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Wpływ szkliwienia lub polerowania na stabilność koloru różnych powierzchni ceramicznych zaprojektowanych/wyprodukowanych z zastosowaniem technologii komputerowych po odklejeniu aparatu ortodontycznego: badanie porównawcze in vitro

Effects of glazing or polishing on the color stability of different computer-aided design/manufacturing ceramic surfaces after orthodontic debonding: An in-vitro comparative study

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Wkład autorów: A Plan badań B Zbieranie danych C Analiza statystyczna D Interpretacja danych E Redagowanie pracy F Wyszukiwanie piśmiennictwa

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Streszczenie

Ze względu na rosnącą popularność aparatów ortodontycznych dla osób dorosłych nieunikniona stała się konieczność klejenia zamków do koron ceramicznych. **Cel.** Celem pracy jest określenie, czy możliwe jest klinicznie akceptowalne odtworzenie koloru koron ceramicznych wykonanych w systemie CAD/CAM (Computer Aided Design/Manufacturing)

Abstract

Due to the increasing popularity of adult orthodontics, the necessity to bond the brackets to the ceramic crowns has become inevitable. **Aim.** The aim of this study is to determine whether clinically acceptable color restoration of computer-aided design/manufacturing (CAD/CAM) ceramic crowns is possible with a manual polishing kit or whether

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przy użyciu ręcznego zestawu polerskiego, czy też wymagane jest szkliwienie po leczeniu ortodontycznym. **Materiał i metody.** Przygotowano dwadzieścia próbek ceramiki litowo-krzemianowej wzmocnionej cyrkonem (Vita Suprinity, Niemcy), ceramiki skaleniowej (Vitablocs Mark II, Niemcy) oraz ceramiki skaleniowej wzmocnionej leucytem (GC Initial LRF Block, Japonia) w celu odtworzenia powierzchni wargowej siekaczy szczęki. Próbki podzielono na dwie grupy (n = 10). Jedna grupa została wypolerowana ręcznie za pomocą zestawu do wykańczania ceramiki (Shofu Inc., Japonia), a druga grupa została poddana ponownemu szkliwieniu po odklejeniu aparatu. **Wyniki.** Kolor ceramiki VS uległ znacznej zmianie, nawet po odklejeniu aparatu przed polerowaniem i szkliwieniem. Istotne statystycznie różnice zauważono po ręcznym polerowaniu i szkliwieniu ceramiki VS w porównaniu z ceramiką MII i GC LRF. Wartości zmiany koloru materiałów CAD/CAM MII i GC LRF wzrosły, ale były poniżej klinicznie akceptowalnego progu (ΔE <3,5), natomiast dla ceramiki VS wartości zmiany koloru były wyższe niż klinicznie akceptowalny próg. **Wniosek.** W odniesieniu do stabilności koloru, w przypadku ceramiki GC LRF i VS, szkliwienie miało statystycznie różny wpływ na zmianę koloru pomiędzy pierwszym pomiarem koloru a końcowym pomiarem koloru w porównaniu z polerowaniem ręcznym. **(Rahmaty EM, Gulnar B, Baser B. Wpływ szkliwienia lub polerowania na stabilność koloru różnych powierzchni ceramicznych zaprojektowanych/wyprodukowanych z zastosowaniem technologii komputerowych po odklejeniu aparatu ortodontycznego: badanie porównawcze in vitro. Forum Ortod 2022; 18 (4): 221-9).**

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glazing is required after the orthodontic treatment. **Material and methods.** Twenty zirconia-reinforced lithium-silicate ceramic (Vita Suprinity, Germany), feldspar-ceramic (Vitablocs Mark II, Germany), and leucite-reinforced feldspar ceramic (GC Initial LRF Block, Japan) specimens were fabricated to replicate the labial surface of the maxillary incisors. The samples were divided into two groups (n = 10); one group was polished manually with a ceramic finishing kit (Shofu Inc., Japan), and the other group was re-glazed after debonding. **Results.** The color of the VS ceramics changed significantly, even after debonding prior to polishing and glazing. Statistically significant differences were noticed after manual polishing and glazing of VS ceramics compared with the MII and GC LRF ceramics. The color-change values of the MII and GC LRF CAD/CAM materials increased but were below the clinically acceptable threshold (ΔE < 3.5), whereas, for the VS ceramics, the color-change values were higher than clinically acceptable threshold. **Conclusion.** In terms of color stability, for the GC LRF and VS ceramics, glazing had a statistically different effect on the color change between the first color measurement and the final color measurement compared with manual polishing. **(Rahmaty EM, Gulnar B, Baser B. Effects of glazing or polishing on the color stability of different computer-aided design/manufacturing ceramic surfaces after orthodontic debonding: An in-vitro comparative study. Orthod Forum 2022; 18 (4): 221-9).**

