2014; 112: 334–339.
7. Davis DM. Role of implants in the treatment of edentulous patients. Int J Prosthodont 1990; 3: 42–50.
8. Kern JS, Kern T, Wolfart S, et al. A systematic review and meta-analysis of removable and fixed implant-supported prostheses in edentulous jaws: Post-loading implant loss. Clinical Oral Implants Research 2016; 27: 174–195.
9. Preiskel HW, Preiskel A. Precision attachments for the 21st century. Dent Update 2009; 36: 221–224, 226–227.
10. Can G, Özmumcu B, Altinci P. In vitro retention loss of attachment-retained removable partial denture. J Contemp Dent Pract 2013; 14: 1049–1053.
11. Burns DR, Ward JE. Review of attachments for removable partial denture design: 1. Classification and selection. Int J Prosthodont 1990; 3: 98–102.
12. Wichmann MG KW. Wear behavior of precision attachments. Int J Prosthodont 1990; 12: 409–14.
13. Fernandes B, Alfenas M, Abi-rached FDO. Maxillary Rehabilitation Using Fixed and Removable Partial Dentures with Attachments : A Clinical Report. 2013; 0: 1–6.
14. Walter MH, Marré B, Vach K, et al. Management of shortened dental arches and periodontal health: 5-year results of a randomised trial. J Oral Rehabil 2014; 41: 515–522.
15. Peršić S, Kranjčić J, Pavičić DK, et al. Treatment Outcomes Based on Patients' Self-Reported Measures after Receiving New Clasp or Precision Attachment-Retained Removable Partial Dentures. J Prosthodont 2017; 26: 115–122.
16. Wang HY, Zhang YM, Yao D, et al. Effects of rigid and nonrigid extracoronal attachments on supporting tissues in extension base partial removable dental prostheses: A nonlinear finite element study. J Prosthet Dent 2011; 105: 338–346.

17. Shetty NB, Shetty S, Nagaraj E, et al. Precision attachments for aesthetics and function: A case report. J Clin Diagnostic Res 2014; 8: 268–270.

18. D. KP, Swaminathan AA, D. AP. A Simplified Approach to Semi-Precision Attachment. J Heal Allied Sci NU 2016; 6: 51–57.

19. Simha YN, Nayakar RP. Prosthodontic rehabilitation of a patient with kennedy's class I and class II using an extended precision attachment: A case report. World J Dent 2020; 11: 226–230.

20. Staubli PE. Attachments and Implants Reference Manual, 6th Ed. Implant Dent 1998; 7: 377.

21. Gupta A, Khanna G, Bhatnagar M, et al. Precision Attachments in Prosthodontics: A Review. Int J Prev Clin Dent Res 2018; 5: 34–39.

22. Zitzmann NU, Rohner U, Weiger R, et al. When to choose which retention element to use for removable dental prostheses. Int J Prosthodont 2009; 22: 161–7.

23. Pelaez J, Cogolludo PG, Serrano B, et al. A four-year prospective clinical evaluation of zirconia and metal-ceramic posterior fixed dental prostheses. Int J Prosthodont 2012; 25: 451–8.

24. Nevalainen MJ, Närhi TO, Ainamo A. A 5-year follow-up study on the prosthetic rehabilitation of the elderly in Helsinki, Finland. J Oral Rehabil 2004; 31: 647–652.

25. Wagner B, Kern M. Clinical evaluation of removable partial dentures 10 years after insertion: success rates, hygienic problems, and technical failures. Clin Oral Investig 2000; 4: 74–80.

26. Rutkunas V, Mizutani H, Takahashi H, et al. Wear simulation effects on overdenture stud attachments. Dent Mater J 2011; 30: 845–853.

27. Marin DOM, Leite ARP, de Oliveira Junior NM, et al. Retention force and wear characteristics of three attachment systems after dislodging cycles. Braz Dent J 2018; 29: 576–582.