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Evaluation of Bond Strength of Denture Base Resin to a Cross-Linked Denture Teeth with Various Auxiliary Retentive Features: An In Vitro Study

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ABSTRACT

Background: This study was conducted to assess the Bond Strength of Denture Base Resin to a Cross-Linked Denture Teeth with Various Auxiliary Retentive Features.

Material and methods: The study was conducted in the Department of Prosthodontics and Crown and Bridge of Mithila Minority Dental College and Hospital, Darbhanga, Bihar. The objective of this study was to compare the bond strength of cross-linked denture teeth to Lucitone199 heat cure denture base resin after various mechanical modification of the bonding surface area of cross-linked denture tooth. 80 left maxillary cross-linked acrylic central incisor denture teeth (Cosmo HXLTM Acrylic two layered teeth, DENTSPLY Dental (Tianjin) Co., Ltd, China) of same size and shade were selected. The 80 teeth were then divided into 4 Groups. The 4 Groups were named Group 1, 2, 3 and 4 according to the mechanical modification of the surface treatments in which group 1 served as control group with no surface mechanical modification. Group 2, round groove Group3, vertical groove and Group4T-shaped groove. Wax models were made using a custom-made jig such that the tooth was placed with a labial inclination of 1300 from the denture base. The wax models were invested.

Results: When comparing the other Groups with the control Group, there is a statistical difference between the mean bond strength values of vertical groove and T-Shaped groove.The mean bond strength values of vertical groove and T-Shaped groove (646.65N and 721.43N) were significantly higher ($p<0.05$) than that of the control Group (510.29N) as proved from Tukey's HSD test.Round groove (519.32N) had no statistically ($p>0.05$) significant mean bond strength values when compared to the control Group (510.29N).When compared to the vertical groove and T- Shaped groove (646.65N and 721.43N), had statistically highest ($p<0.05$) mean bond strength value of 721.43N and was proved statistically with Tukey's HSD test.

Conclusion: The mechanical modification on the bonding surface of acrylic teeth before packing definitely improved bonds strength. The T-Shaped group had the highest mean bond strength values and all the failures were cohesive in nature. Vertical groove group had good bond strength values but more of adhesive failure was noted. There was no statistical difference in mean bond strength values of control, round groove groups. Adhesive failures were seen in the Vertical groove and control groups. T-Shaped had good bond strengths leading only to cohesive failure.

1. INTRODUCTION

Acrylic resins, introduced in 1937, have enjoyed a continued popularity, which is attributed to its simple processing technique and relatively low cost of fabrication.[1] Despite the progress in the development of denture base resin and artifice all tooth materials, dental clinics are still plagued with artificial teeth falling off the denture base.[2-4] Artificial dentures are fabricated by inset moulding prefabricated denture teeth into resin denture base by compressing, injecting, or pouring acrylic resin over and around the ridge lap and collar portions of the teeth. These techniques are designed to create a strong bond between the

parts. Adequate bonding of acrylic resin teeth to denture base resin plays a vital role as it increases the strength and durability of the denture since the teeth become an integral part of the prosthesis. Artificial teeth falling off the denture base is a usual problem encountered by patients during denture usage. This problem is often related to the material properties of the acrylic denture base resin used. A survey showed that 33% of denture repairs were to restore debonded teeth.[5-9] Therefore, in the fabrication of removable dentures, the bond between the denture base resin and artificial teeth is one of the most important considerations in the technical procedure.

Two processes affect the bond between the acrylic teeth and denture base resin: (i) the polymerizing denture base resin must come into physical contact with the denture tooth resin and (ii) the polymer network of denture base resin must react with the acrylic tooth polymer to form an interwoven polymer network (IPN). Examination and analysis of the direction of forces created during function, helps us to better understand the cause of bonding failure. Sagittal section of a maxillary and mandibular denture through the maxillary and mandibular right central incisors suggest, incisal contact of these teeth during function create lingually directed force on the mandibular incisor and an equal and opposite, facially directed force on the maxillary incisor denture tooth.[10]

The mandibular incisor tips lingually towards the denture and the denture base lingual to the tooth resists this movement. So, the forces are on the denture base than at the juncture. The maxillary central incisor rotates facially around a fulcrum located at the cervical portion of the tooth and the gingival cuff of the denture base, away from the denture base. Because resin denture teeth and denture base resins are slightly flexible, this denture tooth may become dislodged from the denture base if or when the adhesion or mechanical retention between the parts fail.[10]

