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Debonding of Resin Bonded Fixed Partial Denture Using Different Surface Treatments and Framework Designs

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Abstract

Objective: Due to the increasing demands of conservative fixed dental prostheses; many dentists have been using resin bonded fixed partial dentures (RBFPDs). Advances in adhesive technology together with a better understanding of the clinical function of such restorations have allowed resin-bonded fixed partial dentures to play an important role in clinical practice. The present in vitro study aimed to determine the effect of basic bridge designs of anterior resin bonded fixed partial dentures and added retentive mean on debonding of metal frameworks with different metal surface treatments.

Material and Methods: Typodont teeth were used and preparation designs of resin bonded fixed partial dentures replacing maxillary lateral incisor were made in two groups: (Fixed fixed RBFPDs and Cantilever RBFPDs) (n=30), each group was divided into 2 subgroups according to retentive mean preparation (n=15) then each subgroup was divided into three divisions according to surface treatments: Air borne particle abrasion, Air borne particle abrasion with primer, Tribochemical coating (n=5).

Frameworks were then cemented to epoxy resin dies then subjected to tensile loading until failure.

Results: The results showed that design had a statistically significant effect on debonding at P- value <0.001. Also retentive means had a statistically significant effect on debonding at P-value <0.001, surface treatments had statistically significant effect at P-value <0.001. The interaction between the three variables had a statistically significant effect on viability % at P-value <0.001.

Conclusion: Use of RBFPD to replace maxillary lateral incisor can be a minimally invasive solution but as with any form of treatment, the use of RBFPD is not without limitations and success is associated with appropriate case selection and planning.

Keywords: Resin bonded, Fixed, Cantilever, Air abrasion, Primer, Cojet

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Introduction

A missing tooth in the anterior region is not only a physical loss, but also may be an emotional experience for the patient as well. To remove healthy tooth structure of adjacent teeth to replace a lost tooth, for some patients and dentists is a very aggressive treatment option. Many treatment modalities are available for replacing a single missing tooth; dental implant, removable partial denture or a fixed partial denture which is further categorized into two types according to the form of the retainers, which include a partial veneer restoration such as resin bonded fixed partial denture (RBFPD) and complete veneer fixed partial denture.[1]

Each modality is a possible treatment option and has its own advantages and disadvantages. Patient awareness of the advantages and disadvantages of different treatment modalities is very important for decision making, therefore there are many factors that make single-tooth replacement one of the most challenging restorations in dentistry.[2]

Resin bonded fixed partial denture is defined as a fixed dental prosthesis replacing one or two missing teeth, which involves bonding ceramic or metal wings to the enamel of the adjacent tooth/teeth (palatal/lingual and proximal surfaces of the abutment teeth) using a special adhesive cement. The replaced tooth is held in place by means of wing (cantilever RBFPD) or two wings (Fixed fixed RBFPD).[3]

A fixed fixed RBFPD has a better retention but cantilever is known for its better esthetics, easy cleaning, less biological damage and no chance of having undetected debonded retainer with decay underneath it. [4] And for improving retention of RBFPDs, added means of retention as proximal grooves at the line angles adjacent to edentulous area or palatal pits are recommended.

The advantages of RBFPD are basically their non-invasive approach to dentin with only lingual and proximal tooth preparation, then tissue tolerance because of supragingival margins.[5]

They can be an option where there may be a lack of 3-dimensional space or bone for implant placement. The benefits of shorter appointments and associated cost, compared to conventional bridgework and implant-supported restorations, are also favored by patients.

Metal–ceramic resin bonded restorations have been successfully used for many years with the development of resin cements that provide a strong link between metal and tooth structure. These restorations may be treated with micro-mechanical retention methods as sandblasting with Al_2O_3 particles, chemical bonding which may be achieved with the use of chemical primers and silanes, or both to improve the bond strength to the metal alloys as tribochemical silica-coating systems.

Resin-bonded fixed partial dentures have an important role to play in the minimally invasive prosthodontic replacement of missing teeth and their performance can be enhanced by well planned and executed designs and adhesive techniques.[6]

Thus the aim of this study was to determine the effect of basic bridge designs of anterior resin bonded fixed partial dentures: fixed fixed and cantilever with and without palatal pit on debonding of metal frameworks with different metal surface treatments: air borne particle abrasion, air borne particle abrasion with primer and tribochemical coating (cojet).

