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SURFACE ROUGHNESS MEASUREMENT OF HYBRID CERAMIC MATERIALS AFTER IMMERSION IN MOUTH RINSE AND REPOLISHING

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ABSTRACT

Background: Hybrid ceramic materials contain both ceramic and resin. Their surface topography has not been thoroughly studied, and there are no standard finishing protocols for these materials.

Objective: The purpose of this study was to determine how repolishing, following immersion in Listerine mouth rinse, affected the hybrid ceramic materials' surface roughness.

Methods: Square ceramic specimens (1×14×14) mm were cut from 3 Hybrid CAD\CAM ceramic blocks (vita Enamic, Shofu HC, and Nacera). Twenty specimens from each ceramic block were prepared and polished as per the manufacturer recommendations. Afterwards, the surface roughness was measured at the baseline, again after polishing, and after submerging in Listerine mouthwash. Non-contact profilometry based on optical approach was used to evaluate surface roughness. The specimens were photographed using a USB digital microscope that had a built-in camera and was linked to a compatible personal computer. The mean and standard deviation were used to express quantitative data. One-way analysis of variance was used for the statistical analysis, and Tukey's post hoc test was then performed.

Results: When comparing the three hybrid materials to their baseline values, a notable change was seen. The maximum value (0.314±0.020) in Shofu HC was obtained after submerging in mouth rinse, and the highest value (0.293±0.016) in Nacera was obtained after repolishing.

Conclusions: Re-polishing had the least impact on the high ceramic content materials (Vita Enamic), but it was able to raise the surface roughness of hybrid ceramic materials. Listerine mouthwash also had this effect.

KEYWORDS: hybrid ceramic, re-polishing, mouth rinse, profilometer surface, roughness.

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INTRODUCTION

One of the most significant aspects of dentistry is aesthetics; many patients want restorations that completely match their smile but are also much whiter. This raises the need for tooth-colored restorations with the right shade and outstanding surface texture. Many patients now prefer that such restorations be delivered in a single visit due to the development of chairside CAD/CAM and intraoral scanners. [1]

Patients' demands were met by the development of hybrid ceramic restorations, which combine the benefits of composite resin infiltration with the color stability, durability, and low abrasiveness of ceramics. [2] There are now a variety of hybrid ceramic CAD/CAM materials on the dental market. One such product is VITA Enamic, a CAD/CAM block that combines the benefits of superior composite elasticity and high flexural strength. It is made of 86% weight glass ceramic in a resin-penetrating matrix. [3] Another novel hybrid ceramic is Shofu HC, which is thought to be a highly esthetic hybrid CAD/CAM ceramic material. It is composed of 61% by weight zirconia silicate ceramics impregnated in a 39% by weight resin matrix comprising UDMA and TEGDMA. [4] Nacera Hybrid is the third example of hybrid ceramics consisting of 50% nano-glass particles for strength and aesthetics and 50% polymer matrix for elasticity and ease of milling. It is a tough, radio opaque composite material with optimized high density filler technology. Both the anterior and posterior segments exhibit a wide range of hues. Nacera Hybrid displays an incredibly uniform surface structure following machining. [5]

The translucency, color, and surface texture of dental restorations all have an impact on their aesthetics. Therefore, wear on opposing teeth may increase if ceramic restorations have a rough surface finish. cause germs and food debris to adhere, which may alter the aesthetic and biomechanical values, increase the risk of dental restorations aging, and cause tooth decay and periodontal disease. Well-polished restorations provide better optical characteristics, less wear on the opposed tooth, and a more consistent color. However, they are also less likely to harbor bacteria. [6]

In certain situations, such as the treatment of halitosis and the avoidance of periodontal disease during orthodontic treatment, mouth rinses are advised. Regular mouthwash usage may have a negative impact on hybrid ceramics. Listerine is a mouthwash with enhanced antibacterial effects that is frequently used to maintain good oral hygiene, as well as the convenience, predictability, and durability of both fixed and removable prosthesis. [7]

The finishing and polishing procedure affects the surface texture and roughness of any restorative material. Ideally, ceramic restorations should keep their final surface polish. Occasionally, ceramics need to be adjusted; this requires new polishing procedures. Compared with glaze, manual final finishing performs better in clinical trials with regards to surface roughness and shade matching.[8]

In addition, polishing can restore the surface gloss and smooth texture to dental restorations that have been damaged by surface finishing procedures.[9]

There are no established finishing procedures, and no research has been done on the surface topography or bacterial adherence of these novel hybrid materials for ceramic restorations. [9]

The three hybrid ceramic materials under investigation were expected to have the same surface roughness measurements following immersion in mouth rinse and repolishing, according to the null hypothesis.

