Original Study

EVALUATION OF BOND STRENGTH ON SURFACE TREATED DENTURE TEETH TO INJECTION MOLDED PMMA DENTURE BASE

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ABSTRACT

This study aimed at comparing the shear bond strength between high-impact injection-molded denture base and ridge lap surface-treated PMMA teeth. A total of 51 samples were scribed with a black line 1mm above the ridge lap area. Samples were grouped into Group A as the control group, Group B sandblasted ridge lap samples, and Group C with diatoric cavity ridge lap samples. Then, the samples were placed in a mold of dimension 7.5×7.5mm. The wax patterns were processed through injection molding and the retrieved samples were subjected to shear bond strength assessment in a Universal testing machine.

The mean shear bond strength of Groups A, B, and C was 991.29, 1038.71, & 1187.41, respectively with a p-value of 0.010. A statistically significant difference was observed between Group C and Group A (P>0.05). The obtained values were analyzed statistically with post hoc and one-way ANOVA tests using SPSS statistical software 17. This study concluded that the samples of Group C exhibited higher shear bond strength because the surface area of the ridge lap portion increases with diatoric cavity preparation.

Keywords: Diatoric cavity, Injection molding technique, High impact resin, Ridge lap surface, Sandblasting.

Introduction

Acrylic and porcelain tooth are the two commonly available materials to rehabilitate edentulism. But acrylic resin teeth are generally preferred to porcelain teeth as a functional unit with acrylic resin denture base as they are bonded by chemical attachment resulting in an overall stronger one unit denture [1].

The failure rate of acrylic resin dentures due to fractures is excessively high [2] and the most prevalent type of failure encountered is the teeth fracture or debonding [3]. The most prevalent type of denture failure occurs between an acrylic resin denture base and acrylic resin tooth, with a prevalence of about 33% [4, 5]. According to studies, 26-33% of denture repairs were due to debonded teeth, commonly leading to cost and distress for patients [6-8]. This detachment is probably due to the lower ridge lap surface area available for bonding and the direction of the stresses that occur during the functions. The bond failure between denture base denture and teeth was mostly cohesive or adhesive [9-12]. An adhesive failure occurred when no trace of denture base material was observed on the ridge laps of the teeth after a fracture. Besides, when there were remnants of the denture base material on the ridge lap of the teeth after fracture bond, the failure was considered cohesion failure [9]. The adhesive failure may be affected by changes in bond interfaces due to laboratory errors the type of resin base material used, the presence of impurities on the tooth surface in close contact with the denture base, and its chemical and physical characteristics, [13-16].

Studies report that surface modification on the ridge lap portion of the acrylic tooth will drastically enhance the bonding nature of the tooth. And many studies had been advocated different surface modifications of the tooth. On the other hand, the type of polymerization technique plays an unavoidable role in the strength of polymers. Various studies reports that the injection molding polymerization technique seems to be more advantageous than conventional and microwave polymerization techniques in terms of dimensional stability, accuracy, and strength. But then, no studies had been employed to measure the bond strength of surface modified acrylic teeth polymerized under injection molding technique.

Material and Methods

A total of 51 polymethyl methacrylate (PMMA) maxillary right central incisor (SR IVOSTAR Small-bold 41of Ivoclorvivadent, USA) with measurement of 9.6mm inciso cervically and 7.7mm mesiodistally were selected. A black line was scribed around the cervical area, 1mm above the

bottom of the tooth (ridge lap area) using a vernier caliper. Then the samples were grouped as,
Group A – 17 samples - No surface treatment (Control)
Group B – 17 samples – Sandblasting on the ridge lap surface
Group C – 17 samples – Diatoric cavity on the ridge lap surface

Surface Treatment
The samples of Group A acts as control which will not have any surface treatment over the ridge lap surface. A putty index (Aquasil soft putty, Dentsply, India) of 3×3cm was made to held the tooth in position while doing surface treatment for Group B and C samples. The ridge lap area of Group B samples was treated with 50 µm aluminum oxide particles (Aluminox, Delta, Chennai, India) at a pressure of 4psi which was kept at a distance of 1 cm for 10 seconds. Group C samples were modified with a diatoric cavity (2.3 mm diameter x2 mm deep) by using round bur no:8 (Midwest, Dentsply, India) at a speed of about 40,000 rpm in a milling machine (Amann Girrbachaf 350, Austria) **(Figure 1)**. To maintain the standardization of procedure, a total of 11 samples were surface treated by a single observer in a day.

