ORIGINAL RESEARCH

Influence of the Coca-Cola Drinks on the Overall Color of Glazed or Polished Porcelain Veneers Fabricated from Different Materials and Thicknesses: An *In Vitro* Study

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Abstract

Aim: The aim of the current study is to assess the influence of Coca-Cola drinks on the overall color of glazed or polished porcelain veneers fabricated of three different porcelain systems and two different thicknesses.

Materials and methods: A total of 96 ceramic disk specimens were fabricated. The ceramic veneers were prepared to a standardized thickness of 1.0 mm $\pm$ 0.025 mm and 0.6 $\pm$ 0.025 (48 samples each group) using the following ceramic systems: Zircon, E-max press, and E-max CAD/CAM. Veneer samples from each system were divided into two subgroups ($n = 8$). First subgroup samples were glazed according to the manufacturer's instructions, and the other subgroup samples were adjusted with diamond burs then polished with ceramic polishing kit. Color was measured with Vita Easyshade spectrophotometer. Then all samples immersed with Cola drink, for 4 weeks, in a thermocycling machine and then the color were measured again and color change was recorded.

Results: Significant differences in color change were noticed before and after immersing with Coca-Cola and thermocycling for all materials and thicknesses used ($p < 0.01$). Significant differences in color changes were noticed between glazed and polished samples ($p < 0.001$). No significant differences in color change were noticed when using different thicknesses for all materials used ($p < 0.05$).

Conclusion: Different porcelain materials have shown significant color changes after immersing and thermocycling in Coca-Cola drinks. The color changes of polished porcelain specimens were more considerable than those of polished specimens for all porcelain materials and thicknesses used. This suggests reglazing of all esthetic restoration after any adjustments might be performed and before final cementation in an attempt to maintain the color stability in oral environment.

Clinical significance: To achieve a perfect color stability of ceramic veneers, clinicians should take into consideration the possible color deviations that might result after any adjustment followed by polishing procedures to the ceramic surface. And, it is always preferable to do reglazing of porcelain restorations after any surface treatments and before final cementation.

Keywords: Coca-Cola, Color, Porcelain veneers.

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Introduction

Teeth appearance has become a significant concern to the majority of patients. Teeth color and shape might have an effect on patients' psychology (i.e., confidence and self-esteem).[1–5]

An option for esthetic restoration is ceramic veneers which can be used in many esthetic procedures to improve tooth shape, color, contour, size, and malalignment.[5,6] The majority of dental practitioner now identified porcelain veneers as a predictable successful and conservative esthetic treatment.[7,8]

Due to the continuing improvements, several materials are utilized to fabricate ceramic veneers including: feldspathic porcelain, glass-based ceramics, and now zirconia-based ceramics.[9] The lithium di-silicate E-max system is considered one of the best materials to fabricate porcelain veneers. However, Zircon-based ceramic is considered the material of choice in some cases to fabricate porcelain veneers, especially when we have deeply discolored teeth.[10]

It is essential to produce an acceptable esthetic-colored ceramic veneer; however, it is also essential to maintain the color stability of these veneers in the oral environment. Many studies have evaluated the color stability of ceramic materials in relation to the surface texture.[11]

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In general, dental practitioner has to do some slight adjustments to the ceramic veneers to be delivered for such reasons. Such adjustments can remove the glazed layer off the ceramic surface, which reveals the pores of the ceramic material, creating a rough surface which can cause discoloration of the restoration that requires either reglazing or polishing in order to maintain the smooth surface and ultimately a stable color.[12–17]

Research studies has compared glazed porcelain surfaces with polished ones. Acar et al. suggested the use of polishing technique as an alternative to glazing.[18] Other studies done by Kursoglu et al. and Gupta et al. claimed that porcelain material discoloration is related to types of surface roughness produced by non-glazed or polished porcelain restorations along with diet and immersion time.[11,13]

Douglas, Kursoglu et al., Sarikaya and Guler, Hamza et al., Colombo et al., Sagsoz et al. and Saba et al. demonstrated the importance of ceramic thickness in masking the discoloration of underlying resin cement or the already discolored tooth structure.[8,11,19–23]

However, it is not clearly illustrated yet if the porcelain thickness is considered a significant factor in surface discoloration of ceramic veneers. It has been clearly stated that the color stability of a porcelain material is affected by dietary habits and commonly consumed beverages, i.e., tea, coffee, and Coca-Cola. Furthermore, Cola and coffee were considered to be the main reason in porcelain material discoloration.[19–24] Nevertheless, it was not clear yet whether Coca-Cola discoloration will be different in relation to surface manipulation of ceramic restorations or ceramic system and thickness used.

