EGYPTIAN DENTAL JOURNAL
www.eda-egypt.org
VOL. 70, 1705:1713, APRIL, 2024
PRINT ISSN 0070-9484 • ONLINE ISSN 2090-2360
FIXED PROSTHODONTICS AND DENTAL MATERIALS
Submit Date : 26-01-2024 • Accept Date : 14-02-2024 • Available online: 10-04-2024 • DOI : 10.21608/EDJ.2024.265050.2907

EFFECT OF REPOLISHING ON COLOR STABILITY OF HYBRID CERAMICS AFTER IMMERSION IN CHLORHEXIDINE MOUTH RINSE

Rawan Ahmed Rabiee* , Waleed Mohamed Elshahawy** *and* Abeer Atef Younes***

ABSTRACT

Aim: The purpose of this in-vitro study was to evaluate the effect of repolishing on color stability of hybrid ceramics after immersion in chlorhexidine mouth rinse using spectrophotometric analysis.

Materials and methods: Sixty rectangular specimens were cut of (A1) shade CAD/CAM blocks into 1mm thickness, 14mm length and 14mm width using Isomat4000. Specimens were divided into 3 groups (Vita Enamic, Shofu HC & Nacera hybrid). Color was measured by spectrophotometer before immersion in mouth rinse (subgroup A: control), after immersion in20ml of Chlorhexidine gluconate (CHX) mouth rinse for 120 hours (sub group B) and after repolishing with diacomp plus diamond polishing discs (sub group C). The data were tabulated and statistically analyzed using ANOVA test.

Results: After staining, ΔE of the tested specimens were 5.63±1.12, 3.45±1.84, 3.37±1.15 for Shofu HC, Vita Enamic, and Nacera Hybrid, respectively.

After re-polishing, ΔE of the tested specimens were 6.66±1.45, 4.19±0.98, and 4.13±1.49 for Shofu HC, Nacera Hybrid, and Vita Enamic, respectively.

Conclusion: CHX mouth rinse had the ability to stain the three hybrid materials with highest effect on Shofu HC hybrid material. Re-polishing improved the color of three stained hybrid material with the highest degree of improvement showed on Shofu HC material.

KEY WORDS: hybrid ceramic, color, stain, chlorhexidine, repolishing

* B.D.S (2013), Diploma in fixed prosthodontics (2018).
** Professor of Fixed Prosthodontics, Faculty of Dentistry Tanta University.
*** Lecturer of Fixed Prosthodontics, Faculty of Dentistry, Tanta University.

INTRODUCTION

Nowadays many materials were used to obtain a natural smile as patient needs. Many materials can service this purpose such as all-ceramics because of their high esthetic properties.[1]

Hybrid ceramics combined advantages of ceramics such as color stability and durability with low abrasiveness and improved flexibility of composite resin.[2,3]

VITA ENAMIC is one of hybrid ceramics which combined advantages of composite and ceramic. It is called double network hybrid (DNH) because it has two interpenetrating networks of ceramic and polymer so high flexural strength values and elasticity have been reported.[4]

Nacera Hybrid is another type of hybrid ceramics which is tough, radiopaque material with optimized, high-density filler technology and it is available in various color for use as a blank and block in CAD/CAM technology.[5]

Shofu HC is also a type of hybrid ceramics which is highly esthetic ceramic based restorative material for milling into dental restoration using a dental CAD/CAM system.[6]

Esthetic of dental restoration is affected by translucency and color. Many factors can affect color stability of restorative material including particle size of restorative material, its porosity, rate of absorption of material and other extrinsic factors including oral enviroment.[7]

Oral environment should maintain healthy to prevent caries and accumulation of plaque. So, antibacterial mouth rinses like chlorhexidine were used to prevent periodontal diseases and dental caries.[8] However, they have a great effect on color stability of natural tooth and restorative material when used for long periods without following dentist's instruction. [9,10]

There are different ways to eliminate restoration staining such as polishing, bleaching or replacement of restoration. Available data about repolishing effect on hybrid ceramic is limited. So, the present study aimed to investigate the effect of repolishing on different stained hybrid ceramic materials.

