Original Article

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A Comparative Evaluation of Surface Roughness of Ceramics after Immersion in Different Oral Rinses: An In-vitro Study

Dentistry Section

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ABSTRACT

Introduction: The novel Coronavirus Disease-2019 (COVID-19) spreads through respiratory droplets, and various strategies have been developed to reduce its spread. One of these strategies is the use of oral rinses, such as chlorhexidine, povidone iodine, and hydrogen peroxide (H_2O_2), to reduce the viral load. However, while these rinses have advantages in preventing the spread of the virus, they may also have adverse effects on restorative materials in the oral cavity, particularly dental ceramics. The usage of mouthwashes during the pandemic may affect the surface roughness of dental ceramics, leading to plaque accumulation.

Aim: The aim of this study was to evaluate the surface roughness of ceramics after immersion in different oral rinses for seven, 15, and 30 days.

Materials and Methods: An in vitro study was conducted in the Department of Prosthodontics at Bharati Vidyapeeth Dental College and Hospital, Sangli, Maharashtra, India. The study was conducted over a period of four months, from October 2021 to January 2022. A total of 51 specimens of dental ceramics were fabricated using a mold with dimensions of 10 mm diameter x 2 mm height. These specimens were randomly divided into three groups based on the immersion solution: distilled water, hydrogen peroxide, and povidone iodine. Each immersion cycle lasted for one minute, and the immersion was performed for 30 days. Surface analysis was carried out using a Surftester at intervals of seven, 15, and 30 days. The data were statistically analysed using the Statistical Package for Social Sciences (SPSS) version 26.0. Intergroup comparison (>2 groups) was performed using the Kruskall-Wallis test, and Analysis of Variance (ANOVA) followed by pairwise comparison using the Mann-Whitney U test. A p-value of <0.05 was considered statistically significant.

Results: The mean values of surface roughness for povidone iodine were 0.641, 1.569, 2.5047, and 3.4447 at 0, seven, 15, and 30 days, respectively. The mean values of surface roughness for hydrogen peroxide were 0.681, 2.360, 4.0324, and 5.7035 at 0, seven, 15, and 30 days, respectively. The mean values of surface roughness for distilled water were 0.747, 0.994, 1.3312, and 1.6088 at 0, seven, 15, and 30 days, respectively.

Conclusion: The surface roughness of ceramics was significantly higher with the use of hydrogen peroxide as a mouthwash, with mean values of 0.681, 2.360, 4.0324, and 5.7035 at 0, seven, 15, and 30 days, respectively, compared to povidone iodine and distilled water. Povidone iodine can be used as a prophylactic oral rinse compared to hydrogen peroxide.

Keywords: Coronavirus disease-2019, Hydrogen peroxide, Mouthwashes, Povidone iodine, Severe acute respiratory syndrome coronavirus 2

INTRODUCTION

The COVID-19 outbreak has severely affected the human population, revealing severe health problems, including those in the oral cavity. The oral cavity plays an important role as one of the main entry routes for the virus. The coronavirus increases the contagion capacity of ACE2 receptors, which are highly prevalent in the oral cavity. The viral load, during which the virus can replicate and increase, can last up to 3 to 4 weeks. The incubation period usually lasts for seven days [1]. Both the general public and healthcare providers have adopted the use of oral rinses as a preventive measure against the spread of the virus, considering them to be simple to use and cost-effective [1]. Oral rinses such as chlorhexidine, povidone iodine, hydrogen peroxide, cetylpyridinium chloride, and distilled water may have the potential to reduce the viral load of Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) in the mouth and oropharynx by damaging or destroying the lipid envelope [2-4].

A review has suggested that 0.23% povidone iodine and 0.5% hydrogen peroxide effectively inactivate the coronavirus, whereas 0.02% chlorhexidine has weak properties in this regard when rinsed for 10 minutes [1]. However, the prophylactic use of these oral rinses may have adverse effects on the restorative materials already present in the oral cavity, such as dental ceramics, due to their alcohol content. Dental ceramics are widely used in clinical practice as a restorative dental material. They possess excellent physical and mechanical properties and are biocompatible with oral tissues, making them the material of choice for replacing dental structures [5]. However, exposure to aqueous environments and chemical solutions may alter the surfaces of dental ceramics due to the low pH and alcohol present in oral rinse solutions [6]. Therefore, the aim of the present study was to evaluate the surface roughness of ceramics after immersion in different oral rinses.

