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ORIGINAL ARTICLE

A COMPARATIVE STUDY OF EFFECT OF ALGINATE MOULD SEAL CONTAMINATION ON BOND STRENGTH BETWEEN RESIN TEETH AND CONVENTIONAL AND HIGH IMPACT HEAT CURING ACRYLIC RESIN DENTURE BASE MATERIAL- AN IN VITRO STUDY

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ABSTRACT:
Denture base material most commonly employed in construction of denture is the heat cure acrylic resin. Acrylic resin teeth are preferred over porcelain teeth because they are claimed to be chemically bonded to the acrylic resin denture base material and are easy to adjust. An in vitro study was conducted to evaluate and compare the effect of alginate mould seal contamination on bond strength between resin teeth and conventional and high impact heat curing resin dental base materials. Eighty specimens, out of which forty were constructed by using conventional heat cure acrylic resin denture base material (Ashvin) (20 in control and contaminated group each), and forty of high impact heat cure acrylic resin denture base material (20 in control and contaminated group each) were taken to measure bond strength between tooth and denture base material. Results showed that for conventional heat cure acrylic resin denture base material (Ashvin), the maximum force needed for deboning was 371.7 N in case of contaminated group (C2) and 502.4 N in case of control group (C1). These forces were equivalent to a stress of 24 MPa and 33.49 MPa respectively. The findings show that the technical laboratory factors that contribute to the bond strength of acrylic resin tooth to the denture base polymethyl methacrylate is surface contamination. The joint surface can be contaminated with denture wax or by a tin foil substitute such as sodium alginate, both of which decreases the bond strength. Hence it was concluded that the strength of the bond achieved at the tooth / denture base interface may be related to the degree of cross-linking and the extent of copolymerization of the acrylic tooth and denture base.
Key words: Denture, acrylic resin, bonding, tooth.

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INTRODUCTION

Denture base material most commonly employed in construction of denture is the heat cure acrylic resin. Acrylic resin teeth are preferred over porcelain teeth because they are claimed to be chemically bonded to the acrylic resin denture base material and are easy to adjust. Adequate bonding to the denture base material is an important aspect as this leads to increase in the stiffness and strength since the teeth become an integral part of the prosthesis and are subjected to masticatory forces/stresses. Unexpected detachment of the tooth from the prosthesis as a whole may be the result of stress concentration at the interface between the tooth and the denture base material. Several factors affect the bond strength: including cross- linking of the material, contamination during

processing and available monomer during processing.[1]

Studies claimed that wax seems to be the principal contaminant and cause of adhesive failure between acrylic resin teeth and denture base resin. Further it has been emphasized that the contamination with sodium alginate does not affect the adhesion, and the use of petroleum jelly also has no adverse effect. It is surprising that wiping the ridge- laps of the acrylic resin teeth with monomer before packing does not reduce adhesive failures.[2,3]

Knott et al[4] suggested that the property of tooth bonding is dependent upon the intrinsic chemistry of both the artificial tooth and the denture base resin. Craig R.G.[1] was of the opinion that the separators such as alginate solution, sodium silicate, soft soap, and cellulose acetate prevents the bonding of plastic teeth to the plastic base if the material is inadvertently coated on the teeth. For many years tin-foil was the most accepted separating medium. The ease of its placement however, leaves a great deal to be desired, and as a result a number of tin-foil substitutes have been developed like sodium silicate, calcium oleate, and sodium or ammonium alginate being some of the few examples. The common alginate separators contain 2% sodium alginate in water with small amount of glycerine, alcohol, sodium phosphate and preservatives. Care must be exercised to avoid coating with these release agents. Further it was added that cross-linked plastic, because of networking structures, is more resistant to solvents, distortion, and heat. Although these properties are desirable, it makes the chemical bonding of the teeth to the base more difficult because of their higher solvent resistance.

It has been found that technical laboratory factor that contributes the bond strength of acrylic resin tooth to the denture can be contaminated with denture wax or by tin-foil substitute such as sodium alginate , both of which decrease the bond strength. It has been suggested that to improve adhesion between an acrylic resin tooth and denture base polymethyl methacrylate (PMMA), it is also possible to use high impact PMMA (i.e. butyadine grafted PMMA) which adheres to the tooth surface better than standard PMMA .[5] Keeping the above said literature in mind it is evident that in spite of introduction of the grafted, cross-linked acrylic resin denture base material and development of more abrasion resistant acrylic teeth , the problem of impact resistance are still present to date.

