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ORIGINAL ARTICLE

Effect of different tetra pack juices on microhardness of direct tooth colored-restorative materials

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KEYWORDS

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Abstract *Purpose:* To examine the effect of apple and orange juices on the surface hardness of direct tooth-colored restorative materials.

Materials and methods: The materials included resin-modified glass ionomer cement (Vitremer 3M™ ESPE™ Core buildup restorative) and composite resin (Filtek™ 3M™ ESPE™ Z350). A total of 45 disks of each restorative material were prepared. The disks were divided into groups of 15, which were immersed for 7 days in deionized water (G1/G4, control group), apple juice (G2/G5), or orange juice (G3/G6). The pH of the apple juice was approximately 4.8 and the pH of the orange juice was approximately 4.9. Surface hardness tests were performed before immersion and at various times following immersion. Statistical analysis included two-way ANOVA with repeated measurement and Tukey's test.

Results: Exposure to juices significantly reduced the hardness of both materials ($p < 0.05$), while deionized water did not affect the surface hardness of either material. The ionomer cement experienced a greater reduction than the composite resin ($p = 0.000$). There was no significant difference in the effect of apple and orange juices.

Conclusion: Juice box-type fruit juices reduced the hardness of direct tooth-colored restorative materials. Material selection should be considered when planning restorations in patients who have experienced tooth surface loss. In terms of the materials evaluated in this study, the composite material provides greater durability under acidic conditions.

1. Introduction

Teeth require restoration for a variety of reasons including dental caries, trauma, abrasion, erosion, and congenital anomalies (Watson and Burke, 2000). Esthetic considerations usually dictate that the restorative materials used to repair tooth defects approximate the natural tooth color. Tooth erosion is a well-recognized problem that has increased in incidence among younger patients over the last few decades (Jaeggi et al., 2006). Dental erosion occurs as minerals are dissolved

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from the tooth surface by acids originating from sources other than bacterial plaques (Imfeld, 1996; Zero and Lussi, 2005). The acid sources may be intrinsic (such as gastric reflux or the eating disorders bulimia and anorexia nervosa) or extrinsic (such as soft drinks, fruits, and fruit juices). Dental erosion not only affects teeth but also reduces the clinical performance and durability of dental restorations. The mechanisms causing degradation of restorative materials are complex due to the conditions within the oral environment (Turssi et al., 2002). Materials used as fillers must possess long-term durability, and the longevity of restorations depends upon factors such as wear resistance, durability of the tooth/restoration interface, and the amount of tooth preparation required. Resistance to biodegradation is another important property of restorative materials (Nomoto and McCabe, 2001). Physical factors involved in the degradation include abrasion (loss of tooth material due to contact with materials other than teeth), attrition (loss due to direct tooth-to-tooth rubbing), and erosion. When selecting materials for repairing erosive lesions, acid resistance is an important property to consider.

A number of restoration materials are currently available to treat erosive lesions, including glass ionomer cement, resin-modified glass ionomer cement, compomer, and resin composite (Jaeggi et al., 2006). Each material has advantages and disadvantages which must be considered during the selection process.

Dental composites consist of a resin-based oligomer matrix such as bisphenol-a-glycidal methacrylate (BisGMA) or Urethane dimethacrylate (UDMA) and a silane-treated inorganic filler such as silicon dioxide (Powers and Sakaguchi, 2006). They are considered the treatment of choice to seal tooth enamel and minimize further loss due to acid exposure (Jaeggi et al., 2006). The main advantages of composites are their esthetic properties and high bond strength to the tooth structure. However, their success in use is sensitive to the application technique.

Glass ionomer cements (GIC) are based on the reaction of silicate glass powder and polyalkenoic acid. They are particularly useful in treating erosive and carious lesions in low stress areas, and for this reason many improvements in these materials have been developed, such as RMGIC (resin modified GIC), dual- and tri-cured GIC, and metal-reinforced GIC (Kenneth, 2003).

Resin-modified GIC is a light-cured combination of glass ionomer cement and composite resin. Some studies have claimed that this composition improves the mechanical properties of GIC (Shabanian and Richards, 2002; Mckenzie et al., 2003).

