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INFLUENCE OF POPULAR BEVERAGES AND SURFACE TREATMENTS ON BOND STRENGTH OF REPAIRED CAD/CAM RESIN COMPOSITE RESTORATIVE MATERIAL

Eman N Diab*, *and* Rehab M Alwakeb*

ABSTRACT

Aim: This study was conducted to evaluate the effect of various beverages and surface treatments on micro-tensile bond strength of repaired CAD/CAM resin composite restorations.

Materials and methods: A total of 12 plates of breCAM High-impact polymer composite (HIPC) (10 × 10 × 2 mm) were used. The plates were randomly assigned to different surface treatments as follow: medium coarse diamond bur, Air abrasion, (Er:YAG) laser and No surface treatment as control group. After the surface treatment was applied, all specimens were repaired with Z250XT resin composite restorative material. The plates were sectioned into slices to produce beams for (μTBS) (n=50) for each group. Each group was then divided randomly into five subgroups according to the beverage used: Distilled water 37° C, Tea 37°C, Tea 60°C, Cola 37°C and Cola 4°C (n=10). The specimens were stored in these solutions for 28 days and then subjected to micro-tensile bond strength(µTBS) test. Universal testing machine was used for (µTBS) test and failure mode analysis was detected for each fractured beam.

Results: Air abrasion group showed the highest bond strength value compared to either bur or laser treated groups. Both Tea and Cola at 37°C presented significantly lower (µTBS) than Distilled water. The Laser group (Tea 60°C) exhibited a statistically significant lower (µTBS) value than (Tea37°C). The specimens immersed in (cola4°C) showed statistically significant higher (µTBS) values than (cola37°C).

Conclusions: Surface treatment using air abrasion improves the (μTBS) of CAD/CAM resin composite to repair material. Long term consumption of cola and tea beverages deteriorate (μTBS) of CAD/CAM resin composite. High temperature of tea beverage had a significant negative influence on (μTBS) of laser treated tested group. Finally patients who received CAD/CAM resin composite repair should be advised to drink cola at 4°c.

KEYWORDS: CAD/CAM resin composite restorations, nanohybrid resin composite, repair, microtensile bond strength, beverages, temperature.

* Lecturer at Operative Dentistry Department, Faculty of Dentistry, Ain Shams University

INTRODUCTION

Dental practices have recently extensively used computer-aided design/computer-aided manufacturing (CAD/CAM) technology. The development of new materials and improvements in adhesive technology are mostly to blame for this.[1] High-stability aesthetic materials and time-saving restoration manufacturing are offered by CAD/CAM technologies.[2]

In dentistry, composite blocks (CBs) have been used extensively. The preferred material for single crowns, inlays, and onlays is CBs. Compared to ceramic restorations, CBs are less abrasive to the opposing dentition, have a modulus of elasticity that is closer to dentin, and are less expensive.[3] However, with long-term serviceability, CAD/CAM composite resin restorations may experience a number of serious issues, including fractures, color changes, and secondary caries. Depending on the degree of damage, there are two treatment alternatives in such cases: restoration replacement or repair.[4]

Compared to replacing the indirect restorations entirely, intraoral repair of damaged restorations with composite resin is more conservative, less expensive, causes less pulpal stress and tooth tissue loss, and can be completed in a single visit.[5] Because of their high degree of conversion, CAD/CAM restorations are thought to be difficult to repair, which makes intraoral repair harder.[6]

The damaged part of CAD/CAM resin-based restorations should be treated before applying the repair material. It has been demonstrated in earlier research that various surface treatments, including air abrasion, tribochemical silica coating, diamond burs, mechanical roughening with silicon carbide paper, acid etching, silane coupling agents, and universal adhesive application can strengthen the resin composite's repair bond to the CAD/CAM blocks.[1]

Due to recent advancements in dental laser technology, erbium-doped yttrium aluminum garnet (Er:YAG) laser surface treatment is being regarded as an alternative to other surface treatments. Laser applications are widely utilized in dentistry. It can improve the adhesion of new repair material to old, damaged restorations and raise the porosities of the aged composite resin.[7]

Composite-based dental restorations are constantly subjected to various harmful elements in the oral cavity. The restorations are significantly impacted by oral environment variables such temperature variations, masticatory stresses, and chemicals from food and drink. In the oral environment, exposure to saliva, food ingredients, and drinks can degrade restorations chemically and negatively impact their esthetics and physical characteristics, including surface roughness, microhardness, and translucency.[8]

Few studies have examined the effects of beverage types and temperatures on the bond strength of repaired CAD/CAM restorations.The purpose of this study is to examine how different surface treatments and widely consumed beverages affect the bond strength of repaired restorations. The null hypothesis was that the (µTBS) of the repaired CAD/CAM resin-composite restorations would not be impacted by various surface treatments or beverages.

