

Bonding Auto-Polymerising Acrylic Resin to Acrylic Denture Teeth

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Abstract - This study investigated the effect of surface treatments on the shear bond strength of an auto-polymerising acrylic resin cured to acrylic denture teeth. The surface treatments included a combination of grit-blasting and/or wetting the surface with monomer. Samples were prepared and then stored in water prior to shear testing. The results indicated that the application of monomer to the surface prior to bonding did not influence the bond strength. Grit blasting was found to significantly increase the bond strength.

KEY WORDS: Acrylic teeth, surface preparation, shear bond strength, grit blasting.

INTRODUCTION

The provision of quality temporary restorations is an essential stage of restorative dental care. Temporary restorations have several important functions namely, pulpal protection, appearance, preservation of tooth structure, occlusal stability and gingival health¹. A temporary crown should fulfil the following criteria:

- Have good marginal fit.
- Have good emergence profile and embrasure space.
- It must not violate the biological width of the gingiva.
- Have a highly polished surface.
- Have appropriate occlusion and contact with the opposing dentition.
- The material must be dense and free of porosity.

Types of temporary crown differ widely. These can be made at the chair-side by the dentist, provided by the manufacturer as prefabricated shells or made indirectly in the laboratory. Temporary crowns are most frequently made chairside, but where aesthetic considerations are paramount or if long-term temporaries are required, laboratory made restorations are the preferred option. Differing methods of fabrication exist in the laboratory; restorations can be made from heat or cold-cured acrylic resin or have a metal substructure. Speed of fabrication and aesthetic outcome are some of the deciding factors on which fabrication method to use.

A technique for fabricating an indirect temporary crown utilises a denture tooth facing where the palatal contours are completed in a tooth coloured auto-polymerising acrylic resin. The advantage of this technique is that a very aesthetic result can be produced. It is also a simple and efficient method of production. The strength of the bond

between the denture tooth facing and the autopolymerising acrylic resin may be a weakness in this restoration, resulting in the adhesive failure of the denture tooth. The preparation of the bonding surface is of interest since it is an indication of the potential survival of the restoration.

A problem with full and partial dentures is the debonding of teeth from the denture base resin material. Much investigation has been carried out regarding the bond of acrylic denture teeth to that of denture base resin material²⁻¹¹. A wide variety of standards exist as to the acceptable values for bond strength of denture teeth to denture base material⁴. Many reasons have been found for the debonding of denture teeth including, the compatibility of materials, the contamination of surfaces (e.g. with alginate mould seal or wax), heat or cold cure materials, curing temperature, treatment of surfaces, or mechanical retention⁴. Some studies have shown that the bond of denture teeth to the acrylic base can be improved with surface modifications^{7,8}. These include treating the surface with chemicals or grinding to create mechanical retention. Conflicting reports exist as to the advantage of surface treating with monomer prior to bonding. One study investigated the chemical treatment of debonded denture teeth as a means of repair⁷. Each group was treated with a different chemical, acetone, methylene chloride and monomer. The surface produced with these chemicals was viewed under SEM; a different surface texture was produced for each treatment. The treated surfaces were all found to be smoother than the control (the untreated group). The treated surfaces all exhibited significantly higher shear bond strength from the control, but did not differ significantly from each other. Another study investigated the optimum duration for methyl methacrylate (MMA) wetting of the surface of a denture tooth¹¹. They determined that a wetting time of 180 seconds produced the highest shear bond strength.

The purpose of this investigation was to investigate the effect of selected surface treatments on the shear bond strengths of an auto-polymerising acrylic resin cured to acrylic denture teeth. The hypotheses to be tested were that the selected physical and chemical surface treatments would result in increased shear bond strengths compared with no treatment.

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MATERIALS AND METHODS

The occlusal surface of acrylic molar denture teeth ($n = 80$), was ground to a flat finish using a tungsten carbide bur, cleaned with steam, and the teeth divided into 4 groups ($n = 4 \times 20$). Group 1 (control) - no surface treatment; Group 2 - grit-blasted with 110 micron aluminium oxide at 1 atmosphere pressure; Group 3 - grit-blasted with 110 micron aluminium oxide; and wetted with the monomer component of an auto-polymerising vinyl ethyl methacrylate resin (Snap™), for 180 seconds; Group 4 – wetted with the same monomer component, for 180 seconds, only. A quantity of the same acrylic resin was immediately cured to the surface in a commercial jig, placed in a pressure pot under 2 atmosphere pressure, to yield a cylindrical button 2mm in diameter for shear testing. After storage in water (37 ± 2)°C for 30 days each assembly was tested

in a tensometer, with a crosshead speed of (0.75 ± 0.2) mm/min (Figure 1). The specimens were analysed visually to determine the mode of failure.