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Introduction

Due to the increasing popularity of adult orthodontics, the necessity to bond the brackets to the ceramic crowns has become inevitable (1-3).The labor and time requirements for renewal or reglazing can be reduced by knowing the crown material in advance as well as the protocol required for sufficient polishing and finishing. After the debonding of brackets, it is important to achieve possible prebonding color and aesthetics of the ceramic crowns (4). To do this, the resin remnants on the crown surface are first cleaned with tungsten carbide burrs and then polished with a ceramic polishing kit (5).

In general practice, due to the difficulty of removing and reglazing, the crowns are cleaned and polished intraorally, as explained above, until the results are clinically acceptable (5,6). Some studies have reported that, though reglazing yields superior results to polishing, removing and reglazing crowns can take a lot of time and is often very costly and dangerous; moreover, the crowns can sometimes be lost or the abutment tooth can be damaged (7-15).

Alternatively, intraoral polishing is an important consideration in dental practice because it is easy and can be applied by the practitioner on the chairside, thus removing the need for a dental technician and laboratory, which, in turn, reduces the time and cutting involved (7,10,16).

Various studies have evaluated shear bond strength, surface color changes, gloss changes and color stability, and the effects of polishing and glazing on ceramic restorative materials (3,4,17-22). However, none have compared the effects of glazing and polishing on the color stability of different computer-aided design/manufacturing (CAD/CAM) ceramic surfaces after orthodontic treatment. This should be addressed because the color stability of these ceramic crowns is vital, especially at the anterior.

According to Grewal Bach et al., air abrasion at 2.5 bar pressure for 4 seconds followed by 9.6% hydrofluoric acid etching with a silane coupling agent produces the highest SBS value. However, applying 9.6% hydrofluoric acid etching with a silane coupling agent produces sufficient results on its own, thus minimizing the need for air abrasion. This application has become the gold standard (23-27).

The purpose of this study is to evaluate the in-vitro color stability of some available aesthetic CAD/CAM ceramic restoration materials, especially those used at the anterior, after orthodontic bonding. The null hypothesis is that; there is no significant difference between the polishing and reglazing procedures in terms of color change of the CAD/CAM samples after the orthodontic debonding.

Material and methods

Specimen fabrication

In this study, commercially available ceramic materials frequently used in the anterior region (for aesthetic reasons) were tested. Table 1 lists the ceramic type, shade, material composition, and manufacturer names. A total of 60 specimens were cut from different CAD/CAM ceramic blocks, i.e., Vitablocs Mark II (MII ceramics -Vita Zahnfabrik, Bad Sȁckingen, Germany), Vita Suprinity (VS ceramics -Vita Zahnfabrik, Bad Sȁckingen, Germany), and GC Initial LRF Block (GC LRF ceramics-GC Corp., Tokyo, Japan) (Fig. 1). The specimen thickness was 1.5 mm to ensure ease of manipulation and polishing, and a digital caliper was used to confirm said thickness for all 60 specimens (21).

Finishing and glazing

A single surface of each sample was then finished and glazed according to the manufacturer's instructions. The surface finishing and polishing were performed using a diamond polishing system for ceramics (Shofu Inc., Japan), as suggested by the manufacturer (Fig. 2). The sequence started with a green coarse polisher for grinding and shaping. A blue polisher was then used for smoothing, followed by a white polisher for high-shine polishing. This procedure was performed using a straight hand piece with a low speed of 10,000 rpm at a moderate pressure and specific angle, as per manufacturer instructions. The grinding and finishing were performed for 20 seconds for each step. The glazing and reglazing of the ceramic surfaces were performed according to the manufacturer's instructions for each material using Vita Akzent Glaze (Vita Zahnfabrik) for the MII ceramics, Vita Akzent Glaze LT for the VS ceramics, and GC Initial LRF Glaze Paste & Liquid (GC Corp., Europe) for the GC LRF ceramics. The specimens were stored in distilled water for 24 hours at 37ºC (Fig. 3).

