

## Comparative Evaluation Of Retention Of Conventional Resin Bonded Fixed Partial Denture And Its Modified Designs: An In Vitro Study

### Abstract

#### Background and Objective

Over the years, RBFPDs have gone through substantial development and refinement. Several studies examined the biomechanics of tooth preparation and framework design in relation to the success rate of RBFPDs and considered retention and resistance form essential for increasing the clinical retention. However, these criteria required preparations to be more invasive which violates not only the original intentions of the RBFPD but may also have an adverse effect on retention due to loss of enamel. The purpose of this in vitro study was to evaluate retention of the two modified designs of RBFPDs and to compare them with that of conventional RBFPDs.

#### Method

Ninety extracted human teeth were randomly divided into three groups (n=15). Specimens in group 1 (conventional RBFPDs) were prepared with proximal grooves, occlusal rest seats, and lingual wings. Specimens in group 2(modified RBFPDs) were prepared with proximal slots, occlusal rest seats and lingual wings. Specimens in group 3(modified RBFPDs) were prepared with Class II inlay cavities. Castings were made and cemented with self-adhesive resin cement. The specimens were then subjected to tensile pull out test using universal testing machine. The force required to dislodge each RBFPD from the teeth was recorded. The data were analyzed using ANOVA and Bonferroni test.

#### Result

The mean tensile bond strength of group 2 was significantly higher than groups 1 and 3. Though the mean tensile bond strength for group 3 was higher than group 1, it was not statistically significant.

#### Conclusion

The modified RBFPDs of group 2 had better potential for retention. Increased resistance to dislodgment of the RBFPDs was related to the surface area available for bonding. The positive findings of this study warrant a long term clinical trial of the modified RBFPDs.

#### Key Words

Resin bonded fixed partial denture; Maryland Bridge; Retention; Tensile strength.

### Introduction

Rochette in 1973 proposed adhesively bonded splints with macromechanical retention through perforated retainers.<sup>[1]</sup> Later, Howe and Denehy<sup>[2]</sup> used this technique for an anterior fixed partial denture, and Livaditis<sup>[3]</sup> described this technique for posterior tooth replacement.

The main advantages of the RBFPDs are reduced pulpal morbidity caused by minimal tooth preparation, as well as less gingival inflammation resulting from supragingival placement of the margins.<sup>[4]</sup> In addition, chairside time and laboratory costs are reduced compared to conventional prostheses.<sup>[5]</sup>

Introducing a minimally invasive preparation design with large surface areas for bonding and vertical grooves

improved the survival rates of RBFPDs.<sup>[5],[6]</sup> In addition, several retentive systems for bonding composite resin to metal were developed. However, clinical results showed unsatisfactory retention rates for RBFPDs. Several studies evaluated the biomechanics of tooth preparation and framework design in relation to the success rate of RBFPDs and considered retention and resistance form essential for increasing the clinical retention of RBFPDs.<sup>[7],[8]</sup> Consequently, the original design of RBFPDs which involved no tooth preparation gradually went through a number of changes such as preparation of proximal grooves, occlusal rest seats, and lingual wings.<sup>[7]</sup> Other modifications like incorporation of pins (pin-retained RBFPDs)<sup>[9]</sup>, retentive slots and inlay preparations<sup>[10]</sup> were also proved to be effective.

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These new modified designs, however, are less conservative than the designs that have been previously used. Therefore, prior to prescribing these designs for the replacement of the posterior teeth in the partially edentulous patients, it is prudent to evaluate their retention in an in vitro study. The purpose of this in vitro study was, therefore, to compare the retention of the two modified designs of the RBFPDs with that of the conventional RBFPDs and to assess their suitability for use as an alternative to partial or full coverage retainers, wherever, indicated.

### Material and Method

Ninety freshly extracted human teeth (forty five 2nd premolars and 2nd molars) were employed in the study. Each selected tooth received two grooves on the mesial and distal surfaces of its root prior to being embedded in the resin. The grooves were placed in the roots in order to secure them in place in the resin base

[self-cure acrylic resin (DPI-RR Cold cure, DPI, Mumbai, India)] during the tensile test. Specimens were then prepared by mounting one premolar and one molar with a space equivalent to 1st molar tooth between them in the resin base, with the long axis of the tooth perpendicular to the horizontal plane, at dough stage. All the specimens were preserved in distilled water until further use.