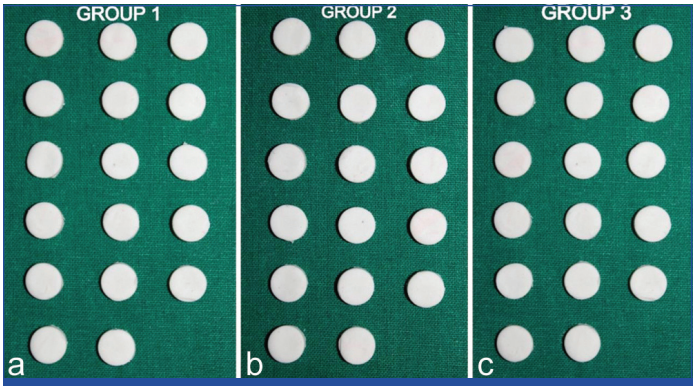
MATERIALS AND METHODS

An in vitro study was conducted in the Department of Prosthodontics at Bharati Vidyapeeth Dental College and Hospital, Sangli, Maharashtra, India. The study duration was four months, from October 2021 to January 2022. Ethical clearance was obtained from the Institute with the number BV (DU) MC and H Sangli/IEC/Dissertation 2021-22/D-18.

Study Procedure

The present study aimed to evaluate the surface roughness of ceramics using a surface tester analyser after immersion in different oral rinse groups at 0, seven, 15, and 30 days. A total of 51 specimens of dental ceramic blocks (VITA VMK) with dimensions of 10 mm diameter and 2 mm thickness were prepared using a

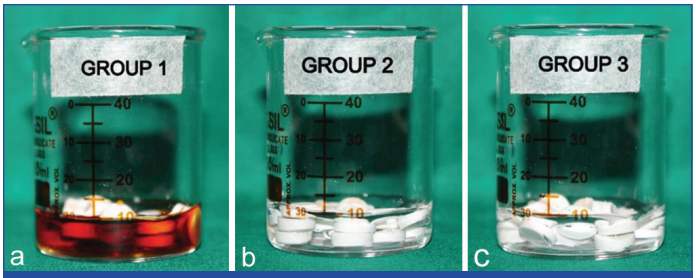
mold [Table/Fig-1a-c]. These specimens were randomly divided into three groups of 17 specimens each based on immersion in three different oral rinses: povidone iodine, hydrogen peroxide, and distilled water, respectively.



[Table/Fig-1a-c]: a) Specimen distribution in group 1 (povidone iodine), b) Group 2 (hydrogen peroxide), c) Group 3 (distilled water).

- Group 1: Povidone iodine mouthwash (0.23%) (Win Medicare Pvt. Ltd.)
- Group 2: Hydrogen peroxide (0.5%) (VL products)
- Group 3: Distilled water (distilled water plant situated in the Institution)

The specimens were immersed in vessels containing 10 mL of the respective oral rinses [Table/Fig-2a-c]. Immersion was carried out for a total of 30 days, with each cycle lasting one minute and performed three times a day with constant agitation. Each immersion cycle was carried out at an eight-hour interval, and the solutions were replenished after each cycle. The specimens were stored in artificial saliva in between cycles. Surface roughness analysis was conducted at baseline (T0) and at intervals of seven days (T1), 15 days (T2), and 30 days (T3) using a Surftester (Mitutoyo SJ-201P). The probe of the Surftester was moved over the surface of the specimen, and the readings were recorded. The readings were recorded three times, and the average of the readings was calculated.



[Table/Fig-2a-c]: a) Immersion of specimens in group 1 (povidone iodine), b) Group 2 (hydrogen peroxide), c) Group 3 (distilled water).

STATISTICAL ANALYSIS

The data obtained was compiled in a Microsoft Office Excel Sheet (version 2019, Microsoft Redmond Campus, Redmond, Washington, United States). The data was subjected to statistical analysis using SPSS version 26.0. The normality of numerical data was checked using the Shapiro-Wilk test, and it was found that the data did not follow a normal distribution. Hence, non-parametric tests were used for comparisons. Intergroup comparisons (>2 groups) were performed using the Kruskall-Wallis test and ANOVA, followed by pair-wise comparisons using the Mann-Whitney U test. A p-value of <0.05 was considered statistically significant, with an α error of 5% and a β error of 20%, giving the study a power of 80%.