Bracket bonding

The ceramic specimens were etched using Ultradent Porcelain Etch (Ultradent Products Inc., Köln, German) 9% hydrofluoric acid for 120 seconds, and then the surface was rinsed with water for 60 seconds and dried for 30 seconds. Silane coupling agent was applied for 60 seconds and dried with light air for another 30 seconds according to the manufacturer's instructions (Fig. 4). Then, 60 stainless-steel brackets for maxillary right central incisors with 0.022-inch slots (Master Series™ American Orthodontics, Shaboygan) were bonded to the prepared facets using the orthodontic adhesive system Transbond XT 3M/Unitek). After positioning/placing the brackets, pressure was exerted and excess resin was removed with an exploratory probe. The samples were light cured with an LED Elipar™ S10 (3M ESPE, St. Paul, MN, USA) for 20 seconds on both the mesial and distal of the brackets (making a total of 40 seconds) and stored in 37ºC water for 24 hours. The brackets were then debonded manually with debonding pliers. All procedures were carried out by a single experienced operator.

Color measurements

Three color measurements were conducted: after the fabrication and glazing of specimens, after debonding and cleaning of the resin remnants, and then after randomly splitting each material into the two subgroups (n = 10) of polishing and glazing. Color measurements were taken using the CIELAB color system (Fig. 5); the color difference (ΔE) was evaluated using colorimetry, which can detect minute changes

Table 1. CAD/CAM aesthetic ceramic materials.

Material	*Color*	*Composition*	*Manufacturer*
Vitablocs Mark II	*A2C LT*	*54%–64% SiO_2, 20%–23% $Al2O_3$, 6%–9% Na_2O, and 6%–8% K_2O*	*Vita Zahnfabrik, Germany*
Vita Suprinity	*A2 LT*	*56%–64% SiO_2, 15%–21% Li_2O, and 8%–12% ZrO_2 (< 10% pigment)*	*Vita Zahnfabrik, Germany*
GC Initial LRF Block	*A2 LT*	*70%–80% Kristallin faz (1.5–3-μm lusit kristal)*	*GC Corp., Tokyo, Japan*

Table 2. Statistical analyses of color-change values.

		ΔE First–Second	ΔE First–Polish	ΔE First–Glaze	ΔE Second–Polish	ΔE Second–Glaze
MII Group 1 (n = 10)	Mean ± Sd.	1.08 ± 0.80	1.60 ± 1.01		1.58 ± 0.83	
	Median (Min-Max)	0.85 (0.21-2.82)	1.36 (0.26-3.52		1.53 (0.39-2.95)	
MII Group 1 (n = 10)	Mean ± Sd.	1.64 ± 1.18		2.67 ± 1.03		2.02 ± 0.91
	Median (Min-Max)	1.37 (0.29-3.53)		2.77 (0.79-3.98)		2.14 (0.64-3.32)
GC LRF Group 1 (n = 10)	Mean ± Sd.	2.38 ± 1.99	1.91 ± 0.78		2.59 ± 1.06	
	Median (Min-Max)	1.67 (0.74-7.38)	2.13 (0.89-3.12)		2.47 (1.43-4.84)	
GC LRF Group 1 (n = 10)	Mean ± Sd.	1.46 ± 0.65		1.52 ± 0.96		2.20 ± 1.06
	Median (Min-Max)	1.49 (0.44-2.38)		1.37 (0.45-3.29)		1.76 (1.13-4.28)
VS Group 1 (n = 10)	Mean ± Sd.	3.48 ± 2.35	5.50 ± 4.10		4.56 ± 2.50	
	Median (Min-Max)	3.70 (0.53-6.42)	5.33 (0.4-12.04)		4.16 (1.27-8.97)	
VS Group 1 (n = 10)	Mean ± Sd.	3.02 ± 1.64		3.41 ± 1.82		3.96 ± 1.72
	Median (Min-Max)	2.90 (0.45-6.05)		2.84 (1.17-7.01)		4.30 (1.55-6.51)

ΔE First–Second = color change of first and second measurements (after fabrication–after remnant resin removal),
ΔE First–Polish = color change of first and third measurements (after fabrication–after polishing),
ΔE First–Glaze = color change of first and third measurements (after fabrication–after glazing),
ΔE Second–Polish = color change of second and third measurements (after remnant resin removal–after polishing),
P < 0.005, ΔE = color change
(SD= Standard Deviation)

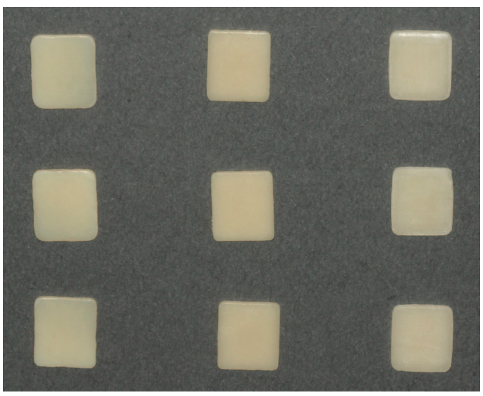

Figure 1. CAD/CAM samples.