Identifying the value of the average color change ΔE^* that is perceptible or clinically acceptable is challenging, and different levels have been suggested.[19–25] However, an *in vivo* study has determined the perceptible and clinically acceptable thresholds to be ΔE^* 2.8 and 4.2 units, respectively.[26] So, these values should be borne in mind when evaluating color change spectrophotometrically. Thus, the aim of the current study is to assess the influence of Coca-Cola drinks on the overall color of glazed or polished porcelain veneers fabricated of three different porcelain systems and two different thicknesses.

Materials and Methods

Study Design

The whole study methods were conducted in King Saud University dental laboratory.

A total of 96 ceramic disk specimens were fabricated for this study to assess the effect of Coca-Cola drink on the overall color change of glazed or polished veneers fabricated in two different thicknesses and from three different ceramic systems. The ceramic veneers were prepared to a standardized thickness of 1.0 mm $\pm$ 0.025 mm and 0.6 $\pm$ 0.025 (48 samples each group) using the following ceramic systems: Zircon, E-max press, and E-max CAD/CAM. Veneer samples from each system were divided into two subgroups ($n = 8$) according to the surface management: polished or glazed samples (Table 1).

First subgroup samples were glazed according to the manufacturer's instructions, and the other subgroup samples were adjusted with diamond burs then polished with ceramic polishing kit (Ivoclar Vivadent) using the recommended protocol for polishing instructed by the company.

Color was measured with the samples placed in the same settings over a gray background using Vita Easyshade spectrophotometer, and color readings were reordered as a reference. Then all samples were immersed in Cola drink (Coca-Cola, Kingdom of Saudi Arabia) for 4 weeks, and then they were taken out and dried where their color measurements were recorded again.

Sample Fabrication

White shades (B light and B1) were used in this study as such light shades are considered the most selected shades in porcelain veneers fabrication in clinical practice.

For the first group (Fig. 1), presintered zirconia blocks were installed in the milling machine (Amann Girrbach, Germany) to produce 16 disks of size (10 mm diameter × 0.6 mm thickness) and 16 disk samples of size (10 mm diameter × 1.00 mm thickness), and then all samples were glazed according to the manufacturer's recommendations.

For the second group, samples of IPS E-max press were fabricated using lost wax technique where the casting wax (Ivoclar Vivadent Inc.) was packed in the Teflon mold with a diameter of 10 mm and a depth of 1.1 mm and 0.7 mm. Then manufacturer instructions were follower for investing the wax and pressing the E-max ingots to replace the wax. Then all samples were glazed according to the manufacturer's recommendations.

For the third group, disk-shaped samples were designed on the CAD software into the desired dimensions and then milled by using the CAM milling machine (Aman Girrbach, Germany) following the manufacturer instructions. After milling, the IPS

Table 1: Materials investigated in the study

Material	*Brand name*	*Manufacture*	*Shade*
Zircon	Ceramill Zolid PS	(Aman Girrbach, Germany)	B light
E-max press	IPS E-max Press HT	(Ivoclar Vivadent, Liechtenstein)	B1
E-max CAD/CAM	IPS E-max CAD HT	(Ivoclar Vivadent, Liechtenstein)	B1

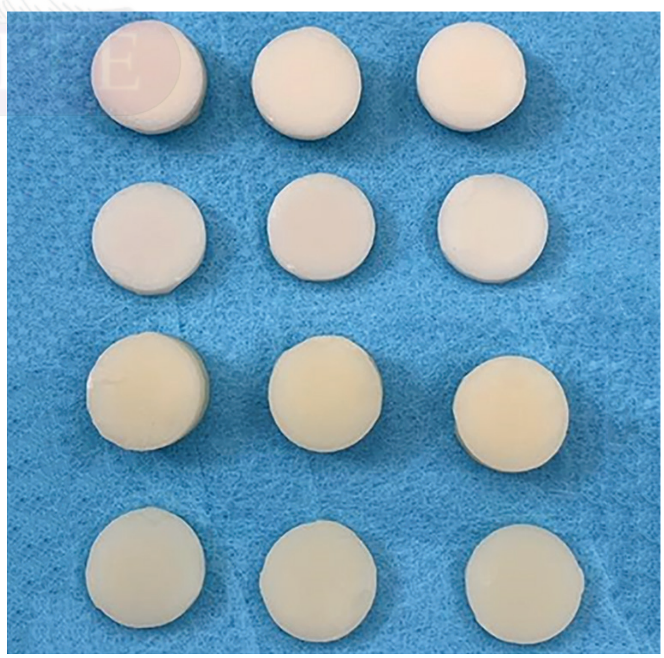


Fig. 1: Some specimens of E-max press disks used in this study

E-max CAD samples were crystallized and glazed according to the manufacturer instructions.

