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Original Article

Color stability of CAD/CAM materials with colored beverages thermocycling

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Abstract

Aim: The aim of this study was to compare the effects of different surface finishing treatments applied to two different CAD/CAM materials on the color stability after thermal aging with coffee and cola.

Materials and Methods: Polymerized resin nanoceramic (LAVA Ultimate, LU) and lithium disilicate glass-ceramic (IPS e.max CAD, EC) were examined in the study. The samples with A1 HT color at a size of 14 x 12 mm and a thickness of 0.5 ± 0.05 mm were prepared from these ceramic materials (N=144). Color measurement of each specimen was calculated with a spectrophotometer using color parameters on a gray backing between baseline color, polishing/glazing and after 5000 cycles of coffee and cola thermocycling. ANOVA and the Fisher's LSD test were used for testing statistical significance ($p < 0.05$).

Results: LU exhibited higher color change values than EC after thermal aging. In the EC group, glazing provided statistically different results as compared to the manual and control groups ($p < 0.05$). The lowest color change for all stages was observed in IPS e.max CAD ceramics that were treated by glazing.

Conclusion: In terms of color stability, glazing can be recommended for EC, and manual polishing as an alternative to glazing for LU.

Keywords: CAD/CAM; ceramics; prosthodontics.

INTRODUCTION

CAD/CAM systems that enable the design and production of dental restorations in a single session and these systems are commonly used in current dentistry practice. It is very important for the patient and the clinician to preserve the natural appearance obtained in state-of-the-art esthetic restorations over many years. Achieving this depends on applying a suitable surface finishing treatment to the restorative material (1,2). Although color selection is optimal, the material used exhibits clinically recognizable color changes over time depending on the oral environment (3). Various in vitro studies have shown that commonly consumed beverages such as coffee, tea and cola can cause significant changes in the color of restorative materials (4,5). It is known that beverages that can cause discoloration such as coffee and cola can result in greater color change and opacity, as well as lower translucency in ceramics (3). It was reported that clinically unacceptable color changes were observed especially in resin nano ceramics as a result of aging with coffee (6). Various surface finishing treatments can be applied to esthetic CAD/CAM restorations and it was shown that these finishing treatments also increase the color stability of restorations (7,8). The most commonly preferred surface finishing treatment before cementation with full ceramics is glazing in a porcelain furnace. Moreover, recent studies have shown that a smooth and bright surface can also be obtained by using manual polishing in addition to glazing (2,9,10).

The aim of this study was to compare the effects of different surface finishing treatments applied to two different CAD/CAM materials on the color stability after artificial aging with coffee and cola. Hypotheses of the study are as follows: groups that undergo glazing would have less color change in comparison to the groups that undergo manual polishing, and all groups will exhibit

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significant color change as a result of the aging process.

MATERIAL and METHODS

In this study, two different CAD/CAM materials cemented resin cement after performing two different and suitable finishing treatments were examined. Then thermocycling with coffee, cola and control were performed on ceramic materials.

Sample preparation

In this study, IPS e.max CAD (EC-Ivoclar Vivadent AG, Shaan, LICHTENSTEIN) and LAVA Ultimate (LU-3M ESPE, St. Paul, MN, ABD) ceramic blocks with A1 HT color at a size of 14x12x18 mm and a thickness of 0.5 ± 0.05 mm were prepared using a precision cutting machine (Isomet 1000, Buehler, Lake Bluff, IL, USA). The samples were cut at low speed under water cooling with 0.8 mm intervals by also taking into account the thickness (0.3 mm) of the diamond blade (Buehler, Lake Bluff, IL, USA). Sample thickness was measured using a digital micrometer (Minitech 233 Presi, Grenoble, FRANCE) that has 0.01 mm accuracy and repeatability. In order to obtain smooth and standard surfaces, the samples in each group were polished using 400, 600 and 800 grit silicon carbide papers (3M ESPE, St. Paul, MN, USA) respectively under running water for 15 seconds. Among the prepared samples, EC was crystallized in a Programat P300 furnace (Ivoclar Vivadent AG, Shaan, LICHTENSTEIN) in accordance with the manufacturer's instructions to complete crystallization. In this way, 144 ceramic samples with two different structures at a size of 14x12x0.5 mm were obtained. Before the measurement of color, they were kept in an ultrasonic cleaner (Easyclean, RENFERT, USA) using distilled water for 10 minutes and then dried. Then they were kept at room temperature in a dry and dark environment before the spectrophotometric measurements were taken.