MATERIALS AND METHODS

The study design:

This study was conducted as an experimental laboratory study.

The study setting:

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

Ethical considerations:

The design and the procedure of the present study was accomplished according to the research guidelines adopted by the research ethics committee, Faculty of Dentistry, Tanta University.

Sample size:

The minimum number of sample size for this study is 27 samples. The samples were collected based on previous study.[30] The significance level was 0.05 and the power sample size was more than 80% for this study and the confidence interval 95% and the actual power is 95.61%. The sample size calculated using a computer program G power version 3.

The formula of sample size

$$\text{Sample size} \quad \frac{Z^2 P^{\wedge} (1-P^{\wedge})}{C^2}$$

Where:

Z = Z value (1.96 for 95% confidence level)

p = percentage picking a choice, expressed as decimal

c = confidence interval, expressed as decimal.

An over sizing of the sample was done to compensate the potential failure and increase the validity of the results, so the sample size was 60.

MATERIALS

TABLE (1) Materials tested in this study.

Material	Manufacturer	Product	Composition	
Hybrid ceramic	Vita Zahnfabrik, Germany	VETA ENAMIC	Monomer 14% UDMA, TEGDMA	58%-63%SiO_2, 20-23%Al_2O_3, 9-11%Na_2O, 4-6%K_2O, 0.5-2%B_2O_3 < 1% ZrO_2 < 1% CaO
	HC block Shofu Inc, Japan	Block Shofu HC	Monomer UDMA, TEGDMA	Filler 61% Silica, silicate, zirconium silicate
	Nacera hybrid, Germany	Nacera Hybrid	50% polymer-matrix	50% nano-glass

METHODS

Specimens grouping:

Sixty ceramic specimens were constructed for this study (N=60). Divided into 3 groups.

Group I: Vita Enamic

Consist of three subgroups (n=20)

- Subgroup A: 20 specimens were measured at baseline (control)(n=20)
- Subgroup B: 20 specimens were measured after immersion in mouth rinse (n=20)
- Subgroup C: 20 specimens were measured after re-polishing(n=20)

Group II: Shofu HC

Consist of three subgroups (n=20)

- Subgroup A: 20 specimens were measured at baseline (control) (n=20)
- Subgroup B: 20 specimens were measured after immersion in mouth rinse (n=20)
- Subgroup C: 20 specimens were measured after re-polishing (n=20)

Group III: Nacera hybrid

Consist of three subgroups (n=20)

- Subgroup A: 20 specimens were measured at baseline (control) (n=20)
- Subgroup B: 20 specimens were measured after immersion in mouth rinse (n=20)
- Subgroup C: 20 specimens were measured after re-polishing (n=20)

Specimen preparation:

Sixty rectangular specimens were cut of (A1) shade CAD/CAM blocks of Vita Enamic, Nacera hybrid and Shofu HC hybrid ceramics to be used in this study using Isomet 4000* with water coolant. Each specimen was 1mm thickness, 14mm of length and 14mm of width. The final thicknesses and dimensions of the specimens were confirmed with a digital caliper for standardization. All specimens were polished according to the manufacture instructions.

Color stability Measurement:

1- Measurament timing:

All samples were tested three times. The first time is a base line assessment (before immersion in mouth rinse). The second time is after immersion in mouth rinse. The third time is after repolishing procedure. All measurements were done using spectrophotometer** (X-rite, model RM 200 QC).

2- Color measurement before immersion in mouth rinse:

The specimens' colors were measured using a portable Reflective spectrophotometer (X-Rite, model RM200QC). The aperture size was set to 4 mm and the specimens were exactly aligned with the device. A white background was selected, and measurements were made according to the CIE L*a*b* color space relative to the CIE standard illuminant D65.[11] The color changes (ΔE) of the

* Isomet 4000, buehler, Germany

** spectrophotometer, neuisenburg, Germany

specimens were evaluated using the following formula:

$\Delta E_{CIELAB} = (\Delta L^*2 + \Delta a^*2 + \Delta b^*2)$ ½

Where:

