

## **Cyclic loading of Veneer-Supported Fixed Dental prosthesis versus Conventional Resin bonded Prosthesis for Replacing missing central incisor: An invitro study**

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**Statement of Problem:** Resin bonded fixed dental prosthesis (RBFDP) are not indicated when the mesiodistal width of the missing tooth is needed to be adjusted. A New design of Veneer retained resin bonded dental prosthesis (VRFDP) is suggested to restore and redistribute the space.

**Materials and Methods:** Two 3D models for 8 maxillary anterior teeth and first premolars; with missing tooth number 11, were drawn on AutoCad software to accommodate resin-bonded FDP (RBFDP) and veneer-supported fixed dental prosthesis (VRFDP). the file was exported and 10 epoxy resin models were 3D printed from each type using stereolithography technology. Ten FDP were milled from each STL file. Using high translucency zirconia blanks (Esthetic Explore) and sintered according to the manufacturer's recommendations. Then, the FDP of each type were bonded to their corresponding dies according to the manufacturer's directions. All specimens were subjected to cyclic loading test. Specimens were cyclic loaded till failure. Data were collected, tabulated, and statistically analyzed.

**Results:** Descriptive Statistics showed higher mean values of the VRB group (520.16±117.07) than the RBB group (449.19±163.97). One-Way ANOVA showed no significant difference between tested groups (P= 0.28).

**Conclusions:** VRFDP scored higher cyclic loads mean values than RBFDP. VRFDP could present an acceptable treatment option for treating the missing central incisor situation. More investigations are needed to support or reject this claim.

**Keywords:** Veneer supported Fixed Dental Prosthesis, Resin bonded Fixed Dental Prosthesis, Zirconia, Cyclic Loading, and RBFDP.

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## Introduction

Restoration of a single missing central incisor yet is one of the most esthetic challenging procedures in prosthetic dentistry. (1) RBFDP is considered a conservative alternative to single implant or traditional tooth-retained fixed partial denture, specially in young patients or those with medical contraindications for implant surgery. RBFDP achieve clinical outcomes in longevity in comparison with those of conventional fixed partial dentures. (2-6)

Resin Bonded FDP was first considered as an intermediate restoration, service for a little time before being replaced by a permanent restoration. They were indicated for young patients because of their conservative preparation which poses less danger to the pulp. (7) One of RBFDP drawbacks is that it can't modify the mesiodistal dimensions of the pontic. The pontic comes exactly with the same M-D width of edentulous space. (8) Initially the retainer part was fabricated from metal and the pontic from metal-ceramic. It involved complicated procedures to surface treat the metal to improve its bonding to cement. (9,10)

More recently successive generations of zirconia ceramics took place as esthetic RBFDP (11,12) offering both esthetics and strength. (13) Multi-layer zirconia offers better esthetics and translucency than mono-color zirconia blocks. (14) An innovation of the multi-layer zirconia is the hybrid zirconia blocks, where each layer has different translucency, color saturation, toughness, and flexural strength than the adjacent layer. Moving strength, toughness higher color concentration towards the cervical where they needed the most, and lighter color and more translucency towards incisal. Its considered state of the art among zirconia blocks offering both esthetics and strength. (15)

Ceramic veneers modify the color, shape, position, and width of anterior teeth. They are the treatment of choice for many patients and dentists seeking more conservative and esthetic treatment options. (16,17) They are the cornerstone of what-so-called "Hollywood smile" (18-20) and are requested by nearly all patients even when veneers are contraindicated. Veneers and whitening are the main two topics in the dental advertisement. (21)

A new design was suggested by the authors combining both RBFDP and veneers having facial veneers as retainers. The new design was constructed of fifth-generation hybrid layers of zirconia ceramics and was subjected to cyclic loading testing against traditional RBFDP as control.

The null hypothesis of this study was that there would be no significant statistical difference between both designs when they subjected to cyclic loading till failure.

## Materials and Methods

**Sample grouping:** From the data of a previous study, (22) a power analysis was done to determine the number of specimens that would be required in each test group to determine statistical differences between the groups. Based on this analysis 2 groups (n=10) were tested: Resin Bonded FPDs (RBFDP) and Veneer-Retained FPD (VRFDP)

### **AutoCAD models' creation:**

Two 3D models for anterior segment of maxillary arch from right to left first premolars; with missing tooth number 11, were drawn on AutoCad software (Autodesk, San Francisco, California).

The first model has palatal preparation on teeth 12 and 21 to accommodate resin-bonded bridge. Both teeth received a palatal preparation till the labio-proximal line angle with 0.4 mm finish line and 6 degrees taper. Two grooves were prepared on each tooth at the disto-palatal line angle and one behind the

labio mesial line angle having 1 mm depth and 1mm width. The second model has labial preparation on teeth 12 and 21 to accommodate zirconia veneers. Both teeth had a facial preparation ending to mid-proximal short of opening the contact. Having a 0.4 mm finish line and 6 degrees taper. The design includes 1.5 mm incisal reduction and extend for 2 mm on the palatal surface ending by palatal chamfer.

