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ORIGINAL RESEARCH

Semi-nutritious Liquids effect on Shear Bond Strength of Repaired Composite with Universal bonding

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Abstract

Background: Composite resins undergo changes in properties due to various oral irritations over time. This study analysed the effect of semi-nutritious liquids on the shear bond strength of repaired composite with universal bonding

Materials and methods: This laboratory experiment used 80 samples of rectangular cubes made of Z250 composite. The samples were subjected to Thermocycling in an incubator and divided into four experimental groups, one control group, and stored in different solutions for seven days. After the aging process, the samples were roughened, bonding was applied, and a composite cylinder was placed on the previous composite. The bond strength was then calculated with an Instron device, and the data were analyzed using one-way ANOVA and Bonferroni's post hoc test (α=0.05).

Results: Maximum average of bond strength in semi-nutrient liquids was recorded in descending order 25.53MPa for saliva , distilled water (20.24MPa), ethanol (18.04 MPa), citric acid (16.24 MPa), and Heptane (9.83 MPa), respectively.

Conclusions: Artificial saliva yielded the highest average bond strength, while distilled water, ethanol, citric acid, and heptane resulted in decreasing bond strength.

Key Words: Composite Resins; Food-simulating liquid; operative dentistry

Introduction

Resin composite is one of the most frequently used direct restorative materials in clinical practice due to the combination of favorable mechanical properties and excellent optical properties that mimic the tooth structure. However, resin composites have limitations related to long-term degradation and polymerization shrinkage, which influences the restoration longevity and often result in a repetitive restorative cycle. In cases where the imperfections of a composite restoration are minor, such as a slight loss of anatomical shape or external discoloration, it might not be necessary to entirely replace the restoration. The repair technique, however, may also serve as an alternative procedure to address these minor issues (1). A wide range of composite materials including hybrid, nano filled, silorane, ormocer and compomers are available for the direct restoration of teeth (2). Distinct mechanical properties of these materials are due to the type of monomer system, the composition of filler, the chemical structure of the filler coupling agents, and the resin matrix (silane), leading to the differential resistance of these composites against mechanical forces and chemical degradation (3).

One of the most common problems in restorative dentistry is the degradation and quality reduction of resin composite, which is caused by the interaction of these materials with saliva, food, and beverages (4). This is a serious problem due to the widespread use of composites (5-7). Changes in pH or moisture in the oral cavity may deteriorate the structure of composites over time (8). Previous studies have indicated that certain diets and beverages can cause surface deterioration of dental materials (9). Components of these foods can soften the organic components of the composites and cause the initiation of dispersed phase

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instability and consequently change in the surface microhardness (10).

Dental bonding are compounds that, in the restoration process, are applied to the tooth structure before placing the composite. The many features and quality of restoration depends on the procedure and properties of composite bonding to the tooth. The composition of the materials and their properties are determinant factors in the application of dental materials (11).

The eighth generation bonding is composed of hydrophilic and hydrophobic monomers (12). The hydrophilic groups interact with dental tissue and the hydrophobic group with restorative materials (due to composites' hydrophobicity). The chemical composition of these bonding includes activators, stabilizers, solvents, and, in some cases, inorganic reinforcement materials (13).

Studies have shown that alcohol-containing mouthwashes can affect the hardness of composite restorations and cause them to soften (14). Given the relationship between food ingredients and surface chemical degradation and composite erosion their application has been restricted (15, 6). Failure to address this problem, the hardness of the composites in the mouth will decrease over time and this will reduce the lifetime of restoration and recurrence of tooth decay (16). Several studies have been conducted to determine the impact of food-simulating liquids on different types of composites. Semi-food liquids such as 25, 50, and 70 percent ethanol and heptane are substances that are being used to simulate the effects of food ingredients on dental composites (5).

In a study by Ghavam et al (6), heptane increased the surface microhardness of Gradia (GC) and P60 (3M ESPE) composites. Torres et al. (8) also showed a significant reduction in the surface microhardness of composites subjected to solutions (e.g., artificial saliva, citric acid, ethanol, heptane), with the largest reduction observed in the heptane group.