Figure 2. MICRACUT125 cutting machine used in study.

that are undetectable by the naked eye (28). According to Abu-Obaid et al. , when ΔE < 1, the color change is undetectable by human eyes; when 1.0 < ΔE < 3.3, only a skilled individual can notice the color change (and values in this range are clinically acceptable); and when ΔE > 3.5, the color change is easily detected and clinically unacceptable (28-30).CIE L* measures the lightness of a material, CIE a* measures the redness (positive value) or greenness (negative value), and CIE b* measures the yellowness (positive value) or blueness (negative value) (30).

The specimen colors were measured under a standard light source D65 (MASTER TL-D Super 80 18 W/865 1SL; Philips, Eindhoven, Holland), with the colorimeter ShadeEye NCC Dental Chroma Meter (Shofu Inc., Koyto, Japan) (Fig. 6). Measurements were performed on a standard neutral grey background. The mean value of the three sequential measurements of CIE L*a*b* was recorded. The ΔE values were calculated using the following CIELAB equation:

ΔE = [(ΔL*)2 + (Δa*)2 + (Δb*)2]1/2

Statistical Analysis

The Number Cruncher Statistical System (Utah, USA) program was used for statistical analysis. Descriptive statistical methods (mean, standard deviation, median, minimum, and maximum) were used to evaluate the study data. The conformity of the quantitative data to the normal distribution was tested with the Shapiro–Wilk test and via graphical examinations. Kruskal–Wallis and Dunn–Bonferroni tests were used to make comparisons between groups of more than two quantitative variables that did not show normal distribution. Statistical significance was accepted as $p < 0.05$

Figure 3. Diamond polishing system for ceramics (Shofu Inc., Japan).

Figure 4. The specimens were stored in distilled water for 24 hours at 37ºC.

Results

Table 2 shows the ΔE values after specimen fabrication, after orthodontic deboning and composite-resin remnant removal, and after polishing and glaze procedures for the MII, GC LRF, and VS ceramics.

For first measurements and after remnant resin removal, the mean ΔE value for VS group 1 (3.48 ± 2.35) and VS group 2 (3.02 ± 1.64) were significantly higher compared with MII group 1 (1.08 ± 0.80), MII group 2 (1.64 ± 1.18), GC LRF group 1 (2.38 ± 1.99), and GC LRF group 2 (1.46 ± 0.65). For first measurements and after polishing, the mean ΔE value for VS group 1 (5.50 ± 4.10) was significantly higher compared with MII group 1 (1.60 ± 1.01) and GC LRF group 1 (1.91 ± 0.78). For first measurements and after glazing, the mean ΔE value for VS group 2 (3.41 ± 1.82) was significantly higher compared with MII group 2 (2.67 ± 1.03) and GC LRF group 2 (1.52 ± 0.96).

After remnant resin removal and polishing, the mean ΔE value for VS group 1 (4.56 ± 2.50) was significantly higher compared with MII group 1 (1.58 ± 0.83) and GC LRF group 1 (2.59 ± 1.06). After remnant resin removal and glazing, the mean ΔE value for VS group 2 (3.96 ± 1.72) was significantly higher compared with MII group 2 (2.02 ± 0.91) and GC LRF group 2 (2.20 ± 1.06).

Discussion

After orthodontic treatment, preservation or even restoring aesthetics is vital when working with CAD/CAM ceramic materials. The CAD/CAM ceramics materials evaluated in this study are widely used to construct anterior crowns, but they are also used for posterior crowns inlays and onlays as well as for dental restoration via implants, fixed partial dentures, veneers, and all-ceramic crowns (31,32). With the introduction of improved materials, dental CAD/CAM applications have essentially advanced toward any type of restoration in the anterior or posterior region. A large number of chairside CAD/CAM systems are available on the market (33).