Figure 1. Surface treated samples of Group A, B, and C

Mold Preparation
A square metal mold containing 8 slots of diameter 7.5mm, height 7.5mm with a flat base was constructed for the fabrication of specimens **(Figure 2)**.

Figure 2. PMMA tooth attached to the mold

Specimen preparation
The mold was filled with modeling wax (Hindustan modeling wax No:2, India) up to the height of mold, on which the PMMA teeth (control and surface treated) were immersed up to the scribed cervical line, which forms 45° angulation with the flat base of wax. The obtained wax patterns of samples were packed in a single flask (Ivoclar BPS processing flask, USA) using type 2 dental stone (Gyprok, Australia). To standardize the procedure, single flasks were used to fabricate about 8 specimens in a day in the presence of one observer. All 8 specimens in each flask were interconnected with wax rolls through which the polymer material was injected. Then, the counterpart was assembled.

Dewaxing was done by immersing the flask in a water bath at100 °C for about 10 mins. The flask was then retrieved and cleaned to remove any excess residual wax. A coat of separating medium (Separating fluid, Ivoclar Vivadent, USA) was applied all over the mold. The two parts of the flask were assembled back. Heat cure acrylic resin (SR Ivocap, Ivoclar Vivadent, USA) available in pre-measured capsules were selected for the acrylization. The monomer and polymer capsules were mixed in a vibrator (Cap vibrator, Ivoclar Vivadent, USA) was attached to the flask unit.

The assembly was fixed to a polymerizing machine through which the resin material enters the mold cavity with the help of 6pa pressure. Later the assembly was immersed into a hot water bath which rises from 37°C to 100°C in about 45 mins for the polymerization to occur. The flask was retrieved and kept for bench cooling for about 30 mins. Then the samples were retrieved from the mold, followed by finishing and polishing done by using abrasive & polishing agents **(Figure 3)**.To prevent any distortion, distilled water was used to store the fabricated samples at room temperature until testings were done.

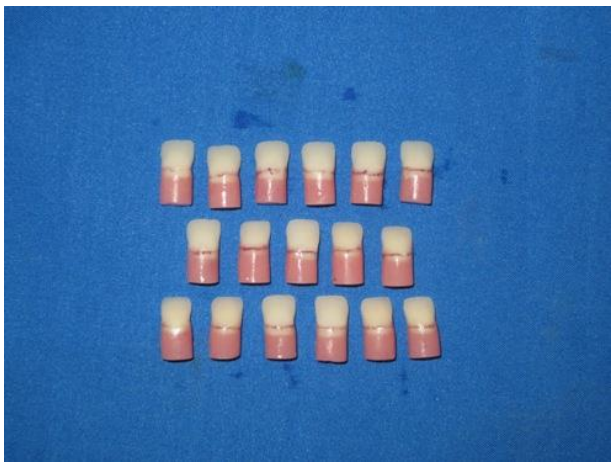

Figure 3. Processed and finished samples

Measuring shear bond strength

The samples are then loaded in a Universal testing machine (Autograph- Shimadzu, Japan) to assess the strength of the shear bond. The acrylic cylindrical parts of the specimen were fixed to the UTM machine at an angulation of 45°. The load was applied using a cylindrical pin on the incisal part from the lingual aspect with 0.5 mm/min cross-head speed. The load was applied until the tooth fractures and the digital values of bond strength were recorded. The obtained values were presented by inNewton's (N). Since due to the irregular morphology and complexity of teeth ridge lap surface, the available surface area was not calculated. Hence, the measured failure load inNewton's was reformed into Kgf.