MATERIALS AND METHODS

Study design

This study was conducted as an experimental laboratory study.

Study setting

The experimental laboratory study was carried out at Fixed Prosthodontics Department, Faculty of Dentistry, Tanta University.

Ethical considerations

The current study's design and methodology were completed in compliance with the research standards that the Tanta University Faculty of Dentistry's research ethics committee accepted. (#R-FP-10-23-3069)

Sample size

In total a sample size of 60 specimens was calculated using G* power software based on the mean and standard deviations of ceramic's values of surface roughness in previous similar studies [1,6]

Specimen grouping

With a precision cutting saw (Isomet 4000, Buehler, Germany), square ceramic slices of CAD/CAM blocks of Vita Enamic (Vita Zahnfabrik, Germany), Shofu Hc (Dental GmbH, Ratingen, Germany) and Nacera (Nacera Hybrid, Germany) were cut; each specimen measured 1 mm thickness, 14 mm length, and 14 mm width. The thickness of all specimens was confirmed with digital caliber. (Mitutoyo IP 65, Kawasaki, Japan)

Therefore, the study involved three groups: Group 1 consisted of Vita Enamic (n = 20), Group 2 consisted of Shofu HC block (n = 20), and Group 3 consisted of Nacera hybrid (n = 20). All specimens were then polished according to the respective manufacturer recommendations using a diamond polishing system (Dia comp plus EVE Diapol Twist, Germany) with the same operator to ensure a standard work. The surface roughness (SR) was measured after polishing and considered as baseline measurements.

Surface Roughness measurement technique

In this study, non-contact profilometry (TR 220 Surface Roughness Fester, TIME Group, Pittsburgh, PA, USA) based on optical methods was chosen as it satisfies the requirements for high efficiency, few scratches, elevated temperature resistance, and quantitative assessment of surface topography without contact.[10]

Using a USB digital microscope with an integrated camera* (U500X Capture Digital Microscope, Guangdong, China) linked to a suitable personal computer, specimens were photographed.

Technique: the following image acquisition system was used to capture the images.

1. The samples were placed 2.5 cm vertically away from a digital camera with a 3 Mega Pixel resolution. The light source and the lens's axis make a 90-degree angle.
2. Eight LED lights were used to provide illumination, and the color index (Ra) was almost 95%.

A resolution of 1280 x 1024 pixels was used to record each image. The photos were cropped to 350 × 400 pixels using Microsoft Office Picture Manager to define and standardize the frame of measurement. [11]

The WSxM software (Ver 5 develop 4.1, Nanotec, Electronica, SL) was used to create and analyze a 3D image since all parameters were expressed in pixels, including limits, sizes and frames. To convert pixels into absolute real-world units, system calibration was performed. In this study, a ruler was used as a calibration object, and a scale generated by the program was compared to the ruler.[12]

After that, 3D images were taken of each specimen in the middle area and on the sides over an area of 10 μm × 10 μm. To calculate surface roughness, average heights (Ra) were calculated using WSxM software in micrometers.[13]

Listerine mouthwash immersion

For 120 hours at 37°C, all specimens were submerged in 20 ml Listerine-mouth rinse (Johnson

GMbH, Italy) which is equivalent to using mouthwash every day for 10 years for two minutes. There are several antiplaque ingredients in Listerine mouthwash, including Eucalyptol, Thymol, Methyl Salicylate, and Menthol. This mouthwash has a low pH, which makes it acidic for our saliva.[14]

Following the immersion time, each specimen was removed, cleaned with distilled water, dried, and the SR was once more recorded at the baseline using the identical methodology.

