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The Impact of Immersion in Different Beverages on the Physical and Mechanical Features of Zirconia Restorations

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Abstract

Objective: This study aimed to evaluate the modifications in surface micro-hardness & roughness of zirconium restoration after exposure to different types of beverages (coca-cola and red bull).

Material and methods: Twenty specimens of Yttrium partially stabilized zirconium disc-shaped with identical size of 10 mm diameter and 1 mm of thickness were made by using of stereolithography file and then milled and sintered. They are divided into two major groups depending on the immersion beverages types (coca-cola and red bull). After exposure, they are subjected to hardness test by using a digital tester and roughness test by using a profilometer device.

Results: The outcome of the current study represent there was a highly significant difference in the hardness and roughness value between both of the major groups. The highest mean value of hardness was for Red bull group which was (355.860 mm), while the lowest mean value was for coca cola group which was (313.810 mm). On the other hand, the highest mean value of roughness was for coca cola which was (2.2702mm), while the lowest value was for red bull group which was (0.9060mm).

Conclusions: The red bull drinks with a (50 ml) had a positive effect on both surface hardness and roughness of zirconia restorations rather than a (50 ml) of coca-cola beverages.

Introduction:

The oral cavity is a complicated aqueous area which is modified by everything that is daily introduced into the mouth, such as beverages and foods which can cause lowering of the salivary pH value, thereby, altering the mechanical and physical characteristics of restorative CAD/CAM materials [(1)] .Some factors like acids, bases and saliva result in a loss of mechanical properties including flexural modulus, flexural strength and for this study in particular, the micro-hardness [(2)].

Recently, energy and carbonated drinks have been consumed frequently, especially in the age group (18–35) years. Several studies showed that dental erosions and consequently restoration erosions were caused by consumption of these drinks [(1)]. Some acids, e.g. organic acids similar to lactic, acetic, and propionic that exist in these drink's formulation may result in low values of micro hardness of esthetic restorations [(3)]. Metal-free restorations became viable alternatives to porcelain fused to metal restorations due to their superior biocompatibility and cosmetic performance. With such advantages, ceramic restorations were suggested for a fixed prosthesis, including ceramic inlay/onlay repair, partial/full bridges, and crowns [(4)]. In the last ten years, zirconia or zirconium dioxide (ZrO_2) has been widely used as an aesthetic material in restorative dentistry due to its exceptional properties involving superior strength, moderately decreased elastic modulus, moderate fracture toughness, wear resistance, and biocompatibility [(2)]. The mechanical and physical characteristics of restorative materials are important considerations for evaluating appropriate restorative materials since they have a significant impact on restoration lifetime. For example, a material's micro-hardness is one of its most important attributes because it is closely related to acid resistance, compressive strength, and conversion degree. Reduced surface hardness usually corresponds with insufficient wear resistance, which has a negative impact on fatigue strength and can lead to restoration failure [(5)] [(6)].

The removal of the porcelain glaze from the repair typically causes a high surface roughness, which might weaken mechanical strength and promote further plaque accumulation, primarily in a contact area. The diffuse and uneven light patterns may also be generated by surface roughness alteration, which may impact the restoration's appearance and color, ultimately affecting their aesthetics [(7)]. The purpose of this study was to determine how the surface micro-hardness and roughness of zirconium restoration changed following immersion in several types of beverages (coca-cola and red bull).The null hypothesis of this study is that the surface micro-hardness and roughness of zirconium restoration will not be changed after immersion in red bull beverage in comparison to coca-cola .

Materials and Methods:

1. Samples grouping

In the current in-vitro study, 20 disc-shaped of computer aided design /computer aided manufacture (CAD/CAM) restorative materials were used. A 10 mm dimension and 1 mm thickness were created by using stereolithography CAD software (STL) file and then milled according to manufacturer's instructions as shown in Figure (1) .Then, they were divided into two main groups according to immersion beverages.