RESULTS

The mean values of surface roughness at 0 days for groups 1, 2, and 3 were 0.641 µm, 0.681 µm, and 0.747 µm, respectively. At seven days, the values for groups 1, 2, and 3 were 1.569 µm, 2.360 µm, and 0.994 µm, respectively. At 15 days, the values for groups 1, 2, and 3 were 2.5047 µm, 4.0324 µm, and 1.3312 µm, respectively. At 30 days, the values were 3.4447 µm, 5.7935 µm, and 1.6088 µm for groups 1, 2, and 3, respectively [Table/Fig-3]. Intergroup comparisons between groups 1 and 2, as determined by the Mann-Whitney U test, showed statistically highly significant differences in the values for all time intervals and differences (p<0.01, 0.05), except for T0, where no statistically significant difference was observed (p>0.05) [Table/Fig-4].

Baseline	Groups	n	Mean±SD	Standard error	Chi-square value	p-value of Kruskal-Wallis test
T0	1	17	0.641±0.1809	0.0439	1.559	0.459#
	2	17	0.681±0.2144	0.0520		
	3	17	0.747±0.2384	0.0578		
T1	1	17	1.569±0.1756	0.0426	41.921	0.001**
	2	17	2.360±0.2176	0.0528		
	3	17	0.994±0.2768	0.0671		
T2	1	17	2.5047±0.17522	0.04250	44.476	0.001*
	2	17	4.0324±0.21661	0.05254		
	3	17	1.3312±0.32175	0.07804		
T3	1	17	3.4447±0.17504	0.04245	44.478	0.001*
	2	17	5.7035±0.21648	0.05250		
	3	17	1.6088±0.30889	0.07492		

[Table/Fig-3]: Mean values of surface roughness measured after 0, seven, 15 and 30 days for group 1, 2 and 3.
T0-baseline, T1- 7 days, T2- 15 days, T3- 30 days
Group 1-Povidone iodine
Group 2-Hydrogen peroxide
Group 3-Distilled water

Baseline	Mann-Whitney U test	z-value	p-value of Mann-Whitney U test
T0	126.000	-0.639	0.523#
T1	1.000	-4.944	0.001**
T2	0.001	-4.979	0.001**
T3	0.001	-4.979	0.001**
T0-T1	0.001	-5.023	0.001**
T0-T2	0.001	-5.004	0.001**
T0-T3	0.001	-4.993	0.001**
T1-T2	0.001	-5.023	0.001**
T1-T3	0.001	-5.038	0.001**
T2-T3	0.001	-5.026	0.001**

[Table/Fig-4]: Intergroup pair-wise comparison between group 1 vs 2 using Mann-Whitney U test at baseline, seven days, 15 days and 30 days.
T0-baseline, T1- seven days, T2- 15 days, T3- 30 days
Group 1 -Povidone iodine
Group 2- Hydrogen peroxide

Intergroup comparisons between groups 1 and 3, as determined by the Mann-Whitney U test, showed statistically highly significant differences in the values for all time intervals and differences (p<0.01, 0.05), except for T0, where no statistically significant difference was observed (p>0.05) [Table/Fig-5]. Intergroup comparisons between groups 2 and 3, as determined by the Mann-Whitney U test, showed statistically highly significant differences in the values for all time intervals and differences (p<0.01, 0.05), except for T0, where no statistically significant difference was observed (p>0.05) [Table/Fig-6].

Baseline	Mann-Whitney U test value	z-value	p-value
T0	107.500	-1.276	0.202#
T1	16.500	-4.411	0.001**
T2	0.001	-4.979	0.001**
T3	0.001	-4.979	0.001**
T0-T1	0.001	-4.995	0.001**

T0-T2	0.001	-4.988	0.001**
T0-T3	0.001	-4.988	0.001**
T1-T2	17.000	-4.418	0.001**
T1-T3	0.001	-5.026	0.001**
T2-T3	0.001	-5.019	0.001**

[Table/Fig-5]: Intergroup pair-wise comparison between group 1 vs 3 using Mann-Whitney U test at baseline, seven days, 15 days and 30 days.
T0-baseline, T1- **seven** days, T2- 15 days, T3- 30 days
Group 1 -Povidone iodine
Group 3-Distilled water

Baseline	Mann-Whitney U test value	z-value	p-value
T0	129.000	-0.534	0.593#
T1	0.001	-4.979	0.001**
T2	0.001	-4.979	0.001**
T3	0.001	-4.979	0.001**
T0-T1	0.001	-5.009	0.001**
T0-T2	0.001	-4.994	0.001**
T0-T3	0.001	-4.985	0.001**
T1-T2	0.001	-4.998	0.001**
T1-T3	0.001	-4.992	0.001**
T2-T3	0.001	-4.999	0.001**

