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COMPARATIVE EVALUATION OF SHEAR AND TENSILE BOND STRENGTH OF CROSS LINKED ACRYLIC DENTURE TEETH TO DENTURE BASE RESINS CURED BY HEAT AND MICROWAVE POLYMERISATION TECHNIQUES- AN IN VITRO STUDY.

Original Research Paper

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ABSTRACT: Background : Debonding of denture teeth from denture base resins present a common clinical problem. Secondly the processing of heat cure denture base resins is time consuming and cumbersome procedure.

Purpose- The aim of the study is to compare and evaluate the shear bond strength and tensile bond strength of cross linked acrylic denture teeth to denture base resin cured by heat and microwave polymerization techniques.

Materials & Methods – A total number of 40 cross linked maxillary central incisors & 40 mandibular molars (Acryrock Ruthinium, badiapolesine - ITALY) of same mould size with regard to size and shape were selected to be bonded to Heat cured resin (Luciton199, Dentsply) by conventional heat cure polymerization method and microwave polymerization method.

The samples were divided into 4 groups:

Group 1 – Specimen for shear bond strength cured by conventional heat cure polymerization method.

Group 2 - Specimen for shear bond strength cured by microwave polymerization method.

Group 3 – Specimen for tensile bond strength cured by conventional heat cure polymerization method.

Group 4 - Specimen for tensile bond strength cured by microwave polymerization method.

Each group consisted of 20 specimens. A total of 80 specimens were prepared.

Group 1 and 2 were tested for shear bond strength and group 3 and group 4 were tested for tensile bond strength on universal testing machine.

Results: The mean tensile bond strength for the heat polymerized specimens was found to be 19.09 Mpa.

2) The mean tensile bond strength for the microwave polymerized specimens was found to be 12.41Mpa.

3) The mean shear bond strength for heat polymerized specimens was found to be 8.66 Mpa.

4) The mean shear bond strength for the microwave polymerized specimens was found to be 10.26Mpa.

Conclusion : The tensile bond strength specimens showed statistically significant differences in the bond strength. The tensile bond strength of the heat polymerized specimens was found to be higher. The shear bond strength specimens did not showed statistically significant difference in the shear bond strength. The shear bond strength of the microwave polymerized specimens was found to be equivalent to that of heat polymerized specimens.

Keywords:
Crosslinked acrylic denture teeth, microwave cured denture base resins, tensile bond strength, shear bond strength, polymerisation

Source of support: Nil
Conflict of interest: None

INTRODUCTION: According to GPT-8, a denture base can be defined as a part of denture that rests on the foundation and to which teeth are attached. The evolution of denture base materials started before 18th century with wood and ivoryand still continuing with the advent of ultra-high modulus polyethylene fiber reinforced denture base material. But the major breakthrough in history of denture base resins was the inception of PMMA in 1936.Rohm and Hass in 1936 introduced PMMA in the form of a transparent sheet and in 1937 Du Dout De Nemours introduced it in powder form[1]. The first acrylic type plastic was available under the name of vernonite.

Conventionally, acrylic denture base reins have been polymerised by temperature controlled water bath methods.In 1968,Nishii advocated the use of microwave energy to polymerize poly(methyl methacrylate) denture base resin[2]. Kimura et al studied the various irradiation duration required for polymerization and acrylic resin thickness[3].Temperature and time of polymerization affect the residual monomer content of heat-polymerized denture base

polymers.Prosthesis fractures may occur due to stress concentrations, increased flexing of thematerial duringmastication, or a suddendrop onto a hard surface.[20]

The most common problem encountered clinically in denture patients is debonding of denture teeth with denture base resins. The debonding is attributed to multifactorial reasons which include:1) improper wetting of ridge lap surface of denture teeth with monomer 2) contamination of ridge lap surface area with wax residues or could mould seal 3) inadequate powder to liquid ratio and curing cycle as recommended by manufacturer 4) Inadequate Mutual solubility or compatibility of two polymers forthe establishment of the interwoven polymer, and thusfor the strength of the bond[4,21],5) Immersion with Fittydent® cleansing tablets, 4% chlorohexidine gluconate and 1% sodium hypochlorite also significantly reduced the bond strength of acrylic teeth to denture bases.[17]Apart from this, conventional water bath polymerisation is time consuming because of its prolonged duration of processing. Microwave processing of dentures requires less equipments, can polymerize the denture base in 3 minutes rather than 9 hours of conventional curing cycle, and requires only a fraction of energy compared to water bath method[5]. Microwave cured resins have demonstrated clinically acceptable mechanical and physical properties and have performed satisfactorily good in clinical situations.[5,23]