2. Specimens designing:

Pre-sintered Zirconia disc-shape block (Upcera, 98 x 14mm, HT- White) was provided by the manufacturing company as shown in Figure(2).It was used in the designing of specimens. To measure Vickers micro hardness (VHN) and surface roughness, 20 monolithic zirconia disc-shaped specimens were prepared. The dimensions of the specimens were prepared according to the reference [(8)] (with a 10 mm dimension and 1 mm thickness), and the specimens were created by using specialist 3D modelling software (Sketchup 3D design program) as shown in Figure(3). The model was created as an Stereolithography file that the CAD/CAM system could be understood, then the

drawings of the specimen were translated into a 3D-template which is milled with the CAD/CAM unit and then sintered according to manufacturer's instructions [9]

3. Glazing process

All the specimens were glazed by using a two thin coats of glazing paste.In accordance with the guidelines of the manufacturers instructions Figure (4). the powder was mixed with the liquid until it became uniform and had a creamy consistency. After that, the specimen was held by a twezeer, and a fine brush was used to paint the mixture uniformly on one side of the complete surface of the specimen. Then, it was fired at (900 °C) in a conventional porcelain furnace, according to the recommended firing program according to manufacturers guidlines . All specimens were done simultanuously to reduce variability.

4. Immersion of specimens in different drinks:

After glazing step, the first group (coca cola group) have been immersed in a container with 50 ml of coca-cola drink (Coca Cola Company, Iraq, Babylon pH level of 2.52) [10] as showed in Figure (5-a). While, the second group (red bull group) have been immersed in a container with 50 ml of energy drinks (Red bull pH level of 2.52) [11] as showed in Figure (5-b). The total period of immersion was 28 days at a room temperature of (37°C). Tap water was used to rinse the immersed specimens every week for prevention any bacterial adhesions then the two different drinks were changed daily for maintaining low pH values [8].

5. Testing procedure:

A -Micro-hardness testing (VHN)

The Vickers hardness number (VHN) was determined by using a digital tester device. Each specimen was put on the device's stage as shown in Figure (6). The indenter was then lowered slowly until it came into contact with the surface of the specimen. A diamond indenter with a right pyramid shape with a square base and 136˚ angle between opposite sides was used for sample indentation. The indentation dots remaining on the specimen's surface, following the load, have been released automatically and determined microscopically. After that, the average estimated area of the indentation's sloping surface was calculated. Vicker indentations per specimen were used to determine the mean hardness with a load of 1000 gm within 15 seconds dwell timing [8].

5B- Surface roughness testing

The profilometer device from (SRT-6200S Surface Roughness Tester, China) with ≤±10 % accuracy was used for testing the surface roughness of 20 specimens. As shown in Figure (7). all specimens were set on a stable and firm foundation. The device was adjusted so as the stylus just touches the surface of the specimen, followed by crossing the stylus along the surface of the specimen in the right directions. The ultimate readings were shown on a digital scale [12] .The mean average values (Ra) were applied to analyze the results statistically. The results were expressed by using the micrometer.

Results:

Statistical analysis was done by using IBM SPSS statistical analysis program version 24 to analyze the results of hardness and roughness test. The t-test was used for comparing between the pair of the two major groups. The results revealed that the lowest mean value of hardness test was (313.810mm) for Coca-cola group, while the highest value was for Red bull group which was (355.860mm) as shown in Tables (1) and (2) and in Figure (8). On the other hand, surface roughness results showed that coca cola group yielded the highest average mean value (2.2702mm). In contrast, the red bull group showed the lowest mean value (0.9060mm) as shown in Tables (3)and (4) and in Figure (9).

Scanning Electronic Microscope analysis:

The scanning electronic microscope device (Inspect –S50, Holland) at different magnifications were used to analysis the surface texture of zirconia restorations before and after the beverages immersion . their results revealed that the surface of the zirconia specimens before have been

soaked in the different beverages were smooth and no morphological changes for their surfaces as shown in Figure(10).While, after immersion produce a moderate rougher surface for zirconia specimens have soaked in red bull drink as shown in Figure (11),micro-retentive grooves and visible roughness were found for zirconia specimens were soaked in coca-cola drink as the Figure(12) .

