EVALUATION OF SHEAR BOND STRENGTH OF RESIN COMPOSITE TO ENAMEL SURFACE OF PERMANENT TEETH ERODED BY TWO CARBONATED BEVERAGES (IN VITRO STUDY)

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ABSTRACT

INTRODUCTION: Dental hard tissue loss is one of the most challenging problems in dentistry. It is caused mainly by two factors, dental caries and erosion.
OBJECTIVES: Evaluating and comparing in vitro the effect of two carbonated beverages on bonding of resin-composite material to human permanent enamel surface.
MATERIALS AND METHODS: Twenty-four sound human permanent teeth were prepared and divided randomly according to exposure media into two equal groups (I and II). Each group was divided into two subgroups. Subgroups Ia and IIa served as experimental subgroups. Subgroups Ib and IIb were protected from the challenge and served as control.
Group I: specimens were exposed to Coca-Cola Regular, group II: specimens were exposed to Fanta Orange; 3x/ 1 minute. Between the challenges, they were stored in artificial saliva for a total of 24 hours. They were then, restored with Adper Single Bond 2/ Filtek Z350 XT nanofilled composite. All specimens were subjected to shear bond strength test.
RESULTS: Mann-Whitney U test and Kruskal-Wallis were used to evaluate the difference between the tested groups. Composite material in eroded specimens showed lower bond strength than that in uneroded specimens with no significant difference between the two-erosive media (P>0.05).
CONCLUSIONS: Retention of composite resin to enamel surface was affected by acidic soft drinks as evidenced by lower shear bond strength.

KEYWORDS: Carbonated beverages; resin composite; shear bond strength; Coca-Cola Regular; Fanta Orange.

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INTRODUCTION

Non-carious tooth tissue loss has become a significant problem in the modern era. It poses the next most significant threat to the function and longevity of human dentition after trauma, caries and periodontal disease (1, 2). Epidemiological data and studies in vitro and in situ suggested that, of all the wear processes, erosion is the most common threat for tooth surface loss (3). The primary source considered responsible for this loss is acid-containing beverages (4). Carbonated beverages are widely consumed by the world population (5, 6). They have a high erosive potential due to their low pH and contain phosphoric acid and low calcium and fluoride concentrations (7, 8). The pH of soft drinks coming into contact with the dentition appears to be the major determinant of dental erosion; the hydrogen ion concentration [H+] or acidity, as measured in pH, is primarily responsible for the immediate dissolution and softening of surface tooth structure (erosive potential) (9, 10). Several studies reported that, titratable acidity or buffer capacity, does not play as critical a role in dental erosion as pH, due to the limited time exposure the dentition has with ingested liquids during each drinking and swallowing episode (11-13). However, it was also previously proved that certain soft drinks (notably Cola beverages) are retained on dental enamel and are less likely than other beverages to be removed by saliva, resulting in an increased demineralization potential (14). Dental erosion may cause a number of clinical problems including esthetics due to enamel fracture, which may progress to shortening of the teeth and loss of occlusal vertical dimension. As a result of enamel loss, dentin sensitivity and difficulty in eating may develop, particularly if erosion is rapid and progressive. Rapid loss of tooth structure from dental erosion in children with immature teeth and large pulps are likely to lead to pulpal inflammation and exposures (15,16).

Because an increased incidence of enamel erosion caused by carbonated beverages has been noted in a number of scientific studies, management schemes have been proposed to determine, restore and treat eroded teeth (17). One of the fundamental treatments of eroded teeth is composite restorative treatment and adhesive techniques (18, 19).

Poor evidence is reported on the adhesion to enamel previously eroded by different carbonated beverages. While enamel is a dental substrate that allows the formation of regular and strong adhesion (20), changes in this substrate might affect the bond strength and the tag formation (21).

Several case reports, case series and studies demonstrated the successful rehabilitation of worn dentitions (erosive) using adhesive techniques (22-24).

Therefore, the purpose of this study was to evaluate and compare in vitro the effect of two carbonated beverages on adhesion of resin-composite material to previously eroded enamel surfaces. The null hypothesis is that acidic soft drinks do not provoke differences on adhesion of resin-composite to enamel of human permanent teeth with no clinical evidence of caries.

MATERIALS AND METHODS

The Ethical Committee at the Faculty of dentistry, Alexandria University approved the research protocol.

Study design: Experimental in vitro study (Fig.1).

Sample size estimation: Using a power of 80%to detect a significant difference in mean shear bond strength between the two groups of extracted human sound permanent third molars, exposed to erosive media (Coca-Cola Regular and Fanta Orange) , and bonded with resin composite material (Adper Single Bond 2/fitek Z350 XT - 3M ESPE, St. Paul, MN, USA). A total sample size of 24 human sound permanent molars, 12 per group was the minimum required and it was calculated using G Power version 3.1.9.2.

