Original Article

Comparative evaluation of different mechanical modifications of denture teeth on bond strength between high-impact acrylic resin and denture teeth: An *in vitro* study

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Abstract

Aim and Objective: Acrylic teeth separates from the denture base and remains a major worry in day-to-day routine dental procedure. The present study was conducted to comparatively evaluate different mechanical modifications of acrylic teeth on bond strength between Lucitone 199 heat cure resin and cross-linked teeth. **Materials and Methods:** The test specimens, central incisors (21) were demarcated into four groups. Group 1 was the control group, whereas Group 2, Group 3, and Group 4 were experimental groups modified with round groove, vertical groove, and T-shaped groove, respectively. The preparation of masterpiece was done by aligning the long axis of the central incisor teeth at 45° to the base of a wax block (8 mm × 10 mm × 30 mm), with ridge lap surface contacting the base. These test specimen (21) was prepared by Lucitone 199 heat cure resin. Evaluation of bond strength of all the specimens was done using universal tester (materials testing machine). Shapiro–Wilk Test, one-way analysis of variance (ANOVA), and Bonferroni test were done to do statistical investigation. **Results:** Group 1 specimens prepared by Lucitone 199 heat cure resin showed the lowest bond strength and Group 4 specimens prepared with T-shaped groove packed with Lucitone 199 exhibited the highest bond strength. **Conclusion:** The bond strength between Lucitone 199 heat cure resin and cross-linked teeth was increased when mechanical modifications was done on denture teeth. The specimens prepared with T-shaped groove packed with Lucitone 199 heat cure resin showed the highest bond strength followed by Group 3, Group 2, and lastly Group 1 prepared by Lucitone 199 heat cure resin.

Key words: *Bond strength, round groove, T-shaped groove, vertical groove*

Access this article online	
Quick Response Code:	Website: www.jispcd.org
	DOI: 10.4103/2231-0762.178740

How to cite this article: Phukela SS, Chintalapudi SK, Sachdeva H, Dhall RS, Sharma N, Prabhu A. Comparative evaluation of different mechanical modifications of denture teeth on bond strength between high-impact acrylic resin and denture teeth: An *in vitro* study. J Int Soc Prevent Communit Dent 2016;6:161-6.

INTRODUCTION

Adhesive bond failure between acrylic teeth and resin material is the most routine type of failure in dental practice.[1,2] Appropriate bonding of acrylic teeth to denture base resin is essential as it increases strength since the teeth becomes an intrinsic part of the prosthesis. The bond strength between acrylic teeth and denture base is multifaceted including mechanical and chemical methods for enhancing the bond between teeth and resin material. Many researchers have over the years tried to improve the bond strength by altering the ridge lap area mechanically. Cardash *et al*. (1986)[3] reported that the there is no advantage of vertical retention grooves prepared in the ridge lap area of cross-linked teeth. However, Cardash *et al*. (1990)[4] contradictated his earlier statement and proved that vertical retention grooves made on cross linked teeth increased bond strength between cross-linked teeth and denture base material.The teeth were divided into three groups: Group A—no tooth preparation, Group B—a mesiodistal groove was prepared in the ridge lap area of the tooth, and Group C—a vertical groove of the same dimensions was prepared at the center of the ridge lap extending halfway up the lingual surface of the tooth. A shear force was applied at an angle of 130° to the lingual surface of the cross-linked teeth until failure occurred. The vertical retention grooves prepared in the ridge lap area of the teeth proved to be beneficial and modified retention to the resin material but there was no benefit of placement of the horizontal grooves. The results of various studies have been mixed and conflicting.The advantage of mechanical modifications of cross-linked teeth for bond strength between high-impact denture base material and cross-linked teeth is unclear. Hence, an attempt has been made to evaluate and compare the bond strength of cross-linked teeth bonded to high-impact denture base material by providing different mechanical modifications of denture teeth.

Aims and objectives

- To evaluate bond strength between heat cure resin material and cross-linked teeth without modification
- To evaluate bond strength between heat cure resin material and cross-linked teeth modified with round groove, vertical groove, and T-shaped groove
- Comparative evaluation of different mechanical modifications done on cross-linked teeth for bond strength between high-impact acrylic material and cross-linked teeth.