Discussion

A significant number of people drink soft and energy drinks, which can boost physical resistance, avoid dehydration, promote metabolism, and replace electrolytes throughout any high-intensity exertion. Nonetheless, these beverages are typically acidic with low pH values, which can cause dentin and enamel erosion while also raising dentine hypersensitivity. These types of beverages are frequently able to degrade restorative materials and have severe effects on dental structures [13][14]. The present study was designed for evaluation of esthetic restorative materials' hardness following a contact with various drinks. Such beverages, when consumed, are contacted with teeth and restorations for short periods of times. The results of the current study showed, following immersion in Coca Cola drink at a pH of 2.52 and Red bull for 28 days which is comparable to more than two years of in vivo conditions, the hardness of zirconia restorations have been immersed in coca-cola have the lowest mean value in comparison with Red bull energy drink, which can be explained by that the exposure to an acid drink causes decreased micro hardness levels of ceramics due to material's dissolution. The elementary components similar to aluminum, potassium and silica are liberated by the glass phases [15]. However, results of our study disagreed with the study conducted by Colombo et al. [11] who reported that immersion of Zirconia-reinforced lithium silicate glass ceramic in Coca-Cola drinks for 28 days was less affected due to its high chemical stability.

In addition, the zirconia restoration surface is often exposed to many oral environmental changes; thus, it is important to change the surface prevention. A study on surface roughness of restoration alteration revealed that it is possible to degrade the surface from beverages or food ingredients with an acidic agent (decreased pH) [16].

Different beverages could impact surface roughness of glazed ceramic restorations. The daily consumed beverages are often composed of different kinds of acids [17]. Coca cola and Red bull are among the most regularly consumed beverages in the world

containing galangal, vanilla, cocoa,liquorice, cinnamons, lemons, gingers, cocaleaves, oranges, corn

mints, pines, cardamoms, maces, cloves as well as lemon juice concentrates, while the content of red bull depending upon the country, the Red bull contains variable amounts

of caffeine, taurine, Bvitamins , glucurono lactone with simple sugars (glucose along with sucrose) in buffer solutions of carbonated waters, sodium bicarbonates and magnesium carbonates [18] . The results of the current study agree with Aldamaty et al. [18], they revealed that the water and other acidic fluids can be absorbed by a restorative material, resulting in a surface degradation. Also, the outcome of the present study in agree with Scotti et al. [19], they showed that the roughness of zirconia restorations have been immersed in Coca-Cola after thirty (30) days have the highest mean value in comparison with Red bull energy drink.

Conclusions

Considering the limitations of the present study the Red Bull drinks (50 ml) had a beneficial effect on both surface hardness and roughness of zirconia restorations compared to Coca-Cola beverages.lithi

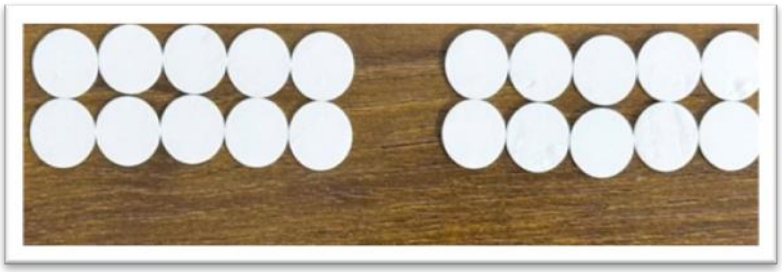

Figure:(1)Twenty disc-shaped of CAD/CAM restorative materials

Figure (2): A monolithic zirconia disc as supplied by the manufacturing company

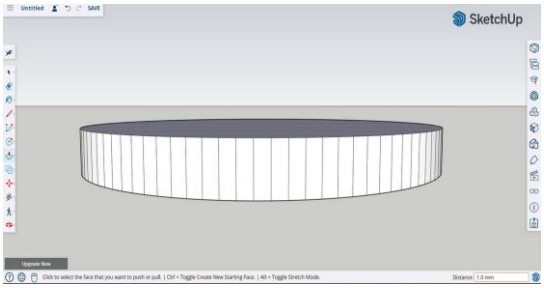

Figure (3): Software picture of designing the specimens with 10 mm diameter & thickness 1 mm