The following formula was used to calculate the bond strength

$$B = F/A \quad (1)$$

Where, A – surface area (mm^2)
F – Load at fracture (N)
B – Bond strength (MPa)

The results obtained in Megapascals (MPa) were analyzed statistically using post hoc test and one-way ANOVA with SPSS v.17.

Result and Discussion

The significant differences in the strength of shear bonding between acrylic resin and surface treated and untreated PMMAteeth were evaluated. The bond strength of all groups measured in the Universal testing machine was analyzed statistically using post hoc test and one-way ANOVA.

Table 1 describes the Mean and SD of shear bond strength of surface treated and untreated PMMA teeth with acrylic denture base. The mean shear bond strength of Groups A, B, and C was 101.03±17.2, 105.88±24.5, and 121.07±13.8 Kgf, respectively with a p-value of 0.010. The mean shear bond strength was in a clinically acceptable range. Statistically, a significant difference was observed between Groups C & B, as well as Groups C & A.

Table 1. Mean and SD of shear bond strength of Group A, B, and C

Groups	N	Mean	SD	Std. Error	95% CI		Minimum	Maximum
					Lower range	Upper range		
A	17	101.035	17.219	4.176	92.182	109.888	66.500	132.800
B	17	105.882	24.587	5.963	93.241	118.524	57.100	148.400
C	17	121.071	13.854	3.360	113.947	128.194	100.700	146.700

As shown in **Table 2**, Group C had a significantly higher value of about 121.071 Kgf than Groups A & B, which were 101.035 & 105.882kgf, respectively.

Table 2. Oneway ANOVA for Groups A, B, & C

Source of variations	Sum of Squares	df	Mean square	F value	P-value
Between Groups	3715.007	2	1857.504	5.099	0.0098
Within groups	17487.379	48	364.320		
Total	21202.386	50			

In **Table 3** the Post Hottest indicating a significant difference between the Group C and Group A samples having the mean difference of 20.035 with a 0.01 p-value. Whereas Group B samples do not show much difference when compared with Group A and Group C

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Table 3. Intergroup Comparison of shear bond strength of Groups A, B, & C using POST HOC test(Bonferroni Test)

Group	Comparison	Mean difference	Std Error	P-value	Interpretation
A	B	-4.847	0.740	p>0.05	NS
	C	-20.035	3.060	P<0.05	S
B	A	4.847	0.740	p>0.05	NS
	C	-15.188	2.320	p>0.05	NS
C	A	20.035	3.060	P<0.05	S
	B	15.188	2.320	p>0.05	NS

Figure 4 shows the mean and SD of all three groups of the study by plotting the measured values on the Y-axis and Groups on the X-axis. The mean bond strength of Group C exhibits a higher range of 121.07±13.8 Kgf followed by Group B and Group A, which were 105.88±24.5 Kgf, 101.03±17.2 Kgf, respectively.

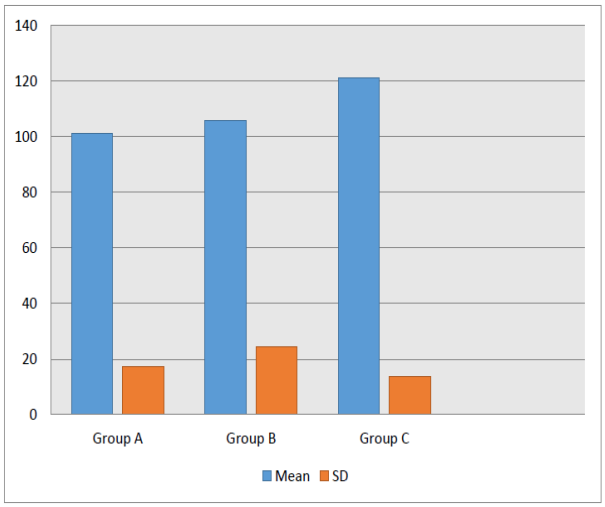

Figure 4. Graphical representation of Mean & Standard deviation of Group A, B, and C