Color measurement

The measurements were undertaken using daylight illuminant D65 in a natural gray background according to the CIE Lab color system with a spectrophotometer (Vita Easyshade, VITA-zahnfabrik, Bad Säckingen, Germany). As a result of the measurements, L (lightness) as well as a and b (chromatic values) values of the ceramic samples were obtained using the CIE Lab system. A standard white disc was measured at intervals specified by the manufacturer so as to calibrate the spectrophotometer. As a result of the spectrophotometric measurements, the first measurements ($L1^*$, $a1^*$, $b1$) and the second measurements ($L2^*$, $a2^*$, $b2^*$) after thermal aging were used to obtain ΔE values using the following formula:

$$\Delta E1\_2 = [(L1-L2)^2 + (a1-a2)^2 + (b1-b2)^2]^{1\backslash 2}$$

Surface finishing procedure

Following the first color measurements, the samples were assigned to three subgroups using simple randomization for each ceramic group, wherein the first group was treated with manual polishing, the second group with glazing and the third group was assigned to be the control group. The polishing method applied to each group. For EC group OptraFine (Ivoclar Vivadent AG, Shaan, Lichtenstein), for LU group Sof-Lex™ Spiral Finishing and Polishing Wheels (3M ESPE, St. Paul, MN, USA) was used. Manual polishing continued for 30 seconds at 10,000 rpm on a single surface for each sample in accordance with the manufacturer's instructions. Manual polishing discs were replaced after every five samples and they were kept in an ultrasonic cleaner for 10 seconds following manual polishing, and then dried. In the glazing process, one layer of suitable polish was applied to each sample in accordance with the manufacturer's instructions. For EC group IPS Ivocolor Glaze Paste Fluo (Ivoclar Vivadent AG, Shaan, LICHTENSTEIN), for LU group Optiglaze (GC America) was used.

Resin cement procedure

A roughening process was performed through air abrasion for the LU group, and a 20-second hydrofluoric acid application was conducted for EC. A 0.1 mm ± 0.05 mm-thick index was prepared to apply the resin cement. After roughening, EC group was etched with hydrofluoric acid (Ultradent Products, Inc, USA) for 20 sec and LU group was treated with air abrasion. 0.1 mm ± 0.05 mm thickness of Variolink N (Ivoclar Vivadent AG, Shaan, Lichtenstein) translucent resin cement was applied to the ceramic samples in accordance with the manufacturer's instructions. Color measurements were repeated three times for each sample during the study and the relevant mean value was noted.

Artificial Ageing

All the samples were assigned to three subgroups for artifical aging (i.e. coffee, cola and a control group) using simple randomization.

A thermal aging device (SD Mechatronic Thermocycler, GERMANY) with a 30-second waiting and 10-second transfer time at 5°C and 55°C was employed. In total, 5,000 cycles were undertaken for each sample. A coffee solution was prepared in accordance with the manufacturer's instructions. Coffee was included at the 55°C thermal cycle tank and cola was included at the 5°C thermal cycle tank. Following the aging process, the samples were washed with distilled water and then dried. Afterwards, the final measurements were undertaken with the same standards for each group. ANOVA was used for the repeated measurements in the data analysis. In accordance with the results obtained, mean color change values (ΔE) and standard deviations were expressed by group. Among the multiple comparison tests, Fisher's LSD test was used to assess the differences between the groups. The analyses were conducted using SPSS 22.0 software.

RESULTS

In LU ceramics, according to the analysis conducted, there was no statistically significant difference between the manual polishing and glazing groups in terms of color change after aging with coffee ($p=0.118$). There was no statistically significant difference between the glazing and control groups (p=0.746). There was no statistically significant difference between the manual polishing and control groups (p=0.215).

There was no statistically significant difference between the manual polishing and glazing groups in terms of color change after aging with cola (p=0.934). There was no statistically significant difference between the glazing and control groups (p=0.087). There was no statistically significant difference between the manual polishing and control groups (p=0.073).

There was a statistically significant difference between the manual polishing and glazing groups in terms of color change after aging in the control group (p=0.026). There was no statistically significant difference between the glazing and control groups (p=0.220). There was no statistically significant difference between the manual polishing and control groups (p=0.313).

In EC ceramics, according to the analysis conducted, there was a statistically significant difference between the manual polishing and glazing groups in terms of color change after aging with coffee (p=0.000). There was a statistically significant difference between the glazing and control groups (p=0.007). There was a statistically significant difference between the manual polishing and control groups (p=0.007). There was a statistically significant difference between the manual polishing and glazing groups in terms of color change after aging with cola (p=0.000). There was a statistically significant difference between the glazing and control groups (p=0.002). There was a statistically significant difference between the manual polishing and control groups (p=0.000). There was a statistically significant difference between the manual polishing and glazing groups in terms of color change after aging in the control group (p=0.005). There was a statistically significant difference between the glazing and control groups (p=0.015). There was no statistically significant difference between the manual polishing and control groups (p=0.709).

DISCUSSION

In this study, two different full-ceramic restorative materials were subjected to cementation and artificial aging following different polishing treatments in order to investigate color changes in the three different subgroups (coffee, cola, control). Among all samples, EC ceramics that underwent aging with coffee after manual polishing exhibited the highest color change values, whereas EC ceramics that underwent aging with cola after glazing had a lower value in comparison to the other groups. As a result of the accelerated artificial aging process applied following the different finishing treatments for the ceramic samples, the different finishing treatments resulted in a statistically significant difference in the EC group, whereas glazing did not result in a statistically significant difference compared to the manual polishing and control groups in the LU group. According to these results, our initial hypothesis is partially refuted.