MATERIALS AND METHODS

A total number of 80 cross-linked maxillary left central incisors (21) (Acryloc), of the same mold with regard to size and shape were selected to be bonded to Lucitone199 resin material. The sample size was calculated using the results of the previous studies by Takahashi, Chai, Takahashi, and Habu.[5] The sample size was calculated to be 20 per group keeping a confidence interval of 95% and a power of atleast 80%. The test specimens' central incisors (21) were divided into four groups.

- Group 1 (control): Denture teeth without any mechanical modification were used as supplied by the manufacturer
- Group 2: A round groove 2 mm in diameter was prepared on the ridge lap surfaces of the croos-linked teeth with round bur
- Group 3: A vertical groove 2-mm deep and 2-mm wide was prepared into the ridge lap area of the teeth with a straight fissure bur
- Group 4: A T-shaped groove 2-mm deep and 2-mm wide was prepared with a straight fissure bur, bisecting the ridge lap surface of the cross-linked teeth.

The preparation of the masterpiece was done by aligning the long axis of the central incisor teeth at 45° to the base of a wax block (8 mm × 10 mm × 30 mm), with ridge lap contacting the base.[5] These test specimens (21) were prepared by Lucitone 199. Silicone mold was prepared with the help of the master specimen. This mold was used for standardizing the angulation of acrylic tooth with the base of all test specimens. The base of the test specimen was created by placement of acrylic teeth (with and without modification) into the silicone mold, into which molten wax was flown. A total of 80 identical wax models were obtained in this study. These test specimens (wax models) were prepared by the Lucitone 199. Four groups were created by demarcating the specimens, with 20 teeth in each group. Each group was tested for bond strength with Lucitone 199. Thus, each group consists of 20 test specimens and a total of 80 specimens from the four study groups.

Curing of specimens

The prepared wax models were invested in the flask following the manufacturer's instructions for water–powder ratio, mixing time, and setting time. One hour after the stone set, flasks were kept for dewaxing by immersing in boiling water for 5 min. A thin film of alginate separating media was applied on all surfaces

of the mold except the saddle portion of teeth with the help of a brush and dried.

A combination of polymer and monomer, used in the ratio of 3:1 by volume was proportioned prior to mixing. Mixing was done in a porcelain jar, which was kneaded by hand upon achieving the dough consistency to increase its homogenecity and integrity and then packed into mold. After the flasks were clamped, closure was done under force of 20 kN and kept for 30 min.[6] The flasks were then kept at room temperature for 1 h.

Then the flasks were submerged in water in an acrylizer at room temperature and processing was done as per the manufacturer's guidelines. After curing of all the specimens, the flasks were brought down to room temperature and deflasked. All samples were placed in water for 72 h to ensure complete polymerization. All 80 test specimens were prepared by means of these procedures [Figure 1].

Figure 1: Specimen after polishing

Bond strength test

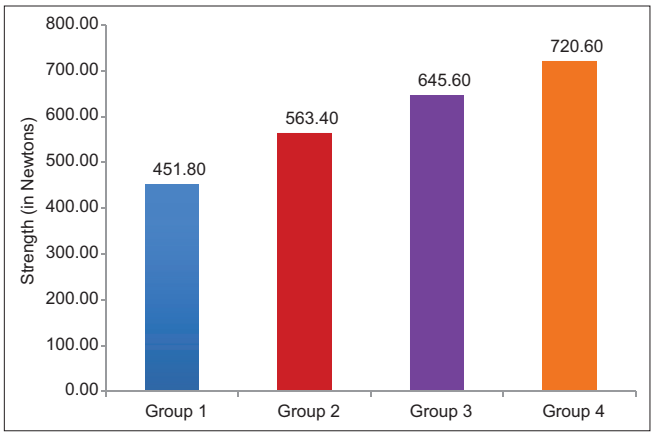
The specimens created were exposed to load testing by Hounsfield Universal Testing Machine (EZ20 20 kN, Computerised, Lloyd Company, Ametek technologies, UK) [Figure 2]. Bond strength test was performed at the Textile Department, Bapuji Institute of Engineering and Technology (BIET), Davangere, Karnataka, India. All trial specimens were placed securely in a specially created stainless steel jig and were placed in such a way that stress was applied on the palatal region of the sample denture teeth when moved in a downward direction. The bond strength was checked by using a cross-head speed of 5 mm/min.[7] Resultant force was applied till debonding of the denture teeth from denture base resin.