Huggett et al and Fletcher et al[13] stated that the quality of denture base resin may contribute to the bond of denture base resin to resin tooth. They suggested that high impact heat cured denture bases exhibit a greater bond strength as compared to autopolymerizing, non high impact denture base resins. Phukela el al suggested that bond strength can be enhanced by combination of diatoric hole and cingulum ledge lock in acrylic resin teeth.[18]

Debonding of tooth from denture base resinstill remains a problem and which type of stresses are responsible for the same.so this study was designed to compare and evaluate the tensile and shear bond strengthof cross linked acrylic denture teeth to heat cured denture base resins and microwave polymerised heat cure resin.

MATERIALS & METHODS

In this experimental study, A total number of 40 cross linked maxillary central incisors,40 mandibular molars (Acryrock Ruthinium, badia polesine - ITALY) of same mould with regard to size and shape were selected to be bonded to Heat cured resin (Lucitone 199, Dentsply) by conventional heat cure polymerization method and microwave polymerization method.

The samples were divided into 4 groups:

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Group 4 - Specimen for tensile bond strength cured by microwave polymerization method.

Each group consisted of 20 specimens. A total of 80 specimens were prepared.

Group 1 and 2 were tested for shear bond strength and group 3 and group 4 were tested for tensile bond strength on universal testing machine.

Specimen Fabrication:

According to ADA specification no 15[6], **40** a metal die, 6 mm in diameter and 23 mm in length was fabricated. Metal die was measured with help of digital vernier calipers with the help of metal die, standardization of samples was carried out. Silicone mould of the metal die was fabricated (Vinyl polysiloxane putty impression material, 3M ESPE Express XT putty soft, USA). Silicone mould was sectioned longitudinally in two halves to facilitate retrieval of wax patterns from silicone mould. Modelling wax was poured into this silicon mould to get identical samples. Wax patterns were measured with digital vernier calipers.

After the fabrications of wax patterns of metal die, ridge lap surface of 40 central incisors and 40 mandibular molars were trimmed flat with acrylic trimmer. 40 central incisors were attached to the wax patterns obtained from silicone mouldand 40 mandibular molars were attached to wax patterns from both sides i.e. ridge lap surface and occlusal surface to facilitate as a holding device for tensile testing.

Specimen processing with conventional heat cure resin:

The prepared wax models were invested in the flasks using dental plaster following the manufacturer's instructions for water- powder ratio, mixing time and setting time. Vibrator was used to prevent air trapping during investing**.** After the plaster sets, flasks were kept for dewaxing by immersing in boiling water for 5 mins. Wax was thoroughly removed using boiling water and flasks were allowed to cool**.** A thin film of cold mould seal was applied on all surfaces except the ridge lap portion of teeth with help of brush and allowed to dry.A

mixture of polymer and monomer in the ratio 3:1 by volume was proportioned prior to mixing. Mixing was done in porcelain jar and once the mix reached the dough consistency it was kneaded by hand to increase its homogeneity and integrity and then packed in the mould. Trial closure was carried out using a hydraulic press. Excess material was trimmed using a BP blade. Finally the flasks were clamped and final closure was done. The flasks were bench cured for 1 hour. Then the flasks were immersed in water in acrylizer and curing was carried out at 72°C for 2 hours followed by 100°C for 1 hour. The flasks were allowed to bench cool for overnight before deflasking. The specimens were finally finished with Acrylic trimmer and 400 grit sand paper accordingly.**[Figure I]**

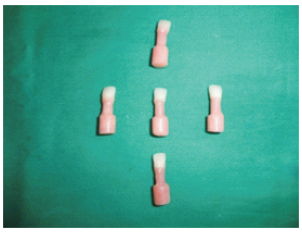


Figure I:Specimens for tensile bond strength Figure II: Specimens for shear bond strength

Specimen processing with Microwave polymerized heat cure resin :

Mixing of the polymer and monomer was done in the same way as in conventional curing. Material was packed in mould cavities and final closure was done. curing was done in specially designed Microwaveable flasks which had three long fasteners to secure both the parts of flask. The flask was kept in microwave (2400hz) at 500 W for 15 mins to complete polymerization. After all the specimens were cured, the flasks were bench cooled to room temperature and deflasked. A total of 40 specimens were prepared using this procedure. The specimens were finally finished with Acrylic trimmer and 400 grit sand paper accordingly.**[Figure II]**

Specimens were stored in water until the test has been carried out. Specimens were tested with Universal testing machine (INSTRON).