Routine consumption of snacks and drinks plays a major role in dental health. Many foods and drinks affect the properties of restorative materials (Mclean et al., 1994), and consumption of acidic foods and beverages is a common cause of dental erosion. Cold drinks, particularly juice boxes, are popular worldwide. Previous studies have demonstrated that many acidic foods and beverages cause surface degradation of restorative materials, although limited literature is available on the effect of juice box-type juices on resin-modified glass ionomer cements and composites. Previous studies demonstrated a general effect, but were limited in methodology and did not accurately reflect the *in vivo* situation. Furthermore, the results of those studies were also conflicting, with some studies reporting changes in surface micro-hardness while others did not. The beverages tested in previous studies included natural orange juices, apple juices, and cola soft drinks, all of which were harmful to restorative materials (Mante et al., 1999; Wongkhantee et al., 2006).

2. Materials and methods

The restorative materials in this study included a resin modified glass ionomer cement (Vitremer core build-up/restorative, supplied as a powder and liquid which were mixed and cured in accordance with the manufacturer's instructions), and a resin composite (Filtek™ Z350, supplied as a one-component paste in 4 g syringes). Detailed descriptions of the material properties are presented in Table 1.

2.1. Specimen preparation

Vitremer is supplied as powder and liquid components that are hand mixed in a 3:1 ratio. A polytetrafluoroethylene mold of 10 mm in diameter and 2.5 mm thick was placed on a substrate consisting of a glass slide covered with a polyethylene sheet. The mold was filled with the uncured paste and covered with a second polyethylene sheet and glass slide and light pressure was applied. This method provided specimens with smooth top and bottom surfaces. The restoration material was cured using an LED curing lamp (Mectron Starlight Pro-LED, intensity 1000 mW/cm^2, Italy) applied for 40 s on each side.

Filtek™ Z350 was supplied as a single-component paste. The uncured paste was molded in a similar manner and cured using 20-s exposures on each side.

While still in their molds, the specimens were matured in an incubator at 37 °C for 1 h after mixing to simulate the time during which the restorations would be exposed to a normal oral environment.

2.2. Storage media

Following incubation, the samples were stored in deionized water (control), apple juice (Nestle Pakistan), or orange juice (Nestle Pakistan). In order to maintain the original pH of the storage solutions, the juices were replaced daily throughout the experiment.

2.3. Micro hardness testing

A total of 45 specimens of each restorative material were randomly divided into groups of 15. The hardness of each specimen was determined using a micro-hardness tester (Micro-vickers hardness tester, Wolpert group, China) equipped with a diamond Vickers indenter. The indentation load was 0.1 N and the dwell time was 10 s. Three indentations spaced equally over a circle were made on the surface of each specimen. Surface hardness tests were carried out 1 h after mixing (before immersion) and 1, 5, and 7 days after immersion. Between hardness measurements the plastic cups containing the specimens were stored in an incubator at 37 °C.

2.4. Ethical statement

This study employed only restorative materials and there were no ethical issues.

Table 1 Restorative materials used in this study.

Product	Types of material	Mixing	Setting reaction	Lot No.	Manufacturer
Vitremere shade A_3	Resin-modified glass-ionomer cement	Hand mixed	Acid–base reaction	20090114	3 M ESPE dental product USA
Filtek Z350 shade B_2	Resin composite	One-paste	Light-activated polymerization	20090114	3 M ESPE dental product USA

Table 2 Anova result for microhardness of both materials.

Results	Sum of squares	df	Mean square	F	Sig.
Between groups	159232.959	5	31846.592	284.903	.000
Within groups	39570.336	354	111.781		
Total	198803.296	359			

3. Statistical analysis

Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) software version 16.00 (SPSS Inc, USA). Descriptive analyses included calculations of mean and standard deviation for hardness measurements. The hardness values were tested for significant differences at a 0.05 level of significance using two-way ANOVA with repeated measurement and Tukey's Honestly Significant Difference (HSD) for multiple comparisons.

4. Results

The ANOVA results indicated statistically significant differences with respect to both material type and surface hardness ($p < 0.05$, Table 2). The effect of storage medium on the hardness of both materials over 7 days is described in Table 3, which lists the mean (SD) surface hardness of the Filtek™ 350 and Vitremer specimens following each storage time.

Prior to immersion Filtek Z350 had the highest surface hardness. Following immersion both materials experienced softening in both juices, but not in water. The hardness of both restorative materials decreased significantly between day 1 and day 5, with minor reductions from day 5 to day 7. There was no significant difference with regard to the type of juice ($p > 0.05$). Filtek™ Z350 performed better than Vitremer and experienced a smaller reduction in hardness.

5. Discussion

Once in the oral cavity, restorative materials are exposed to a variety of adverse conditions including the presence of acidic foods and drinks (Chanothai et al., 2011). The increased incidence of dental erosion highlights the need for understanding degradation processes in restorative materials (Honorio et al., 2007).