MATERIALS AND METHODS

The current study evaluated (µTBS) of an industrial prepolymerized block of indirect resin composite, with three different surface pretreatment methods. All materials categories, compositions, manufacturers and lot numbers were listed in table (1).

Sample size calculation

G*Power version 3.1.9.7 was used to calculate the sample size based on the findings of a prior *study (Yiğit et al., 2023)*[9]. To apply a two-sided statistical

TABLE (1) Material brand names/manufacturers, chemical compositions and lot number

Material	Manufacturer	Composition	Lot number
breCAM. High-impact polymer composite (HIPC) CAD/CAMresin composite disc	BreCAM.HIPC, Bredent, Eiterfeld, Germany	Matrix: ultracompact Thermoplastic amorphous cross-linked; PMMA Filler:ceramic microfiller (20%).	510761
Scotch bond Universal Plus Adhesive (SB)	3M; Seefeld, Germany	Adhesive: 2-HEMA 10-MDP, Bis-GMAethanol, photoinitiator, fillers, silane, water	7988470
Filtek™ Z-250XT composite resin Nanohybrid universal restorative A2 shade	3M; Seefeld, Germany	Bis-GMA, UDMA, Bis-EMA Zirconia/Silica (60%)	NE44583
Porcelain primer	Bisco,Inc. Schaumburg USA	Silane coupling agent in an alcohol and acetone base	2100008551

HEMA: ***2-hydroxyethyl methacrylate;*** **BisGMA:** ***Bisphenol-A glycidyl methacrylate;*** **10-MDP:** ***10-methacryloyloxydecyl dihydrogenphosphate; UDMA*****:** ***urethane dimethacrylate ; Bis-EMA; Bisphenol-A ethyle methacrylate***

test and reject the null hypothesis that there is no difference between groups, a power analysis was designed. Based on the findings of a previous study, an effect size (d) of 0.34 and an alpha level of 0.05 and beta of 0.2 were determined, i.e. power= 80%.). The predicted sample size (n) was 50 samples per group; divided into four groups, and each group is divided into five subgroups (a total 200 samples and a total 20 sub-groups). To detect the micro tensile bond strength (µTBS) of all the groups.

Preparation of CAD/CAM composite resin Specimens.

A high-precision low-speed water-cooled cutting machine (Micracut 151, Metkon, Bursa, Türkiye) was used to cut 12 CAD/CAM resin composite plate specimens (10 mm x 10 × mm × 2 mm). A permanent marker was used to identify each plate's bottom surface. Silicon carbide abrasive paper with grits of 600 and 1200 was used to grind and polish each of the specimen's upper surfaces under cold running water. Three minutes after polishing, distilled water ultrasonic cleaning was done. Before surface treatments, the specimens were kept in distilled water for a 24 hours.

Grouping of specimens.

The Specimens were assigned into 4 groups (n=3) CAD/CAM plates according to the method of surface pretreatment into; Group 1: no surface pretreatment serving as a negative control, Group 2: surface pretreatment by Air abrasion, Group (3): surface pretreatment by medium diamond bur and Group (4) ER: YAG laser surface pretreatment.

Surface pretreatments.

All groups of the study were divided into:

Group (1) No treatment: The specimens didn't receive any treatment and were considered as a control group.

Group (2) Air abrasion pretreatment: The specimens were subjected to air abrasion (air prophy, Guangdong, China) with 50µm aluminum oxide particles operating at 3 bars pressure at a 10mm distance and 90^{o} to the specimen surface for four seconds.[10]

Group (3) Diamond grinding bur pretreatment: The specimens were subjected to roughening with medium diamond coated(106-125 µm) tapered bur with rounded end (Oko dent,Germany). The surface was roughened for 5seconds with a high-speed handpiece (Sirona) at 200.000 rpm with water coolant. Roughening was done in one direction for five strokes. The bur is changed after every 5 specimens. The specimens were cleaned by water spray for 30 seconds then air-dried.

Group (4) Laser surface pretreatment: 2940 wavelength Er:YAG hard laser machine (Fontana; AT Fidelis,Ljubljana,Slovenia) in non-contact mode at power of 5 watt [11](250mj/pulse and 20 Hz) by a non-contact handpiece that was perpendicular to the surface of the specimen with optical fiber (1.3mm in diameter and 8mm in length) was utilized. The surfaces were irradiated with sweeping movement under water coolant for 20seconds with pulse duration of 50µs (super short pulse mode) at a distance of 1mm and then air dried for 20seconds. For standardization all steps were applied by a single operator.

