ORIGINAL RESEARCH

Evaluation of the Bond Strength of Acrylic Teeth to Denture Base after Various Chemical Surface Treatments: An *In Vitro* Study

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Received on: 12 April 2024; *Accepted on*: 13 May 2024; *Published on*: 23 September 2024

Abstract

Aim: The purpose of the present study was to assess the bonding capacity and efficacy of acrylic teeth to denture bases following two different chemical surface treatments.

Materials and methods: A two-metal mold measuring 35 mm in length and 12 mm in diameter was created specifically for the investigation in order to standardize the wax pattern-based tooth attachment at 45°. Following standard protocol, 75 wax cylinder specimens were flasked, dewaxed, and surface treatment of teeth was done as follows with 25 samples in each group—group I: control group, group II: monomethyl methacrylate monomer group, group III: acetone group. The curing process was completed following the packing of the denture base material. The samples' shear bond strength was assessed using a universal testing machine. Every sample was taken out when it fractured, and the shear load (Newton, N) was noted. The significance of the variation in applied shear load was assessed using one-way analysis of variance (ANOVA) and *post hoc* ANOVA Tukey's honestly significant difference (HSD) test at the 5% level of significance.

Results: The maximum shear bond strength was found in the samples treated with acetone (183.21 $\pm$ 0.06) followed by samples treated with monomethyl methacrylate monomer (171.64 $\pm$ 0.12) and the control group (149.32 $\pm$ 0.04). A statistically significant difference was found between the different groups ($p < 0.001$).

Conclusion: In conclusion, according to the current study's findings, acetone chemical surface treatment of acrylic teeth produced the strongest bond when compared with the control group and monomethyl methacrylate monomer.

Clinical significance: In prosthodontic practice, artificial teeth regularly de-bond and separate from the denture base. A weak interface is produced when certain clinical conditions, such as ridge prominence, cause excessive cutting of the acrylic teeth and base. Where the denture base polymer meets the teeth's highly cross-linked matrix, it de-bonds adhesively. Therefore, the bonding between the acrylic teeth and the denture base material can be improved by the chemical surface treatment.

Keywords: Acetone, Acrylic teeth, Bond strength, Monomethyl methacrylate.

The Journal of Contemporary Dental Practice (2024): 10.5005/jp-journals-10024-3670

Introduction

The majority of individuals are extremely concerned about natural tooth loss, and maintaining oral health depends on replacing lost teeth with artificial ones, such dentures. The patient experiences severe psychological distress if the prosthesis is damaged. Because acrylic resin can chemically attach to the denture base resin, it is a favored material for denture teeth over porcelain. Highly cross-linked acrylic teeth with improved stain, abrasion, and fracture resistance have just been made available.[1]

De-bonding of acrylic resin teeth from the denture base is still a significant issue in daily practice, despite advancements in the production of denture base resins and acrylic teeth. De-bonded teeth typically occur in the anterior part of the denture and account for about 26–33% of denture repairs. The primary reasons for de-bonding in the anterior region could be the direction of pressures experienced during function and the availability of a reduced ridge lap surface. Wax residues on the ridge lap surface of denture teeth, the type of tooth material utilized, the polymerization technique used, processing variables including the length of the curing cycle, and the availability of monomer during the process are some of the factors that contribute to the failure at the acrylic tooth and denture base resin interface.[2]

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How to cite this article: Chaudhuri NG, Lahiri B, Francis NT, *et al*. Evaluation of the Bond Strength of Acrylic Teeth to Denture Base after Various Chemical Surface Treatments: An *In Vitro* Study. J Contemp Dent Pract 2024;25(6):514–517.

Source of support: Nil

Conflict of interest: None

Table 1: Comparison the mean shear bond strength of acrylic teeth to denture base after chemical surface treatment

		95% CI for mean			
Chemical surface treatment	*Mean ± SD*	*Lower*	*Upper*	*F value*	*p-value*
Group I: Control group	149.32 ± 0.04	137.26	158.07	27.826	0.001
Group II: Monomethyl methacrylate monomer group	171.64 ± 0.12	162.74	188.49		
Group III: Acetone group	183.21 ± 0.06	171.16	195.31		