Statistical analysis

As data did not meet the assumption of constant variability, a Kruskal-Wallis test was performed to compare shear bond strengths between the four groups (control, sandblasted, sandblasted and monomer, and monomer only). Post hoc comparisons were performed using Mann-Whitney U tests and employing the Bonferroni correction to ensure that an overall Type I error probability of 0.05 was not exceeded. Mean ranks, medians and interquartile ranges (IQR 25th to 75th percentile) are used for summarisation. Box plots are used to illustrate the findings (Figure 2). All tests were two-tailed. Significance was determined using $P < 0.05$.

RESULTS

A significant difference in shear bond strengths emerged between the four groups ($KW=39.1$, $P < 0.001$, Figure 2). Mean ranks and medians (interquartile ranges (IQR)) for each group are presented in Table 1. As illustrated in Figure 2 and shown in Table 1, each treatment involving grit-blasting (grit-blasted, $P < 0.001$; grit-blasted and monomer, $P < 0.001$) had significantly greater shear bond strengths compared to the control group. The two treatment groups involving grit-blasting did not differ significantly ($P=1.000$). Monomer only treatment did not differ significantly from the control group ($P=1.000$) and each treatment involving grit-blasting (grit-blasted, $P < 0.001$; grit-blasted and monomer, $P < 0.001$) had significantly greater shear bond strengths compared to the monomer only group. Median (interquartile range) shear bond strengths were (MPa): Group 1, 4.5 (4.1-5.8); Group 2, 13.0 (9.8-16.4); Group 3, 11.7 (8.8-16.0); Group 4, 5.4 (3.6-8.5).



Figure 1. Close fitting guillotine is positioned at the sample interface.

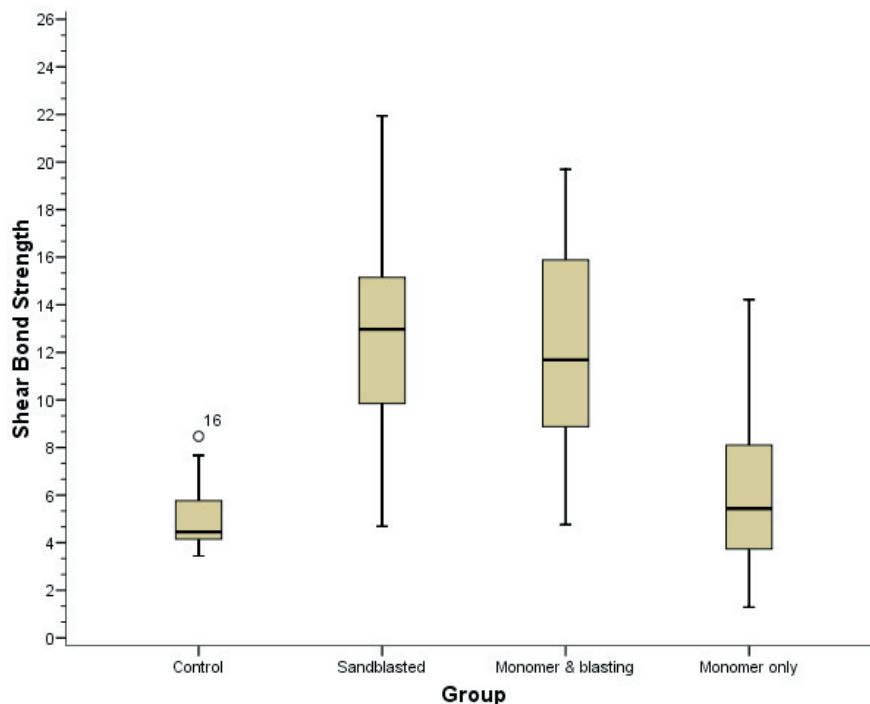


Figure 2. Box plots of Shear Bond Strengths (MPa) by Group.

Table 1. Medians (interquartile ranges) of Shear Bond Strength by Group.

Group	N	Mean rank	Median ¹	IQR
Control	19	19.6	4.5a	4.1 – 5.8
Sandblasted	17	55.0	13.0b	9.8 – 16.4
Sandblasted and monomer	17	51.8	11.7b	8.8 – 16.0
Monomer only	20	25.6	5.4a	3.6 – 8.5

¹Values within a column not sharing a common letter differ, P<0.05.
IQR = interquartile range

The mode of failure was found to be adhesive for all of the specimens.