The null hypothesis that Basic design, added retentive mean and the surface treatments will not affect debonding of RBFPDs was suggested.

Material and Methods:

In this study two typodont teeth1 (maxillary central incisor and canine) were used for the purpose of standardization.

Sample grouping:

Preparation designs of resin bonded fixed partial dentures replacing maxillary lateral incisor were made in two groups: (Fixed fixed RBFPDs and Cantilever RBFPDs) (n=30), each group was divided into 2 subgroups according to retentive mean (palatal pit) preparation (n=15) then each subgroup was divided into three divisions according to surface treatments: 1- Air borne particle abrasion, 2- Air borne particle abrasion with primer, 3-Tribochemical coating (n=5).

Designs without palatal pit were made first and then after wax pattern fabrication the palatal pits were made and steps were continued.

The frameworks were cemented to epoxy resin dies then subjected to tensile loading for debonding testing.

Teeth preparation:

Finish line Preparation was done using milling machine2 for standardization, parallelism and adjustment of path of insertion using a tapered diamond stone with round end 1 mm in diameter3resulting in a 0.5 mm supragingival chamfer finish line (1 mm away from the free gingival margin of the tooth in the cast). (Fig. 1)

Preparation was extended proximally terminating just lingual to the facioproximal line angle to increase the surface area for bonding and to allow a definite path of insertion.

The depth of palatal surface preparation was kept 0.5 mm with the help of depth orientation grooves made with a round bur and the remaining islands were removed till the depth of original grooves at the palatal fossa using wheel stone.

An additional palatal pit in the cingulum area of central and canine (depth, 0.5 mm; diameter 1.5 mm) was made using round bur perpendicular to the palatal surface.

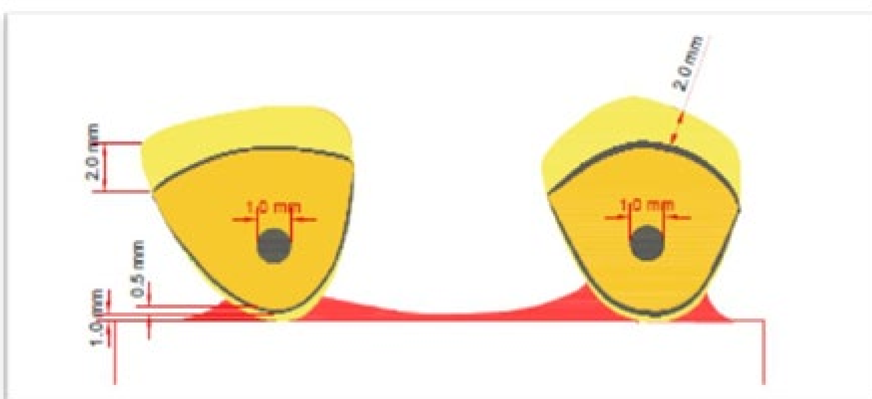

Figure 1: Diagram showing fixed fixed design with palatal pits.

Impression:

Impressions were taken for each type of preparation by addition silicone impression material and then poured into master stone models which were further duplicated to form epoxy resin dies using silicon indices.

Wax pattern fabrication:

Wax patterns were designed using Exocad software version 2014.02 4 in windows 7 ultimate then milled by CAD/CAM system then sprued, invested, casted and finished to form metal resin bonded bridges (NiCr base metal alloy) 5with veneered pontics.

A specially made groove was designed at the center of the tissue side of the pontic for later application of the tensile bond strength testing with the help of a specially made hook shaped attachment at this groove (Fig. 2) which was scanned to achieve proper fit and standardization of the groove dimension in all designs.[7] (Fig. 3)

Figure 2: Specially made hook shaped attachment for tensile testing.