Basic understanding of the above causes and mechanism of bond failure could make us improve the various parameters in processing of dentures, thus improving the bond strength between acrylic teeth and denture base to the best possible extent. The removable denture wearing population will be highly benefited along with the dental professionals, if frequent repairs and corrections of dentures are avoided. The psychological fear of the patients while eating harder food substances with the denture can also be reduced. Thus, improving the denture base-acrylic teeth bond also improves the bond values in dentist-patient relations. In literature, various mechanical modification treatments, macro-mechanical retention on the ridge-lap surface of teeth were adopted to improve the bond strength between cross-link acrylic denture teeth and Lucitone199 denture base resin.

2. MATERIAL AND METHODS

The study was conducted in the Department of Prosthodontics and Crown and Bridge of Mithila Minority Dental College and Hospital, Darbhanga, Bihar. The objective of this study was to compare the bond strength of cross-linked denture teeth to Lucitone199 heat cure denture base resin after various mechanical modification of the bonding surface area of cross-linked denture tooth. 80 left maxillary cross-linked acrylic central incisor denture teeth (Cosmo HXLTM Acrylic two layered teeth, DENTSPLY Dental (Tianjin) Co., Ltd, China) of same size and shade were selected. The 80 teeth were then divided into 4 Groups. The 4 Groups were named Group 1, 2, 3 and 4 according to the mechanical modification of the surface treatments in which group 1 served as control group with no surface mechanical modification. Group 2, round groove Group3, vertical groove and Group4T-shaped groove. Wax models were made using a custom-made jig such that the tooth was placed with a labial inclination of 1300 from the denture base. The wax models were invested.

3. RESULTS

Table 1: Illustrates the sampling based on this study

80 SAMPLES of maxillary left central incisor teeth				
4GROUPS–Based on mechanical modification on bonding surface of acrylic tooth.				
GROUP	GROUP 1	GROUP 2	GROUP 3	GROUP 4
SAMPLES	20 samples of left central incisor	20 samples of left central incisor	20 samples of left central incisor	20 samples of left central incisor

TYPE 0F MACHINICAL MODIFICATIN	No mechanical modification	Round groove	Vertical groove	T-shaped groove

In group 1, there were 20 samples of left central incisor with no mechanical modification. In group 2, there were 20 samples of left central incisor with round groove. In group 3, there were 20 samples of left central incisor with vertical groove and in group 4, there were 20 samples of left central incisor with T-shaped groove.

Table 2: Bond strength values and type of failure results of cross-linked denture teeth to Lucitone199 denture base resin with no mechanical modification on the bonding surface of acrylic teeth before processing.

GROUP 1-(CONTROL,NO SURFACE MODIFICATION)

SAMPLE NO.	BOND STRENGTH VALUES IN NEWTON(N)	TYPE OF FAILURE A-Adhesive C-Cohesive
1	433.96	A
2	447.15	C
3	526.77	A
4	447.91	C
5	432.08	C
6	499.80	C
7	619.26	C
8	452.83	A
9	565.19	C
10	487.42	C
11	499.55	C
12	505.61	C
13	499.31	A
14	533.63	C
15	576.18	C
16	579.46	C
17	575.33	C
18	579.13	C
19	448.14	A
20	497.13	C

MEAN	510.29	5A, 15C

Table 3:Bond strength values and type of failure results of cross-linked denture teeth to Lucitone 199 denture base resin with round groove 2mm in diameter mechanical modification on the bonding surface of acrylic teeth before processing.

GROUP 2-(ROUND GROOVE 2 MM IN DIAMETER)

SAMPLE NO.	BOND STRENGTH VALUES IN NEWTON(N)	TYPE OF FAILURE A-Adhesive C-Cohesive
1	590.16	C
2	516.36	C
3	469.04	C
4	596.87	C
5	495.29	C
6	593.57	C
7	486.59	C
8	389.97	C
9	483.51	A
10	521.40	C
11	452.67	C
12	452.60	C
13	557.53	C
14	480.05	C
15	579.47	C
16	489.08	C
17	564.03	C
18	596.19	C
19	579.86	C
20	492.35	C
MEAN	519.32	1A,19C

Table 4: Bond strength values and type of failure results of cross-linked denture teeth to Lucitone 199 denture base resin with a vertical groove 2mm deep and 2mm wide mechanical modification on the bonding surface of acrylic teeth before processing.