The composition of the resin matrix and filler in terms of volume, particle size, distribution, and adhesion to the resin matrix can affect the level of microhardness of a composite (7, 17-19).

Several studies have investigated the effect of organic acids and food liquids on some of the surface properties of methacrylate-based composites such as abrasion, hardness, and surface roughness (20-24). However, the effect of these liquids on composites repaired with universal bonding agents has not been evaluated. This study aimed to determine the effect of food-simulating liquids on the microshear bond strength of composite to composite by universal bonding.

Materials and Methods

In this experimental study, Z250 universal composite (3M ESPE, USA) was used (Figure. 1).

Figure 1. Z250 composite

80 rectangular cubes were prepared with dimensions of 17×17 mm and a height of 15 mm using radiographic films. At the center of each acrylic cube, a hole with a diameter of 6 and a depth of 2 mm was created and filled with the desired composite (Figure 2). After being pressed by a glass slide, they were exposed to curing light (Dentamerica, Litex 695, Taiwan) for 20 seconds, without removing the slides.

Figure 2. Prepared samples

Then, the glass slide was removed from the surface of the samples and the composites were exposed to the light for another 20 seconds.

To simulate clinical conditions, the samples were subjected to 3400 cycles of Thermocycling procedure in an incubator with a temperature range between 5 and 55 °C.

Samples were divided into 5 groups of 16, including 4 experimental and one control group (immersion in distilled water). The samples in each experimental group were stored in either 2% citric acid, heptane, 75% ethanol, or artificial saliva at 37 °C for 7 days.

After aging process completed the surface of the samples were roughed by Opti Disc (Kerr Co, USA), a universal bonding agent (G-premium bond - GC Corporation, Tokyo, Japan) was applied according to the manufacturer's instructions. In brief, samples were etched with phosphoric acid for 10-15 seconds, and then washed and a bonding agent was applied to the samples using micro-brush. Afterward, the surface of the samples was dried for 5 to 10 seconds with gentle air pressure. For polymerization, the samples were exposed to curing light for 20 seconds and a composite cylinder with a diameter of 4 mm and a height of 2 mm was placed on the previous composite and the surface was polished. The samples were exposed to curing light for 20 seconds, and then the matrix was removed from the cylinders.

Then, the samples mounted in acrylic were placed in the Universal Testing Machine (SANTAM STM-20, Iran), and vertical force was applied at the speed of 0.5 mm/min until the separation of the upper composite from the junction point. The maximum force (Newton) was recorded, and the bond strength (MPa) was calculated by dividing the obtained force (Newton) to the surface unit area (mm) at the interface of two composites.

Considering the normality of the data distribution by Shapiro-wilk test, the data was analyzed with one-way ANOVA and Bonferroni post hoc test and SPSS software version 25. A significant level of 0.05 was considered.

Results

The mean bond strength (MPa) among the studied experimental groups showed a significant difference ($P < 0.001$) (Table 1). The mean bond strength for each experimental groups was as follows: artificial saliva with the highest strength (25.53), distilled water (20.24), ethanol (18.04), citric acid (16.24) and heptane with the least strength (9.83) (Figure3).

Table 1. Bond strength (MPa) in studied groups

Groups	Mean± SD	P value
distilled water	20.24±10.76	
citric acid	16.24±4.40	
artificial saliva	25.53±4.83	0.001
ethanol	18.04±4.08	
Heptane	9.83±3.65	

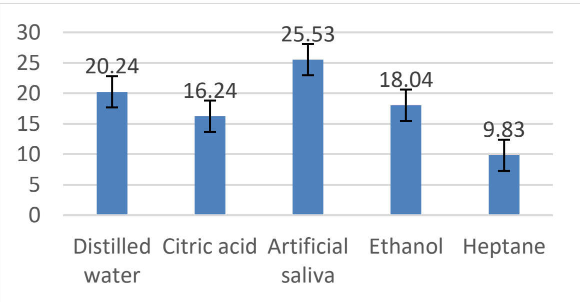

Figure 3. Mean bond strength (MPa) in studied groups

In a comparison of groups using a two-by-two method, it was found that the mean bond strength of samples that were treated with heptane was substantially lower than all other experimental groups ($P < 0.001$).

