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Evaluating bond strength of acrylic teeth to conventional and high impact denture base resin incorporating various groove designs

Shireen R Kumar
Consultant Prosthodontist, Chandigarh

Sanjeev Mittal
Professor, Department of Prosthodontics, M.M. College of Dental Sciences and Research, Mullana, Ambala
Email: ambaladental@yahoo.com

Sandeep Kalra
Reader, Department of Prosthodontics, M. M. College of Dental Sciences and Research, Mullana, Ambala

Vishwas Kharsan
Professor Department of Prosthodontics, Nair Hospital Dental College, Mumbai, Maharashtra

Gazal Soni
Senior Lecturer, Maharishi Markendeshwar College of Dental Sciences and Research, Mullana, Ambala

Deepti Garg
Senior Lecturer, Maharishi Markendeshwar College of Dental Sciences and Research, Mullana, Ambala.

***Abstract*---**Purpose: In spite of chemical union between acrylic resin teeth and acrylic denture base material, detachment of teeth particularly anterior teeth is a frequent observation. The purpose of this study was to evaluate shear bond strength between denture base resin and acrylic resin denture teeth after incorporating various grooves on the ridge lap area. Materials & Methods: A total of 60 samples were prepared and divided into two groups with 30 samples each. Sample in group I were processed with conventional resin whereas in group II with high impact resin. The teeth in each group were subjected to no treatment, vertical groove & Horizontal retentive goove placement on the ridge lap area. In each group unmodified teeth

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***Corresponding author**: Mittal, S.; Email: ambaladental@yahoo.com*
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served as control. A shear force was applied at an angle of 130 degrees to the lingual surface of teeth using instron universal testing machine until fracture occurred. Data obtained was statistically analysed using Post hoc and Mann-Whitney Test. Results: Unmodified resin teeth showed the least bond strength. Modification of teeth with vertical and horizontal groove significantly improves the bond strength with denture resin. A significantly greater force was required to fracture teeth from high impact resin and with vertical groove. Conclusion: Use of high impact denture resin, incorporating vertical retention grooves in ridge lap area of resin teeth improves the shear bond strength.

***Keywords*---**retention grooves, high impact resin, surface treatment, bond strength.

Introduction

In the prosthesis of today, acrylic teeth introduced in 1940, are bonded to a suitable denture base resin. Inspite of the benefits obtained with this combination, there have been frequent reports of debonded teeth. Several reasons may be put forward to explain the causes of debonding such as: Contamination of the joining surfaces, difference in structures of the two components, weak mechanical union between the teeth and the denture base, excessive stress, insufficient heat polymerization, defective proportion of materials.[1] Further investigations have revealed that between 22-30% of denture repairs involve tooth debonding usually in maxillary incisors and canines region of the denture. This detachment may be attributed to a lesser ridge lap surface area available for bonding and the direction of stresses encountered during function. The most probable reason for ultimate failure is crack propagation from areas of high stress concentration. Attempts to improve bond strength have involved chemical treatment or mechanical modification of the ridge lap surface. Conflicting results with the use of different types of denture base resins, use of monomer, removal of tooth glaze, placement of diatorics or incorporation of various groove designs have been reported.

Morrow et al[2] reported that shear bond strength of high impact resin to plastic teeth was not significantly greater than that of the conventional resin. On the contrary Cardash et al[3] reported better performance of high impact with respect to bond strength with acrylic teeth. Spratley[4] concluded that painting the ridge laps of teeth with monomer or grinding the ridge laps did not seem to significantly change the bond strength. Cardash et al[3,5] found both decrease and increase in bond strength with mechanical modification of ridge lap. Whether the use of high impact resin and tooth grooves improves bonding of teeth to denture base resins requires further investigation. It is in the light of this background that the present study attempted to evaluate the bond strength of acrylic teeth to conventional and high impact denture base resins incorporating various groove designs.