After the sample was mounted on the jig, tensile forces were applied along the direction of long axis of the sample using universal testing machine until failure or debonding of acrylic tooth from denture base resin occurred **[Figure III]**. For shear bond strength testing, horizontal forces were applied **[Figure IV].** The reading obtained on the digital monitor attached to the machine was calculated, tabulated and statistically analyzed using unpaired t test. P value <0.05 was considered statistically significant.

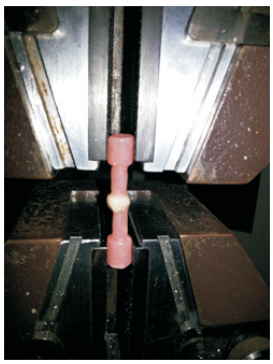


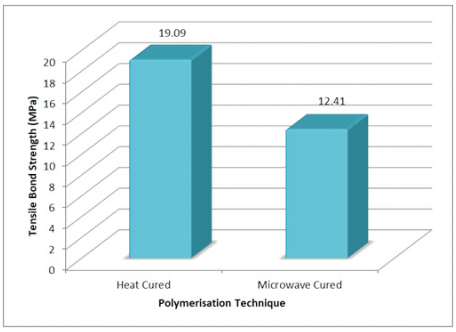
Figure III- Tensile testing of sample Figure IV-Shear testing of sample

RESULTS:

Within the limitations of the study, all the specimens were tested for tensile and shear bond strength respectively in universal testing machine. Unpaired t-test applied for comparison of two group's means. It is used when two separate sets of independent and identically distributed samples are obtained, one from each of the two populations being compared. This test is only used when both the two distributions follow normal curve (Gaussian distribution) and have the same variance. All the failure types were Adhesive which means between acrylic and tooth. Specimens with excess porosity and distortion were discarded. Table 1 and graph 1 shows comparative tensile strength values for both heat and microwave polymerised samples. Table 2 graph 2 shows Mean, Standard Deviation (SD), Minimum and Maximum values of Shear Bond Strength (MPa) of acrylic resin denture teeth to heat cured denture base and microwave cured denture base.

	n	Mean	SD	Minimum	Maximum
Heat Cured	20	19.09	4.67	11.35	27.77
Microwave Cured	20	12.41	3.97	4.73	18.35
Mean Difference	6.68				
t-test value	4.870				
df	38				
P value	0.000 (<0.001), Significant Difference				

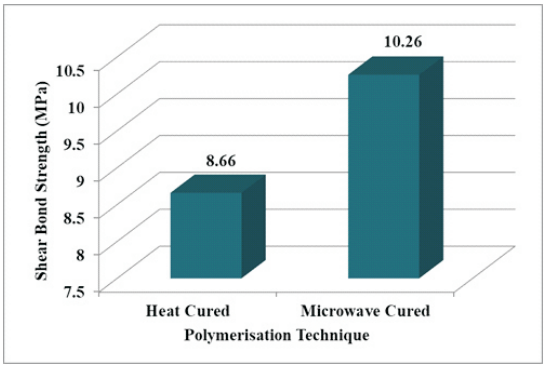
Table 1: Comparative tensile strength values for both heat and microwave polymerised samples



Graph 1- Comparative tensile strength values for both heat and microwave polymerised samples

	n	Mean	SD	Minimum	Maximum
Heat Cured	20	8.66	3.67	4.41	17.91
Microwave Cured	20	10.26	2.78	5.67	16.21
Mean Difference	-1.60				
t-test value	-1.550				
df	38+				
P value	0.129 (>0.05), Not Significant				

Table 2:Minimum and Maximum values of Shear Bond Strength (MPa) of acrylic resin denture teeth to heat cured denture base and microwave cured denture base.