In the present study we investigated erosion by static immersion of restorative materials in fruit juices for a period of 7 days while monitoring changes in hardness. The time period was chosen to permit stabilization of acid–base reactions in the GIC and post-irradiation hardening of the composite (Mohamed-Tahir et al., 2005).

The surface microhardness of Vitremer (resin modified glass ionomer cement) samples decreased more than the samples prepared using Filtek™ 350 (resin composite). These results are similar to those of Chanothai et al. (2011), who reported that composites resisted acidic solutions better than Fuji II LC (another brand of resin modified glass ionomer cement). Ibrahim (2011) also concluded that low pH beverages aggressively attacked RMGIC materials, while composite resins were relatively less affected. Water did not affect the hardness of the restorative materials. Reasons for the greater reduction in RMGIC include selective acid attack on the poly salt matrix between the residual particles and release of fluoride from the material following immersion in acidic environments. The fluoride release occurs during dissolution of the matrix-forming constituents within the material (Wilde et al., 2006). Reductions in the microhardness of Filtek™ Z350 may be due to hydrolytic breakdown of the silane/filler particle bond or hydrolytic degradation of the filler materials (Söderholm et al., 1984; Medeiros et al., 2007; Bagheri et al., 2008). Aliping-Mckenzie et al. (2004) suggested that RMGIC materials may resist acidic environments better than conventional glass ionomer cements.

An important finding in this study was that the hardness of both materials was significantly reduced between day 1 and day 5, with minor additional reductions in surface microhardness occurring between day 5 and day 7. In the case of Vitremer cements this may be due to a negligible amount of residual particles remaining available for further acidic attack and in the composite materials no further hydrolytic breakdown of the bond between the silane and filler particles was possible.

Table 3 Mean (SD) surface micro-hardness of composite (Filtek 350) and Resin modified cement glass ionomer (Vitremer) at different time intervals.

Storage time	Material	dH_2o	Apple juice	Orange juice
1 h	Composite	72.8 (10.8)	72.9 (10.4)	72.8 (10.4)
	Resin modified glass ionomer cement	36.9 (3.7)	37.0 (3.6)	37.1 (3.5)
1 day	Composite	82.1 (6.2)	60.2 (9.9)	57.5 (4.6)
	Resin modified glass ionomer cement	37.3 (3.3)	19.4 (1.8)	17.5 (3.2)
5 day	Composite	80.1 (5.5)	46.3(5.3)	43.8(6.4)
	Resin modified glass ionomer cement	38.1 (4.2)	13.2 (0.8)	13.5 (3.2)
7 day	Composite	78.5 (5.9)	46.0 (5.1)	48.0 (7.5)
	Resin modified glass ionomer cement	36.5 (5.5)	12.9 (1.2)	10.3 (1.7)

The storage media employed in this study included deionized water, apple, and orange juices. Orange juice contains citric acid and apple juice contains malic acid. These acids behave differently in promoting dissolution and eroding the resin materials. Wongkhantee et al. (2006) also found that organic acids induced softening of BIS–GMA based polymers. Another important finding was that there was no significant difference in hardness change between samples stored in orange or apple juice ($p > 0.05$), possibly due to the similar pH of the juices. Although the hardness of both materials decreased during storage in either juice, the resin-modified glass ionomer cement was affected to a greater extent.

Previous studies have compared the erosive effects of fresh juices against cola drinks. The acidic beverages were placed in contact with the restorative materials for limited periods of time (Honorio et al., 2008; Lussi et al., 2004). However, in practice calculus and food debris deposited at the restoration margin can absorb chemical agents from soft drinks and juices, resulting in continuous exposure. The current study was designed to overcome the limitations of previous *in vitro* studies by employing a 7-day contact period to examine the effect of extended contact with acidic solutions.

The limitations of the current study include incomplete replication of the complex oral environment and disregard for the effects of saliva and thermocycling. While future studies may examine the *in vivo* effects of fruit juices, this study at least confirms the erosive potential of certain acidic juices, a potentially damaging factor of which the public should be aware.

6. Conclusions

Within the limitations of this study, we concluded:

- Resin composite (Filtek™ Z350) materials are more resistant to acidic degradation than resin-modified glass ionomer cements (Vitremer).
- The acidic agents tested (apple and orange juices) have an equal effect on the surface hardness of restorative materials.
- Deionized water had no effect on either restorative material.

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