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EFFECT OF SIMULATED GASTRIC ACID ON SURFACE ROUGHNESS OF DIFFERENT TYPES OF DENTAL CERAMICS

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ABSTRACT

Purpose: The purpose of this in vitro study was to evaluate the effect of simulated gastric acidity on surface roughness of different types of dental ceramics.

Methods: Fifty specimens were divided according to type of the material into five groups (n=10), as follows: Partially stabilized zirconia (PSZ) (**Prettaue),** Fully stabilized zirconia (FSZ) **(Prettaue Anterior),** lithium disilicate ceramics (**IPS**. **Emax**), Zirconia-containing lithium silicate ceramics (ZLS) **(Vita Suprinity)** and Hybrid ceramics (**Vita Enamic**). Specimens were cut using a low-speed diamond saw (Isomet) into a rectangular shape with the following dimension: 12mm width x 14mm length x 1 mm thickness. Surface roughness was evaluated by optical profilometer. Each specimen was immersed in 5 ml of the simulated acid of ph 1.2 for 96 h in a37˚C incubator. Surface roughness of all tested groups was revaluated. One-way ANOVA was used to compare mean difference between groups. Paired t-test was used for comparing (before and after) roughness in each group.

Results: There was significant difference (**P=0.002**) between all groups. There was increase in surface roughness for all materials tested, but it was non-significant (P>0.05) for Prettaue (**P=0.607**), Prettaue Anterior (**P=0.273)** and Vita Suprinty group (**P=0.201**). There was significant increase (P≤0. 05) for IPS. Emax group (**P=0.007**) and Vita Enamic groups (P=**0.021**). Prettaue Anterior group showed the least amount of surface roughness change (**0.0006±0.002)**, while Vita Enamic group showed the highest surface roughness change (**0.0100±0.011).**

Conclusions: The gastric acid significantly increased the surface roughness of hybrid ceramics and lithium disilicate ceramics.

KEY WORDS: Dental ceramics; Roughness; Gastric acid

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INTRODUCTION

Loss of tooth surface may be due to four main reasons: erosion, abrasion, attrition and abfraction[1]. Dental erosion is the irreversible loss of the dental hard tissue due to acid dissolution from either the extrinsic (e.g. dietary) or intrinsic (e.g. gastric acid)[2,3]. Common causes for the presence of the gastric acid in the oral cavity include gastroesophageal reflux disease (GERD), bulimia nervosa, eating disorders, chronic vomiting, and persistent regurgitation and rumination[4,5]. Demineralization of enamel will occur once the oral environmental pH reaches the critical threshold of 5.5 for both erosion and caries development[6]. PH of the gastric acid ranges between 1 and 1.5 which is far below the critical pH of 5.5 at which tooth surface enamel will dissolve [3,7].

Management of advanced erosive lesions may require restorative treatment. The restorative intervention depends on the complexity and extension of the erosive lesions, ranging from simple procedure as direct conservative restoration to indirect fixed or even full mouth reconstruction[8].

Ceramics are considered fairly chemically inert biomaterials; however, due to major differences in the structure and composition of available ceramics, this inertness may not be oversimplified[9,10]. There are concerns about degradation of ceramics in the presence of low pH in the oral cavity[11,12]. Gastric acid could also affect dental ceramic restoration made to restore worn dentition. Chemical degradation of dental ceramics can lead to increase abrasion of the opposing dentition, increase plaque accumulation and possibly release harmful elements from the ceramics[13,14].

The first null hypothesis to be argued in the current study was "Gastric acidity doesn't increase the surface roughness of dental ceramics". A second null hypothesis to be criticized in the present study was: «No difference among the evaluated materials in terms of resistance to chemical wear after immersion in simulated gastric acid».

MATERIALS AND METHODS

Preparation of the specimens

Fifty Specimens were cut from CAD/CAM blocks or blanks of five different ceramic materials. The specimens were cut with a low-speed diamond saw*. The specimens were divided according to the type of ceramic material into five groups (n=10) as follows:

Group I: Partially stabilized zirconia (PSZ)**

Group II: Fully stabilized zirconia (FSZ)***

Group III: lithium disilicate ceramics ****

Group IV: Zirconia-containing litiumsilicate ceramics (ZLS)*****

Group V: hybrid ceramics******

The specimens were rectangular in shape and their dimensions were 14mm length, 12 mm width and 1mm thickness.

