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Research Article

Effect of surface treatment on the bond strength of Multilithic denture teeth to heat-polymerized denture base resin

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ABSTRACT

Debonding of denture teeth from denture base resin is a considerable problem for patients who wear removable prosthesis. Different surface treatments were applied on the ridge lap area of teeth to manage this problem. The aim of this study was to evaluate the effect of various surface treatments of multilithic teeth on the shear bond strength of these teeth to denture base resin.88 maxillary first molar were selected and ground on the ridge-lap portion using a diamond bur. The teeth randomly divided in 8 groups according ridge lap surface treatments. The experimental groups included: controls(C), polish plus methyl methacrylate monomer (MMA) (CM), grinding (G), grinding plus MMA (GM), sandblast (S), sandblast plus MMA (SM), diatoric (D) and diatoric plus MMA (DM). After packing the acryl and polymerization each Specimens (n=11) was loaded by universal testing machine with cross head speed of 1 mm/min until fracture occurred. Peak load to dislodgment was recorded and statistically analyzed at fracture was recorded (One-way ANOVA, Tukey's HSD tests, P-value>0.05).The specimens were then examined using optical microscope to determine failure mode as adhesive, cohesive or mixed. The mean bond strength in polish plus MMA was significantly (P-value>0.001) higher than the other group, and it followed by diatoric plus MMA. The mean bond strength of groups diatoric, grinding, grinding plus MMA and sandblast plus MMA was not have statistically differences (P-value>0.05) and there were higher than sandblast group. The least bond strength belongs to control group.Monomer treatment of polished surfaces of denture teeth resulted in high bond strength than other groups. The diatoric and grinding had significant improvement in bond strength rather than sandblasting.

Keywords: Shear bond strength, Surface treatment, Multilithic denture teeth

INTRODUCTION

The literature showed approximately 20% to 33% of denture repairs are due to debonded teeth, frequently causing distress and cost to the patients (1, 2). followed the current use of implant supported prosthesis, particularly over dentures, the magnitude of biting forces was increased and subsequently mechanical failures such as tooth debonding may be common(3, 4)Denture tooth debonding depends on several factors such as tooth and base properties(5, 6),polymerization methods(7)and conditions of tooth-base interface(8, 9). After developing composite denture teeth in 1980(10),in order to overcoming some of their problems, the multhilithic teeth were created by combination of composite and acrylic resin. These teeth have high abrasion resistance of composite resins and bonding properties of acrylic resins(11, 12).

Attempts to improve bond strength of denture teeth through conditioning of tooth-base interface have involved mechanical (such as grinding, diatoric recess, retention grooves, ,airborne-particle abrasion and laser treatment)(13-15) and chemical (such as monomers adhesives, organic solvents, curing agents)(16) preparation of denture tooth ridge lap. It been determined that ridge lap painting with methyl methacrylate monomer increased bond strength significantly(9, 17, 18).contrary Some authors resulted that applying monomer did not affect bond strength (19-21)or reduced it(22).The effectiveness of mechanical treatment in ridge lap area of denture teeth was rejected by some authors(1, 20, 23).On the other hand the importance of different mechanical regimen was surveyed. Bragaglia et al showed that ridge lap grinding with Al2o3 stone increased bond strength rather than cutting a diatoric(20).Mosharraf and mechanic reported higher bond strength in diatoric preparation compared with grinding (14).It been showed sandblasting of ridge lap surface versus grinding significantly improved bond strength(15) .Barpal et al reported broken glaze surface with sandblasting result in lower failure load in Lucitone 199 heat polymerized denture base resin(23).

The variability of ridge lap area treatments and results increases the need for a study to find a reliable surface treatment of denture teeth leading to appropriate bond strength with acrylic denture base. The purpose of this study was to evaluate the effect of various mechanical surface treatments with or without chemical treatment on the shear bond strength of multilithic denture teeth to heat polymerized acrylic resin. The null hypothesis was that neither type of mechanical treatment nor monomer application would affect shear bond strength between multilithic denture teeth and acrylic denture base resins.

