The Effect of Sports Drinks on Flexural Strength of Provisional Restorative Materials

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Abstract: Background: Energy and sports drinks are being consumed by a major portion of the population globally. Thus, an experimental research design was used to evaluate and analyze the effects of soft drinks on flexural strength of provisional restorative materials. **Material and Methods**. The flexural strength of five provisional restorative materials; TemPhase™, UNIFAST III, Protemp™, Everest C-Temp and CAD Temp® monoColor were examined after being stored in 3 different sports drinks; including Red Bull, Cod Red, and Vitene in addition to the control group, distilled water, for 7 days at 37° in Memmert oven. All 25 x 2 x 2 mm bars were washed and dried after the conditioning period. Three-point flexural strength was carried out for all samples in the universal testing machine with 10 kN load cell at a crosshead speed of 0.5 mm/minute. **Results:** Two-way ANOVA and Tukey HSD tests were used to analyze the data at 0.05 level of significance. The findings have shown a positive and significant difference between distilled water and red bull ($p = 0.000$), distilled water and vitene ($p = 0.025$), and distilled water and cod red ($p = 0.047$). Red Bull, Vitene and Cod Red improved Temphase and Protemp flexural strength while they reduced the flexural strength of CAD Temp significantly. **Discussion:** It was concluded that C-Temp maintained the highest flexural strength while UNIFAST III flexural strength became the lowest amongst the five tested provisional restorative materials with sport drinks consumption. However, more studies are needed to investigate the effect of sport drinks on other restorative materials flexural strength and different physical and mechanical properties.

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1. Introduction

Temporization is the procedure of placing a provisional prosthesis for a short period of time. It is the construction of a temporary restoration that restores not only the form of the tooth, but also the functional and aesthetic harmony of the oral cavity. Apart from this, the provisional restorations prevent gingival overgrowth and unwanted tooth movement. Furthermore, they cover the exposed dentin to prevent plaque buildup and pulpal sensitivity. A good robust provisional restorative material has many features and characteristics; such as, accurate marginal fit, good pulpal protection, wear resistance, dimensional and positional stability. Additionally, it is an essential diagnostic aid in aesthetics and treatment outcome assessment (Shillingburg et al., 1997).

The success of any restorative material is directly associated with its durability. Durability and longevity are guided by the inherent mechanical and physical features of the restorative materials. Moreover, the durability of any restorative material is also influenced by the environment, in which the material is in contact with. Most importantly, its flexural strength, microhardness, and durability are vulnerable to the effect and the fluctuations in the pH factor due to the influence of various food and beverages introduced to the oral cavity (Saba et al., 2017). The exposure to highly acidic beverages affects the mechanical properties and the aesthetics appurtenance of dental restorations (Erdemir et al., 2013).

The newest provisional restorative material, known as nano hybrid resin composite, is emerging as a popular composite increasingly, based on its aesthetic, physical, and mechanical properties. A high-volume ratio of filler particles with a wider particle size distribution is incorporated within the new restorative material. As the preference of people has been inclined towards the consumption of fruit juices, dental resinous surfaces' damage result from the consumption of excessive amount of fruit juices, soft drinks, coffee, tea, wine, and acidic food, which affects the hardness and aesthetic quality of the resin composite (Tanthanuch et al., 2014; Al-Samadani, 2017; Erdemir et al., 2016). The sports drinks have higher amounts of sugar and low pH levels than other drinks (Fatima and Hussain, 2014). The interaction and exchange among these beverages and saliva can age, degrade and damage various dental restorations in an oral environment including resin composites (Lowe, 1987).

Dental clinics have widely reported problems associated to consuming sports and energy drinks (Al-

Samadani, 2017). Various types of sports drinks; such as, isotonic, hypertonic and hypotonic cause dehydration problems in individuals (Fatima and Hussain, 2014). It is evidently reported that the pathogenesis of dental erosion is due to the consumption of acidic drinks. Furthermore, severe dental diseases and gum infections are caused by prolonged exposure to sports drinks. High levels of sugar are present in sport drinks, which can have a negative impact on the overall health of an individual (Nunes et al., 2015). Regardless, it has been recommended to athletes to consume sports drinks in low quantities. Therefore, the study aims to find the relationship between sports drinks and restorative materials. The study investigates the negative impact of excessive consumption of soft drinks on the flexural strength of temporary restorative materials. The objective of the study is to evaluate and analyze the effects of three stimulating sports drinks, namely; Red Bull, Cod Red and Vitene on the flexural strength of the five provisional restorative materials TemPhase™, UNIFAST III Protemp™, Everest C-Temp and CAD Temp® monoColor.

2. Literature Review

Rajaee, Vojdani & Adibi (2014) have investigated the effects of food stimulating agents on the flexural strength and hardness of three denture bases acrylic resin materials. One-Way ANOVA and Tukey Test was used to analyze the data obtained for flexural strength specimens of the three acrylic resin materials. The findings have shown the VHN of FuturaGen specimens was reduced significantly after water storage. The FuturaGen and FS of Meliodent were decreased significantly under heptane conditioning.