DISCUSSION

The results indicate that wetting the surface of the tooth with monomer prior to acrylic bonding was redundant in these protocols. This finding was surprising and is at variance with others, including one study which concluded that chemical treatment of the surface of a denture tooth improved the bond strength to denture base resin material⁷. In the present study, the surface of the denture tooth was wetted for 180 seconds, this duration was based on the findings of another study which was found to result in the optimum bond strength of a denture tooth to denture base resin polymethyl methacrylate (PMMA)¹¹. It is possible that this wetting time is not optimal for the materials used in this study. Alternatively, the treatment of denture teeth with monomer and subsequent bonding of Snap™ resin (vinyl ethyl methacrylate) simply has no effect on the resultant bond strength.

Grit blasting alone was the most influencing factor on increasing the bond strength. This increased the bond strength almost threefold (13.0MPa) compared with the control group (4.5MPa). It appears that grit blasting creates a rough surface with an increased surface area for micro-mechanical interlocking of the resin to the denture tooth. A combination of grit blasting and wetting with monomer (11.7MPa) did not increase the bond strength compared to grit blasting alone (13.0MPa).

The mode of failure was adhesive for all of the specimens; this indicates that the bonded surface was the weakest area of the specimen. It is likely that the bond is one of mechanical retention and little or no chemical retention is being achieved. This is possibly due to the high crosslink density of the denture tooth. SEM studies of the surface of the materials would be required to elucidate the physical condition of the sandblasted and monomer treated specimens.

CONCLUSION

The optimum surface treatment for bonding auto-polymerising vinyl ethyl methacrylate resin to a denture tooth was found to be grit-blasting.

ACKNOWLEDGEMENT

Dr Kathleen O'Sullivan, Director of Statistical Consultancy Unit, School of Mathematical Sciences, University College Cork, for statistical advice

MANUFACTURERS' DETAILS

- Acrylic teeth- Replica Delphic, Schottlander and Davis, Ltd., Letchworth, Herts, SG6 2WD, England.
- Tungsten carbide bur- TC-Cutter 5970.060HP, Edenta, AG, Switzerland.
- Steam cleaner- Electronic steamer II, Amann Girschbach, Herrschaftswiesen 1, 6842 Kobiach, Austria.
- Aluminium oxide - Korox 110 micron, Bego, Wilhelm-Herbst-Strasse 1, D-28359 Bremen, Germany.
- Snap™- Parkell Bio-Materials Div., Farmingdale, NY 11735, USA.
- Commercial jig- Bencor Multi-T, 1287 Nicole Ave, London, Ontario, Canada.
- Huber water bath 118A and CC1 controller- Huber, D77656, Offenburg, Germany.
- Tensometer- Tinius Olsen H10KS, Tinius Olsen Ltd, Perrywood Business Park, Redhill, Surrey, UK.

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REFERENCES

1. Wassell RW, St George G, Ingledew RP, Steele JG. Crowns and other extra-coronal restorations: provisional restorations. *Br Dent J.* 2002; **192**: 619-30.
2. Cunningham JL, Benington IC. A new technique for determining the denture tooth bond. *J Oral Rehabil.* 1996; **23**(3): 202-9.
3. Geerts GA, Jooste CH. A comparison of the bond strengths of microwave- and water bath-cured denture material. *J Prosthet Dent.* 1993; **70**(5): 406-9.
4. Patil SB, Naveen BH and Patil NP. Bonding acrylic teeth to acrylic resin denture bases: a review. *Gerodontology* 2006; **23**: 131-9.
5. Vallitu PK. Bonding of resin teeth to the polymethyl methacrylate denture base material. *Acta Odontol Scand.* 1995; **53**(2): 99-104.
6. Kawara M, Carter JM, Ogle RE, Johnson RR. Bonding of plastic teeth to denture base resins. *J Prosthet Dent.* 1991; **66**(4): 566-71.
7. Sarac S, Sarac D, Kulunk T and Kulunk S. The effect of chemical surface treatments of different denture base resins on the shear bond strength of denture repair. *J Prosthet Dent.* 2005; **94**(3): 259-66.
8. Takahashi Y, Chai J, Takahashi T, Habu T. Bond strength of denture teeth to denture base resins. *Int J Prosthodont.* 2000; **13**(1): 59-65.
9. Catterlin RK, Plummer KD, Gulley ME. Effect of tinfoil substitute contamination on adhesion of resin denture tooth to its denture base. *J Prosthet Dent.* 1993; **69**(1): 57-9.
10. Papazoglou E and Vasilas A. Shear bond strengths for composite and autopolymerized acrylic resins bonded to acrylic resin denture teeth. *J Prosthet Dent.* 1999; **82**(9): 573-8.
11. Vallitu PK, Lassila VP, Lappalainen R. Wetting the repair surface with methyl methacrylate affects the transverse strength of repaired heat-polymerized resin. *J Prosthet Dent.* 1994; **72**(6): 639-43.