GROUP 3- (VARTICAL GROVES 2MM DEEP AND 2MM WIDE)

SAMPLE NO.	BOND STRENGTH VALUES IN NEWTON(N)	TYPE OF FAILURE A-Adhesive C-Cohesive
1	657.84	C
2	512.97	A
3	586.11	C
4	589.19	C
5	572.78	C
6	732.82	C
7	601.51	C
8	582.81	C
9	593.11	C
10	644.87	A
11	735.49	C
12	769.41	C
13	761.54	C
14	598.76	A
15	748.61	C
16	583.18	C
17	802.62	C
18	675.01	C
19	616.68	A
20	567.78	C
MEAN	646.65	4A, 16C

Table 5: Bond strength values and type of failure results of cross-linked denture teeth to Lucitone 199 denture base resin with a T-shaped groove 2mm deep and 2mm wide mechanical modification on the bonding surface of acrylic teeth before processing.

GROUP 4-(T-SHAPED GROOVE 2MM DEEP AND 2MM WIDE)

SAMPLE NO.	BOND STRENGTH VALUES IN NEWTON(N)	TYPE OF FAILURE A-Adhesive C-Cohesive
1	703.31	C
2	720.69	C
3	803.48	C
4	669.64	C
5	804.06	C
6	695.07	C
7	828.56	C
8	655.96	C
9	708.15	C
10	789.00	C
11	686.38	C
12	693.91	C
13	800.73	C
14	626.42	C
15	674.32	C
16	679.92	C
17	690.12	C
18	730.11	C
19	778.78	C
20	690.02	C
MEAN	721.43	20C

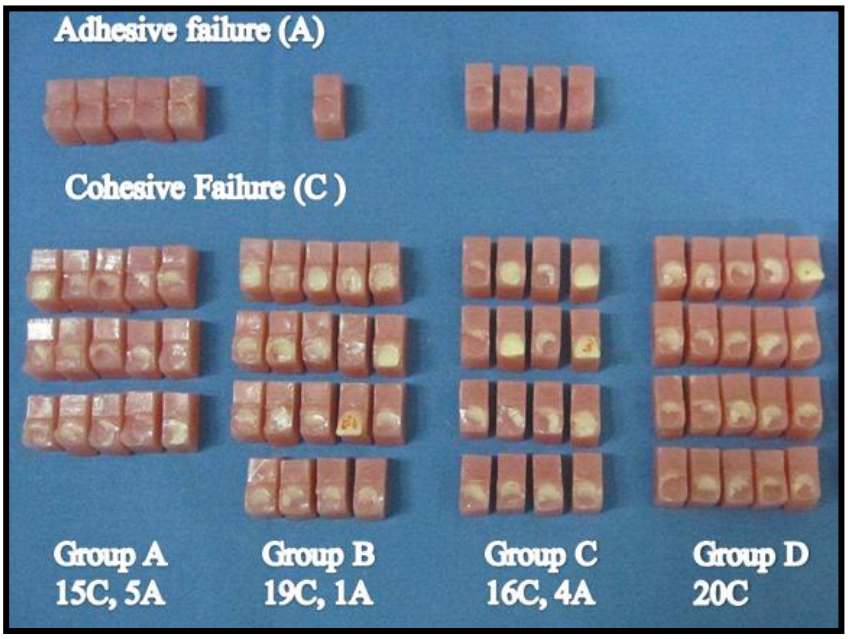
Table 6: The mean bond strength values of the groups and their type of failure summarized.

Group name	Mean bond strength values in Newtons	Type of failure (Adhesive/Cohesive)
Group1 (no surface treatment)	510.29	5A,15C
Group2 (Round groove)	519.32	1A,19C
Group3 (Vertical groove)	646.65	4A,16C
Group4 (T-shaped groove)	721.43	20C

The above test values were then subjected to statistical analysis to verify for their significance.

ANOVA test was used to uncover the main and interaction effects of categorical independent variables (called “factors”) on an interval dependent variable. One Way ANOVA is used to compare the means of three or more groups to determine whether they differ significantly from one another and to estimate the differences between specific groups. The mean bond strength values were subjected to this test and a null hypothesis was formed.