Therefore, the following study was conducted to evaluate and compare the effect of alginate mould seal contamination on bond strength between resin teeth and conventional and high impact heat curing resin dental base materials.

MATERIALS AND METHODS

An in-vitro study was conducted by preparing eighty specimens, out of which forty were constructed by using conventional heat cure acrylic resin denture base material (Ashvin), and other forty of high impact heat cure acrylic resin denture base material (Travalon HI, Dentsply England, **(Figure 1)**. Separating media- Ashvin cold mould seal was used in common for both the materials **(Figure 2)**. Further, upper central incisor resin teeth i.e. mould N_1(Orateek) was used in preparing test specimens to keep uniformity in the results. In each case twenty specimens served as control group, and twenty as contaminated group which were designated as:-

In case of conventional heat cure acrylic resin;

C1- Control Group

C2- Contaminated Group

And in case of high Impact heat cure resin;

H1- Control Group

H2- Contaminated Group

Figure 1: Travalon Hi and Ashvin Heat Cure Acrylic Resin Denture Base Material

Figure 2: Separating Medium Ashvin Cold Mould Seal used in study

PREPARATION OF MAXILLARY MASTER DIE OF HEAT CURE ACRYLIC RESIN

The impression of edentulous maxillary aluminium die was taken with impression compound material, and poured in stone plaster to obtain the stone die.

The prepared stone cast was cut in the anterior region, i.e., the area of central incisors to the dimensions of 1cm x 2 cm x 1.5 cm. A platform of 5cm x 5cm x 2cm was constructed by adapting modelling wax on the anterior portion of the cast obtained after cutting from the master die. It was flasked, and cured in heat cure acrylic resin by using the standard technique. The Cured acrylic die was removed from the flask, finished, and polished (Figure 3), and was used for fabrication of test specimen.

A specially designed wooden inclined plane was prepared having an angle of 130 degree with the base (Figure 4). The inclined plane was used to obtain and ensure the position of the tooth at an angle of 130 degree to the base of the specimen to be tested.

Figure 3:- Edentulous maxillary master die of heat cure acrylic resin

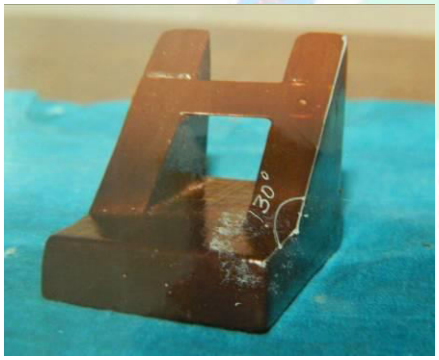

Figure 4:- Wooden inclined plane having an angle of 130 Degree

PREPARATION OF SPECIMENS OF CONVENTIONAL HEAT CURE ACRYLIC RESIN (ASHVIN)

The impression of acrylic master die was made with hydrophilic vinyl polysiloxane impression material, in a tray prepared from acrylic resin, to secure the stone die. The manipulation was done according to the manufacturer's directions.

The modelling wax was adapted to the stone die. The central incisor made of acrylic resin (Orateek-Mould N_1) was attached to it at an angle of 130 degree with the help of specially prepared wooden inclined plane (Figure 5). The final curing of the specimens were done using regular methods and the cured specimens were deflasked and examined to ensure that no denture base resin was in contact with the tooth at any location other than ridge-lap area. The specimens were finished and polished (Figure 6). This was called as our control group (C1)

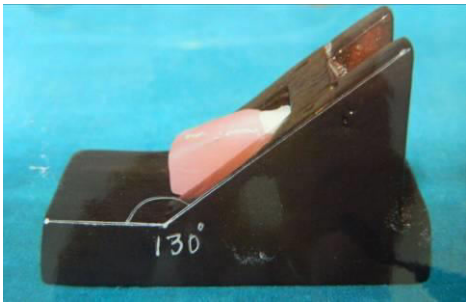

Figure 5:- Verification of 130 degree angle of long axis of the tooth with base

Figure 6:- Prepared Specimen

In the same way twenty specimens of the contaminated group (C2) were prepared with the difference that during application of alginate mould seal the ridge lap area of the tooth was also painted before packing the conventional acrylic resin in the flask. The cast and stone area was painted with alginate cold mould seal with care being taken that alginate cold mould seal should not touch the ridge-lap surface of the tooth at all and was allowed to dry.

PREPARATION OF SPECIMENS USING HIGH IMPACT HEAT CURE ACRYLIC RESIN DENTURE BASE MATERIAL (TRAVALON HI, DENTSPLY ENGLAND)

Similar preparation of specimens using high impact heat cure acrylic resin (Trevalon HI, Dentsply England) was done both for control group (H1) and contaminated group (H2).