The specimens were then assigned at random to three different preparation designs, consisting of 15 specimens each. The division was made in such a way that there was a similar distribution of teeth (small, medium, large) and type (maxillary and mandibular) in each group.

**Group 1-** Specimens in group 1 were prepared with proximal grooves, occlusal rest seats, and lingual wings to receive conventional RBFPDs. (**Figure 1**).

**Group 2-** Specimens in group 2 were



Figure 1 : Group 1 Specimens

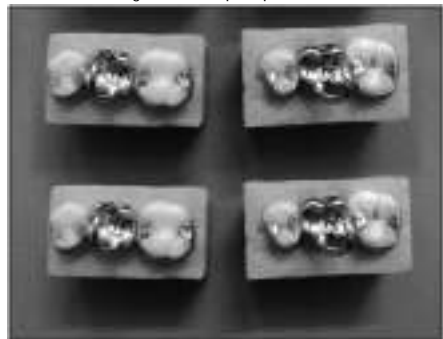


Figure 2 : Group 2 Specimens

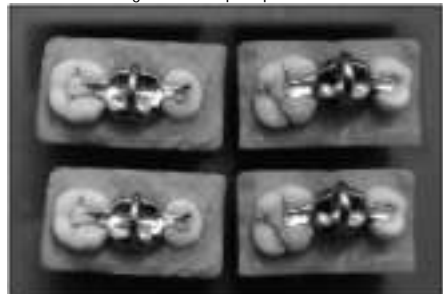


Figure 3 : Group 3 Specimens

prepared with proximal slots, occlusal rest seats and lingual wings to receive modified RBFPDs. (**Figure 2**).

**Group 3-** Specimens in group 3 were prepared with Class II inlay cavities to receive modified RBFPDs. (**Figure 3**).

#### Tooth preparation

Putty index was made using addition silicone impression material (3M ESPE, Express™ STD, vinyl polysiloxane impression material, Germany, Lot no. 153490) for each specimen before starting the preparation.

**Group 1** specimens consisted of proximal grooves, lingual wings and occlusal rest seats on the abutment teeth. The lingual reduction was done using micromotor handpiece attached to the Jelenko surveyor. The margins were placed 1mm above the cemento-enamel junction with a wing preparation of 0.6mm depth. The lingual reduction was extended further onto the other proximal surface to ensure a total circumferential coverage of more than 180°. The proximal grooves were placed in the center of the mesial surface of the premolar and in the center of the distal surface of the molar, 0.5mm above the finish line. Occlusal rest seats were prepared in the distal fossa of the premolar and in the mesial fossa of the molar. Occlusal rest seat was roughly rounded triangular in shape with apex towards the center of the occlusal surface. The depth of the rest seat was 1.5mm in the central fossa and 0.5mm at the marginal ridge with buccolingual width of 1/3rd the intercuspal distance and mesiodistal width 1/3rd the mesiodistal width of the concerned tooth.

**Group 2** specimens consisted of proximal slots, lingual wings and occlusal rest seats on the abutment teeth. Occlusal rest seats were prepared in the mesial fossa of the premolar and the distal fossa of the molar. The preparation of occlusal rest and lingual wing preparation was done in the same way as it was done for specimens in group 1. The proximal slots, 3mm deep, 2mm wide bucco-lingually and 1.5mm wide mesio-distally, were prepared on the disto-occlusal surface of the premolar and the mesio-occlusal surface of the molar.

**Group 3** specimens consisted of class II inlay cavity on the distal side of the premolar and mesial side of the molar.

Inlays were 2mm deep occlusally extending till the central fossa with an occlusal dovetail (0.5mm) and buccolingual width of 1/3rd the intercuspal distance; proximal box was made 3mm deep with straight parallel walls, beveled axio-pulpal line angle, flat pulpal and gingival floors.