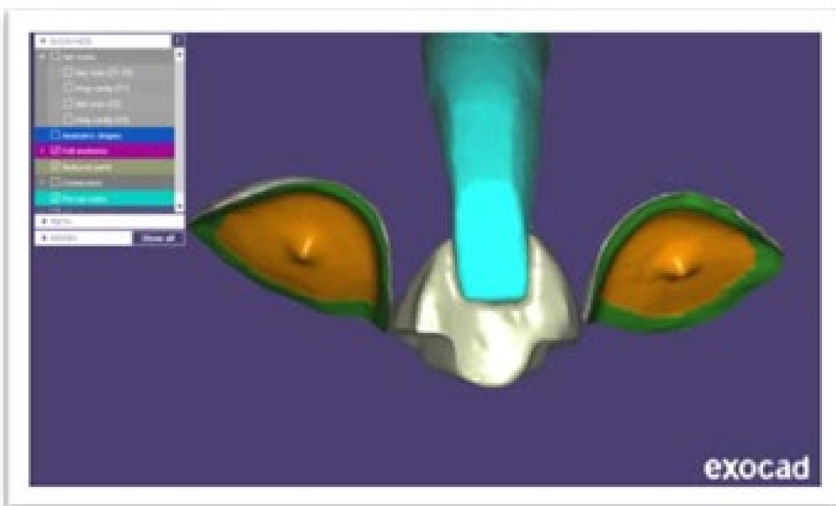

Figure 3: Specially made attachment fitted in the groove included in the design.

Surface treatments of fitting surfaces of restorations:

Subgroup A: Airborne particle abrasion

Sample surface were subjected to airborne particle abrasion in an air abrasive unit, samples were sandblasted with 110 um aluminum oxide powder 6 /20 s, 2.8 bars, at a standardized distance of 10 mm perpendicular to the surface in a holder device to standardize the distance between the bridges and sandblasting tip.[8]

Subgroup B: Airborne particle abrasion and metal primer

Sample surface were subjected to airborne particle abrasion as mentioned previously then treated with alloy primer7.

Application of metal primer was done in the fitting surface of bridges by disposable brush applicator.[8]

Subgroup C: Tribochemical coating (cojet)

Sample surface was blasted with 30 µm silica-modified aluminum oxide sand (Cojet Sand) 8for 15 s at pressure of 2 bars and the distance was maintained at 10 mm from the specimen surface in cojet holder device.[9]

Cementation:

Metal frameworks were cemented on corresponding epoxy resin casts using self-adhesive dual cured resin cement (Rely x u 200 automix)[9]

Tensile bond test:

After water storage for 24 hours specimens were subjected to tensile loading at 1 mm/min. crosshead speed in a vertical direction in universal testing machine10 using a special attachment to permit application of the tensile load at a specially made groove that was prepared during wax pattern fabrication at the center of the tissue side of the pontic.

Each specimen was photographed using USB Digital microscope with a built-in camera[11] connected with an IBM compatible personal computer using a fixed magnification of 65X for evaluation of mode of failure.

Results

Three-way ANOVA analysis was used to compare the effect of different variables on debonding.

One way ANOVA followed by tukey post-hoc test was used to compare between more than two non-related samples while independent sample-t test was used to compare between two non- related samples.

The results were presented in table (1) showing the effect of different variables on debonding.

Effect of basic design on debonding:

The results revealed that the type of design had a great effect on debonding and the results were statistically significant with the highest mean values found in group I (fixed fixed) in all three divisions.

Effect of retentive mean (palatal pit) on debonding:

There was a statistically significant difference between sub group A and sub group B only in fixed fixed group with the highest mean values in IB1 and IB3

Effect of surface treatment on debonding:

For fixed fixed group a statistically significant difference was found between division IA2 (with the highest mean value) on one hand and each of division IA1 and IA3 on the other hand where ($p \leq 0.001$).

For cantilever group a statistically significant difference was found between IIA3 (with the highest mean value) on one hand and each of IIA1 and IIA2 on the other hand where ($p=0.001$) and ($p=0.002$) respectively.

Variables			1- Air abrasion	2- Air abrasion and primer	3- Tribochemical coating
Group I (Fixed fixed)	Subgroup A (Without palatal pit)	Mean (SD)	114.24 (±15.46) ^{Bb}	211.06(±27.27) ^{Aa}	124.54(±21.92) ^{Bb}
	Subgroup B (With palatal pit)	Mean (SD)	196.99 (±25.77) ^{Aa}	208.43(±30.62) ^{Aa}	188.11 (±26.27) ^{Aa}
Group II (Cantilever)	Subgroup (A)	Mean (SD)	46.42 (±11.17) ^{Bc}	50.28(±7.4) ^{Bb}	73.40 (±5.29) ^{Ac}
	Subgroup (B)	Mean (SD)	44.40 (±9.53) ^{Ac}	63.69 (±13.91) ^{Ab}	59.41(±13.22) ^{Ac}

Table 1: Effect of basic design, retentive mean and surface treatments on debonding

Same capital letters within rows are not statistically significant at $P \leq 0.05$.