After surface pretreatments were performed, the plates were placed in a special fabricated mold. All specimens were cleaned with 37% phosphoric acid which applied for 15 seconds, rinsed and dried. The surface of all groups was then silanized according to manufacturer's instructions using porcelain primer (Bisco) for 60 seconds and air dried for 5 seconds. Adhesive application and polymerization were accomplished according to manufacturer's instructions. The universal adhesive was applied by microbrush and light cured for 10 seconds with overlap technique using photopolymerizing LED unit (woodpecker B-cureplus, China). Fresh direct nanohybrid resin composite was built on top of the treated surface of each specimen in 2 layers of 2mm thickness. Each layer was photocured for 20s using overlap technique using LED light curing unit that was checked regularly with radiometer (to be of light output: 1200mw/cm2). After curing, the indirect/direct resin block was removed from the mold. All specimens were prepared by the same operator at 22.0°C (room temperature) and relative humidity of 50%. The specimens were stored in distilled water at 37 °C in the incubator (Biotech, Egypt) for 24 hours.

Specimens were sectioned into slices to produce beams with cross sectional area around one mm^2 as determined by a digital-caliper. using diamond disc at low speed under water cooling (Isomet 4000, Buehler Ltd., Lake Bluff, IL, USA). producing a total of approximately 20 beams per plate with total beams of 50/per group whereas peripheral beams were excluded forgiving insufficient resin composites at the margins. Each group was further divided into five sub groups (n=10) beams each according to the type and temperature of beverages.

Immersion in beverages:

Subgroup (1): Samples were immersed in distilled water at 37°C in an incubator (Biotech, Egypt) (as a control group).

Subgroup (2): Samples were immersed in 60°C tea solution, which was prepared by steeping 1tea bag (Lipton, UK) added to 200 ml of boiling distilled water and leaving it for 10 minutes then placed in an incubator at 60°C.

Subgroup (3): Samples were immersed in 37°C tea solution, which were prepared as group 2 and placed in an incubator at 37°C.

Subgroup (4) Samples were immersed in 37°C cola (coca-cola, Egypt) in an incubator.

Subgroup (5): Samples were immersed in 4°C cola in a refrigerator (Sharp, SJ 58C SL, Japan).

The specimens of each subgroup were immersed individually in a graduated test tube for 28 days during the test period. The solutions were renewed daily to prevent microbial growth. The specimens were washed with distilled water, left to dry, and then assessed for (µTBS) testing.

Microtensile bond strength testing.

Each beam was attached using cyanoacrylate glue to a stainless steel notched Geraldeli's jig 25 and tested under tension using universal test machine (Instron, MA, USA) at a rate of 0.5 mm/min crosshead speed till fracture. The broken bonded area of specimens and load were recorded. Microtensile bond strength was calculated with (Bluehill Lite software, Instron, MA, USA) in MPa using the following equation:σ (MPa)= f(newton)/A(mm^2) where f is the load recorded till being fractured, A is the surface area of each beam in mm^2.

Failure mode analysis.

To identify the failure modes—cohesive, adhesive, or mixed—the broken beams were examined under a stereomicroscope at 15X magnification (Figure 1). Adhesive failure is the kind of failure observed at the interface between restorative and repair material, whereas cohesive failure is the kind of failure whose boundaries stay inside the composite resin (either restorative or repair material). A mixed failure occurs when the restorative or repair material fails both cohesively and adhesively.[12]

RESULTS

Microtensie bond strength:

The results of (µTBS) tests are shown in (Table 2). Air abrasion group (Distilled water) showed the highest statistically significant bond strength value compared to other groups, while the lowest statistically significant (µTBS) value was noted in no surface treatment group(control). There was no statistically significant difference between tea and cola at (37°C) for the treated groups. Laser treated group (Tea 60°C) exhibited the lowest statistically significant (µTBS) value compared to the treated groups (Tea 37°C). At group (cola 4°C) showed higher statistically significant (µTBS) value than (cola 37°C) for all groups except for the diamond bur group which showed no statistically significant difference between them.