MATERIAL & METHODS

In this experimental in vitro study, 88 maxillary first molar multilithic teeth (Apple, Ideal Makou, Tehran , Iran) were selected. The ridge lap surface of all teeth reduced 1 mm simulating ridge adaptation using a silicon positioning mold in order to keep uniform surface area for bonding and isolate the ridge lap area. The ridge lap surfaces were ground with a diamond bur (acrylic grinder AG860-085SC-HP; NTI-Kahla GmbH, Germany) at speed of 15000 rpm. A new bur was used after preparation of 11 teeth to ensure similar efficacy. The grinded teeth were separated randomly into 4 primary groups (n=22) according the type of mechanical conditioning of ridge lap area.

The control group (C) was polished with a set of acrylic polishers (NTI-Kahla GmbH, Germany) according to manufacturer’s instruction .The diatoric recess group (D) was prepared with a 1.6 mm hole using a round bur (H1-016; NTI-Kahla GmbH, Germany) in the center of ridge lap , then a diatoric undercut (2mm deep×2.5mm diameter) was created with an inverted cone bur (H2-018; NTI-Kahla GmbH, Germany).

The sandblast group (S) was airborne-particle abraded with 50-μm aluminum oxide particles (Kavo EWL, Type 5423, Biberach, Germany) under 2 bar pressure at a distance of 5 mm for 5 seconds using silicon positioning mold. 22 remained teeth did not receive any treatment unless primary grinding(G). All teeth were cleaned ultrasonically for 10 minutes in distilled water to remove any residual debris.

Teeth were attached to the cylindrical wax patterns (25 mm × 20 mm) while the long axis of each tooth was perpendicular to upper surface of wax cylinder. Wax level was 1mm high from cervical area to simulate most realistic clinical condition(20). The tooth-wax combinations were conventionally molded and then wax was boiled out with a powdered detergent to clean the ridge lap surfaces of teeth.

Before packing heat polymerized acryl in the mold, the ridge lap surface of 11 teeth from each 4 mentioned groups were primed with MMA monomer (Acropars, Tehran, Iran) for 180 seconds(24). Therefore 4 chemically treated groups (CM, DM, SM and GM) were prepared. Samples cured using long-cycle heat polymerized processing, following the manufacturer's instructions (Acropars, Tehran, Iran). The polymerized specimens were deflasked and cleaned with a carbide bur (Tungsten carbide cutter, HF079CN-040; NTI-Kahla GmbH, Germany) to remove any excess acrylic resin or processing material. Special care was given to the bonding surfaces to ensure no extra grinding was done. All samples were stored in distilled water at 37°C for 7 days. Then treated with thermocycling;1000 cycles alternated from 5 to 55°C with a dwell time of 30 seconds(TC_300,Vafaei Industrial, Iran)

For cyclic loading, the specimens were mounted in a coil cycler electromechanical fatigue machine (Fatigue Tester; Proto-Tech, Portland, Ore) for sinusoidal loading treatment at 2 Hz for 14,400 cycles, from 0 to 22 N, in a 37°C distilled water bath.

The shear bond strength test was performed on a universal testing machine (MTD-500 SD Mechatronik, Feldkirchen-Westerham, Germany) using a cross head speed of 1 mm/min until failure occurred and load at fracture was recorded for each specimen. The applied force was directed on occlusal third of palatal surface of the teeth.

After shear bond testing, the samples were examined at the debonded surfaces with optical microscope (Genus, Germany) at <10 magnifications. The failure mode was classified as a cohesive (either within the acrylic resin or the denture tooth), adhesive (between the resin and the tooth interface) or mixed (both adhesive and cohesive) failure.

The data were statistically analyzed, using a 1-way analysis of variance (ANOVA) and mean values were compared by Tukey HSD post hoc test honestly significant difference (P<0.05).