Acrylic resin teeth are mainly made of Polymethylmethacrylate and had been significantly mutated to enhance their basic properties by incorporating different monomer units, cross-link agents, and fillers [17]. Cross-linking agents usually improves the physical strength and makes prosthesis resistant to crazing. On the other hand, cross-linking agents prevent the monomer diffusion onto the surface area [18, 19]. Hence the ridge lap surface of the acrylic teeth is made in such a way that it is minimally cross-linked, to enhance better bonding with acrylic denture base resin [20]. Among the available denture processing techniques, the injection molding technique gained interest because of the indemnity of polymerization shrinkage by continuous injection of acrylic resin through pressure [21]. Thus injection molding polymerization technique was considered to be the more meticulous method than the conventional compression molding technique as far as acrylic resins are considered [9].

The failure percentage of acrylic dentures because of fracture is very high [22], and also the maximum commonplace type of failure that occurred was due to fracture or debonding of the teeth [23]. But, there has been little or no disclosure about bond strength of acrylic teeth and acrylic denture base resin through manufacturer also studies comparing the shear bond strength of PMMA teeth attached to an injection-molded denture base material. Many kinds of literature had proved that the wax residues or any contaminants on the ridge lap surface of the acrylic teeth would reduce the bonding capacity in the interface between the denture and tooth [24-26]. And it had been taken into consideration while preparing the samples. All the samples were cleaned thoroughly to make sure there were no residues over the ridge lap surface. This helped in enhancing the bonding nature between acrylic tooth and denture base resin. In this present study, the shear bond strength of Group C samples was in accordance with Cardash et al. [27], where they assessed acrylic teeth bond strength modified with and without mechanical retentive grooves and polymerized using high impact and standard denture base resin. In that study, the mechanical retentive grooves were placed horizontally vertically over the ridge lap surface. They accredited that increasing the surface area for physical and chemical bonding will enhance the bond strength of denture base resin and acrylic teeth. Also, many other studies had proven that mechanical modifications of the ridge lap portion of the acrylic teeth would significantly modify the bonding capacity of the teeth [28-31].

A study conducted by Kawara [9] who used a scanning electron microscope to assess the surface texture of modified acrylic teeth had found that acrylic resin teeth with rough inner surfaces had the worst bond strength values [9, 32]. The present study contradicts this result as the bonding nature of acrylic teeth was well improved with the surface treatment [33-35]. Many studies have conceded significant improvement in bond strength after sandblasting using alumina of about 250μ, signifying that this is due to improved micromechanical retention [36-38]. In this study, identical enhancement in shear bond strength was achieved for Group B samples by sandblasting with 50μ of alumina, which could be due to increased available surface area for bonding.

There are various results regarding the effect of different surface treatments on the strength of the shear bond, which

may be due to various bond-testing methods, measuring instruments, and experimental designs in the studies. There were some limitations of the study, which includes only the mechanical modifications in the ridge lap portion of acrylic teeth. Application of chemical surface treatments and a combination of mechanical & chemical surface treatments may influence the outcome of the study. The further scope of the study may include a combination of mechanical and chemical modifications in the ridge lap portion of different strands of acrylic teeth with denture base resin material that mimics the intraoral environment will be performed.

Conclusion

Preparing a diatoric cavity on the ridge lap portion of denture teeth increases the surface area and thereby increases the bonding strength between the acrylic tooth and denture base made by an injection molding technique.

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Conflict of interest: None

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Ethics statement: The study was approved and completed as per the research protocol approved by the Institutional Review Board with the approval number SRMDC/IRB/2015/MDS/No.208,

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