Materials and Method

The present study was conducted in the department of Prosthodontics, M. M. College Of Dental Sciences and Research, Mullana, Ambala. The study was designed to investigate the influence of denture base resin and incorporating mechanical retention groove in acrylic teeth on the strength of the tooth - denture base bond. Two different denture base resin materials viz. conventional (Trevalon-Dentsply, India) and high impact denture base resin (Trevalon Hi-Dentsply, India) and 60 sets of six anterior maxillary teeth of the mold S2-23 acrylic teeth (Ashoosons, India) were used in the study.

Custom made equipments were fabricated for the investigation. A three piece aluminium mold was specially cast for obtaining uniform denture bases with six anterior maxillary teeth for all the samples. Platform with metal cast and clamp was specially designed to meet the needs of the testing machine. Metal rod with a tip of 1mm diameter was designed in order to apply a point force in the universal testisng machine.

"Sample standardization"
60 samples were prepared. They were divided into
Group I: Consisting of 30 samples prepared from conventional heat cure resin.
Group II: Consisting of 30 samples prepared from high impact denture base resin.
Each group was divided into three Sub-Groups with 10 samples each according to different surface alteration of teeth.
Subgroup A, A' ------- No surface alteration (Control group)
Subgroup B, B' -------- Horizontal groove
Subgroup C, C' -------- Vertical groove

Groove preparation

Horizontal groove: In right central incisors single horizontal grooves prepared bisecting the ridge lap surface from mesial to distal using straight fissure bur and straight hand piece. The bur had fully penetrated to get grooves of uniform dimensions of 2mm in depth, 2mm width and 4mm long.
Vertical groove : Single vertical grooves prepared bisecting the ridge lap surface of right central incisor from lingual to buccal. The preparation with straight fissure bur continued till the bur had fully penetrated to get grooves of dimensions 2mm in depth and width.

The waxed dentures for all the six subgroups were made similarly. The six anterior teeth were placed in the custom fabricated mold and molten wax was poured into it. It was then waxed up onto the cast. Thirty waxed up dentures in the group were processed using conventional heat cure acrylic and thirty using high impact denture base resin. The samples retrieved were thoroughly finished and polished.

Fig.1 (a) Tooth without groove, (b) Tooth with horizontal groove, (c) Tooth with vertical groove

Bond strength measurement

Each sample was mounted on the custom made platform and placed on the Universal Testing Machine. A point force was applied with the help of custom designed metal rod at an angle of 130 degrees to the long axis of the tooth until fracture occurred (Fig.2,3)**.** The UTM cross head speed was maintained at 5mm/min. The fracture load was measured in Newton. The readings were evaluated and subjected to statistical analysis.

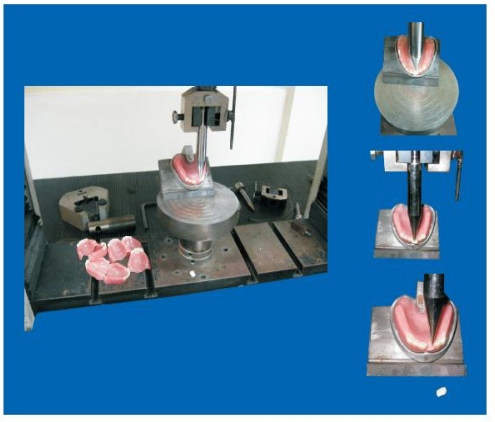

Fig.2

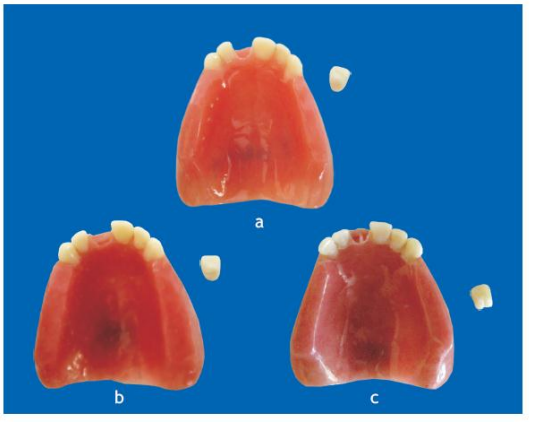

Fig.3

Fig.2 Universal Testing Machine and stepwise debonding procedure
Fig.3 Debonding in (a) no groove tooth, (b) horizontal groove tooth, (c) vertical groove tooth

Results

On the basis of the data it was inferred that the mean debonding force for control, vertical groove and horizontal groove subgroups was higher in high impact denture base resin as compared in conventional heat cure resin.(Table 1) Surface modification of ridge lap area of teeth increase the bond strength with Vertical groove teeth show higher bond strength than horizontal groove teeths.