A number of techniques have been used to improve the bonding between acrylic resin teeth and denture bases. These techniques can be divided into two categories: chemical and mechanical ridge lap area alteration, or a combination of the two.[3] Chemical procedures involve the application of monomers, solvents, or adhesive bonding agents, such as silane coupling agent (SCA), to the contact surfaces. In order to improve the development of the polymer network and increase monomer diffusion, chemical agents were employed. In the hopes that the solvent would improve monomer diffusion and polymer network formation, monomer has been employed with solvents such as dichloromethane or monomethyl methacrylate monomer. These include non-polymerizable solvents such as dichloromethane, trichloromethane, ethyl acetate, acetone, and dissolved PMMA. Many polymerization methods, including chemical, thermal, light, and microwave irradiation have been employed.[4]

To strengthen the binding for denture repair, solvents such as acetone and ethyl acetate were utilized as surface preparation agents.[5] However, a dearth of information on the impact of chemical agents on the adhesive strength of acrylic teeth. Hence the present study was conducted to assess the bonding capacity and efficacy of acrylic teeth to denture bases following the application of monomethyl methacrylate monomer and acetone chemical surface treatments.

Materials and Methods

Sample Preparation

The present *In vitro* study was conducted in Kalinga Institute of Dental Sciences, India during the year of 2019 and institutional approval was obtained for this study. A two-metal mold measuring 35 mm in length and 12 mm in diameter was created specifically for the investigation to standardize the wax pattern-based tooth attachment at 450. The wax cylinder was precisely shaped to accommodate the tooth only up to the central incisor's neck. These measurements matched the jig's measurements that were connected to the universal testing machine. Because it uses a single maxillary front tooth to test the bond strength between denture base resin and acrylic resin teeth—de-bonding typically occurs in the maxillary anterior teeth—standard acrylic teeth were chosen due to their reliability. The teeth were attached to 75 of these wax cylinders at the appropriate places. Three groups of 25 samples each were assembled by randomly dividing and coding the wax samples. Following standard protocol, these 75 wax cylinder specimens were flasked, dewaxed, and teeth were surface-treated in the method mentioned below.

Group I: Control Group

All of the teeth's ridge laps were untreated.

Group II: Monomethyl Methacrylate Monomer Group

The ridge lap was painted with a microbrush once using monomethyl methacrylate monomer (Dentsply, India), and it was left for three minutes before packing.

Group III: Acetone Group

The ridge lap area of the teeth received continuous brush application of acetone (Merck Specialties Pvt. Ltd., Mumbai, India) for 30 seconds. The surfaces were fully cleaned after a 30-second application duration. Packing with denture base resin was completed in 30 seconds.

Packing of Denture Base Material and Curing Cycle

Following the packaging of the denture base material (Trevalon; Dentsply, India), the curing process was carried out in accordance with the guidelines provided by the manufacturer. The flasks were placed in the Acrylizer (Unident Dental Equipments) and submerged in room temperature water. The samples were processed using two different curing cycles: a short cycle in which the resin is processed for about 2 hours at 74°C, followed by an hour-long rise in temperature to 100°C in the water bath, and a long cycle in which the resin is processed for 8 hours in a 74°C water bath, followed by an hour-long rise in temperature to 100°C. The acrylic samples were polished and then put to testing.

Evaluation of Bond Strength of Acrylic Teeth to Denture Base after Chemical Surface Treatment

The samples' shear bond strengths were assessed using a universal testing machine (Instron Corp). Force was applied by a stainless steel pin, 1 mm in diameter, at an angle of 130° to the long axis of the tooth at a crosshead speed of 5 mm/min until fracture occurred. Every sample was taken out when it fractured, and the shear load (Newton, N) was noted.

Statistical Analysis

The software program SPSS for Windows 17.0 (SPSS Inc., Chicago, IL) was used to conduct the statistical analysis. The significance of the applied shear load difference (Newton, N) was assessed using one-way analysis of variance (ANOVA) and *post hoc* ANOVA Tukey's honestly significant difference (HSD) test at a 5% level of significance to determine the superiority of the surface treatments over the control (which lacked any surface treatment) and to compare the effects of the two surface treatments among themselves.

Results

Table 1 depicts the comparison of the mean shear bond strength of acrylic teeth to denture base after chemical surface treatment. The maximum shear bond strength was found in the samples treated with acetone (183.21 ± 0.06) followed by samples treated with

Table 2: Pairwise comparison between the bond strength of acrylic teeth to denture base after chemical surface treatment

Chemical surface treatment	*Mean difference*	*Significance*
Control vs monomethyl methacrylate monomer group	−22.32	0.001
Control vs acetone group	−33.89	0.001
Monomethyl methacrylate monomer group vs acetone group	−11.57	0.588

monomethyl methacrylate monomer (171.64 ± 0.12) and control group (149.32 ± 0.04). A statistically significant difference was found between the different groups ($p < 0.001$).