TABLE (2) Mean± SD values of (µTBS) Mpa results of three-way ANOVA and post hoc tests for the comparison between different tested groups

Groups	Water	Tea		Cola	
		Tea 60'c	Tea 37'c	Cola 37'c	Cola 4'c
No surface treatment	56.91±9.53aA	40.66±9.37cA	37.28±5.35cA	48.02±10.85bA	53.65±7.63aA
Diamond bur Group	45.98±11.79aB	38.02±6.70bA	38.43±5.09bA	37.05±8.28bB	40.30±9.37bB
Air abrasion Group	52.29±9.03aAB	34.69±5.68bA	17.55±4.28cC	36.31±2.86bB	53.23±7.49aA
Laser Group	45.06±10.03aB	5.79±1.28cB	23.63±3.91bB	21.44±4.35bC	43.39±8.20aB

Data are expressed mean± and standard deviation

Different small letters indicate significant difference at (p<0.05) among means in the same row and different capital letter indicates significant difference at (p<0.05) among means in the same column

Failure mode analysis

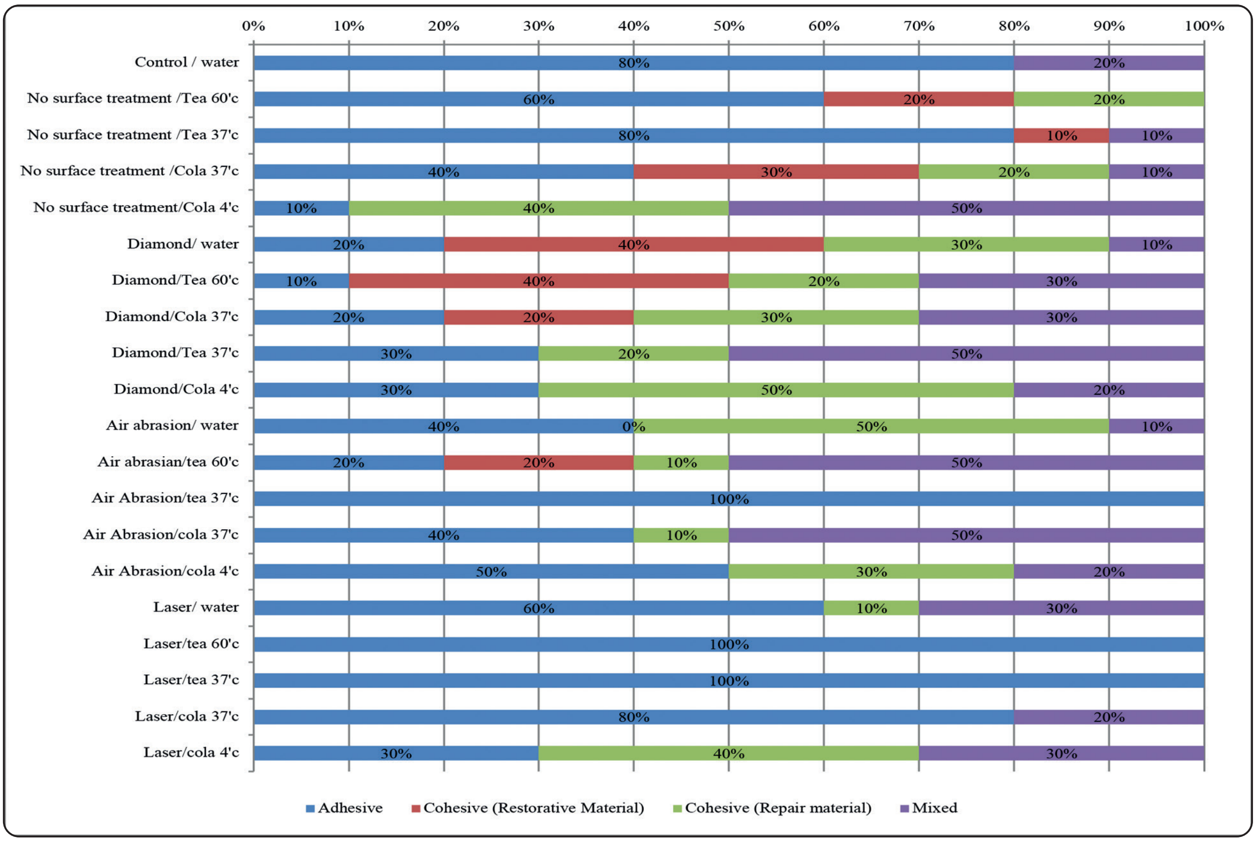

Fig. (1) Schematic diagram of failure mode analysis of the tested groups

DISCUSSION

CAD/CAM resin-based composite restorations manufacturing promotes high degree of conversion, leaving small number of free radicals available for bonding. Although a high degree of conversion improves the mechanical and physical properties of restoration. It may limit bonding of new direct resin composite on their surfaces making the intra oral repair more difficult. [13,14]