It is very difficult to recognize minor color changes in dental materials with the human eye. Previous studies reported that ΔE values lower than 1.1 cannot be detected by the human eye, whereas values higher than 3.3 are clinically unacceptable (11,12). According to our study, ΔE the value was below 3.3 in the thermal cycle control group that underwent glazing in LU ceramics, in the thermal cycle control subgroup and the cola subgroup that underwent glazing in EC ceramics and in the artificial ageing cola subgroup of the control group that did not undergo any surface finishing treatment.

In a study by Kılınç et al., Lava Ultimate, Vita Enamic, Vita Suprinity and Vita Mark II ceramics were used and color changes were investigated after different finishing treatments. Among the samples that underwent UV-aging, the highest color change was observed in the Lava Ultimate group (2). In a study by Alp et al.(13), color changes in IPS e.max CAD and Vita Suprinity ceramics were investigated after applying different surface treatments and following a thermal cycle with coffee. It was concluded that the material properties have an important impact on color difference. The study reported clinically acceptable color changes for all samples. Color changes were below the clinically acceptable level for all groups except for the LDS polished. LDS material exhibited a higher color difference in the groups that underwent glazing and manual polishing. In a study by Kanat et al. (14), IPS e.max CAD and Vita Suprinity ceramics were used and the samples were subjected to three different finishing procedures, i.e. manual polishing, glazing and staining-glazing. For both CAD/CAM ceramics kept in coffee and tea, the glazing process resulted in lower color change values in comparison to the mechanical polishing and staining-glazing procedures. In another study by Palla et al. (15), IPS e.max CAD, IPS e.max Press non-glaze, IPS e.max Press glaze, and IPS e.max Ceram were used. All aging processes carried out using the thermal cycle, coffee, tea and red wine affected the final color of lithium disilicate samples. After the thermal aging processes, the lowest ΔE value was observed in IPS e.max CAD and IPS e.max Press non-glaze group.

In the current study, the manual polishing and glazing resulted in a value higher than the clinically acceptable level following the artificial ageing with coffee and cola in the LU group, and there were no statistically different results. As a result of aging in the control group, color change in the manual polishing group was above the clinically acceptable level, but below the same level in the glazing group. The aging treatment in the control group affected the manual polishing and glazing groups differently. In the EC group, the color change was above the clinically acceptable level in ceramics that underwent manual polishing. However, in the glazing group, the color change was below the clinically acceptable level for the cola and control subgroups. The comparison of manual polishing and glazing revealed a statistically significant color change for all subgroups (coffee, cola, control) following the artificial ageing. In EC ceramics, the highest color change was observed in the manual polishing group that underwent the thermal cycle with coffee. Again in EC ceramics, the lowest color change was observed in the glazing group that underwent the artificial ageing with cola. Karaokutan et al. (16) compared the color stability of three different full ceramic materials after applying 300 hours of artificial aging in their study, wherein they reported that the color change value of Lava Ultimate resin nanoceramics was significantly different from the color change values of IPS e.max CAD ceramic and Feldspathic glass ceramic materials. In the current study, LU ceramics exhibited a higher color change compared to EC ceramics, while the mean color change values was above the clinically acceptable level for both groups. According to the study by Gawriołek et al. (17), ceramic materials exhibit better color stability in comparison to composite materials. Resin nanoceramic structure contains Bis-GMA. Hydroxyl groups within Bis-GMA increase viscosity and are not stable in terms of color change. TEGDMA and UDMA were added to the structure in order to reduce viscosity and enhance mechanical properties by increasing crosslinks. However, color stability is still questionable. Moreover, most of the polymers contain functional groups in molecular chains that absorb UV light. It was reported that in the artificial aging process, the composite structure absorbs water and disrupts the filler and resin structure as well as leading to the rupture of the chemical bonds (18). In the current study, the highest change value between the first and final color measurements was observed in the LU group. This color change can be explained by the chemical structure of LU resin nanoceramics. There is a water absorption level due to the hydrophilic\hydrophobic property of the resin matrix as the main reason for the color change of resin-containing composite materials. The hydroxyl groups in the bis-GMA found in the resin nano-ceramic structure increase the viscosity and are not resistant to color change. In addition, for EC ceramics, glazing resulted in a statistically lower color change compared to manual polishing. In LU ceramics, on the other hand, the manual polishing and glazing provided similar results in terms of color change.

CONCLUSION

The following results were obtained within the scope of this study:

1. Resin nanoceramics (LU) exhibited higher color change values than lithium disilicate (EC) ceramics after thermal aging.

2. Coffee and cola have negative effects on dental ceramic's color stability

3. Manual polishing and glazing resulted in similar color changes for LU

4. Glazing has more color stability than manual polishing for EC ceramics

5. In terms of color stability, glazing can be recommended for EC, and manual polishing as an alternative to glazing for LU

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