Both surfaces of E-max press samples were finished using abrasive paper to give a finished thickness of 1.0 mm ± 0.025 mm and 0.6 ± 0.025 (measured with digital calipers and rejected if outside given range). A single operator then recorded a color reading for samples to determine standardization.

Materials' Surface Treatment

Specimens of each thickness and material were divided into two subgroups according to the following surface treatments: (1) samples were kept glazed without any change and (2) samples were adjusted in a way to mimic the clinical adjustment of ceramic restorations by using red-band finishing bur (3M, Germany), and then polished with ceramic finishing and polishing kit (Shofu, USA) according to the polishing protocol supplied by the manufacturer (Fig. 2).

Color Measurement

Color was measured for all assigned samples by one operator, same setting, and gray background (Fig. 3). Color measurements were made using an "Easyshade" Vita probe spectrophotometer (Vita Easyshade, Vita, Germany). Spectrophotometers measure CIE-LAB values giving a numerical representation of a 3D measure of color. These measurements have been previously used in studies assessing shades of both porcelain and teeth. Readings of *L**, *a**, and *b** were performed three times and the mean value used. Means of color data with the standard deviations of tooth surfaces were calculated as described in many studies.[11,18–21,23,24,26]

Samples Immersion and Thermocycling

All samples were then immersed in Coca-Cola drink for 4 weeks as done in previous *in vitro* studies.[21,27,28] During this immersion time, an ageing process was conducted using a thermocycling machine where 10 cycles were accomplished every day; first in 5°C cold water and then in 55°C hot water (Ivoclar Vivadent). Then, all samples were dipped in distilled water following removal from the Cola drink, and moved up and down (10 times) to make sure they were well-cleaned. Samples were then wiped dry with white tissue paper and left in place for complete dryness. Colors were measured again by the same operator, same settings, and same gray background.

Fig. 2: Polishing the sample disk with ceramic finishing and polishing kit

Data Analysis

The color average values of color differences of the porcelain restorations (Zircon, E-max press, and E-max CAD) were evaluated by comparing the color change (ΔE^*) produced by each porcelain material in terms of glazing and polishing, and the color changes between different thicknesses. SPSS 22.0 software (Chicago, USA) and excel Microsoft 10 were used to insert the data. *t* test was used at p value < 0.05. Then color change values were compared to a perceptible threshold of 2.8 and a clinically acceptable threshold of 4.2 mentioned by Alghazali et al.[26]

Results

The color changes caused by Coca-Cola drink of the all-ceramic materials used in the current study were evaluated by comparing the color change (ΔE^*) of each individual of all-ceramic porcelain material in terms of surface manipulation, glazed or polished, and in terms of thickness used. Significant differences in color change were noticed before and after immersing with Coca-Cola and thermocycling for all materials and thicknesses used ($p < 0.01$). Significant differences in color changes were noticed between glazed and polished samples ($p < 0.001$). No significant differences in color change were noticed when using different thicknesses for all materials used ($p < 0.05$).

For 0.6 mm thick samples: the mean ΔE^* values of Zircon porcelain used were 1.79 for the glazed samples and 4.41 for the polished ones. The mean ΔE^* values of the E-max press porcelain were 1.88 for the glazed group and 5.3 for the polished ones. Finally, the mean ΔE^* values of the E-max CAD material were 1.62 for the glazed samples and 4.81 for the polished ones (Fig. 4).