Repolishing procedures:

In accordance with the manufacturer's instructions, a diamond polishing kit (Dia comp plus EVE Diapol Twist, Germany) was used for the repolishing process. For smoothing, use a pink medium polisher first, and then for surface shine, use a grey fine polisher. Every step was performed for thirty seconds on every surface. Again, the SR of all specimens was measured with the same previous way and recorded.[15]

Statistical Analysis

To analyze the data, the statistical software used was IBM Corp's SPSS Statistics for Windows, Version 21.0 (IBM Corp, 2012, IBM SPSS Statistics for Windows, Version 21.0, Armonk, NY: IBM Corp). The Kolmogorov-Smirnov test, a standard test for normality, yielded SR values, which were then displayed as mean ± SD. One-way ANOVA was used to compare the surface roughness of various materials after different phases, and the Tukey's post hoc test was used. If the P-value was less than 0.01, the level of significance was met.

RESULTS

Statistical analysis of the mean and standard deviation values of SR (μm) of studied materials at the three time points of measurements (base line, after mouth rinse and after repolishing) are presented in **Table 1 and 2**.

The current study's findings demonstrated a statistically significant variation in the three hybrid materials' surface SR values at each of the three measurement time points. Shofu HC had the highest SR value (0.314±0.020) after immersion in mouth rinse, followed by Nacera Hybrid (0.310±0.023) and Vita Enamic (0.264±0.017). There was a considerable disparity between the SR values and baseline values in every material.

Nacera Hybrid has the greatest SR value (0.293±0.016) after repolishing, followed by Shofu HC (0.289±0.017) and Vita Enamic (0.252±0.018). For Enamic and Nacera Hybrid there was a non-significant difference between SR values with after immersion values. For Shofu HC there was a significant difference between SR values with after immersion values.

Using a digital microscope, optical images were captured to the surface of the three tested materials as shown in **figure 1:** surface roughness at baseline for Vita Enamic, Shofu HC and Nacera Hybrid shown in (column A) and after repolishing showed in (column B), and after immersion in mouthwash showed in (column C) respectively. These images were then processed using computer software to create 3D images.

TABLE (1) Showing the results of statistical analysis for the mean± SD of SR values of the 3 materials at the 3 time points.

Material	Timepoints			ANOVA	
	Baseline	Mouthwash	Repolishing	F	P
Vita Enamic	0.248±0.019	0.264±0.017[1]	0.252±0.018	6.485	0.002
Shofu HC	0.283±0.016	0.314±0.020[1]	0.289±0.017[2]	27.480	<0.001
Nacera Hybrid	0.287±0.016	0.310±0.023[1]	0.293±0.016[2]	11.770	<0.001

1: Indicates significant difference between SR after mouthwash and baseline.

2: Indicates significant difference between SR after repolishing and after mouthwash.

TABLE (2) Showing comparisons of SR values at different time points among the 3 materials.

Timepoints	Materials			ANOVA	
	Vita Enamic	Shofu HC	Nacera Hybrid	ANOVA	P
Baseline	0.248±0.019	0.283±0.016[1]	0.287±0.016[1]	48.588	<0.001
Mouthwash	0.264±0.017	0.314±0.020[1]	0.310±0.023[1]	55.112	<0.001
Repolishing	0.252±0.018	0.289±0.017[1]	0.293±0.016[1]	51.838	<0.001