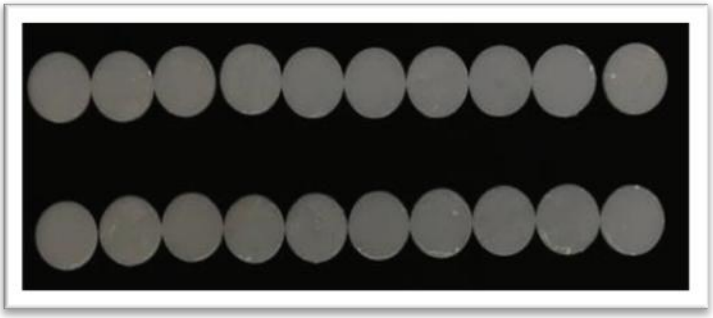

Figure (4): All specimens after application of glaze

Figure (5): a- Coca-Cola immersion group, b-Red bull immersion group

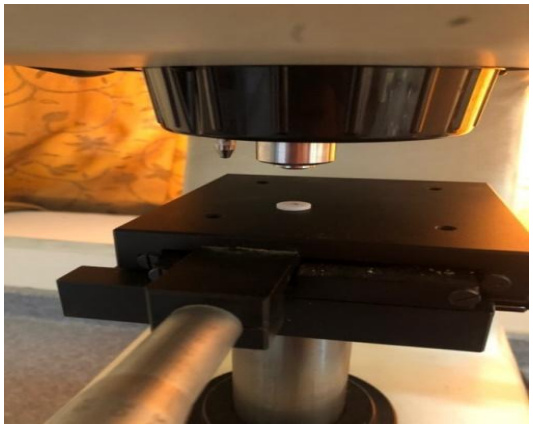

Figure (6): A close-up view of a specimen on the stage

Figure (7): Specimen under profilometer surface roughness testing unit

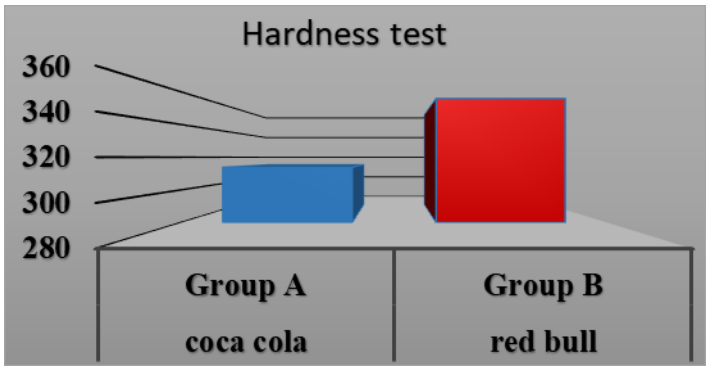

Figure (8): Bar chart demonstrating the mean hardness values in (µm) of the study groups.

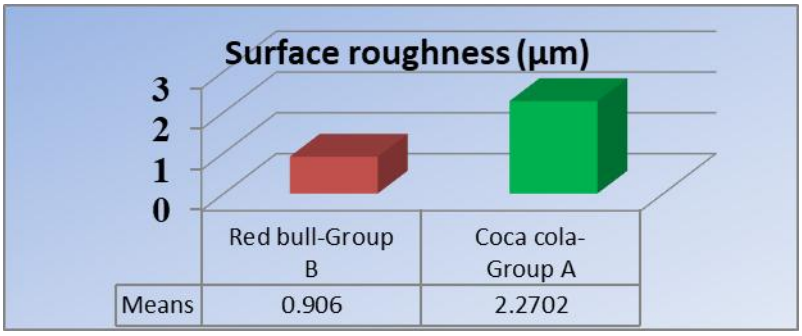

Figure (9): Bar chart demonstrating the mean surface roughness values of studied groups.