Szalewski et al. (2017) evaluated the effects of beverages, including tea, and coffee on the temporary restorations' mechanical properties. The analysis was conducted through the experimental research design. The findings have shown that mechanical properties of selected materials were changed significantly, indicating a reduction in microhardness and mechanical strength of materials tested.

Hanieh, et al. (2016) evaluated the impact of mouthwashes on the flexural strength of interim restorative materials. A two-way ANOVA and Tukey HSD tests were used to analyze the five studied interim materials. The findings revealed statistically insignificant impact of the mouthwashes on flexural strength of studied interim materials. Yanikoğlu et al. (2014) evaluated the effects of different solutions on the flexural strength through an *in vitro* model test system. One-way ANOVA and Tukey HSD multiple comparison tests were used to evaluate the effects of different solutions. The findings have indicated that there is a statistical insignificant impact of different solutions on the flexure strength values.

Hamouda, Ibrahim, & Alwakeel (2016) have evaluated the impact of sport and energy drinks on resin-modified and conventional glass ionomer restorative materials in term of fluoride release, fracture toughness, and surface roughness. The energy drinks include Power Horse and Red Bull while Pocari sweat and Gatorade Perform 2 were used as sport drinks. A three-point bending method was used to determine the fracture toughness, while surface profilometer was used to measure surface roughness. A three-way ANOVA was used to analyze the data. The results have shown insignificant difference between sport and energy drinks with respect to fracture toughness at different intervals. Surface roughness changes was significantly observed through both conventional and resin-modified glass ionomers.

Fan et al. (2014) have evaluated the impact of assorted acidic solutions on the surface mechanical properties of commercial resin composites with different microstructures. Orange juice, distilled water, and cola were used to immerse specimens for 5 days and the nanoindentation determines elastic modulus, wear behavior, and nano-hardness of the samples. The findings have shown hardest and highest elastic modulus through the nano-filled resin composites. After immersion in acidic solutions, scanning electron microscopy revealed that all resin composites undergone surface degradation and erosion. The composition of the acidic solution was associated with the elastic modulus and the nanohardness through the wear resistance.

3. Material and Methods

3.1 Study Design

An experimental research design is used to evaluate and analyze the effects of soft drinks on flexural strength of provisional restorative materials. The rationale for using an experimental research design is to investigate the effects of soft drinks among included samples. The experimental research gives accuracy while investigating the effects of flexural strength of provisional restorative materials.

3.2 Specimens

The flexural strength of five provisional restorative materials; such as, TemPhase™ (Kerr Corp., Orange California), UNIFAST III (GC Corp., Tokyo, Japan), Protemp™ (3M-ESPE. Seefeld Germany), Everest C-Temp (KaVo Dental Corp, Biberach, Germany) and CAD Temp® monoColor (Vita Zahnfabrik, Bad Sackingen, Germany), and 3 different sports drinks; including Red Bull, Cod Red, and Vitene are examined. A master teflon mold was fabricated to provided 25x2x2 mm standardized bars from the resinous provisional restorative materials

used in the study according to the American National Standards Institute/American Dental Association Specification no.27. TemPhase™, UNIFAST III and Protemp™ were mixed according to the manufacturer instructions', then injected into the slot created by the mold and held under compression with a glass slab for complete polymerization. Everest C-Temp and CAD Temp® monoColor were milled into the standardized bars using KaVo Everest® CAD/CAM System (Everest®, KaVo Dental GmbH, Germany). After complete setting and exclusion for the presence of any defects, a total of 200 samples, 40 samples from each material under investigation in this study was retrieved. A set of 10 samples from each provisional material was stored in a container filled with one of the three energy drinks used in the study (Red Bull, Cod Red and Vitene) and the control group in distilled water for 7 days at 37° in Memmert oven (Cooled vacuum oven V0200Cool, Memmert GmbH + Co.KG, Schwabach) before being tested. All specimens were washed under running water and air-dried after the conditioning period. Three-point flexural strength was carried out for all samples in the universal testing machine (AGS-500; Shimadzu, Kyoto, Japan) with 10 kN load cell at a crosshead speed of 0.5 mm/minute. The flexural strength was calculated using the following formula:

$3FL/2bd^2$, where:

- F is the load (force) at the fracture point,
- L is the length of the support span,
- b is the width of specimen, and
- d is the thickness of specimen.

3.3 Statistical Analysis

Statistical Package for Social Sciences SPSS (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp) was used as an analysis software. Descriptive statistics were presented as means and standard deviations. To assess significant changes within each group, two-way ANOVA and Tukey HSD tests were used to analyze the data at 5% level of significance.

4. Results

The mean flexural strength and standard deviation of each provisional restorative material stored in each solution is presented in (Table 1). It has been revealed that the flexural strength of Everst C-Temp stayed consistent and higher than all the other provisional restorative materials, when tested in all the three beverages, namely; Red Bull, Cod Red and Vitene as well as control.

The flexural strength of the self-cure acrylic UNIFAST III was not affected by storing in any of the tested beverages. UNIFAST III remained the weakest material in comparison to any other restorative material included in the study when tested in all three drinks. In regard to Tempahse, Protemp, C-Temp and CAD Temp, all three beverages affected the flexural strength of the restorative material significantly. Red Bull, Vitene and Cod Red improved Temphase and Protemp flexural strength while they reduced the flexural strength of CAD Temp significantly.