L* = lightness (0-100), a* = (change the color of the axis red/green) and b* = (color variation axis yellow/blue) figures (16-17)

3- Immersion in chlorhexidine mouth rinse:

All Specimens were immersed in 20ml hexitol* mouth rinse. The mouth rinse consists of (125mg/100ml) chlorhexidine hydrochloride, glycerin, propylene, glycol, alcohol 96%, anise oil, peppermint oil, ponceau red, chromophore RH 40, purified water. The mouth rinse solution was replenished every 12 hours. Immersion was continued up to 120 hours.[12] All specimens were incubated for 120 hours at 37˚C.

4- After immersion in mouth rinse:

After 120 hours of immersion, all specimens were washed with the distilled water and dried. Then, the color of all sixty stained samples was measured by spectrophotometer.

5- Repolishing procedures:

Repolishing was done by using a diamond polishing system (Diacomp plus)** with a sequence to decrease abrasiveness with intermittent movements as suggested by the manufacturer, starting with a pink medium polisher for smoothing, then followed by a gray fine polisher for shine polishing and each step lasted for 30 second for each surface. [13,14]

Specimens were polished horizontally in one direction using the edge of Diacomp plus diamonds discs with light pressure. Repolishing of

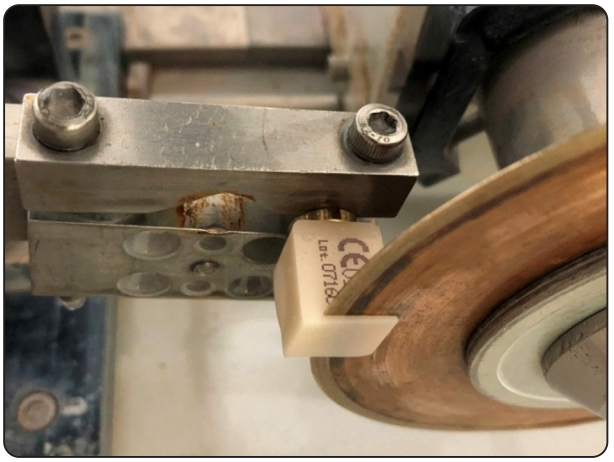

Fig. (1) Isomer cutting the CAD-CAM block

Fig. (2) First step of repolishing

Fig. (3) Second step of repolishing

* The Arab Drug company for pharmaceuticals& chemical industries, Egypt

** Eve Diacomp plus twist Eve Ernst Vetter GmbH, Germany

all specimens was done with the same operator for standardization.

6- Color measurement after repolishing:

The color of all sixty repolished specimens were measured by spectrophotometer.

7- Statistical analysis:

The results were tabulated and statistically analyzed using ANOVA test. Statistical analyses were performed using Statistical Package for Social Sciences (SPSS version 26). Numerical variables were expressed by descriptive statistics as mean, standard deviation, and range. P-value <0.05(*) was considered significant difference & P-value <0.001(**) was considered highly significant difference.

RESULTS

Comparing the color (ΔE) between Vita Enamic, NaceraHybrid and Shofu HC after immersion in mouth wash and polishing :

Numerical data of color change for (group 1) Vita enamic & (group 2) Nacera Hybrid and (group 3) Shofu HC was recorded by descriptive statistics as mean, standard division and an ANOVA test was carried out to compare staining after mouth wash and polishing affinity of each group (Table 2) (Figure 4).

TABLE (2) Comparison staining after mouth wash and polishing affinity of each group

Groups	Mouth Wash	Polishing	T	p-value
Group1 (Vita enamic)	3.45±1.84	4.13±1.49	1.252	0.219
Group2 (Nacera Hybrid)	3.37±1.15	4.19±0.98	2.366	0.024*
Group 3 (Shofu HC)	5.63±1.12	6.66±1.45	2.459	0.023*