The specimens were ground sequentially on wet SiC paper (600, 1,000, and 1,500 grits). Grinding and polishing were performed on one side of the samples which were adjusted and polished to simulate clinical intraoral procedures. The final dimensions of the specimens were confirmed with a digital caliper for standardization. The specimens

* (Isomet, Buehler, Lake Bluff, IL, USA)
** Prettaue® (PRT), Zirkonzahn, Taufers, Italy
*** Prettaue anterior Control (PRTA) , Zirkonzahn, Taufers, Italy
**** IPS e.max CAD (IPS e.max), Ivoclar Vivadent AG, Schaan, Liechtenstein
***** VITA Suprinity VITA Zahnfabrik, Bad Säckingen, Germany
****** VITA ENAMIC®, Vita Zahnfabrik, Bad Säckingen, Germany

were ultrasonically cleaned in distilled water for 10 minutes, dried with compressed air. Firing conditions of the tested groups, except for vita Enamic, were done according to manufacturer recommendations.

Preparation of Gastric Acid

A generic formula simulating gastric acid has been used. The simulated acid was prepared using Hunt and McIntyre's method to cause erosive lesions in enamel similar to those seen clinically[16]. Hydrochloric acid (HCl) 0.06 M (0.113% solution in deionized water, pH 1.2) was prepared. The pH was monitored every 24 h and each sample was immersed in 5 ml of the simulated acid for 96 h in a 37◦C incubator [17].

Measurement of Surface Roughness

Surface roughness of all specimens were measured using an optical method without touch to fulfill the need for quantitative characterization of surface topography . Samples were photographed by using USB Digital microscope with a built-in camera* connected to an IBM compatible computer using fixed magnification of 50x. The images were recorded at a resolution of 1280 x 1024 pixels per image and then cropped to 350 x 400 pixels using Microsoft office picture manager to specify and standardize roughness measurement area. Cropped images have been analyzed using WSxM software**[18]. Three 3D images per window were gathered for each specimen with an area of 10 mm x10 mm. WSxM software was used to calculate the average surface roughness (Ra) expressed in micrometers[19].

Statistical Analysis

Mean values for each group were calculated, and differences between the groups were tested for statistical significance by use of one way analysis of variance (ANOVA). Then, Paired t-test was used for comparing the results before and after exposure to gastric acid for each group.

RESULTS

Mean values and standard deviation (SD) of surface roughness measured in micrometers for all tested groups were summarized in (Table 1)

Statistical Package for Social Sciences (SPSS version 25) was used to statistically analyze data. Paired t-test showed an increase of surface roughness for all material tested, but it was not significant difference for prettaue, prettaue anterior and vita suprinity group (P>0. 05). There was significant increase for emax and vita enamic groups (P≤0. 05). P-value for emax group was (.007) and for vita enamic group (.021) which is significant difference (Table 1).

TABLE (1) Surface roughness values (µm) of all tested groups before and after immersion in gastric acid indicating the descriptive analysis of data and P values for all group after paired t-test :

Materials		Mean±S.D (µm)	Min –Max	T	P-value
Prettaue	Before	0.251±0.003	0.532	0.532	0.607
	After	0.252±0.001	0.249—0.253		
Prettaue anterior	Before	0.252±0.001	0.250—0.254	1.168	0.273
	After	0.253±0.001	0.251—0.255		
E.max	Before	0.250±0.003	0.245—0.253	3.457	0.007*
	After	0.253±0.001	0.252—0.255		
Vita suprinity	Before	0.251±0.003	0.248—0.255	1.379	0.201
	After	0.252±0.001	0.251—0.253		
Vita Enamic	Before	0.251±0.002	0.248—0.254	2.802	0.021*
	After	0.261±0.01	0.252—0.285		

* (Scope Capture Digital Microscope, Guangdong, China)
** (Version 5 develop 4.1, Nanotec, Electronica, SL)

Statistical analysis using one way ANOVA showed a significant difference (P=0.002) between all groups. Prettaue anterior group showed the least amount of surface roughness change (0.0006±0.002), while vita enamic group showed the highest surface roughness change (0.0100±0.011). The results were also graphically presented in (Fig. 1)

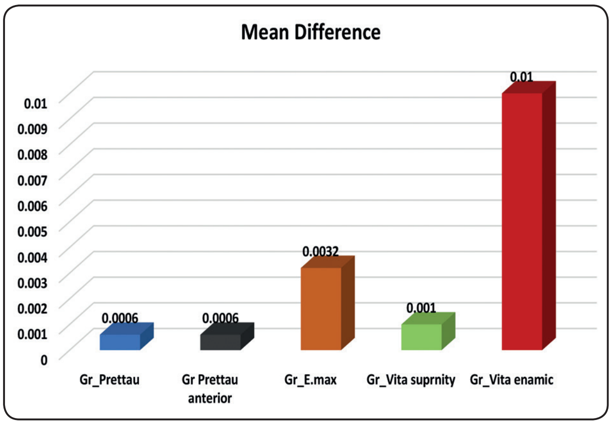

Fig. (1) Column chart showing mean surface roughness difference between all groups.