TESTING OF SPECIMENS

All the specimens were stored at room temperature in plastics bags containing distilled water for seven days before testing. Each specimen was placed in a jig on an instron testing machine Lloyds (JJ Lloyds, London) (Figure 7). A 5mm bar was placed on the lingual surface of the teeth at 130 degree angle relative to the long axis of the tooth (Figure 8). The instron instrument was set at the cross head speed of

2mm /min with a 5kg load cell. The specimens were loaded until fracture of the denture tooth and denture base bond or cohesive fracture in the tooth or base occurred. The readings of the maximum force in Newton (N) causing fracture of the specimen were noted.

Figure 7:- Universal instron testing machine

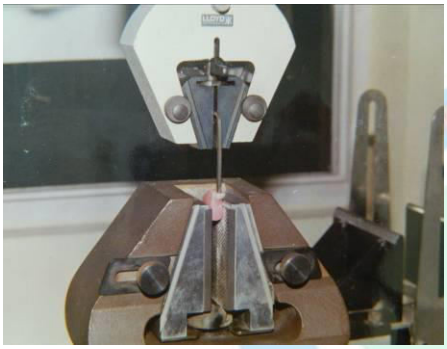

Figure 8:-Testing of specimen in universal instron testing machine

OBSERVATIONS

The present study was conducted in vitro, to evaluate and compare the effect of alginate mould seal contamination on bond strength between conventional acrylic resin (Ashvin) and high Impact denture base material (Travalon HI) with tetra cross-linked resin teeth (Orateek).

It was interpreted that for conventional heat cure acrylic resin denture base material (ASHVIN) showed the maximum force needed for debonding was recorded to be 371.7 N in case of contaminated group (C2) and 502.4 N in case of control group (C1). These forces were equivalent to a stress of 24 MPa and 33.49 MPa respectively.

Computed as:-

Stress = Force in Newton x $(\pi \times 2.5^2)^{-1}$ Nmm $^{-2}$ or MPa

In the high impact acrylic resin denture base material (Travalon HI) the maximum force needed for debonding was found to be 571.2 N in case of control group (H1) and 411.2 N in case of contaminated group (H2). These forces were equivalent to a stress of 38.08 MPa and 27.41 MPa respectively. These observations were statistically analysed and with a view to draw conclusions from the experimental data, various statistical measures, such as mean, standard deviation, coefficient of variation (C.V.) and confidence intervals (C.I.) were computed. **(Table 1)**

Table 1: Showing statistically computed values of conventional and high impact heat cure acrylic resins.

Name Of Group	Mean	S.D.	C.V.(%)	C.I.	
				95%	99%
Conventional Heat Cure Acrylic Resin					
Control Group (C1)	429.18	56.65	13.20	401-456	392-466
Contaminated Group (C2)	286.89	52.39	18.26	261-312	252-321
High Impact Heat Cure Acrylic Resin					
Control Group (H1)	488.91	46.28	09.47	466-511	458-519
Contaminated Group (H2)	311.14	50.95	16.28	286-335	277-344

Table 2: Analysis of variance for testing the significance of difference between various effects

Source of variations	Degree of freedom	Sum of squares	Mean squares	Computed variance ratio
Between type of acrylic resin	1	35258.7	35258.7	12.53**
Between control and contaminated within a type of acrylic resin	2	518503.9	259252.0	92.14**
Control vs contaminated	1	512207.7	512207.7	182.03**
Interaction between type of resin and control vs contaminated	1	6296.2	6296.2	2.24^{ns}

Where ** denotes $p<0.05$ and NS denotes Non significant

Observations drawn from the C.V. values of table 1 revealed-

- Variability among the observations in the control group was less than among the contaminated group for each of the two types of heat cure acrylic resin denture base materials.
- Variability among the observations in high impact heat cure acrylic resin denture base material was less than that in conventional heat cure acrylic resin denture base materials with respect to both control and contaminated specimens.

Further **Table 1** revealed that C1 group in conventional heat cure acrylic resin denture base material, C.I. varied between 401.98 to 456.39 N. As to what it implies is that experiments are performed repeatedly, and then in the long run chances are 95% that observations from such a group will fall within the range of 401.98 to 456.39 N. Similarly for group C2 such an interval was 261.74 to 312.05 N. Values for H1 and H2 groups are given in **Table 1**.