Putty index was used to verify the amount of lingual reduction. William's graduated periodontal probe was used to measure the depth, width and height of the proximal slots and class II inlay preparations. All the preparations were done by single set of burs for the particular group to standardize the preparations.

The putty wash impression technique was employed for making the impression of all the specimens using addition silicone- putty (3M ESPE, Express™ STD, vinyl polysiloxane impression material, Germany, Lot no. 153490) and light body (3M ESPE, vinyl polysiloxane impression material, Germany, Lot no. 128670) material. Impressions were poured using type IV die stone (Gyprock, Rajkot (Gujarat), India).

Wax patterns were fabricated using casting wax. A round sprue wax (Bilkim Polywax, Duron, Turkey) was shaped as a loop and attached to the center of the occlusal surface of the pontic buccolingually, parallel to the long axis of the tooth to allow tensile testing. Castings were made using Ni-Cr alloy, trimmed and polished.

Castings were cemented using self-adhesive resin cement (Smart cem™2, Dentsply Caulk, USA, Lot no. 1105181). The specimens were then subjected to tensile pull out test using universal testing machine (Llyod LR 50K, FIE, India) after 24h of water storage (**Figure 4**). The force required to dislodge each RBFPD from teeth was recorded. The data were analyzed using one-way ANOVA and Bonferroni test.



Figure 4 : RBFPD Dislodged From The Mounted Specimen

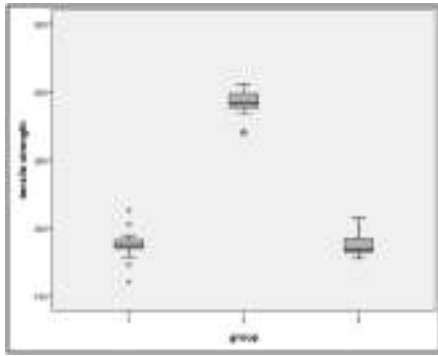


Figure 5 : Box Plot Of Tensile Bond Strength

## Results

Mean values and standard deviations were calculated for each group. The highest mean tensile bond strength was obtained for group 2 (382.30 N) and the lowest was obtained for group 1 (Figure 5). One way Analysis of Variance (ANOVA) was done using Statistical Package for Social Scientist (SPSS) at a level of significance of 0.05 and at a confidence interval of 95%. From the results of the analysis it was found that there was a highly significant difference between the three groups with respect to the mean load ( $F = 512.870, p < 0.01$ ).

In order to find out among which groups there exists a significant difference, multiple comparisons using Bonferroni test was done. (Table I) shows the pair wise comparisons of groups. There was significant difference in the mean load of group 1 when compared with group 2 ( $p < 0.01$ ). However, the difference in mean load between groups 1 and 3 was not statistically significant ( $p > 0.05$ ). There was statistically significant difference between the mean loads of group 2 when compared to both groups 1 and 3 ( $p < 0.01$ ). The difference in mean load between group 3 & group 2 was found to be statistically significant ( $p < 0.01$ ). No statistically significant difference was observed between groups 3 and 1 with respect to the mean load ( $p > 0.05$ ).

## Discussion

Teeth extracted for orthodontic treatment and periodontal treatment were chosen for the study as this would increase the chances of finding tooth with intact clinical crown and root. Human teeth were used for the study in an effort to simulate clinical conditions so that the results would be comparable and applicable in clinical situations.

An RBFDP is subjected to repeated

Table I : Pair-wise Comparisons: Bonferroni Test

(I) Group	(J) Group	Mean Difference (I-j)	P-value	95% CI For Mean Difference	
				Lower Bound	Upper Bound
Group 1	Group 2	-207.007	< 0.001*	-225.597	-188.417
	Group 3	-0.470	1.000	-19.060	18.120
Group 2	Group 1	207.007	< 0.001*	188.417	225.597
	Group 3	206.537	< 0.001*	187.947	225.127
Group 3	Group 1	0.470	1.000	-18.120	19.060
	Group 2	-206.537	< 0.001*	-225.127	-187.947

tension, compression and torquing forces in the mouth. Until now, it has not been possible to simulate these forces in vitro. Although the tensile test does not directly reflect the intraoral dislodging forces, it does estimate the retentive properties of the RBFDPs. Hence, in the present study tensile force test was used as it is a widely accepted estimate for retention of RBFDPs.