When comparing the other Groups with the control Group, there is a statistical difference between the mean bond strength values of vertical groove and T-Shaped groove.The mean bond strength values of vertical groove and T-Shaped groove (646.65N and 721.43N) were significantly higher ($p<0.05$) than that of the control Group (510.29N) as proved from Tukey’s HSD test.Round groove (519.32N) had no statistically ($p>0.05$) significant mean bond strength values when compared to the control Group (510.29N).When compared to the vertical groove and T- Shaped groove (646.65N and 721.43N), had statistically highest ($p<0.05$) mean bond strength value of 721.43N and was proved statistically with Tukey’s HSD test.



4. DISCUSSION

Dentures – the mode of replacing teeth had become very popular since the introduction of acrylic resins in removable prosthodontics since 1937.The acrylic resins and acrylic resin denture tooth combination had been used since they both shared the common composition, and were able to form a chemical bond.[11] Adequate bonding of acrylic resin teeth to denture base resin plays a vital role as it increases the strength and durability of the denture since the teeth become an integral part of the prosthesis. Artificial teeth falling off the denture base is a usual problem encountered by patients during denture usage. This problem is often related to the material properties of the acrylic denture base resin used. A survey showed that 33% of denture repairs were to restore debonded teeth.

Therefore, in the fabrication of removable dentures, bond strength between denture base resin and artificial teeth is one of the most important considerations in the technical procedure. Bond strength like any other strength property is statistical in nature, since the presence of intrinsic or extrinsic flaws strongly influences fracture. The mechanical testing of strength is complicated by specimen geometry, size, test grip alignment, force direction and other variables that usually produce complex stress distribution.[12] Different testing methods had been employed in the studies examining the denture base to tooth bond to establish suitability for clinical use.

In light of the above, the bond strength between heat polymerized denture base resin and acrylic resin denture teeth with three different surface treatments of the bonding surface area were evaluated and compared with that of untreated teeth.

In this study, 80 highly cross linked maxillary left central incisor acrylic denture teeth (CosmoHXL, Dentsply) was used. Clancy reported that heat- cured plastic teeth were 40% higher in bond strength than with IPN crosslinked teeth.[13]

Chai et al and Caswell et alhad reported that there was no significant difference in bond strength values of conventional and cross linked acrylic teeth.[14,15] As the cross-linking enhanced strength and abrasion resistance, presently crosslinked acrylic teeth are more preferred for dentures. In this study, cross-linked acrylic teeth (Cosmo HXL, Dentsply) were used.Lucitone199 denture base resin of the same company was used. using the same combinations as recommended by the manufacturer had improved bond strength than different combinations.

The adhesive and cohesive nature of the failure of the fractured specimens on visual examination was evaluated.[16] These test values were subjected to statistical analysis using one way-ANOVA, Tukey's HSD tests with the SPSS software (version 11.5). 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,andHarrision (1994)[8] was used to calculate the occurrence of denture fracture. The resultant data showed that 33% of the repairs performed were to correct debonded teeth.[8] Acrylic teeth are used for prosthetic rehabilitation as they have the property of good color stability and show perfect aesthetic results.

The null hypothesis of this study was that there was no significant difference in the bond strength values of acrylic resin denture tooth to the heat polymerized denture base resin after mechanical modification of surface and there was no significant difference in the modes of failure. The results obtained from the study rejected the null hypothesis. There was a significant improvement in the bond strength due to mechanical modification on bonding surface of acrylic teeth. It yielded the highest mean bond strength than the other groups with only cohesive mode of failure. Even though the study proved to be effective;

in comparing the bond strength between different surface treatments on the bonding surface area of acrylic tooth to the denture base resin,it had certain limitations. The effects of the inherent strengths of acrylic tooth and denture base material cannot be eliminated. It is well accepted that in vivo performance does differ from an invitro setting. This in vitro study design did not consider the effects of thermocycling and cyclic loading of the test specimens. The denture is normally held against a resilient mucosa and some stresses may be distributed to the denture bearing mucosa also which may not be simulated in such in-vitro studies. The mechanism of action of the bonding agents on the bond strength effects had to be studied. Future experiments, to investigate and understand the effects of the internal strength of both the acrylic tooth and denture base material on the mechanism of debonding with or without surface modifications are recommended.

5. CONCLUSION

The mechanical modification on the bonding surface of acrylic teeth before packing definitely improved bonds strength. The T-Shaped group had the highest mean bond strength values and all the failures were cohesive in nature. Vertical groove group had good bond strength values but more of adhesive failure was noted. There was no statistical difference in mean bond strength values of control, round groove groups. Adhesive failures were seen in the Vertical groove and control groups. T-Shaped had good bond strengths leading only to cohesive failure.

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