Same small letters within columns are not statistically significant at $P \leq 0.05$.

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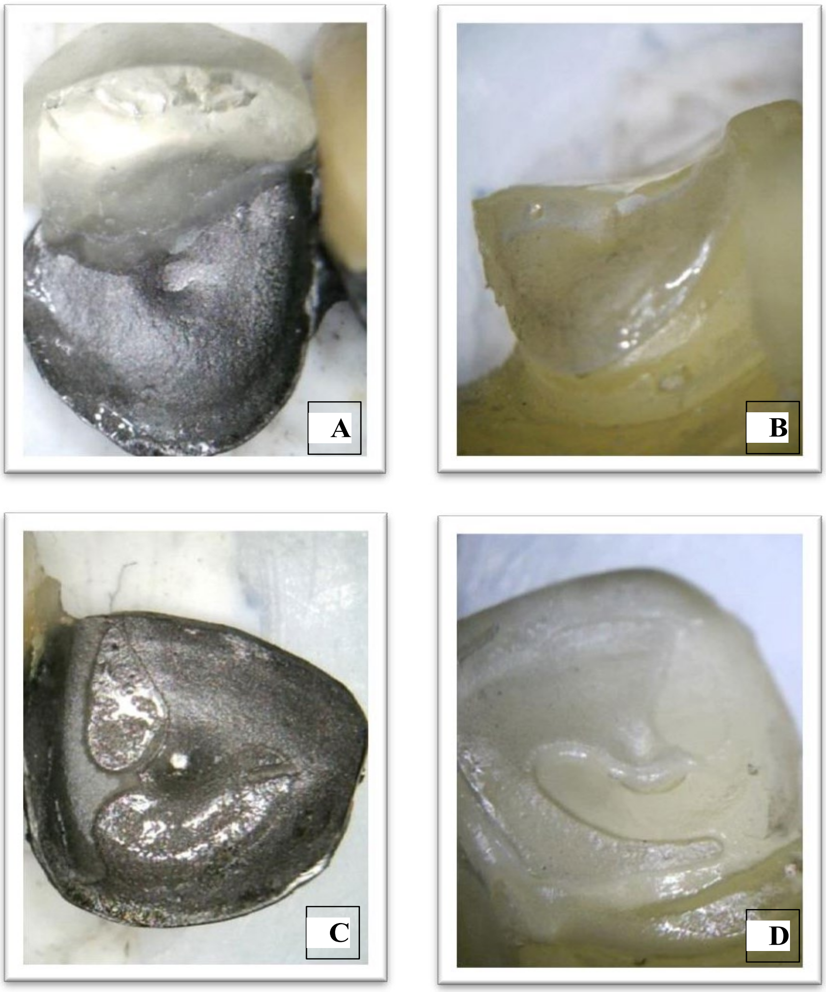
Failure mode evaluation:

All specimens showed mixed mode of failure (Fig. 4)



All specimens showed mixed mode of failure (Fig. 4)

Figure 4: Mixed mode of failure with fracture of canine abutment in fixed fixed with pit design treated with air borne particle abrasion. (a) Debonded canine retainer with part of the fractured die. (b) Fractured canine abutment. (c) Debonded central retainer. (d) Central abutment

Discussion

Significant developments have occurred in the design of resin bonded fixed partial dentures over the past two decades and with the development in adhesive dentistry RBFPDs are commonly used as an alternative treatment option for a single missing tooth.

The most common technical reason for RBFPD failure is debonding. Proper case assessment and use of careful clinical techniques with precision and attention to detail are just as important in RBFPDs as they are in conventional prostheses to provide a long-lasting prosthesis.

Designs of preparation used in this study were identical except for the presence of the palatal pits. The comparison between these designs was based on assumption that additional retention can be gained by preparing a palatal pit.

The resin cement links the underlying tooth structure to the internal surface of the restoration. Regardless of the type of resin cement, a bond should exist between the tooth structure and the cement (tooth-cement interface) and between the cement and the internal surface of restoration (cement-restoration interface) for these bonds to form, the tooth and the internal surface of the restoration should be pretreated.[10]

The null hypothesis that Basic design, added retentive mean and the surface treatments will not affect debonding of RBFPDs was fully rejected.