Figure 2: Hounsfield universal testing machine

SPSS 16 software package. (IBM Company, New York, US) and Epi-info version 3.0 were used for examining the statistical data. Shapiro–Wilk Test, one-way analysis of variance (ANOVA), and Bonferroni test were done to do statistical investigation.

RESULTS

The comparative bond strength values (Newton) of different groups created with Lucitone 199 are shown in Table 1 and Graph 1. The relative study of bond strength value among different groups preprared with Lucitone 199 proved to be statistically significant. Out of all the specimens prepared using Lucitone 199, the highest bond strength value (720.6 N) was observed in Group 4 followed by Group 3 (645.6 N), Group 2 (563.4 N), and lastly Group 1 (451.8N).



Graph 1: Comparative bond strength values (Newton) of different groups prepared with Lucitone 199 heat-cured denture base resin

Table 1: Comparative bond strength values (Newton) of different groups prepared with Lucitone 199 heat-cured denture base resin

			Difference between groups		
	Mean	SD	Group 2	Group 3	Group 4
Group 1	451.8	38.3	$P<0.001$, S	$P<0.01$, S	$P<0.05$, S
Group 2	563.4	23.9		$P<0.001$, S	$P<0.001$, S
Group 3	645.6	26.1			$P<0.001$, S
Group 4	720.6	32.8			
F value			212.687		
P value			$P<0.001$, S		

Significance level (P value). P value<0.001 was considered to be significant. The relative study of bond strength among different groups prepared with Lucitone 199 proved to be statistically significant. SD=Standard deviation

DISCUSSION

One of the major issues in prosthodontic practice is failure of tooth-denture base bond.[8] Acrylic teeth are the first choice of artificial teeth for creating dentures. Woelfel (1977) listed the principal factors in correct fabrication of acrylic resin dentures:[9] (1) The relationship obtained from the patient and sent to the dental laboratory must be mechanically and physiologically sound; (2) The wax bulk and contour of the trial denture should be as nearly like that of the final denture as far as possible so that only minimal reduction of the processed denture is necessary; (3) Flasking should be done using entirely dental stone, which is 2½–3 times stronger than plaster; (4) The boil-out procedure must be timed so that wax is not permitted to soak into the dental stone from prolonged heating but can be removed by lifting it out in one piece, with the wax just softened or melted only around the necks of the teeth and in the ridge undercuts; (5) The tinfoil substitute should be applied while the flasks are warm and wet; and (6) During the packing procedures, several things are of utmost importance — (a) Powder to liquid ratio should be 3:1, (b) On all trial closures, the press closing force must be applied slowly, thus permitting adequate time for the dough to flow and become compressed for optimum density, and (c) The packed flask should be allowed to stand for 30–60 min before beginning the processing cycle.

Studies have calculated the occurrence of various denture repairs and shown tooth separation to be the most common repair for conventional prosthodontics.A survey conducted by Darbar, Huggett, and Harrison (1994)[1] was used to calculate the occurrence of denture fracture. The resultant data showed that 33% of the repairs performed were to correct debonded teeth.[1] Acrylic teeth are used for prosthetic rehabilitation as they have the property of good color stability and show perfect aesthetic results.[10,11] The failure of bond was thought as cohesion failure in the case of remnants of denture base materials, as reported by Khalaf, Abdulsahib, and Abars (2011).[12] Yadav, Somkumar, Mishra, Hazari, Chitumalla, and Pandey (2015)[13] reported that debonding occurs within the body of the tooth rather than tooth acrylic interface; so, there is no need of surface treatment of ridge lap surface. Consani, Pucciarelli, Mesquita, Nogueira, and Barao (2014)[14] reported that different polymerization cycles have the same effect on the hardness of heat cure resin material. Grando, Pacheco, Botega, Hirakata, and Hilgert[15] reorted no significant difference in the wear resistance of different brands' (Trilux, Soluut PX) teeth. Akin, Kirmani, Tugut, and Coskum (2014)[16] worked upon the effects of different surface treatments in the ridge lap area of acrylic resin teeth on shear bond strength to heat polymerized poly (methyl methacrylate) (PMMA) denture base resin. They concluded to vanquish tooth debonding, surface treatment should be included as a part of denture fabrication. Cardash, Liberman, and Helft (1986)[3] researched to report the effetiveness of retention grooves of various shapes, cut into the ridge lap surface of acrylic resin teeth in increasing the shear strength bond among heat-cured resin and acrylic teeth. They determined that the force needed for debonding of acrylic resin teeth from denture base was nearly similar to the force needed to fracture the acrylic resin base. A lack of significant improvement was noted on introducing retention grooves of various shapes into the ridge lap portion of acrylic resin teeth in the combined shear compressive strength of bond to heat-cured standard resin and to high-impact denture base resin. Cardash, Applebaum, Baharav, and Liberman (1990)[4] checked whether horizontal or vertical retention grooves prepared on the ridge lap area of cross-linked teeth would improve the combined shear compressive strength of the bond to heat-cured resin and to high-impact resin. They interpreted that the presence of vertical retention grooves prepared on ridge lap area of teeth enhanced the retention to acrylic resin. The results of various studies conducted by researchers were mixed and contradictory.