In the present study, group 2 showed highest mean tensile bond strength and the difference was statistically significant as compared to the other two groups. The results were consistent with the study done by El-Mowafy O and Rubo MH.<sup>[10]</sup> They concluded that the addition of the slot cavities resulted in an increase in the preparation area, thereby increasing the surface area for bonding. Lankford and Christensen stated that modifications in teeth, such as grooves or slots, were required to provide adequate resistance form.<sup>[16]</sup> Eshelman JR et al stated that an increase in the resistance form can be obtained by incorporation of proximal slots which would interfere with the rotational movement of the prosthesis.<sup>[17]</sup> Crispin BJ from his longitudinal study concluded that the proximal segments act as connectors for the pontic and contribute to the buccolingual bracing of the abutments, while the lingual segments increase the surface area available for bonding and add to dissipation of laterally directed forces.<sup>[18]</sup>

Group 3 showed higher tensile bond strength than group 1 but the difference was not statistically significant. The results were consistent with the study done by Cotert SH and Ozturk B, where after 3 years follow up no significant difference in survival rate was found between the inlay design and the conventional design. They concluded that a layer of enamel should be retained on the pulpal walls and floor to maintain the enamel-resin-metal bond.<sup>[19]</sup> Isidor F and Stockholm R conducted a 4 year longitudinal study that used inlay

preparation on abutments with twenty three RBFDPs reported no failures.<sup>[20]</sup>

Kiremitci A et al also found in their in vitro study that self-adhesive resin cement showed higher bond strength to enamel than dentin.<sup>[21]</sup> In this study group 3 preparation was in dentin so this might be a reason for less bond strength as compared to group 2.

Maximizing the contact area for bonding the retainer to the enamel is one of basic concepts, which can be achieved by extension of the preparation around 1800 of the axial surface.<sup>[22],[23],[24]</sup> As the group 3 preparations lacked this feature, this might be another reason for less retention as compared to group 2.

Visual inspection of the surface of the prostheses (71.33%) after dislodgement from the teeth showed that there were no remnants of the luting agent on their surfaces. This implies an adhesive failure at the interface between the cement and the prosthesis. 26.67% prostheses after dislodgement from the teeth showed that cement was retained on their surfaces, but there were areas free of cements, implying that the mode of failure was a combination of adhesive and cohesive failures. Only 2% of prostheses showed cohesive failure.

Most of the adhesive failures in this study occurred at the metal-cement interface indicating that this was the weakest link in the system. This observation was in agreement with the several clinical studies done by Hansson and Moberg<sup>[25]</sup>, Rammelsberg et al<sup>[26]</sup>, Boening<sup>[27]</sup>, Hansson and Bergstrom.<sup>[28]</sup>

The extrapolation of the results from work of a purely in vitro nature must always be made with caution. In the oral environment, failure of RBFDPs takes place under conditions of repeated compressive and lateral forces of mastication, under the influence of thermal changes, and under changing pH of the salivary fluids, not under a continuous tensile load similar to that used in this study. This study assessed the tensile bond strengths of RBFDPs after 24 h of water storage. It is possible that a longer storage time and/or thermal cycling and cyclic (fatigue) loading would give different results.

Another crucial factor is the ability of an RBFDP to distribute stress under

function. Hence a photoelastic stress analysis study may be useful in this regard.

### Conclusion

Within the limitations of the study, the following conclusions were made:

1. The mean tensile bond strength of modified RBFPDs with proximal slots, occlusal rest seats and lingual wings was significantly higher than that of conventional RBFPDs and modified RBFPDs with class II inlays.
2. Modified RBFPDs with class II inlays had higher mean tensile bond strength than that of conventional RBFPDs, the difference was not statistically significant.
3. The tensile bond strengths were significantly affected by the surface area covered i.e., area available for bonding. Incorporation of slots, 1800 wraparound and occlusal rest seats increase the surface area thereby increasing the retention of the RBFPDs.
4. The positive findings of this study warrant a long term clinical trial of the modified RBFPDs.

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