#### **Models 3D printing:**

STL file was exported and 10 epoxy resin models ((Model resin, FormLabs, Boston, MA, USA)) were 3D printed from each type using Stereolithography technology (MoonRay S, Sprintray, 3577 N Figueroa St, Los Angeles, CA 90065). Models were dried and post-cured (ProCure2, Sprintray, 3577 N Figueroa St, Los Angeles, CA 90065) for 25 Min. The model STL file was exported to Exocad (exocad GmbH, Rosa-Parks-Str. 2, 64295 Darmstadt, Germany) to design a Zirconia Resin Bonded FDP for the first model and Veneer Retained FDP for the second model.

#### **Milling of the FDP:**

The STL was exported to CAM and 10 fixed dental prosthesis were milled from each STL file. Using high translucency zirconia blanks (Esthetic Explore, Shenzhen Upcera Dental Technology CO., Ltd.) and sintered according to the manufacturer's recommendations. Then, the bridges of each type were ultrasonically cleaned and each was assigned to its corresponding abutment.

#### **Bonding Procedures:**

Before cementation, the fitting surface of the veneers and resin-bonded FDPs were treated with airborne particle abrasion using 50  $\mu\text{m}$  Al<sub>2</sub>O<sub>3</sub> at 0.2 MPa pressure (23) and a distance of 1 cm. (24) After that, water steaming followed by ultrasonic cleaning in distilled water for 10 mins.

At that point, all FDPs were cemented using resin cement (RelyX U200; 3M ESPE).

Excess cement was removed by a sickle scaler after initial polymerization. (Fig 1 to 3)



Fig 1: Palatal view of VRFPD



Fig 2: Labial view of VRFPD



Fig 3: Palatal view of RBFDP

#### **Cyclic loading testing:**

All specimens were individually mounted in the lower fixed compartment of a computer-controlled materials testing machine (Model 3345; Instron Instruments Ltd., USA) with a loadcell of 5 kN, and data were recorded using computer software (Bluehill Lite; Instron Instruments).

A typical clinical model with a facio-lingual tooth inclination of a 45-degree angle was chosen for the fabrication of the cyclic test secured to the lower fixed compartment of

computer-controlled materials testing machine.

The samples underwent load cycles between a minimum of 10 N (To prevent lateral dislocation of load applicator and help in stabilizing the specimen during the test) and a maximum of 49 N with a load profile in the form of a sine wave at a frequency of 1 Hz. The rate was used as equivalent to the average masticatory cycle of 0.8–1.0 s. (23) Which considered clinically relevant. Force was applied with a custom-made load applicator [steel rod with a round tip 4.2 mm placed palatally] attached to the upper movable compartment of the machine. Cyclic loading was continued till failure and number of cycles for each sample was recorded using computer software (Bluehill Lite; Instron Instruments).

#### **Statistical Analysis:**

Recorded data were coded and analyzed using descriptive statistics (mean and standard deviation) for quantitative variables. Data were found to be normally distributed according to the Shapiro-Wilk test. Significant differences between groups were determined using the parametric One-Way ANOVA test. Confidence-level in the current study was kept at 95.5%. Therefore, P-values equal to or less than 0.05 were considered statistically significant.

#### **Results**

Load cycles required for veneer-retained fixed dental prosthesis to fail ( $520.16 \pm 117.07$ ) was greater than that required to fail resin-bonded fixed dental prosthesis ( $449.19 \pm 163.97$ ). Although the difference was not statistically significant. All bridges failed by joint fracture. (Fig. 4 & 5)



Fig 4: Fractured VRFDP at the connector



Fig 5: Fractured RBFDP at the connector

#### **1) Shapiro-Wilk test, using a right-tailed normal distribution**

The test was run on both groups to determine the homogeneity of the specimens' results. This decides the statistical analysis implemented.

The results of the test showed homogeneity of specimens in each group. This assumed that the data is normally distributed. In other words, the difference between the data sample and the normal distribution is not big enough to be statistically significant.

#### **2. Descriptive Statistics**

Analysis showed higher mean values of the VRFDP group ( $520.16 \pm 117.07$ ) than the RBFDP group ( $449.19 \pm 163.97$ ). (Figure 6)

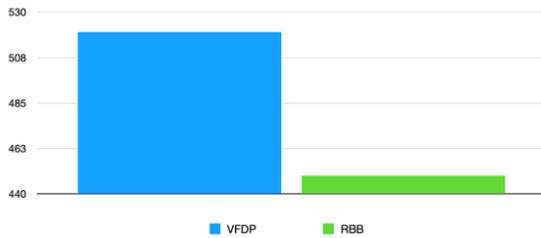


Fig 6: Descriptive statistics

### 3. Analysis of Variance (ANOVA) - One-Way ANOVA: (Table 1)

The test showed no significant difference between tested groups ( $P= 0.28$ )

P value and statistical significance: (Table 1)

	SS	df	MS	F	p
<b>Between:</b>	25,186.543	1	25,186.543	1.241	0.280
<b>Within:</b>	365,320.961	18	20,295.609		
<b>Total:</b>	390,507.504	19			

Table 1: One-Way ANOVA results

The two-tailed P value equals 0.2799. By conventional criteria, this difference is considered to be not statistically significant with a 95% confidence interval.