In this study mechanical surface treatment was performed by using different methods. Diamond bur has been reported to render retentive properties at the micro and macro levels[15]. Abrasion by airborne particles was effective in strengthening bonds. Nevertheless, it had a number of disadvantages, such as the potential for material weakness owing to crack development, the expensive device, the risk of health issues, excessive volume loss from the treated surface, and contamination of the surface with sand particles.[16] Recently, lasers like Er:YAG lasers have been used as an alternate method. According to reports, Er:YAG lasers are among the best laser types for cavity preparation because of their efficacy, particularly on dentin. Additionally, when used with proper water cooling, there is no risk of pulp damage. It can be used to repair composite resins for surface treatment utilizing ablation.[17].[18]10-methacryloyloxydecyldihydrogen phosphate monomer (MDP) was utilized in a universal adhesive. By creating a stable nanolayer at the adhesive contact, MDP monomer can interact chemically with hydroxyapatite.

μTBS test allows the use of a small amount of material and more uniform stress distribution during loading, which leads to higher bonding values and less failure rates.[19] Several *in vitro* studies have investigated methods to repair existing restorations by using various surface treatments and coating layers without taking into account aging of the repaired resin composite restorations.[2,4,20] In the present study, the type of surface treatment and the age of repaired composite resin restorative material were considered as remarkable variables.

Dental restorations are exposed to thermal changes in oral cavity due to food and hot or cold beverages.[21,22] As a result, this will cause aging and clinical failure in the restorative material. As Tea and cola are two of the most commonly consumed beverages so they were selected as immersion media. The period of 28 days immersion is reported in the literature to be equivalent more than two years.[23]

Based on the current results, surface preparation by air abrasion group (Distilled water group) showed the highest statistically significant bond strength value compared to either bur or laser treated groups. Differences in the results appeared to be due to different patterns of surface roughness following the use of these methods.[24,25] also many previous studies documented that the use of air abrasion has been shown to increase significantly the bond strength of repair direct.[26–28] and indirect resin composite restorations.[29–31]In addition, another study has shown that surface pretreatment of the indirect composite resin using air abrasion reported higher repair bond strength compared to surface preparation with Er,Cr:YSGG laser.[32] It has been reported that air abrasion caused exposure of fillers, covalent bond is formed between the fillers and the monomers of adhesive, after silane application resulting in enhancement of bond strength.[33] Nevertheless, the crystalline phase and matrix may be destroyed by laser use, and these two phases may also separate. Furthermore, lasers have the ability to create deep surface voids that weaken bonds and cause subsurface destruction. [32]

In the present study, the tested immersion tea and cola (37°C) had statistically decreased the bond strength of repaired restorations compared to distilled water. This might be due to the acidity of cola and tea which softened the matrix of the adhesive and the filler leached resulted in lowering the bond strength of the repaired restorative material.[34]These results were in accordance with Yigit, et al 2023**,** who observed that the bond strength decreased significantly in the tea and cola groups of repaired CAD/CAM Restorative Materials.[9]

The higher temperature (tea 60°C) caused significantly decrease in(μTBS) values than immersion in (tea 37°C) in laser treated group compared to other groups. This could be attributed to the unequal and lower microscopic depth of porosities created and excessive destruction of the matrix phase and crystals or layers damaged by high temperature induced by laser[35]. This damage was synergistically increased by high temperature of tea. All treated groups immersed in (cola37°C) showed lower statistically significant (μTBS) values than (cola 4°C). It was explained that acidic drinks have a higher erosive power (lower pH values) if they are consumed at high temperature.[36]So increasing the erosive capability of beverage induce solubility, surface erosion and dissolution of the materials. [37] Similarly, Tuncer, et al, 2013 investigated the effect of beverages' temperature on the surface roughness, hardness, and color stability of a composite resin, and they detected significant decrease in microhardness in the samples stored in 37°C cola. [38]

The null hypothesis was rejected based on the study's findings. The repair bond strength of CAD/CAM restorations may be impacted by intraoral factors, such as the patient's oral hygiene and mastication habits. Additional invivo research will help in enhancing the repair procedure for CAD/CAM restorations.

CONCLUSION

Within the limitations of the study, the following conclusions can be reached:

1. Surface treatment using Air abrasion followed by separate silane step application improves the (μTBS) of CAD/CAM resin composite to nanohybrid resin composite repair material.
2. Long term consumption of cola and tea beverages deteriorate (μTBS) of CAD/CAM resin composite to nanohybrid resin composite repair material.
3. High temperature of tea beverage had a significant negative influence on (μTBS) of laser treated tested group.
4. Patients who received CAD/CAM resin composite repair should be advised to drink cola at 4^{o}c.

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