Table 1. Comparison of Different Beverages and Restorative Materials

Beverages	Materials									
	Temphase		UNIFAST III		Protemp		Everest C-temp		CAD Temp	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Distilled Water (Control)	65.47	2.86	43.76	0.35	65.06	5.49	301.66	3.53	78.81	4.68
Red Bull	73.78	3.27	41.65	1.11	71.71	1.05	334.75	10.21	73.08	1.099
Vitene	72.08	2.75	43.99	4.06	76.89	3.05	201.74	7.44	71.94	1.08
Cod Red	72.09	1.17	44.58	1.51	84.62	2.38	343.97	8.13	72.76	2.13

Table 2. ANOVA Testing for Different Materials and Restorative Materials

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Red Bull	Between Groups	58932.800	3	19644.267	9822.133	.007
	Within Groups	2.000	1	2.000		
	Total	58934.800	4			
Vitene	Between Groups	15406.700	3	5135.567	410.845	.036
	Within Groups	12.500	1	12.500		
	Total	15419.200	4			
Cod Red	Between Groups	61382.300	3	20460.767	242.139	.047
	Within Groups	84.500	1	84.500		
	Total	61466.800	4			

Table 2 has presented ANOVA testing for different materials and restorative materials. In this regard, the distilled water was treated as control group whereas red bull, vitene and cod red were treated as dependent variables. The findings have shown that there was a significant difference between red bull and distilled water at 5% level of significance (p = 0.007). Similarly, the results have shown a positive and significant difference between vitene and distilled water (p = 0.036) at 5% level of significance. In addition, the findings have indicated a positive and significant difference in usage of cod red and distilled water (p = 0.047) at 5% level of significance.

5. Discussion

The present study has used five provisional restorative materials TemPhase™, UNIFAST III, Protemp™, Everest C-Temp and CAD Temp® monoColor to evaluate and analyze the effects of three stimulating sports drinks including Red Bull, Cod Red and Vitene on their flexural strength. It has been revealed that the flexural strength of C-Temp composite remained consistent and higher than all the other provisional restorative composite materials, when tested in all the three beverages, namely; Red Bull, Cod Red and Vitene. Conversely, the flexural strength of UNIFAST III acrylic resin was found to be the lowest among the other restorative materials, when tested on all the three drinks.

The resin matrices of the restorative dental composites become softened, when they are exposed to different food and liquids and to organic acids. In a study conducted by Nejatidanesh et al. (2009); the flexural strength of interim resin composite materials that were stored in artificial saliva were analyzed. Furthermore, they were thermocycled for 2500 cycles between 5-55 degree Celsius. It was revealed that bis-acrylic interim materials showed higher flexural strength as compared to monomethaacrylate resins for the purpose of interim prostheses (2009).

Al-Samadani and Al-Dharrab (2013) have evaluated and compared the impact of a soft drink and fresh fruit juice on surface texture and microleakage. A total of 70 non-carious human premolars was extracted and collected for orthodontic treatment purpose. These samples were divided into two groups of 30 teeth each. However, a total of 10 teeth comprised in the control group. A statistically significant surface roughness and microleakage was shown by the teeth and pellets when the immersion regime expanded. The study has revealed the longevity of restorations and its association with the available low pH beverages.

Hamouda, Ibrahim & Alwakeel (2014) have evaluated the impact of sport and energy drinks on resin-modified glass ionomer and conventional glass ionomer restorative materials. The study used a three-way ANOVA and least significant difference test to analyze the data. The results have shown no significant effect on fracture toughness in terms of energy drinks, distilled water and sport drinks for both conventional glass ionomer and resin modified glassionomer restorative materials at the different time intervals. More fluoride is released by both conventional and resin-modified glass ionomers in acidic beverages as compared to distilled water.

Saba, Salama & Haridy (2017) have investigated and compared the effects of beverages on microhardness and color stability of CAD/CAM hybrid blocks. This study has selected two commercially available CAD/CAM ceramic-blocks and feldspathic. Vickers microhardness and spectrophotometer were used for measuring color and microhardness respectively. A one-way ANOVA was used to analyze the data collected. The results have shown insignificant difference between in color change between both materials. Microhardness in different solutions was found to be lower before or after hybrid immersion as compared to feldspathic immersion. However, there have been very few studies on the effects of these food-simulating solutions on the provisional restorative composite materials (Wu et al., 1984; Yap et al., 2004).

A significant range of published literature is available that has investigated the effects of food-simulating solutions on the mechanical properties of numerous dental restorative materials. This study used five provisional restorative materials to test the impact of various beverages like Red Bull, Cod Red and Vitene on their flexural strength. Amongst the five materials, C-Temp proved to be the strongest and had the highest flexural strength regardless of the solution being exposed to. In contrast, the self-cure acrylic resin UNIFAST III was found to have the lowest flexural strength. It is recommended that more research must be conducted with regard to provisional restorative composite materials along with the effects of stimulating acidic beverages.

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