Numerous methods are available to evaluate the color of dental materials. Electronic devices allow objective and quantitative evaluation of dental samples. It has been shown that human observers are unreliable in recording the color of samples over time and are influenced by dental experience (34-36). Digital devices have many potential advantages, as they eliminate subjectivity when selecting or evaluating color for ceramic or any other dental restoration material. The key advantages of spectrophotometric or colorimetric measurements include the ability to analyze the principal components of a range of spectra and the ability to convert these measurements into various color measurements. The ability to transform a reflectance or transmittance spectrum into multiple colorimetric data is facilitated by high-intensity illumination and the two main observer features (37, 38). In addition, the ability of colorimetric and spectrophotometric devices to record quantitative data is a great theoretical advantage (39).

Several studies have evaluated the effects of shear bond strength, surface roughness, color/gloss changes and color

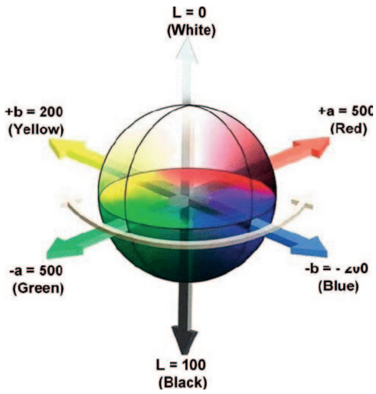

Figure 5. Ultradent Porcelain Etch (Ultradent Products Inc., Köln, German).

Figure 6. Silane coupling agent.

stability, and various polishing treatments on ceramic restorative materials (3,4,17-22). However, at present, no study has compared the effects of polishing and reglazing on the color stability of different CAD/CAM ceramic surfaces after orthodontic bonding – two processes that are vital in the anterior region after orthodontic treatment.

In an in-vitro study, Oliveira-Junior et al. concluded that manually polished CAD/CAM ceramics are smoother than glazed feldspathic ceramics in terms of the surface roughness of CAD/CAM and conventional ceramic disks after polishing or glazing (40). In another study, Flury et al. reported good results with the Sof-Lex system compared with other polishing techniques used for MII ceramics and IPS Empress (41). They reported that, among all the polishing methods, Sof-Lex discs produced the smoothest surfaces (smoother than glazed ones).

Kilinc et al. evaluated aesthetic CAD/CAM materials (Lava Ultimate, Cerasmart, Vita Enamic, VS ceramics, and MII ceramics) by applying different finishing and polishing procedures (control C, manual polishing M, glaze G) and ultraviolet (after UV) aging (22). The highest ΔE value was observed in the Lava Ultimate glaze group (ΔE = 22.7) and the lowest in the MII control group (ΔE = 0.86). There was no statistically significant difference between the ΔE values of the unpolished, manually polished, and glazed VS and MII ceramics ($p > 0.05$). VS and MII ceramics had similar color-stability resistance using the manual polishing and glazing method. The color-change parameters for VS ceramics were satisfactory regardless of the finishing and polishing procedures and were similar to the MII ceramics. Thus, for VS and MII ceramics, either manual polishing or glazing is recommended for color stability. In our study, the MII ceramics had the most stable ΔE values after both manual polishing and glazing, and VS ceramics had higher ΔE values in both manual polishing and reglazing groups. Based on the results of our study, the null hypothesis that reglazing or manual polishing procedures has no different effect on the stainability of CAD/CAM ceramic materials can be rejected. The results showed that, for MII ceramics, reglazing caused more staining compared with manual polishing, while, for VS ceramics, manual polishing caused more staining, followed by GC LRF ceramics. These outcomes must be associated with differences in the composition and crystal structure of the materials, as reported by some studies (42,43).

Gülce Alp et al. , in their in-vitro study, evaluated the effects of coffee thermocycling on the color and relative translucency of CAD/CAM VS ceramics and lithium disilicate glass ceramic (IPS e.max CAD) (44). Two different surface treatments (glaze or polishing) were applied to the samples. Different surface treatments of CAD/CAM monolithic VS and IPS e.max CAD ceramics resulted in clinically acceptable color changes after coffee thermocycling. Color changes could not be detected in all groups, except the polished IPS e.max CAD group. The researchers suggested reglazing in the light of these results.

Gunay et al. investigated the effects of porcelain surface treatments on the color change of feldspathic porcelain before and after exposure to distilled water, coffee, red wine, and cola (45). The samples were divided into four groups: natural glaze, double ion exchange glaze, overglaze, and polishing. Samples were preserved in red wine, coffee, or cola. After removal, the samples were rinsed in distilled water and dried. In their study, the color change that occurred at different periods for all samples, surface treatments, and dyeing solutions was statistically significant. In essence, the ΔE values changed as the staining time increased, especially for the polishing group.