RESULTS

The mean fracture strength between composite denture teeth and heat polymerized denture base resin conditioned by four mechanical surface treatments with or without monomer application are shown in Table1. The 1- way ANOVA comparing surface treatment types showed significant differences between groups (P<0.001). The T-test comparing the mechanical treatment versus joined mechanical and chemical treatments demonstrated that there was a significant difference among two types of treatments (P□0.001).

The Tukey HSD post hoc evaluation revealed that only groups C, CM and S showed significant differences versus other groups. The DM group showed significant differences compared with other groups except with GM group. There were no statistically significant differences between remained groups.

The Tukey HSD post hoc evaluation revealed that the mean shear bond strength of the repolished monomer treated group (CM) was significantly higher than the other groups (P<0.001) and it was followed by the DM group (P-value<0.05). The least shear bond strength was recorded for control group(C) (P-value<0.001) and it was followed by the sandblast(S) group (P-value<0.05). There were no significant differences between the other groups (P-value<0.05).

Results of the failure mode analysis are shown in figure 1.The control group displayed 80% adhesive failure. The CM group displayed nearly 9% adhesive and 63% cohesive failure.

Table 1: Mean and SD values (N) of shear bond strength for each group

Surface Treatment Group	Means	SD
C	104.45	21.07a
S	177.36	24.78b
G	217.09	27.87c
D	243.18	27.00c
CM	342.09	45.32e
SM	222.09	32.15c
GM	254.73	28.25dc
DM	281.91	24.02d

C, repolished control group; S, sandblast group; G, ground group; D, diatoric group; CM, repolished monomer group; SM, sandblast monomer group; GM, ground monomer group; DM, diatoric monomer group

Identical superscripted lowercase letters indicate that values are not statistically different (P> 0.05)

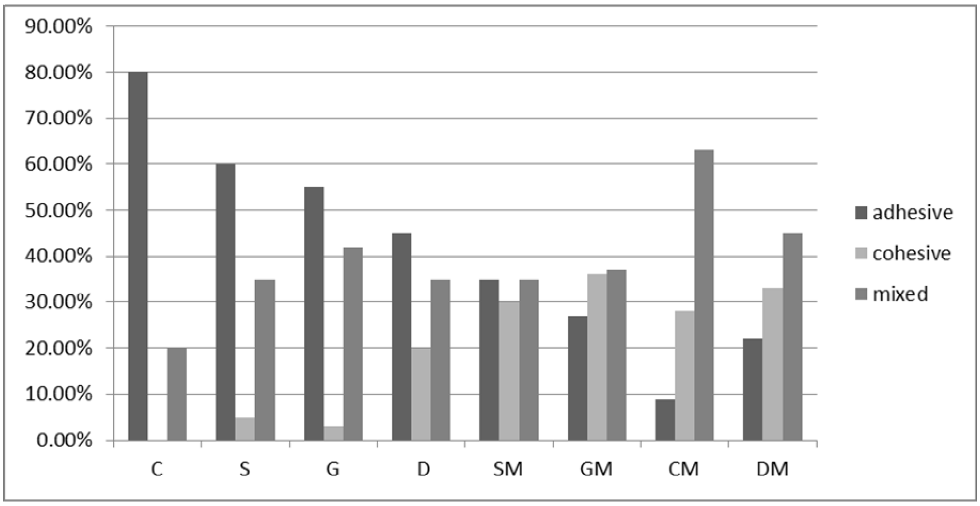

Fig1: Fracture analysis of different surface treatment groups

DISCUSSION

This study evaluated the bond strength of multilithic teeth with different surface treatment to resin denture base. The null hypothesis could be partially rejected.

T test showed, groups with chemical surface treatment had significantly higher bond strength than groups only mechanically treated.