Post Hoc Test compared the performance of the subgroups within a group. Modification of teeth surface with horizontal and vertical groove significantly (P< 0.001) improve the bond strength with both the denture base resin. However, there was statistically insignificant difference in bond strength between vertical groove and horizontzal groove teeth (Table 2).

Statistical comparison of group I & II with respect to their subgroups with Mann-Whitney Test shows that difference between conventional resin and high impact resin subgroups is significant only with vertical groove teeth (C vs C') (Table 3).

Table 1 Group wise descriptive statistics

Groups	Subgroups	N	Mean (Newton)	SD	SE
	A	10	404.64	80.31	25.39
I	B	10	696.42	164.54	52.03
	C	10	711.16	143.52	45.38
	A'	10	511.89	136.05	43.02
II	B'	10	862.80	158.68	50.17
	C'	10	1008.14	156.46	49.47

N - Number of samples, SD – Standard Deviation, SE – Standard error.

Table 2 Multiple comparisons of subgroups in both the groups by Post Hoc Tests

Group	(I) Subgroup	(J) Subgroup	Mean Difference (I-J)	p-value	95% Confidence Interval	
					Lower Bound	Upper Bound
I	A	B	-291.78000(*)	<.001**	-445.1056	-138.4544
	A	C	-306.52000(*)	<.001**	-459.8456	-153.1944
	B	C	-14.74000	1.000	-168.0656	138.5856
II	A'	B'	-350.91000(*)	<.001**	-522.9806	-178.8394
	A'	C'	- 496.25000(*)	<.001**	-668.3206	-324.1794
	B'	C'	-145.34000	.120	-317.4106	26.7306

Table 3 Statistical comparison of group I & II with respect to their subgroups by NPar Tests - Mann-Whitney Test

SUBGROUP	OBSERVATIONS	
A vs A'	Mann-Whitney U	26.000
	Wilcoxon W	81.000
	Z	1.814
	P-Value	.070
	Exact Sig.	.075(a)
B vs B'	Mann-Whitney U	25.000
	Wilcoxon W	80.000
	Z	1.890

	P-Value	.059
	Exact Sig.	.063(a)
	Mann-Whitney U	10.000
	Wilcoxon W	65.000
C vs C'	Z	3.024
	P-Value	.002**
	Exact Sig.	.002(a)

Discussion

In this era of polymers just as there has been no replacement for acrylic denture bases, so have acrylic teeth become indispensible. The problem with this combination, which has most frequently been the major complaint of artificial denture wearers, is the debonding of the tooth from the denture base. A number of possible causes have been suggested for this most prevalent problem. Schoonover et al[6] was probably one of the earliest to examine the bonding of plastic teeth to heat cured denture base resins. In another study made by Anderson JN[7] the strength of the joint between plain co-polymer teeth and denture base resin was examined. An investigation of the stress analysis in the dentures by Darbar et al[8] found that the maximum stress concentration (magnitude 74-90 MPa) in dentures occurred at the beginning of palatal aspect of tooth-denture base interface. Morrow et al[2] and Schoonover et al[6] who investigated the effect of tin foil substitute contamination and reported decrease in bond strength. Yadav et al[9] concluded that conventionally cured specimens possess statistically higher bond strength than microwave cured specimens. Takahashi *et al*,[10] concluded that conventional resin teeth possessed higher bond strength than cross-linked denture teeth.