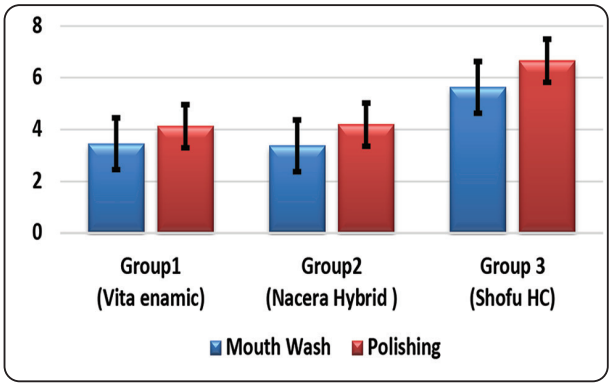

Fig. (4) Groups after mouthwash and polishing.

For all investigated groups, Shofu HC group showed the highest polishing color change (6.66±1.45) followed by the staining after mouth wash in change (5.63±1.12).

For Vita Enamic, polishing color change (4.13±1.49) followed by the staining after mouth wash recorded color change (3.45±1.84).

For Nacera Hybrid, polishing color change (4.19±0.98) followed by the staining after mouth wash recorded color change (3.37±1.15).

DISCUSSION

In this in-vitro study, the color change was examined for three hybrid ceramic materials after staining by chlorhexidine mouth wash then after repolishing.

Hybrid ceramics is developed of ceramic / polymer material which combined advantages of ceramics such as color stability and durability with low abrasiveness and improved flexibility of composite resin. These materials include Vita Enamic, Cerasmart, Lava ultimate, Shofu HC and Nacera.[15,16] So, in this study, three hybrid materials were tested. The tested materials were Vita Enamic, Shofu HC, and Nacera Hybrid.

The difference in chemical composition and structural organization of Vita Enamic and shofu and Nacera hybrid materials was the reason for the choice of these materials, as Vita Enamic contains

14% resin, Shofu HC contains 39%resin and Nacera Hybrid contains 50%resin. [17]

The three-hybrid materials Vita Enamic, Shofu HC, and NaceraHybrid were cut in 1 mm thickness by isomet low-speed sectioning machine which cut in many different materials with minimal waste and deformation.[18] This thickness was chosen to simulate the thickness of a full crown in the clinical condition. In addition, it was not possible to get accurate samples of the tested materials with a thickness lesser than 0.8 mm because of possible cracks, deformation, or even fracture of the samples during preparation.[19] So, the thickness of 1 mm was chosen for all tested materials.

The thickness was verified using a digital caliper to rule out any factors that might have an impact on the final results of color stability. According to pervious investigations, ceramic thickness has an impact on color outcomes[20, 21, 22, 23,24].

Color of specimens was measured first before immersion in mouth rinse as baseline, after immersion in 20ml chlorhexidine of mouth rinse and after repolishing by spectrophotometer device.

In the present study spectrophotometer was chosen instead of colorimeter, because colorimeters only measure reflected light at three wavelengths, but spectrophotometers measure reflected light across the whole visible spectrum.[25]

The specimens were exactly aligned with the device and the aperture size was set to 4 mm. white background was selected due to color difference evaluation was the focus of the current study and measurements were made according to the CIE L*a*b* color space relative to the CIE standard illuminant D65.[11]

In the current in vitro study, the CIE lab system was utilized to evaluate a small color variation. ΔE represents the numerical values between the three coordinates L*a*b* and shows how the values of color vary.[26,27.]

Oral hygiene solutions and acidic solutions have an impact on the surface roughness and optical characteristics of dental hybrid ceramics materials. So, chlorhexidine (CHX) was used in the present study.

The specimens were immersed in 20ml chlorhexidine mouth rinse (hexitol) for 120 days at 37˚C replenishing every 12 hours which equals 2min daily mouth rinse using for 10 years.[28]

There are many ways to eliminate staining after any restoration staining such as polishing, bleaching or replacement of restoration. There is limited available data about repolishing effect on stained hybrid ceramics. Therefore, re-polishing of stained hybrid ceramics materials was used.

In the current study, block of blue wax surrounding the specimens was used to fix specimens of materials during polishing steps for standardization. The specimens were re-polished with diamond polishing discs to eliminate the stain. The manner of repolishing (direction, pressure, time) was standardized for all specimens.