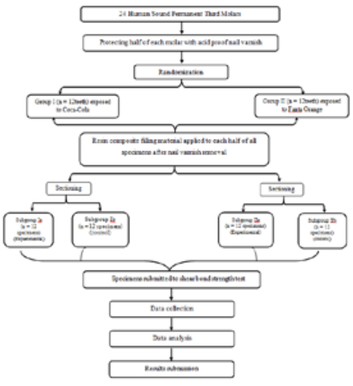

Fig.(1): Flow chart for the study design.

Figure 1: Flow chart for the study design.

The samples were randomly divided according to exposure media into two equal groups (I and II). Each group was further divided into two subgroups by sectioning the teeth of each group. Subgroups Ia and IIa were exposed to the challenge Coca-Cola Regular and Fanta Orange respectively and served as experimental subgroups, while subgroups Ib and IIb were protected from the challenge and served as control.

Methods

The teeth were thoroughly cleaned using fluoride free pumice and stored in normal saline solution at room temperature until required for use (25).

Enamel of each tooth was minimally ground from buccal surface using silicon carbide papers (grades600-1200) under water irrigation and polished to produce a flat surface using a water-cooled low-speed polishing machine in order to make the surface flat (100 µm).

Each tooth was washed and dried, then a self-adhesive label was applied to half of the buccal surface of each tooth to serve as the experimental half. The other half of the buccal and occlusal surfaces was coated with acid-proof nail varnish to serve as control half. After complete setting of the nail varnish, the adhesive label was removed from the experimental half (Fig. 2).

Erosive procedure (26)

Composition and chemical characteristics of each immersion media are presented in (Table 1) (27,28).

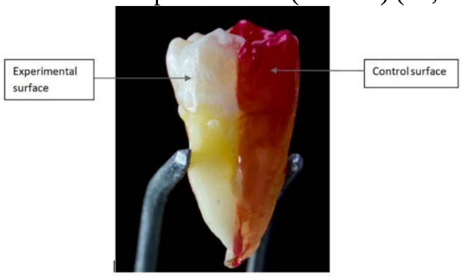

Fig.(2)

Figure 2: Experimental and control surfaces.

Table 1: Composition and chemical characteristics of each immersion media.

Immersion Media	Composition	pH
Coca-Cola Regular	Carbonated water, high fructose corn syrup, caramel color, phosphoric acid, natural flavor and caffeine	2.48
Fanta Orange	Carbonated water, high fructose corn syrup, citric acid, Sodium Benzoate, natural flavors, modified food starch, sodium polyphosphate, glycerol ester of Rosin, Yellow 6 and Red 40	2.92
Artificial Saliva	2.00g methyl - p - hydroxy benzoate,10.00g sodium carboxy methyl cellulose,0.625g potassium chloride (KCL),0.059g Magnesium chloride hydrated ($MgCL_2$- 6H),0.166g Calcium chloride hydrated ($CaCl_2$& H_2O),0.804g dipotassium Hydrogen phosphate (K_2HPO_4),0.326g KH_2Po and one-liter distilled water.	6.8

Each tooth was immersed in the corresponding immersion (erosive) challenge medium three times, one minute each, with an interval of eight hours. A fresh erosive medium was used each time for each tooth which was then stored in artificial saliva separately, artificial saliva was changed every 8 hours for a total of twenty four hours between the erosive challenges.

Restorative procedure (26)

After the erosive challenge cycle, each tooth was carefully cleaned with distilled water. The crown of each tooth was separated from the root 2mm below the cementum-enamel junction with a water-cooled, low-speed diamond disc (19).

The acid proof nail varnish on the buccal surface was removed with acetone except for 1 mm line and that on the occlusal control surface, to mark and distinguish between the experimental and control halves. Each tooth was then cleaned and dried.

Acid etching was performed using 37% phosphoric acid for 15 seconds, then washed out for 30 seconds. A gentle air stream was used to promote water evaporation.

Two thin coats of an etch-and-rinse dentin bonding system were subsequently dispensed with a disposable micro brush and gently air-dried for 2-5 seconds; to allow solvent evaporation followed by light curing for 10 seconds with LED unit (Dte Lux V Dental Blue LED Light Cure machine, Woodpecker, China).

Two increments (2mm thickness/ increment) of composite resin were inserted in transparent cylindrical plastic tubes (4.25mm in diameter and 4 mm in height marked in the middle with a marker each) and placed on each side of the etched enamel surface of each specimen and stabilized by sticky wax (Fig. 3). The first increment of composite was placed in the plastic tube to the marked point, and light cured for 20 seconds. The second increment was then placed till the top of the plastic tube.

Fig.(3)

Figure 3: Composite placed on the buccal surface.