Vallitu et al (25)showed the swelling effect of resin teeth caused by methyl methacrylate monomers. Monomer can dissolve and diffuse in to polymethyl methacrylate structure of denture teeth so facilitate infiltration of resin denture base to form an interpenetrating polymer network with the tooth during polymerization. Through this mechanism, monomer application significantly increased bond strength .Adhesive failure in chemical treated groups was less than groups with mechanical treatment showing softening and swelling effect of monomer on polymer denture teeth. Chaves et al showed monomer treatment did not improve the bond strength. It may be due to insufficient time of monomer application (60 s).Barbosa et al explained different protocols of monomer treatment did not affect on the bond strength.

Monomer application on polished surfaces of teeth in CM group caused significantly higher bond strength than other groups. This result is similar to previous studies showed that painting unmodified ridge lap surfaces with monomer resulted in highest bond strength(23, 26).Greets and Jooste found that priming of acrylic teeth with monomer resulted higher bond strength than sandblasting of those(9) .While Rupp et al(27) and morrow et al (22)support lower values of bond after monomer painting on unmodified ridge lap surface. The polished surfaces of CM group couldn't be same as a glaze or unmodified surface and may help to monomer penetration.

Wax contamination seems to be the major cause of tooth debonding (21, 22, 28).Rough surfaces retained more wax than smooth surfaces(29).so polished surfaces of CM group could be easily cleaned from the wax residue by boiling water, detergent and monomer rather than other groups.

DM group showed numerically higher bond strength than GM group but without statistical difference. Analysis of failure mode showed more mixed failure in DM group rather GM group. previous studies determined that mixed fracture is the most common failure mode when a correctly chemical bond has formed(30).Meng et al(13) showed a mixture of micro and macromechanical retention topography in the diatoric recess group by SEM. This may cause higher bond strength rather grinding and sandblasting. In the present study preparation of a diatoric on ridge lap area (group D) improved bond strength versus grinding (group G) but there was no significant difference. Although adhesive failure of group D(45%) was less than group G(55%).Previous studies reported that diatoric preparation in the ridge lap area of denture teeth increased the bond strength(13, 16).Some authors showed diatoric recess preparation and grinding have same effect on bond strength. In our study near 86% of cohesive failures occurred at the denture base. Also, border sharpness of diatorics can cause stress concentration and denture base fracture at region. Low cohesive strength of denture base resin may fail keeping diatorics filled with acryl.

Lower bond strength of SM group than GM group was not statistically different but adhesive failure in SM group (35%)was higher than GM group(27%).This may be as a result of low efficacy of 50µm Al2o3 than roughness made with grinding, Just as shown in group S versus group G($P<0.05$.)Chung et al (15) reported a significant increase in bond strength when ridge lap area was roughened by sandblasting with 250 µm AL2O3 instead of microblasting with 50 µm AL2O3 for glaze breaking that used by Barpel et al(23)and Meng et al(13).sever irregularities and undercuts were apparent in SEM pictures of their research(15).Mahadevan et al showed improvement in bond strength by sandblasting with 250 µm particles.

The least bond strength related to group C as a control which didn't receive any mechanical or chemical treatment .As previously mentioned polished surfaces of this group couldn't be same as a glaze or unmodified surface. 80% of the fractures in this group were adhesive indicating the importance of surface treatment of denture teeth to better bond with resin denture base.

In this study, 14% of cohesive fracture in all specimens occurred at the tooth indicating appropriate cohesive strength of applied multilithic teeth.

In this study surface treated of teeth did not survey by SEM that was a limitation. Finally, there were several new proposals for further investigation. Since the polished plus monomer group had the highest bond strength, a research involving treatment unmodified teeth with monomer and other bonding agents should be considered. Also the other types of teeth and denture base resins are used.

CONCLUSION

Within the limitations of this study, the following conclusions were drawn:

1-There was a significant higher bond strength in groups treated chemically rather mechanically.

2-The polished and monomer group demonstrated significantly higher, shear bond strength than the other groups.

3-The diatoric and grinding groups demonstrated significantly higher shear bond strength than sandblast and control groups.

Competing Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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