[Table/Fig-6]: Intergroup pair-wise comparison between group 2 vs 3 using Mann-Whitney U test at baseline, seven days, 15 days and 30 days.
T0-baseline, T1- seven days, T2- 15 days, T3- 30 days
Group 2- Hydrogen peroxide
Group 3-Distilled water

DISCUSSION

Oral hygiene intervention, including gargling or using mouthwash with antiseptic properties, is imperative during the COVID-19 pandemic. It is believed that the components of oral rinses can affect the degradation of restorative materials. Studies have reported that, mouthwashes containing alcohol or having low pH levels can have harmful effects on restorative materials by plasticising the polymeric matrix, resulting in increased ductility [6]. In the present study, dental ceramic, which is known for its inertness and excellent clinical performance, was used to evaluate surface roughness. Previous studies have shown that dental ceramic can be affected by solutions present in the oral environment. For example, Kukiattrakoon B et al., found a decrease in microhardness when ceramic was immersed in low pH solutions [7]. Similarly, Esquivel Upshaw J et al., stated that, ceramic veneers were susceptible to degradation when exposed to low and high pH solutions due to an ionic exchange mechanism [8]. However, Esquivel Upshaw J et al., also mentioned that significant degradation would only occur after a long period of use [8].

Hydrogen peroxide (H_2O_2) has been used in dentistry alone or in combination with salts for many years. As a mouthwash, it is an odorless, clear, and colorless liquid [2]. Rosling BG et al., reported no adverse effects on soft tissues when 1%-1.5% H_2O_2 was used as a daily rinse [9]. Peng X et al., stated that, SARS-CoV-2 is vulnerable to oxidation [10]. Therefore, oral rinses containing oxidative agents like 1% H_2O_2 have been suggested to reduce the viral load in saliva before conducting any dental procedures [5,10]. However, several studies have reported that, these agents may have certain effects on restorative materials used intraorally for tooth restoration and replacement. In the current study, hydrogen peroxide showed higher surface roughness compared to povidone iodine and distilled water. This finding contrasts with a study conducted by Polydorou O et al., who showed that, the effect of various agents on surface texture was material and time-dependent [11]. They found that, polished ceramic surfaces exposed to 38% hydrogen peroxide for 45 minutes showed slight changes in surface texture, while no significant difference was noted when ceramic surfaces were exposed to 15% carbamide peroxide for 56 hours [6].

Povidone-iodine (PVP-I) is a water-soluble iodine complex that is commonly used as a mouthwash. A study by Vergara-Buenaventura A, suggested that, a 1% concentration of PVP-I is effective for mucositis, prophylaxis of oropharyngeal infections, and prevention of ventilator-associated pneumonia [2]. PVP-I exerts its antimicrobial action by dissociating into free iodine, which then penetrates microbes to disrupt proteins and oxidise nucleic acid structures, leading to microbial death. Lachapelle JM reported that PVP-I is safe to use and has a low prevalence of allergic reactions (0.4%) [12]. Slots also mentioned that PVP-I does not cause tooth or tongue discolouration or taste disturbances, unlike alcohol-based products, and it is safe to use as an oral rinse [13]. The effectiveness of PVP-I against various viruses, including SARS-CoV-2, MERS-CoV, and influenza virus A (H1N1), has been demonstrated in several in vitro studies conducted by Parhar HS et al., Kariwa H et al., and Eggers M et al., [14-16]. Eggers M et al., suggested the use of 0.23% PVP-I mouthwash for at least 15 seconds before dental procedures to reduce salivary viral load, particularly in COVID-19 positive patients [2]. In the present study, PVP-I showed lower surface roughness compared to hydrogen peroxide, indicating that it can be safely used as an oral rinse.

Limitation(s)

It is important to note that although mouthwashes may have an effect on the surface roughness of restorative materials, this effect may not be significant over a short period of time. Future research with a larger sample size should be conducted in a clinical environment and over a longer duration to further investigate this aspect.

CONCLUSION(S)

Within the limitations of the study, the surface roughness of all evaluated dental ceramics was significantly affected by treatment with hydrogen peroxide compared to povidone iodine and distilled water. Therefore, povidone iodine can be considered a safer option for use as an oral rinse compared to hydrogen peroxide.

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