Each tooth was then sectioned into two halves in a buccolingual/ palatal direction with a water-cooled, low-speed diamond disc that was replaced for every tooth in order to obtain two specimens: experimental and control (Fig. 4).

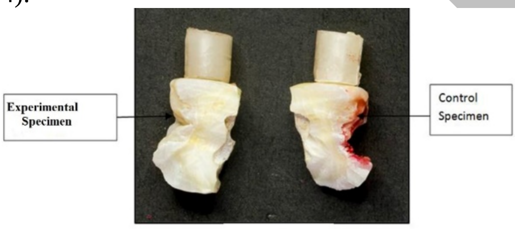

Fig.(4)

Figure 4: Sectioning of the tooth into two equal halves (experimental and control).

Each specimen was then mounted in self curing acrylic resin (14 mm diameter and 20 mm length) with the restored buccal surface displayed perpendicular to the long axis of the block (29) (Fig. 5). The cylindrical plastic tube was then removed leaving the composite resin.

Shear bond strength test (30)

Each specimen was mounted in a special attachment on a Universal Testing Machine (Instron Testing machine, Instron Corporation, Comten Industries, Inc. St. Petesburg, Florida, USA). Force was applied with a metallic loading blade placed as close as possible, parallel to the junction of the tested material and the enamel surface, with cross head speed 1mm/ min. Shear bond strength was then measured by determining the force required to dislodge the composite from the enamel surface using the Universal Testing Machine.

Peak break point (load in Newton) was recorded for each specimen. Bond strength was calculated in megapascals (MPa) by dividing the load at failure by the adhesive surface area of the attachment (mm^2) according to the following equation:

Shear bond strength (MPa) = Weight (N)/ Surface area (mm^2).

Statistical analysis (31)

Data analysis was performed using the Statistical Package for Social Sciences (SPSS) version 20.0 (IBM) (32). Data were entered as numerical values, and comparison for two independent sample was done using Mann-Whitney U test (33). In the present study a significance level of 95% was adopted.

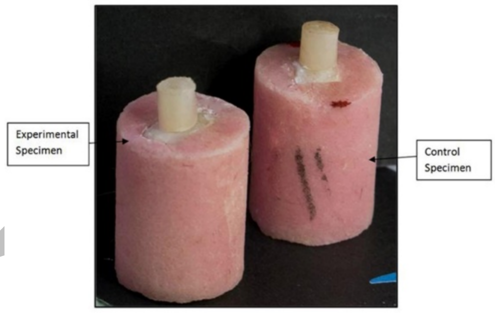

Fig.(5)

Figure 5: Each specimen mounted in acrylic block with plastic tube filled with composite resin.

RESULTS

Comparing the shear bond strength (MPa),the results revealed that the experimental subgroups (Ia and IIa) showed lower shear bond strength than the control subgroups (Ib and IIb) in both study groups (I and II). For group I (Coca-Cola Regular group), Mann Whitney U test revealed a statistically significant decrease in mean shear bond strength of subgroup Ia (p=0.002). Regarding group II (Fanta Orange group), Mann Whitney U test revealed a statistically significant decrease in mean shear bond strength of subgroup IIa (p=0.001) (Table 2).

Using Kruskal-Wallis test, there was no statistically significant difference in mean shear bond strength neither between the two experimental subgroups (Ia and IIa) (p=0.890), nor between the two control subgroups (Ib and IIb) (p=0.928) (table 2) (Fig. 6).

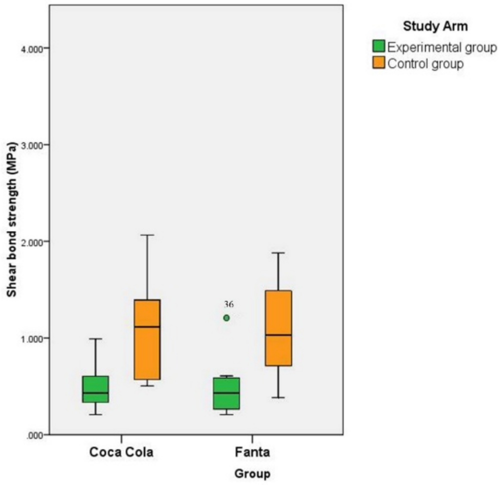

Fig.(6)

Figure 6: Box and whisker graph of shear bond strength (MPa) in the studied groups. The thick line in the middle of the box represents the median, the box represents the inter-quartile range (from 25^{th} to 75^{th} percentiles), the whiskers represents the minimum and maximum after excluding outliers (filled circle). Number indicate the serial number of the case within the master table.

Table 2: Comparison of shear bond strength (MPa) between the two studied groups.