1: indicates significant difference compared to Vita Enamic

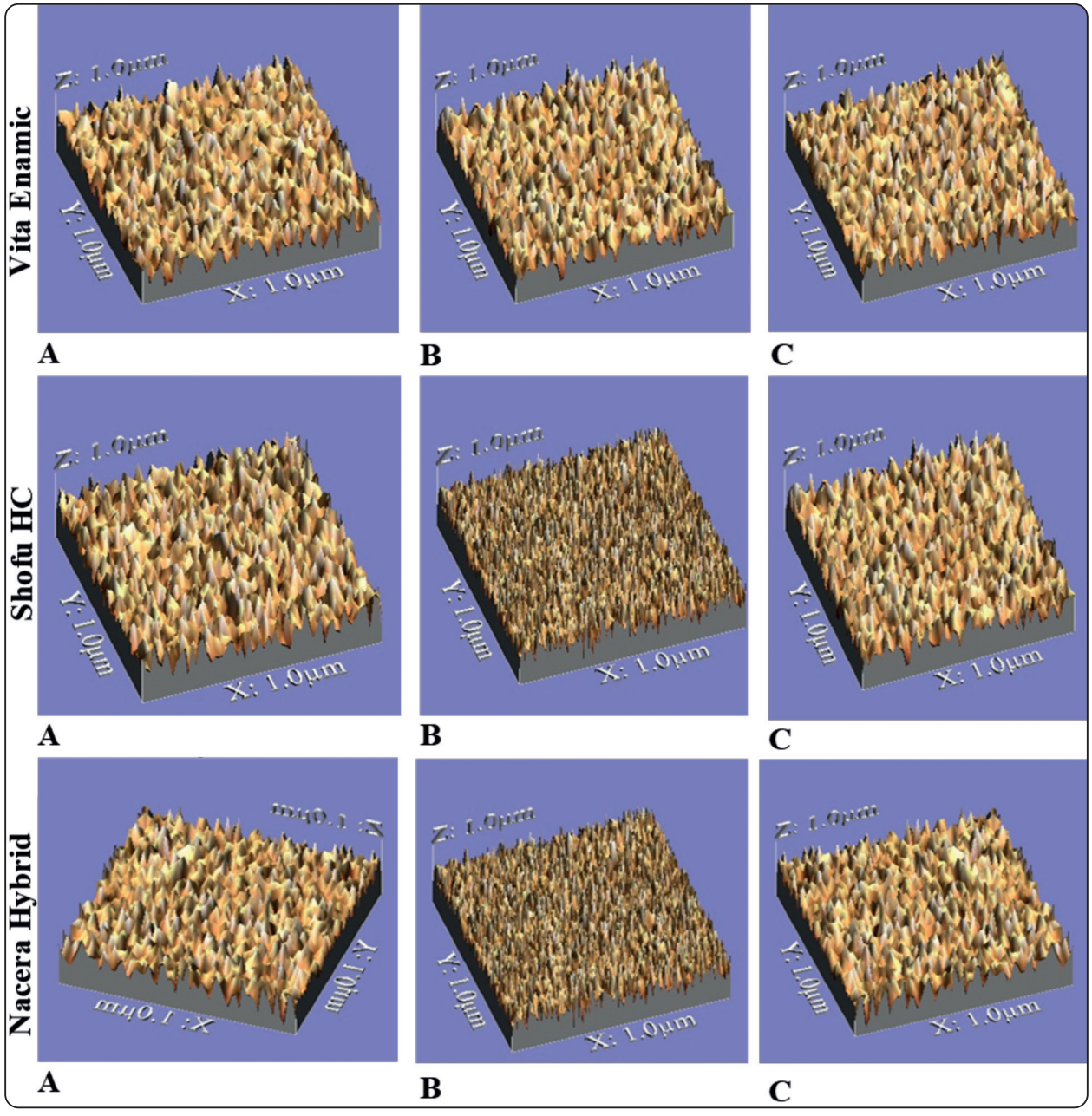

Fig. (1) Surface roughness at baseline for Vita Enamic, Shofu HC and Nacera Hybrid shown in (column A) and after repolishing showed in (column B), and after immersion in mouthwash showed in (column C) respectively.

DISCUSSION

In the present study, the SR of three hybrid ceramic materials—Enamic, Shofu HC, and Nacra—was assessed following their immersion in Listerine mouthwash and after repolishing.

The study's null hypothesis was partially rejected because the findings revealed that, following immersion in mouth rinse, the SR values of the three hybrid ceramic materials differed significantly from their baseline values. But only after repolishing, the SR values of Shofu HC and Nacera were significantly different. By combining the flexibility of composite resin with the strength, durability, and color stability of ceramics, hybrid ceramics made of both ceramic and polymer have been created. Thus, the materials that were examined in this study were Nacera Hybrid, Vita Enamic, and Shofu HC. The chemical makeup of these materials varies, as does the proportion of glass and resin that each material contains, which is anticipated to affect variations in surface roughness.[16]

To ensure validity and reliability, standardization of all procedures was followed. Using an isomet low speed sectioning machine, 1mm thick ceramic specimens were cut from the three hybrid ceramic materials with very little waste and deformation of the cut materials. [17] The thickness of all specimens was confirmed with digital caliber.