Therefore, an effort has been made to check and compare the bond strength of denture teeth bonded to high-impact resin material.

Group 1 specimens prepared by the Lucitone 19 resin material showed significantly lower bond strength value (451.8 N) compared to that of Group 2 specimens (round groove) prepared with Lucitone 199 resin material (563.4 N). The probable reason is

that the round groove on the ridge lap surface of the teeth permits mechanical joint between the tooth and resin material. The control group specimens prepared by the Lucitone 199 showed significantly lower bond strength value (451.8 N) compared to that of Group 3 specimens (vertical grooves) prepared by the Lucitone 199 (645.6 N). These results were similar to the results reported by Caradash, Applebaum, Baharav, and Liberman.[4] They stated that vertical retention grooves provide more consistent mechanical joint between cross-linked tooth and the resin material.

The control group specimens prepared by Lucitone 199 showed significantly lower bond strength value (451.8 Newton) compared to that of Group 4 specimens (T-shaped groove) prepared by Lucitone 199 (720.6 N). The probable reason for these results might be that the T-shaped groove increases the surface area available on the cross-linked teeth to interact with polymerizing denture base resins. This mechanically strengthens the bond between cross-linked teeth and the resin material.

Group 3 specimens (vertical grooves) prepared by Lucitone 199 showed a significantly higher bond strength value (645.6 N) compared to that of Group 2 specimens (round groove) prepared by Lucitone 199 (563.4 N). The probable reason is that the vertical groove area allows better mechanical bonding between the cross-linked teeth teeth and resin material compared to the bond induced by round groove.

The Group 4 specimens (T-shaped groove) prepared by Lucitone 199 showed significantly higher bond strength value (720.6 N) compared to that of Group 3 specimens (vertical grooves) prepared by Lucitone 199 heat cure denture base resin (645.6 N). The probable reason for these results might be that the T-shaped groove area being wider area than vertical groove area has more chances of greater flow of acrylic resin denture base material into that area and provided better mechanical retention between the tooth and denture compared to mechanical retention induced by vertical grooves.

Limitations of the study

- Only high-impact resin material was used in our study. Hence, further studies are required using different types of denture base resins (convetional and high-impact resin materials)
- We evaluated lone standing denture teeth for bond strength evaluation since adjacent denture teeth also have reinforcing bond strength. Further studies are required with denture teeth being present on either side of the the denture tooth being evaluated for the study
- We have used only one type of cross-linked denture teeth in our study. There are various composite multilayered denture teeth available in the market, which require further evaluation of bond strength with different mechanical modifications.

CONCLUSION

- The bond strength between Lucitone 199 heat-cured denture base material and denture teeth was increased with mechanical modifications of denture teeth
- The control group specimens without any modification prepared by Lucitone 199 heat cure resin showed the lowest bond strength value, whereas the specimens prepared with T-shaped groove packed with Lucitone 199 heat cure resin showed the highest bond strength value. Therefore, this modification can be a recommended method to secure denture teeth in denture bases.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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