	Experimental group (n=12)	Control group (n=12)	Test of significance (p value)
Group I: Coca-Cola group			
- Minimum-Maximum - Mean ± S.D. - Median (IQR) - KS test of normality	**0.208-0.992 0.499±0.217 0.432 (0.328-0.622) D=0.205, p=0.175 NS**	**0.504-2.064 1.095±0.488 1.116 (0.554-1.426) D=0.174, p=0.200 NS**	**$Z_{(MW)}$=3.120 p=0.002***
Group II: Fanta Orange group			
- Minimum-Maximum - Mean ± S.D. - Median (IQR) - KS test of normality	**0.208-1.208 0.471±0.271 0.432 (0.256-0.598) D=0.224, p=0.097 NS**	**0.384-1.880 1.087±0.504 1.028 (0.660-1.492) D=0.130, p=0.200 NS**	**$Z_{(MW)}$=3.154 p=0.001***
Kruskal-Wallis test	**$X^2_{(df=2)}$=0.234 p=0.890 NS**	**$X^2_{(df=2)}$=0.150 p=0.928 NS**	

S.D.: Standard deviation
IQR: Inter-quartile range
KS: Kolmogorov-Smirnov test of normality(D)
NS: Not statistically significant ($p \geq 0.05$)
*: Statistically significant ($p<0.05$)
MW: Mann-Whitney U test
df: Degree of freedom

DISCUSSION

In the present study, the overall results indicated that carbonated beverages do affect the adhesion of composite to enamel surface of human permanent molars, thus rejecting the null hypothesis. There was a statistically significant difference in the values of shear bond strength between experimental and control subgroups in favor of the control subgroups in both study groups.

Two different types of beverages were chosen for this study, namely Coca-Cola Regular and Fanta Orange. This was intended in order to determine if one type bore a potential of erosive capacity more than the other.

In the present study, natural sound extracted permanent third molars were used. Permanent molars were preferred over premolars because it is wider in mesio-distal dimension than premolars, thus they were easier in separation in a bucco lingual /palatal direction, to obtain two equal specimens.

The present study methodology attempted to simulate the oral condition by using artificial saliva as a remineralizing solution and exposing half of the tooth to the erosive medium, while protecting the other half to minimize the confounding variables. Artificial saliva was preferred over the natural saliva because of its availability, simplicity, stability and it allows for better standardization required for the in vitro study (34).

The results of the present study was supported by Casas-Apayco et al (26) who concluded that all Cola-based drinks reduced the bond strength except for Zero Coke (ZC) as ZC has lower titrable acidity than other tested Cola based drinks. This less-erosive potential was attributed to the presence of the amino acid phenylalanine, which is provided by the hydrolysis of aspartame (artificial non-saccharide sweetener) in the presence of saliva. While, Wang et al (35) found that there was no significant difference in the bond strength of composite restoration between eroded and uneroded specimens, although both studies used bovine teeth, the same erosive media, the same restorative and adhesive materials.

In addition, the results of the current study mismatched those of Giacomini et al (36), who suggested that bonding to enamel surface after erosive challenge by orange juice was not affected, and it depended on the type of resin used. This contradiction in results may be attributed to the method of remineralization process and the duration of the study, as Casas-Apayco et al study used artificial saliva (in vitro) for a total of twenty-four hours only, and Wang et al and Giacomini et al used natural saliva (in situ) for five days. The limitation in in- situ studies is that there are many volunteers who certainly have many variables in salivary flow rate, chemical composition and buffering capacity of saliva, pellicle formation, oral hygiene practices and dietary habits, which in turn may affect the results.

The results of the present study were contrary to that of Lenzi et al (37), who claimed that the bond strength of etch-and-rinse adhesive system increased in eroded enamel surfaces than that of uneroded enamel surfaces. Although, they used the same erosive medium (Coca-Cola Regular) and the same preservative medium (artificial saliva). This result may be attributed to the type of enamel (bovine teeth), the prolonged duration of the study (3times/5minutes/7days) and the change in resin material.

A possible limitation in this study is that extracted teeth lack the pulp pressure and inter-tubular fluid pressure present in natural teeth in the oral cavity. This, of course would have an influence on tooth moisture level, affecting restoration-tooth interface (38). In addition, in vitro studies can exaggerate bonding capabilities due to a well-controlled environment that could not be possible in the clinical situation. In addition, the in vitro design exposes the tooth to the beverage for a defined time period without consideration of rate of beverage consumption, length of swallow, movement within the mouth during swallowing, clearance by saliva and remineralization potential of saliva (39). Moreover, it is not possible to equate experimental conditions to levels of beverage consumption in humans.

Within the limitation of this study and the previously cited studies, one can find out that, acidic soft drinks do affect the retention of composite to enamel surface.

CONCLUSION

From the present in vitro study, it was concluded that retention of composite resin to enamel surface was affected by acidic soft drinks as evidenced by lower shear bond strength.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest.

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