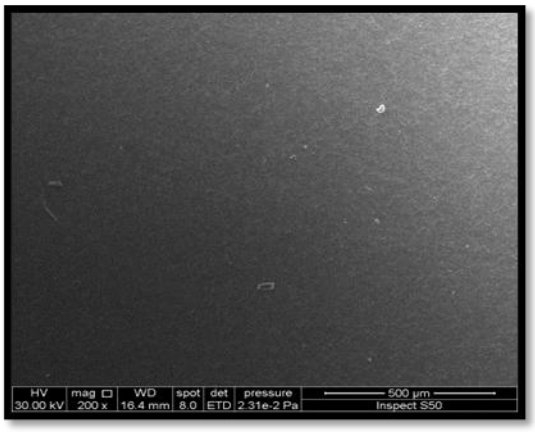

Figure (10): The surface of zirconia before immersion

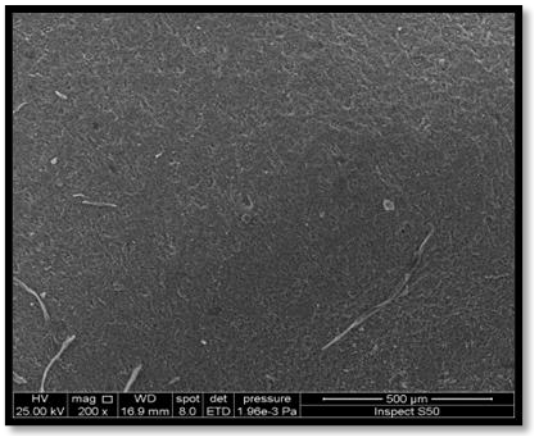

Figure (11): The surface of the zirconia after immersion in red bull drink

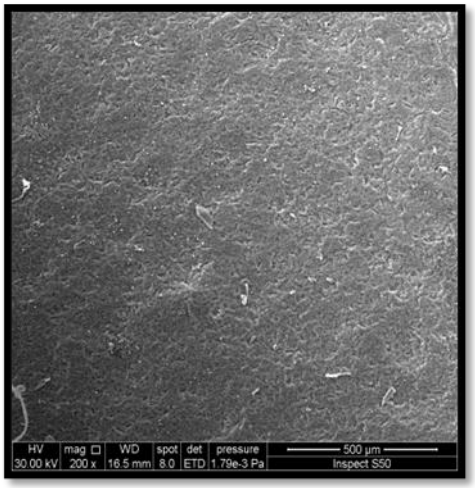

Figure (12): The surface of the zirconia after immersion in coca cola drink

Table (1): Descriptive Statistics of hardness among groups

Studied groups	Groups	N.	Mean Hardness	Std. Deviation	Min.	Max.
Coca cola	**Group 1**	**10**	**313.810**	**1.605**	**310.8**	**315.5**
Red bull	**Group 2**	**10**	**355.860**	**1.544**	**353.0**	**358.6**

Table (2): The comparison between the hardness of coca cola and red bull group.

Groups	T	(P-value)	Sig.
Coca cola & Red bull	**13.077**	**.000**	**HS**

Table (3): Descriptive Statistics of surface roughness among groups.

Study Groups	N	Mean roughness	Std. Deviation	t-test	P-value	Min	Max
Coca cola	10	2.2702	0.51150	7.180	≤0.001 (H.S)	1.53	2.73
Red bull	10	0.9060	0.31527			0.60	1.51

Table (4): The comparison between the roughness of coca cola and red bull groups.

Group	t-test	P-value	Sig.
Red bul & Coca cola	7.180	≤0.001	H.S

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