To simulate the thickness of a full coverage crown applied in a clinical setting, a thickness of 1mm was chosen. Furthermore, because tested materials with a thickness of less than 0.8 mm are prone to fractures, deformation, and even breakage, it is challenging to obtain an exact cut. [18]

The most popular technique for determining the average roughness of ceramic surfaces is the SR value, which does not indicate that there are no flaws in the surface's local area. Therefore, non-contact optical profilometers were used to quantify the surface topography without contact.[19]

The surface topography of dental ceramic restorations may be impacted by prolonged contact to acidic, low-PH oral hygiene solutions. Listerine mouthwash as an example of these solutions is frequently used with patients experiencing gingivitis because it has an antimicrobial impact by reducing the count of Streptococcus mutans [20] so it was selected for use in the current study.

Shofu HC and Nacera Hybrid, which have higher polymeric contents (40% and 50%, respectively) than other glass ceramic materials, showed higher surface roughness because prolonged exposure to acidic solutions weakens the material's structure and causes some of its inorganic contents to leak out. Although Shofu Hc has a rougher surface than Nacera hybrid, this could be because of variations in the particle's size, shape, and chemical makeup. [17,21]

El Zayat et al.'s findings, which examined at how two energy drinks affected the microhardness, surface roughness, and color stability of a few ceramic and hybrid materials (Celtra Duo, IPS e.max, and Nacera hybrid), are in line with the results of this study. The results showed that the Nacera hybrid had a much higher surface roughness when compared to the other two materials. [17]

The current study further extends the research of Hamdy TM et al., who investigated how the composition of mouthwash affected the dental nanohybrid resin composites' microhardness and color stability. The chemical composition of mouthwash was found to influence resin composites' surface hardness significantly.[22]

The findings of this study disagreed with Bohner et al. The researchers found that mouthwashes had no discernible effect on the surface roughness of ceramic and resin composite materials after measuring surface roughness upon immersion.[23]

Repolishing is essential for the restoration's smooth surface, reduced plaque retention, easier

hygiene, increased aesthetics, decreased tissue irritation, and comfortable surface. [24]

The three material groups' surface roughness significantly decreased in the current study after being submerged in Listerine mouthwash. Out of the three hybrid materials, only two; Shofu and Nacera showed a significant difference after repolishing and returned to their base line SR values. This result could be due to higher surface hardness of Enamic compared to the Shofu HC and Nacera.

Vita Enamic had the lowest surface roughness score, followed by Nacera Hybrid and Shofu HC. This could be because the material's microstructure plays a crucial role in determining surface roughness.

These hybrid materials consist of acrylate-based polymer mesh supporting feldspathic ceramic crystal networks, which are infiltrated with polymers. As the polymer percentage increases, the materials' wear resistance decreases and their surface roughness increases. [25]

When the fillers wear away from the structure, the network can continue to exist inside the structure in the form of a more durable mesh. This is made possible by the materials' interpenetrating network structure and the filler's close network structure, which gives the filler its mechanical and physical properties. This causes the surface roughness to increase in this situation. [19]

Each of the three tested materials contains a different proportion of polymer, with Vita Enamic having a ceramic network of 86% and a polymer network of 14%, Shofu HC having 61% zirconia silicate and 39% densely packed nanofillers and Nacera Hybrid having 50% nano glass and 50% polymer networks.

In terms of repolishing's impact, the current study concurs with Makkeyah F and Al Nkily MM,[26] who examined how various polishing techniques affected the surface roughness of lithium disilicate ceramics and discovered that polishing improved the surface topography with decreasing surface roughness.

The current study has limitations. The in vitro nature doesn't reflect the actual intraoral conditions. Only one type of mouthwashes was considered. Furthermore, the hardness of the materials was not investigated. Future studies should consider these limitations.

CONCLUSIONS

It was determined that within the limitations of this in vitro study.

- The three tested hybrid materials' surface roughness could be altered by Listerine mouthwash.
- Following immersion in mouth rinse, Shou HC exhibited the highest level of surface roughness.
- Repolishing was effective in reducing the surface roughness of all three hybrid materials; the material with the highest ceramic content was least affected.
- In hybrid ceramic materials, the higher the resin content, the rougher the material's surface.

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