DISCUSSION

Limited researches have been conducted to study the effect of simulated gastric acid on the currently available ceramic restorative materials.

Regarding the choice of dental ceramics to be tested in the present study, five different types were selected as they are becoming increasingly popular for use due to their excellent aesthetic properties, their biocompatibility and wear resistance[20,21]. The specimen thickness of 1.0 mm was selected on the basis of suggested occlusal thickness of monolithic zirconia restorations[22].

In regards to the concentration of corrosive acid and the time of immersion, the ISO testing standard for solubility testing of ceramics proposes the use of 4% acetic acid for 161 hours at 80°C, which corresponds to an in vivo period of 2 years, based on the research of De Rijk et al[23]. In the present study, a stronger acid (HCl, pH 1.2) was used. Based on Hunt and McIntyre's method [16], HCL is stronger acid rather than the ISO standard of 4% acetic acid. In addition, the immersion time was increased to 96 h at 37°C which is expected to simulate over 10 years of clinical exposure[17].

The results of the present study showed an increase of surface roughness for all materials tested. This increase was non-significant for partially stabilized zirconia (P=0.607>0.05) and fully stabilized zirconia (P=0.273>0. 05). These finding were similar to other studies that indicates that zirconia is the most resistant material against acid attack[14, 24]. This may be due to their polycrystalline microstructure that provides strength and fracture resistance. Additionally, the absence of a glass phase makes the polycrystalline ceramics more resistant to acid attack[25]. On the other hand, unlike this study, S*ulaiman et al.(2015)* [17] found that increased vulnerability of the fully stabilized zirconia to corrosive acids. This difference may be due to the different research methods used.

In zirconium reinforced lithium silicate (Vita Suprinity group), there was also non-significant increase in surface roughness (P=0.201>0. 05). This finding could be attributed to the incorporation of zirconia filler of approx. 0.5 µm crystal size that gives Vita Suprinity higher abrasion resistance. These findings coincide with other studies that conclude that zirconia reinforced lithium silicate glass-ceramic revealed higher mechanical properties compared with lithium disilicate glass-ceramic[26]. On the other hand, unlike this study, *Cruz et al (2019)*[27] found that simulated gastric acid significantly changed surface roughness of vita suprinity. This may be attributed to that they tested the specimens without glazing.

There was significant increase in surface roughness with lithium disilicate ceramics (P=**0. 0.007> 0.05**). The fact that IPS e.max has a different microstructure than zirconia probably explains the rise in surface roughness during acid immersion. It contains approximately 70% of the volume of needle-like crystals in a glassy matrix, making it more prone to corrosive acid compared to zirconia[28]. These findings are similar to other studies[17,24] that concluded that the surface roughness of e.max ceramics had been affected by acid treatment. On the other hand, unlike this study, other studies showed there was non-significant increase in surface roughness for IPS e.max[13,14], but that the exposure time was relatively shorter and the pH of the corrosive solution was higher than that in the present study.

Also, there was significant increase in surface roughness with hybrid ceramics (P**=0.021*> 0.05**). This can be due to the fact that the weaker polymer matrix is feasibly segregated from the ceramic network leading to higher roughness values[29]. This finding could be due to the ability of acidic media to soften resin-based restorative materials[30]. These findings are similar to another study by *Alnasser et al (2019)*[14] that found significant increase in surface roughness for hybrid ceramics. *Cruz et al (2019)*[27] reported a significant decrease in surface roughness after gastric acidic challenge for Vita enamic, which was not found in the present study. According to *Cruz et al (2019)*[27], the decrease in its roughness was possibly due to the dissolution of the ceramic portion that constitutes most of this material. The boundaries between the ceramic and polymer portions became more evident with the dissolution of the feldspathic matrix by the acid.

The main limitation of this study is that there are differences between the clinical environment & the in vitro environment such as the amount of saliva and the nature of it varying from person to person and the frequency of tooth brushing. All these variables can affect the outcome data.

CONCLUSION

Based on the results and within the limitations of this study, the following conclusions can be drawn:

1. The gastric acid significantly increased the surface roughness of hybrid ceramics and lithium disilicate ceramics.
2. Partially and fully stabilized zirconia showed higher resistance to gastric acid compared to other tested ceramic materials.

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