A pairwise comparison between the bond strength of acrylic teeth to denture base after chemical surface treatment is given in Table 2. Highly significant difference was found between the control vs monomethyl methacrylate monomer group and the control vs acetone group ($p < 0.001$). There was no significant difference found between the monomethyl methacrylate monomer group vs the acetone group ($p > 0.001$).

Discussion

Many variables, including excessive stress, fatigue, inadequate tooth cleaning during denture base resin placement, contamination from wax and tinfoil substitutes, faulty material properties, and improper heat-polymerizing technique can lead to bonding failures between artificial teeth and heat-polymerized denture base resins. Various elements have been identified as responsible for the strong connection between the denture base and the denture tooth. Technical ways to strengthen this relationship have been suggested by the data obtained from the investigation of these components using various testing methods.[6,7]

According to estimates, tooth de-bonding occurs in 22–30% of denture restorations; this mainly occurs in the anterior area of the denture. The direction of the pressures from frequent chewing and unintentional falling, as well as mechanical fatigue and a reduced ridge lap surface area available for bonding in the anterior region, may be the cause of this detachment.[8]

The composition of the denture base resin, surface modification of the ridge lap area, and the type of acrylic tooth are the main factors influencing the bond strength. The denture base resin's polymer network must react with the acrylic tooth polymer to form an interpenetrating polymer network (IPN), and the polymerizing denture base resin must come into physical contact with the denture tooth resin in order to achieve a bond between the acrylic teeth and the base resin. Incompatible surface conditions at the tooth-base interface may cause de-bonding. The majority of manufacturers construct dentures and base resin for teeth with little to no reference to the compatibility or bond strength between the teeth and base materials, which may affect the longevity and possibility of repair.[9]

The samples treated with acetone had the highest shear bond strength in the current investigation, followed by those treated with monomethyl methacrylate monomer and the control group. The chemical compound acetone has the formula $(CH_3)_2CO$. It is the most basic of the ketones; it is a colorless, combustible liquid that is mobile. Acetone is used by the pharmaceutical industry as a denaturation agent in denatured alcohol. It is miscible with water and works well as a solvent for most plastics and synthetic fibers, including those used in laboratory bottles made of polystyrene, polycarbonate, and some forms of polypropylene. The monomethyl methacrylate applied on the ridge lap area also acts by removing the surface contaminants like wax remnants and tin foil substitute used as cold mold seal, thereby providing more physical contact between the polymerizing denture base resins and denture tooth resin.[10,11]

When acetone was used, the surface became smoother but had more surface pits. In a study similar to this one, Sarac YS et al.[12] discovered that when acetone was applied to PMMA surface texture, the surface seemed smoother and cleaner than when monomer was used.

It was found by Dalal et al.[13] that regardless of the type of heat-cured acrylic resin utilized, specimens with poor bond strengths were produced by a short curing cycle. Extended cure periods yielded specimens with satisfactory binding strengths. Shear pressures are, from a clinical perspective, the most significant stressors that cause bond breakdown. Because of this, the shear test was deemed to be a better method for assessing the bond's strength under masticatory forces.[14]

The monomethyl methacrylate monomer bond strength in this investigation was superior to that of the control group. This was consistent with the findings of Papozoglou E and Vasilas AI[15] and Adeyemi et al.[16] which demonstrated a noteworthy enhancement in bond strength upon treatment with monomethyl methacrylate monomer. Using monomer liquid to prime the denture tooth surface produced a much stronger binding than using other methods. The application of monomer causes the polymer to swell, which increases the amount of monomer that penetrates the resin teeth and strengthens the joint between the denture base resin and the teeth of the denture. This is the explanation for the enhanced strength.

The current study's limitations include the fact that not all oral circumstances were simulated, chewing simulation and mechanical fatigue were not taken into account. It is important to use various surface treatments to gauge the varying penetration depth. Future research should examine how surface treatments affect various denture base materials.

Conclusion

On conclusion, according to the current study's findings, acetone chemical surface treatment of acrylic teeth produced the strongest bond when compared with the control group and monomethyl methacrylate monomer. Simple and quick tooth chemical surface treatment with acetone could be an effective option in decreasing bonding failures and also avoid repeated denture repairs improving patient satisfaction.

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