The tensile forces required to dislodge resin bonded retainers from epoxy dies were recorded and forces from 114 N to 211N were required for debonding the retainers of fixed fixed retainers and from 44 N up to 73 N for debonding cantilever retainers. These results were consistent with those reported by ***Nair et al***.[11] and ***Ibrahim et al*** [12] whose results of the debonding forces were within the physiological ranges taking into consideration that failure of RBFPDs in the oral environment takes place as a result of fatigue whose loads are less than tensile loads used in in vitro studies.[13]

For cantilever RBFPD, early debonding may have occurred due to loads on the cantilever free pontic end which initiates stress concentration and crack propagation through the only retainer that eventually debonds[14] but for a fixed-fixed resin bonded design the opportunity for such free movement is lost as the abutment teeth are splinted together by the rigid framework. Also as bond strength is directly proportional to the amount of surface area available for bonding.[15]

Results of this study also showed that designs with palatal pit revealed effective added mean of retention in fixed fixed designs which came in agreement with the results of ***Rosentritt et al*** [16] who found an increase in frequency of failure through adhesive debonding in non-retentive preparations and the results of ***Nemoto et al*** [17] who believed that added retentive means enhanced the retention of RBFPDs by increasing the attachment surface area and by mechanical locking.

But for cantilever group the presence of palatal pit was not effective which agreed with the results of ***Mourshed et al*** [18] which revealed that additional retentive means of the preparation didn't provide any mechanical retention in anterior cantilever RBFPD and that it relied completely on the resin bond.

The results of this study showed that airborne particle abrasion had the lowest retentive mean value. This came in agreement with the results of ***Petrie et al***[19] who proved that airborne particle abrasion of the metal surface before cementation creates micro-pores that may trap air that subsequently inhibits the polymerization of the resin cement.

Results of this study showed the highest retentive mean value with air borne particle abrasion and primer in agreement with the results of ***Petrie et al***[19] who stated that the potential advantages of primer could be attributed to the fact that the primer may promote "wetting" of the metal surface and eliminate or substantially reduce the amount of air trapped in micro-pores created by airborne particle abrasion. This was in disagreement with the results of ***Filho et al***[8] who found lower bond strength values with primer than cojet and with the results of ***Frietas and Francitoni***[20] who found that despite the Alloy Primer increased the retention between the Rely X cement and the polished surface of the Co-Cr-Mo alloy, yet its bond strength was not greater than that obtained with air abrasion alone.

Results of this study showed high retentive mean values with cojet and this agreed with the results of ***Watanabe et al***[21] who proved that Silica coating by cojet system was effective in improving the bonding strength to dental alloy as this system has the purpose to create silica covering on alloys, promoting higher union values with resin materials.

The results of this study showed that tooth preparation and pretreatment procedures of casting alloys play an important role in retention of RBFPD which came in agreement with the results of ***Arora et al***[22] who used different types of preparation designs and alloy pretreatment methods and found that their combination had an influence in increasing the retention of RBFPDs

compared to standard preparations and untreated casting alloys and this was irrespective of the design pattern or the pretreatment method used , but this disagreed with the results of ***Wei et al***[23]who suggested that it is all about the resin cement and not any additional mechanical retention.

Failure modes had been classified as adhesive, cohesive and mixed. **Durey et al** [24] had thought that in weaker adhesive systems, fracture type was adhesive and minimal resin penetration occurred in these systems.

All specimens showed mixed type of failure with some resin present on the retainer and this reflects positively on the strength of resin bonding.[24]

Conclusions

In the essence of this study, these conclusions could be established:

-Fixed fixed design is more retentive than cantilever one.

-Palatal pit is only effective in improving RBFPD retention in fixed fixed designs.

-The type of surface treatment was critical when no added mean of retention was used, where both air abrasion with primer and tribochemical coating performing better than air borne particle abrasion alone in both designs.

-All specimens showed mixed type of failure and this reflects positively on the strength of resin bonding.

Recommendations

-Further in vivo studies should be made for RBFPDs.

-Follow up studies are needed in terms of longevity.

-Further studies should be made including resin cements as a variable.

Conflicts of interest

The authors declare that there is no conflict of interest related to this study.

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