The null hypothesis of this study was "no difference in color stability between the three chlorhexidine-stained hybrid materials tested in the study: Vita Enamic, Shofu HC, and Nacera Hybrid after repolishing". The results of the present study partially rejected the null hypothesis. Shofu HC material showed significant difference in color change whereas other two materials Vita Enamic and Nacera Hybrid showed no significant difference.

Chlorhexidine mouthwash had the ability to change color of the three hybrid materials (Vita Enamic, Shofu HC, Nacera hybrid). ΔE for VitaEnamic, Nacera Hybrid and Shofu HC groups were (3.45, 3.37 and 5.63) respectively. These values of ΔE were higher than the detectable value for $\Delta E \geq 3.3$ [29.]

This could be water absorption of the monomer in the resin due to higher resin content. Also, hydrophilic materials such as UDMA, and TEGDMA exhibit color change. [30]

Water infiltration causes the organic matrix to enlarge and become plasticized, which encourages color changes in hybrid ceramics caused by mouth rinse. The resin formulation is a significant factor that affects a resin-based composite material's optical characteristics.[31] A previous study[32], noted that the amount of inorganic filler was directly correlated with the loss of translucency. And there is process known as composite plasticization occurs where the abraded surface reveals a layer that is rich in resin and contains bigger particles, increasing the water sorption capacity.[33,34.]

The three tested hybrid ceramics materials have different composition, particles shape, particles size, resin concentration, number of fillers, physicochemical interactions, hydrophilicity, and water sorption.[35-37] All these previous differences explain results gained for the tested martials in the current study.

The elevated staining affinity of Shofu HC (5.63±1.12) might be due to the increased resin content. The greater polish ability of Shofu HC (6.66±1.45) might be due to the size and shape of its particles (nanofiller spherically shaped particles) that mimic natural dentition's optical properties of light diffusion. The smaller size of the fillers relative to the light wavelength reduces the likelihood of light scattering, absorption, and reflection.[38]

Nacera hybrid showed color change (3.37±1.15), (4.19±0.98) after mouth wash and after polishing respectively which was close to that of Vita Enamic (3.45±1.84),(4.13±1.49) as 100% sinalized glass particles of Nacera is permanently integrated into the polymer-matrix which responsible for a long shine and minimal discoloration affinity, and there wasn't high degree of cross-linking.

The result of present study revealed that chlorhexidine mouthwash increased staining ability of the three hybrid materials. This result agreed with a previous study[12] which showed that non-alcohol group of mouth rinses such as chlorhexidine significantly changed the color of two ceramics materials (Vita Enamic& Vitablocks Mark II).

The results of current study were in accordance with a previous study[39] which showed significant difference in color stability of two ceramic materials (monolithic zirconia and feldspathic porcelain) after immersion in chlorhexidine. For those two materials, the ΔE values were highest in CHX, followed by the Listerine and distilled water.

The result of the current study showed re-polishing with ceramic polishing kit (Diacomp plus) improved the stain in the three hybrid materials; Shofu HC,Vita Enamic, and Nacera Hybrid. This result agreed with a previous study[13] which showed the highest staining resistance was found in a group polished with ceramic polishing kit (Diapol, EVE) (P>.05) for Cerec blocs, Lava Ultimate, Vita Enamic and CeraSmart.

The result of increased staining ability of the three hybrid materials revealed in the present study disagreed with a previous study[40] which concluded that the effect of the chlorhexidine mouth rinse on the color change of nanohybrid resin was not different from that of control solution.

The result of the current study showed that re-polishing with ceramic polishing kit (Diacomp plus) improved the stain in the three hybrid materials: Shofu HC, Vita Enamic, and Nacera Hybrid. A pervious study[41] revealed less effect of repolishing on color stability of composite resin restorative materials. The reason for the difference between the two studies could be related to the difference in composition of tested materials.

Finally, there are some limitations for the present study. There was no use for a polishing paste in addition to the polishing diamonds discs. In addition, there was no use for natural staining drinks such as tea and coffee.

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