### Discussion

Advancements in the mechanical and esthetic properties of contemporary ceramics and development in bonding mechanisms, have encouraged dentists to use them in partial-coverage restorations. Educators have the responsibility of training future dentists to able to deliver a professional dental care while producing restorations in high quality and cost-effective manner. There is a continuous debate around partial coverage retainers in fixed dental prostheses (FDP). Some authors recommend it for its ease of preparation and conservative outcome for the tooth. (27) Some do not advise using it for its lower mechanical properties than full coverage. (28)

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 congenitally missing tooth

or a tooth lost to decay, trauma, root fracture, failed root canal treatment, or pathology is, for some patients and dentists, a very aggressive treatment option. (27,28)

Many treatment modalities are available for replacing a single missing tooth; removable partial denture, fixed partial denture or dental implant. 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 mandatory for decision making, therefore there are many factors make single-tooth replacement one of the most challenging restorations in dentistry. (12,28)

The current suggested design was meant to combine both the aesthetic outcome of veneer ceramic restorations and the conservative preparation of partial coverage. it could be considered the opposite of RBFDP as the latter cover the palatal surface of teeth and the current suggestion is to cover the facial surfaces of teeth. It's mainly indicated where the adjacent teeth to the missing tooth need to be esthetically modified. Current suggested designs surpass RBFDP in that they could change the M-D dimensions of missing tooth, and moreover it is considered as conservative preparation.

A possible shortcoming of the design is that; the biting force exert unseating force pushing the dental prosthesis away from the teeth. A point worth mentioning is that the preparation design of VRFDP includes incisal wraparound ending by palatal chamfer. This design provides mechanical retention and maximize the bonded surface area. Theoretically speaking, RBFDP engaging most of the palatal surface will be more resistant to these forces. On the other hand, veneer-retained bridge VRFDP only engages 2 mm of the palatal surface through palatal overlap.

RBFDP was selected as the control because it is an accepted treatment modality for missing central incisors. (29,30) In the current methodology, certain procedural steps were taken to standardize in vitro specimens in order to analyze the results and simulate clinical situations as close as possible to in vivo settings.

The model used in this study was 3D printed to be exactly similar to each other so that standardization is guaranteed. Epoxy resin models having modulus of elasticity similar to that of jaw bones. (24, 26) were selected instead of dental stone to withstand cyclic loading and not fail during testing. On the other hand, natural extracted teeth could not be used because they cannot be standardized.

The resin surface could be treated to promote good adhesion with the RBFDPs. Those surface treatments include etching with 40% phosphoric acid (22) or sandblasting. (24) In the current study, sand blasting with 50 microns aluminum oxide particles was used. Moreover, resin abutments have been used to standardize the specimen's dimensions and the condition of the substrate where the prostheses were bonded. (26,27)

Zirconia was selected over lithium disilicate as the latter requires more connector thickness incisio-cervically which hinders esthetics and may block the papillary area. On top of that, the survival rate of lithium disilicate FDP is questionable. Zirconia explores esthetic blocks that were selected as they represent state-of-the-art multilayer technology. The color, translucency, toughness, and strength change from cervical to incisal. Giving more strength and toughness cervical and more translucency and lighter color incisal.

Nevertheless, that zirconia ceramic does not contain glass phase, it can achieve a reliable bond with a special protocol including sandblasting and 10-

Methacryloyloxydecyl dihydrogen phosphate (MDP monomer) contained in the adhesive resin. (30,31)

Self-adhesive resin cement was used as it contain fewer steps with less human variables to facilitate standardization of the bonding step. (28,30) Cyclic loading was within the physiologic occlusal forces for adults in the anterior region which is in a range of 10 and 49 N. (25,26) Load cycles were kept continuous to prevent lateral dislocation of load applicator and help in stabilizing the specimen during the test.

Results showed a bit higher mean values of the suggested design over the traditional RBFDP. Both designs exhibited catastrophic fractures starting at connectors. At this area maximum shear force was generated. The design of VRFDP allowed for a wider labio-palatal dimension of the connectors, which explains the more load cycle required to fracture the joint in comparison to RBB.

The samples of this in-vitro study was lacking the cushioning effect of periodontal membrane and this may explain the fracture of the bridges after relatively few numbers of load cycles.

One-way ANOVA revealed no significant difference between the tested groups. This could suggest the new design could be an amiable treatment option for missing central incisor situations. More dedicated research is needed to authors support or rejects this claim.

The null hypothesis suggested was accepted as no statistical difference in fatigue resistance under cyclic loading was found between the tested groups.

### Conclusion

Within the limitation of the current study, the following conclusions could be suggested:

1) The fatigue resistance under cyclic loading of VRFDP was comparable to that of RBFDP.

2) VRFDP could be considered as an acceptable treatment option for treating missing central incisor situation.

### Recommendations

More investigations are needed to support or reject this claim.

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