The present study was planned using an experimental model that simulated the intra oral situation as closely as possible. The forces applied to maxillary denture teeth matched clinical situation and a shear compressive force was applied to the lingual surface of teeth at an angle of 130 degrees to the long axis. The angle was chosen to simulate the average angle of contact found in a class I occlusion between maxillary and mandibular anterior teeth.

Huggett et al[11] suggested that the quality of denture base material may contribute to the bond strength of the tooth to the denture base. Consequently researchers tested a variety of acrylic denture base resin modifications in order to determine the resin giving a better bond strength. It was observed in the present study that the force required to cause fracture was more in high impact denture base resin than in conventional resin. Morrow et al[2] while investigating bond strength of acrylic teeth to conventional and high impact denture base resins also made similar observations and reported that the mean bond strength of teeth bonded to high impact denture base resin was 11% higher that the bond to conventional resin. The results o btained during the present study were supported by the findings of Huggett et al,[11] Fletcher et al,[12] Dandiwal et al[13] and Krishna et al [14] who on the basis of their investigations concluded that the high impact heat cured denture bases gave a better bond than autopolymerizing or non high impact heat cured denture bases resin.

Cardash et al[5] made a similar observation while studying effect of retention grooves in combination with different types of denture bases on the tooth-denture base bond. They reported a statistically significant better performance when high impact resin was used in comparison with the standard resin. Other previous studies such as those of Cunningham and Benington[15] who investigated variables that might affect the bond also corroborated the findings of the present study that a significantly stronger bond was obtained in all cases when a high impact denture base resin was used.

Investigations on modifications, manipulations, alterations and types of denture base resins and acrylic teeth on the tooth denture base bond progressed side by side. On one hand researchers were investigating influence of denture base material while on the other ridge lap area modifications of the tooth on the bond strength of teeth to denture base were being investigated.

Fletcher et al[11] found that mechanical preparation of the tooth bonding surface enhanced the tooth-base bond significantly. Contrarily Cardash et al[3] who investigated effect of cutting retention grooves in the tooth ridge lap area reported that no statistically significant advantage was derived by preparing retention grooves of different shapes in the ridge lap surface of acrylic teeth. They themselves refuted their findings in a subsequent study (Cardash et al),[5] and reported that the bond strength of teeth modified by retention grooves was significantly higher ($p<0.01$) when compared to unprepared teeth.

During the course of the present study it was found that the bond strength of teeth with vertical grooves was higher, when compared to teeth with horizontal groove for conventional and high impact denture base resins. This could be explained by the fact that the vertical groove was closer to the point of application of the force, and shorter lever arm as in the case of vertical groove require greater force to separate the tooth from the denture base.

Different mechanical retention designs in the form of a diatoric or grooves placed on the ridge lap were shown to increase the strength of the tooth-denture bond as reported by Vallittu PK,[16] Mahadevan et al [17] and Darbar UR et al.[8] This was in accordance with the results obtained during the present study. The combined results of the present study on the type of denture base resin material and groove designs in maxillary anterior tooth conclusively suggested that the combination of high impact denture base resin with a single vertical groove cut on the ridge lap surface of tooth was significantly better than horizontal groove or no groove.

We have used only one type of denture tooth material, the interaction between denture teeth material and various denture base resin need to be evaluated further. It is well-accepted that in vivo performance does differ from an invitro setting. This invitro study design did not consider the effects of aging, saliva, thermocycling and cyclic loading of the test specimens. Future experiments designed and performed to investigate the effects of the internal strengths of both the acrylic tooth and denture base material on the mechanism of debonding with or without surface modifications, simulating in vivo conditions are recommended to enhance the results obtained in the present study.

Clinical implication- it was inferred from the study that the use of high impact denture base resin along with incorporation of vertical grooves on the ridge lap surface of teeth required a much higher force for debonding. This can be incorporated in our day to day clinical practice to help reduce the failures due to debonding and provide a longer life to the patients restoration.

Conclusion

It could be concluded that:

1. Vertical & horizontal groove placement in resin teeth improves the bond strength with denture base resin. However, vertical groove provide more bond strength than horizontal groove.
2. Higher debonding force was required in high impact denture base resin as compared to conventional heat cure resin.

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