Graph II: Comparative Shear bond strength values for both heat and microwave polymerised samples

DISCUSSION :

Debonding of acrylic teeth from denture base is a commonly encountered clinical problem. This adhesion may be influenced by: the type of resin base material and its physical and chemical properties; contamination of the bond interfaces during laboratorial procedures and the presence of impurities on tooth surface in close contact with the denture base.[7]Tooth structure and surface composition of the tooth ridge lap can affect bonding to the denture base resin. Currently, most of the available acrylic teeth are essentially composed by cross-linkedpolymethyl methacrylate. Cross-linking agents aregenerally used to improve strength, crazing and stainingresistance (Takahashi *et al.*). The cross-linked polymermatrix is not evenly distributed in the tooth structure and the gingival ridge lap area may not be as highly crosslinkedas the incisal area of the tooth. The higher degree of cross linking agents may restrict the diffusion of polymer chains into the denture base to form a polymernet work.[14]Cunningham and Benington and Thean et al[8,9]affirmed that the bond failure between denture base material and resin teeth remained a significant problem for treatment success and that wax or separating media contaminated surfaces produced highly significant weaker bonds. Wax removing is an important step in obtaining a consistently high bond strength value.[19] Bond strength can be significantly enhanced by monomer application and mechanical modification. Monomer application is the easiest method and also provides the highestbond strength values without any extracost and time.[15]

In the present study, The tensile strength ranged between 11.35 Mpa to 27.77 Mpa for the group 1 (conventional heat cured group), for the group II (microwave cured) tensile strength ranged from 4.73 to 18.35 Mpa. The P valve was 0.000 (<0.001) which suggested significant difference between the groups. The results were similar with the study conducted by Schneider, Curtis, And Clancy[5].The probable reason for these results might be that microwave-polymerization of resin resulted in less penetration of the tooth and denture base polymer networks. According to Vallittu and Ruyter[10], when a solvent comes in contact with a polymer, the surface of the polymer swells because of diffusion of the solvent into the polymer. Since the unpolymerized base material was in contact with the tooth surface for significantly less time with the microwave procedure than with the conventional procedure it may be that less swelling led to less penetration and thus to reduced bond strength.

Clinically the most important stress factors leading to bond failure are the shear stresses. For this reason the shear test was chosen as the more appropriate one to determine the bond strength under masticatory stresses.[7]For the shear bond testing, load was applied on the cingulum part of the central incisor to simulate forces during the clinical condition. Load was applied at the rate of 1mm/min by universal testing machine.

The shear bond strength ranged from 4.41 Mpa to 17.91 Mpa for group III while for group IV it ranged from 5.67 to 16.21

Mpa. The P value was 0.129 (>0.05) which was Not Significant. The shear bond strength of lucitone 199 to cross linked acrylic teeth (acryrock, ruthinium Italy) cured by both heat and microwave polymerization techniques was statistically not significant. Hence results of the present study indicate that microwave polymerization of the denture base resins is equivalent to that of heat polymerization technique.

From the statistical analysis it can be inferred that conventional heat cure resins can be effectively polymerized by the microwave energy without compromising the tooth resin bond. This process can also be carried out in clinical practice, which can significantly reduce the processing time and result in shear bond strength similar to that of conventional heat cure resins, less cumbersome equipment since the water bath can be eliminated, and a cleaner method of processing in the usual laboratory setting.

At low power, Reitz et al.[11] found that curing was achieved in 13 min at 90 W. In present study, curing time was 15 mins at 500 W, in order to achieve complete polymerization and to reduce porosity to a minimum level. Differences between the microwave ovens and materials may create these contrasting results.[12] Porosity in thicker areas may be evident which needs to be further evaluated. If longer curing at a lower power is carried out, porosity decreases significantly. It has been stated that choice of a suitable acrylic type, correct power and polymerization time is important in order to reduce porosity to a minimum level. The percentage porosity in microwave curing of conventional heat cured denture base resin is insignificant.[22]

CONCLUSION:

Within the limitations of this study following conclusions can be drawn:

The tensile bond strength specimens showed statistically significant differences in the bond strength. The tensile bond strength of the heat polymerized specimens was found to be higher.

The shear bond strength specimens did not showed statistically significant difference in the shear bond strength.

The shear bond strength of the microwave polymerized specimens was found to be equivalent to that of heat polymerized specimens.

The functional stresses experienced by the denture teeth are mostly lateral or shear stress. From present study it can be concluded that conventional heat cured resins can be effectively cured by microwave polymerization technique thereby reducing the denture processing time and chair side time.

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