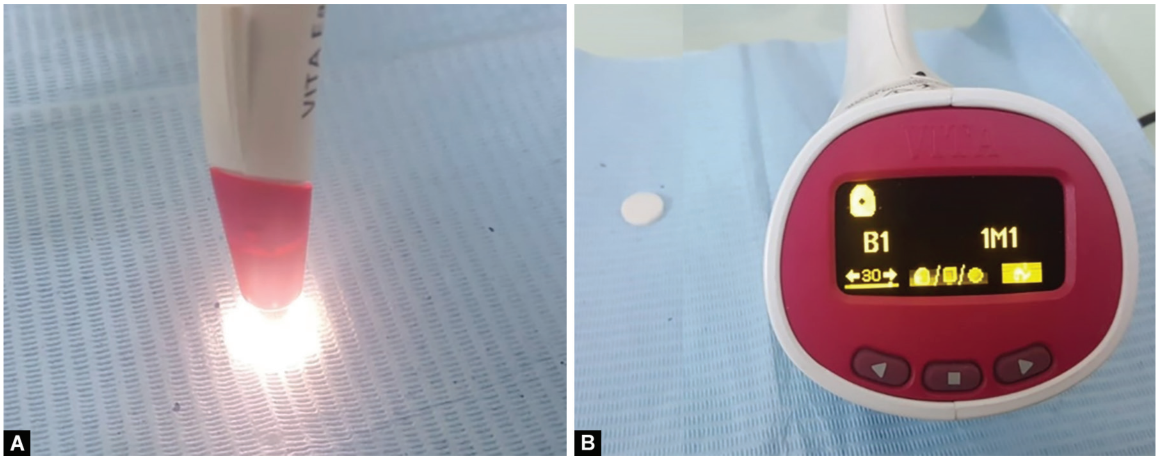
For 1.00 mm thickness: the mean ΔE^* values Zircon porcelain were 2.39 for the glazed group and 4.39 for the polished ones. The mean ΔE^* values of the E-max press porcelain were 2.0 for the glazed samples and 4.7 for the polished ones. Finally, the mean ΔE^* values of the E-max cad were 1.55 for the glazed group and 4.32 for the polished ones (Fig. 5).

Discussion

Nowadays, patients are acquiring esthetic restorations which can satisfy their esthetic needs.[29] Such esthetic restorations should be biocompatible in the oral cavity and be color stable also in oral environment.[1,10,30]

The great improvements of visual and physical properties of all ceramic restorations have, to an extent, met such patients' needs. However, these materials are still susceptible to various factors that might cause staining and some degrees of color changes. One of these factors are the Cola drinks which has special additive colorants.[24,31] This study was performed to assess the influence of Coca-Cola drinks on the overall color change of glazed and polished ceramic veneers samples fabricated of three different ceramic systems and two different thicknesses.

Evaluating the color change of ceramic veneers restorations caused by food and beverages is ideally studied *in vivo*. However, *in vitro* treatments such as thermocycling, pH cycling, and aging of materials might provide important information about the essential



Figs 3A and B: Color measurements of the sample using Vita Easyshade spectrophotometer

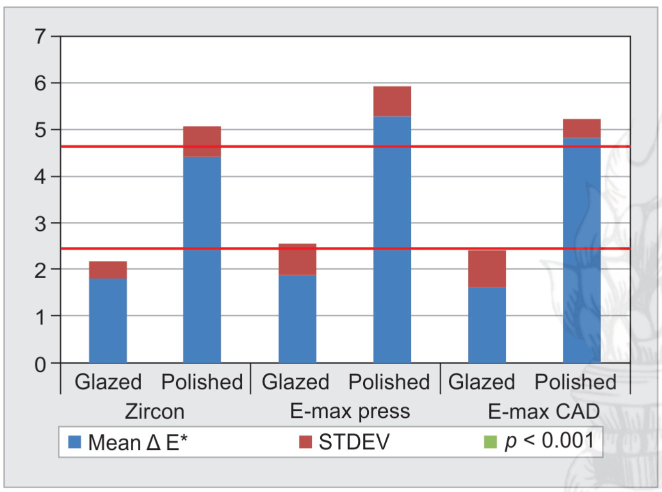


Fig. 4: Color change Δ*E** values of ceramic materials used of 0.6 mm thickness and different surface treatments, polished or glazed

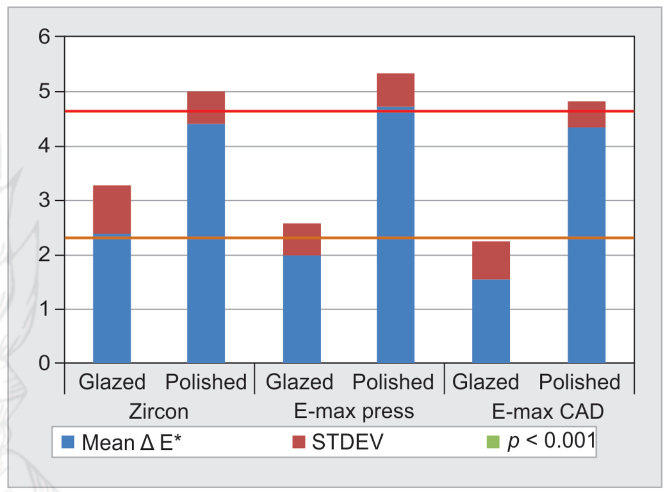


Fig. 5: Color change Δ*E** values of ceramic materials used of 1.0 mm thickness and different surface treatments, polished or glazed