These results were further subjected to ANOVA test, least significance difference (LSD) test, and F test in respect to two factors that are:-

- The type of acrylic resin denture base material, and
- Type of specimens, as laid out in a completely randomized design

For making such computations the texts have also been followed in studies of Koutsoyiannis (1977)[6] and Montgomery (1991)[7].

The computations from the ANOVA approach have presented in the **Table 2**

The comparison of the means of the conventional and high impact resin bond strength yields LSD-31.54. Whereas the comparison for the means of the control vs. contaminated within the given type of acrylic resin yields LSD 44.60.

A perusal of ANOVA test **(Table 2)** revealed that the bond strength between conventional and high impact resin were significantly different from each other. Similarly the difference between control and contaminated groups was highly significant as revealed by a sufficiently high value (182.03) of its variance ratio.

However, the variance ratio (2.24) for the interactive effect between conventional and high impact acrylic resin and control vs. contaminated specimens was statistically non significant. This implies that the relative performance of bond strength of conventional and high impact resin was similar whether we consider control group or the contaminated group.

For comparison means of conventional and high impact acrylic resin bond strength, the least significant difference at one percent probability level turned out to be 31.54. Since the observed difference between the means of these two resin bond strength **(Table 3)** was of the order of 42.0 which happened to be larger than the corresponding LSD value, therefore, the two acrylic resin bond strength differed significantly at 1% probability level. Similarly the observed difference between the mean of the contaminated group within each of the two acrylic resins were substantially larger than the corresponding LSD value of 44.60. Thus the bond strength differed significantly.

Table 3: Mean bond strength of conventional and high impact acrylic resin denture base material

Name Of Group	Conventional Heat Cure Acrylic Resin	High Impact Heat Cure Acrylic Resin	Mean
Control Group (C1 AND H1)	429.19	488.92(13.92)++	459.05
Contamnianted Group (C2 and H2)	286.90(-33.15)+	311.14(8.79) (-36.36)	299.02(-34.86)
Mean	358.04	400.03(11.73)	379.03

+ denotes % reduction in the bond strength of contaminated materials over control group

++denotes % increase in the bond strength of high impact acrylic resin over bond strength of conventional heat cure acrylic resin denture base material.

A further glance at **table 3** reveals that the bond strength of high impact acrylic resin denture base material was superior to conventional acrylic resin denture base material through an extent of nearly 11.7%. However the contaminated groups (C2 and H2) were observed to be inferior to the control group (C1 and H1) by an extent of nearly 35 %.

DISCUSSION

In present study, it was observed that high-Impact heat cure acrylic resin denture base material provides superior bond strength, i.e. at 1% probability level, than that provided by conventional heat cure acrylic resin. On an average, the increase in bond strength of the former material over the later one was of the order of 11.7%. These findings are in concurrence with the findings of the studies conducted by Cardash et al[8] while Morrow et al[9] observed no statistical difference between the mean bond strength of the types of the resin. The reason for disagreement may be that in the present study the compressive stress was measured but Morrow et al[9] noted the tensile stress in their study.

Contaminated groups resulted in a statistically lower bond strength, i.e. , at 1% probability level, as compared to control group. On an average, the former groups resulted in a bond strength which was nearly 35 % less than that of the later group. The results of the study are in accordance with the findings of the studies conducted by Catterlin R.K[10] and Shiba A[11] where they concluded that tin foil substitute contamination of ridge laps prior to packing the denture base resin greatly reduced the bond strength. The study is in disagreement with the statements of Spratley MH[2] and Cummingham JL[3] that contamination with sodium alginate did not affect the adhesion . The reason may be difference in formulation of the products used by the investigators.

The relative performance of control and contaminated groups was statistically similar at each of the two study materials, and consequently. Alginate mould seal prevents chemical union between acrylic resin dentures base materials and the teeth.The findings show that the technical laboratory factors that contribute to the bond strength of acrylic resin tooth to the denture base polymethyl methacrylate is surface contamination.

The joint surface can be contaminated with denture wax or by a tin foil substitute such as sodium alginate, both of which decrease the bond strength. To improve adhesion between an acrylic resin tooth and the denture base polymethyl methacrylate, it is also possible to use high-impact polymethyl methacrylate, which adheres to the tooth surface better than standard polymethyl methacrylate.

Hence it is concluded that the strength of the bond achieved at the tooth / denture base interface may be related to the degree of cross-linking and the extent of copolymerization of the acrylic tooth and denture base. However, poor laboratory techniques involving faulty boil out procedures and indiscriminate use of separating medium i.e. alginate mould seal are the cause of preventing optimum boding being achieved between the denture base resin and tooth.

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