On the other hand, the mean bond strength of samples that were subjected to artificial saliva was significantly higher compared to the other experimental groups ($P < 0.001$). There was no significant difference found in mean bond strength between the saliva and control groups (distilled water) ($p= 0.136$) (Table2).

Table 2. Comparison of bond strength (MPa) in studied groups

Groups	Distilled water	Citric acid	Artificial saliva	ethanol	heptane
Distilled water	-	0.601	0.136	1.00	0.001*
Citric acid	0.601	-	0.001*	1.00	0.001*
Artificial saliva	0.136	0.001*	-	0.006*	0.001*
ethanol	1.00	1.00	0.006*	-	0.001*
heptane	0.001*	0.001*	0.001*	0.001*	-

* $P< 0.05$

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Discussion

The findings of this study revealed that artificial saliva has the highest mean bond strength among experimental groups. On the other hand, the bond strength of composites subjected to distilled water, ethanol, citric acid, and heptane, respectively, showed a decrease. Notably, heptane had the most significant impact on reducing the bond strength of the universal bonding agent in repaired composites. Therefore, it can be concluded that artificial saliva has the least and heptane has the greatest effect on the bond strength of the composite. Compared to artificial saliva, the bond strength of the composite in distilled water was lower despite the lack of solutes and a neutral environment. The resin matrix composites can potentially be damaged by organic solutions such as heptane (25). In addition, the degradation of inorganic filler particles plays a role in reducing the mechanical properties of a composite (26).

A study conducted by Irari et al. (27) examined the impact of artificial saliva on the shear bond strength of aged and fresh composites. The study found that the shear bond strength of aged composite at the repair interface was significantly reduced. This finding, however, is inconsistent with the results of the present study.

Potential disparities in our study outcomes may be attributed to the use of different composites. A study by Sideridou et al. (28), also evaluated the sorption properties of Food simulating liquids by Kalore GC nanohybrid composite. The results indicated that the sorption characteristics of a composite depend on the composite structure and its surrounding fluid, such that, absolute ethanol, artificial saliva, and heptane respectively had the highest to lowest sorption effect on the composite. These findings contrast with our study results.

We used nano-hybrid composites in our study, similar to the study by Sideridou et al. (28). However, our study found that the bond strength of the composite in artificial saliva was significantly higher than in ethanol. While Sideridou et al. (28) only investigated the effect of sorption on the composite, we explored the effect of liquid sorption on the bond strength of universal bondings and the composite. Additionally, our study used an 8th-generation bonding agent (universal bondings), whereas the study by Irari et al. (27) used a 7th-generation bonding agent.

Kooi et al. (29) conducted a study to explore the effect of Food-simulating liquids on the hardness and surface roughness of restorations by two types of composites: Z250 hybrid and CM nanohybrid. The composites were exposed to normal air, distilled water, 50% ethanol alcohol, and citric acid (0.02 N). The results indicated that all Food-simulating liquids, except citric acid, reduced the bond strength of the composites. In contrast with Kooi et al.'s study, our study indicated that distilled water after artificial saliva preserved the highest bond strength compared to other Food-simulating liquids. While Kooi et al (29), investigated the hardness and surface roughness of the composites, in our study, we explored the bond strength.

A study conducted by Yap et al. (18) found that food simulating liquids do not affect the surface characteristics of Dyract AP, Spectrum TPH, and F2000. However, Bis-GMA-based composites such as P50, Z100, and Cylox Plus were found to be susceptible to softening when exposed to food simulating liquids. Another study mentioned that ethanol solution is more effective in softening the composite surface compared to other food simulating liquids (21).

According to a study conducted by Yap et al. (30), the effect of food solvents on the strength of various dental materials was investigated. The materials studied included Filtek supreme nanofilled composite, Ormocer admira (Vocco), compomer (F2000), Z250 (3M) composite, and Ketac molar, a high viscosity glass ionomer. The research found that the strength of these materials was not affected by food solvents. However, this result is different from the findings of our study which was conducted on a different type of composite

Conclusion

Artificial saliva had the lowest effect on reducing bond strength, followed by distilled water, citric acid, and heptane, respectively.

Conflict of Interests: The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non-financial in this article.

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