mechanisms of color changes of all ceramic restoration by Coca-Cola drinks.[31,32] Moreover, in an attempt to mimic what happened in the oral environment as possible, all samples were immersed in Coca-Cola drink into a thermocycling machine where high numbers of cycles were performed at low and high temperature alternatively.[20,21,27,28]

In some cases, dentists tend to accomplish some adjustments of their esthetic restorations, and then, they tend to do polishing after such adjustments while neglecting, in some cases, to do the glazing step.[33] Moreover, some dentists might perform such adjustments after cementation where they even cannot do reglazing at all and they will be satisfied doing some polishing procedures of the adjusted restorations.[33] Based on this, we attempted in this study to evaluate the color changes of different all-ceramic materials in relation to different surface treatments.

Significant differences in the average color changes were determined between glazed and polished samples for all types of ceramic materials and thicknesses used, with the color changes of polished samples are more recognized than those of glazed samples. Such findings might be logically explained and understood as polishing techniques might leave the porcelain surface rougher and more porous which might lead to more significant color changes caused by staining beverages such as Coca-Cola. This will assure the importance of reglazing any ceramic restoration after performing any kind of adjustments and will, also, emphasis that polishing protocols are not significantly enough to maintain the color stability of such esthetic ceramic. Moreover, the findings of the current study agree with those of other studies conducted by Acar et al.; Sarikaya and Güler; Colombo et al.; and Sagsoz et al. and Saba et al. that concluded and recommended the reglazing step of samples after immersions in commonly used beverages such as tea, coffee, juice, and Turkish coffee.[18,19,21–23] Nevertheless, many polishing kits and protocols have been demonstrated and recommended to be an alternative to reglazing of the all-ceramic restoration. Therefore, other studies evaluating different polishing techniques and instruments are recommended, as one polishing kit and protocol has been utilized in this study.[34]

A relationship between the color changes of ceramic restorations and the ceramic thickness has been demonstrated. Uludag et al. in their study assessed the influence of porcelain thickness on the color stability of porcelain restorations and found out that as the ceramic thickness increased, a considered decrease in color change values Δ*E** were reported by Uludag et al.[35]

Nevertheless, such color change might be resulted from the color change of the underlying resin cement rather than color change of the ceramic itself. This statement might be supported by the results of this study where no significant differences in color change were recorded when using different thicknesses (1.00 mm and 0.6 mm) of all materials used.

The perceptible and clinically acceptable thresholds determined by Alghazali et al. have been used in this study as 2.4 and 4.8, respectively.[26] Most color changes caused by Cola drinks on glazed groups cannot be detectable by a human eye ($\Delta E^* < 2.4$) with a few of them might be perceived ($\Delta E^* > 2.4$), However, majority of color differences caused by Cola drinks on polished samples were perceived by human eye ($\Delta E^* > 2.4$) with some of these changes were unacceptable in clinical situations ($\Delta E < 4.8$). This, in turn, reflects that Cola drinks are considered beverages that can cause color change to different porcelain materials, with color difference is more significant when polishing ceramic restorations rather than reglazing them before final cementation in the patient's mouth.[26]

One of the limitations of the current *in vitro* study is that it allows staining of both sides of the tested porcelain veneers, where, in clinical situations, one surface of the veneer is bonded to a tooth structure and only the other surface is exposed to Coca-Cola and susceptible to be stained. Further *in vivo* studies are necessary to evaluate the susceptibility of the brands of all ceramic materials to discoloration by other beverages and nutrients.

Conclusion

Different porcelain materials have shown a significant color change after immersing and thermocycling in Coca-Cola drinks. The color changes of polished veneers were more considerable than those of glazed veneers for all porcelain materials and thicknesses used. This will suggest to reglaze any esthetic restoration in case that any adjustment might be performed and before final cementation in an attempt to maintain the color stability in oral environment. The color changes caused by Coca-Cola beverage were not significant when using different thicknesses (0.6 mm and 1.00 mm) for all-ceramic porcelain materials used.

Acknowledgment

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