Özen et al. evaluated the effects of different surface finishing treatments on the color stability of IPS e.max CAD, VS ceramics, and resin nanoceramics (Lava Ultimate) after artificial aging (20). After preparation, the samples were divided into three subgroups: manual polishing, glazing, and a control group. The samples were placed in a thermal aging device (SD Mechatronic Thermocycler, Feldkirchen-Westerham, Germany), and a total of 5,000 cycles were performed for each sample. As a result, the researchers reported that Lava Ultimate exhibited higher ΔE values than VS and IPS e.max CAD ceramics. Manual polishing and glazing resulted in similar color changes for Lava Ultimate and VS ceramics ($p > 0.05$). The IPS e.max CAD group had statistically different results compared with glaze, manual polishing, and control groups ($p < 0.05$). For VS and IPS e.max CAD ceramics, the ΔE values for the glaze subgroup were below the clinically acceptable level (ΔE < 3.5). The lowest color change for all stages was observed in VS ceramics. In our study, though there were no statistically significant results after both manual polishing and glaze application of VS ceramics, the ΔE values were higher than 3.5. Alternatively, for MII and GC LRF ceramics, ΔE values were below 3.5, and there were no statistically significant differences.

Kilinc et al. , in their in-vitro study, evaluated the optical properties of CAD/CAM materials (Lava Ultimate, Cerasmart, Vita Enamic, VS ceramics, and MII ceramics) after applying different finishing and polishing procedures (control C, manual polishing M, glaze G) and ultraviolet (after UV) aging (22). Significant interactions were noted between aging conditions, material type, and finishing/polishing procedures for all evaluated parameters ($p < 0.001$). The highest ΔE value was observed in the Lava Ultimate glaze group (ΔE = 22.7) and the lowest in the MII control group (ΔE = 0.86). There was no statistically significant difference between the ΔE values of the unpolished, manually polished, and glazed VS and MII ceramics ($p > 0.05$). Glaze treatment resulted in significantly higher ΔE values for the Lava Ultimate and Cerasmart groups than for the other subgroups ($p < 0.001$). The glazed Vita Enamic (ΔE = 4.64) samples showed lower ΔE values than the manual polished (ΔE = 6.6) and unpolished (ΔE = 6.09) groups. In their study, ΔE values greater than 3.3 were clinically unacceptable, and Lava Ultimate, Cerasmart, and Vita Enamic showed ΔE values greater than 3.3 for all subgroups, in contrast to the VS and MII ceramics. Indeed, VS and MII ceramics had similar color-stability resistance using the manual polishing and glazing methods. VS ceramics had satisfactory ΔE values regardless of the finishing and polishing procedures and were similar to MII ceramics. The authors reported that the optical properties of CAD/CAM materials were affected by the type of material and the applied surface finishing and polishing procedure, with manual polishing being the better choice for Lava Ultimate and Cerasmart and glazing for Vita Enamic. For VS and MII ceramics, either manual polishing or glazing is recommended for color stability. Similarly, in our study, MII ceramics had the most stable ΔE values after both manual polishing and glazing. However, VS ceramics had higher ΔE values in both groups, higher after manual polishing. The outcomes of our study must be related to acid surface treatment because VS ceramics had significantly higher ΔE values in both groups, even after debonding prior to reglazing or polishing applications. None of the above-mentioned studies applied acid surface treatment.

An in-vitro study investigeted the color stability of Lithium disilicate glass-ceramic (IPS E.max CAD) and zirconia-reinforced lithium silicate ceramic (Vita Suprinity) CAD-CAM aesthetic ceramic blocks which were stored in various beverages for 1 week, 2 weeks, 1 month and 2 months and after application of polishing paste (46). All specimens were prepared using 3 surface finishing procedures: glaze, mechanical polish and exterior paint and glaze according to manufacturers' instructions. Lithium disilicate glass-ceramic (IPS E.max CAD) showed higher color stability compared to zirconia-reinforced lithium silicate ceramic (Vita Suprinity). In addition, the polishing paste resulted in a reduction in discoloration to clinically acceptable values. In conclusion, the author reported that glazing alone resulted in greater color stability in relation to mechanical polishing and exterior staining and glazing for zirconia-enhanced lithium silicate (Vita Suprinity) and lithium disilicate glass-ceramic (IPS e.max CAD). In our study, we also found that glaze application alone showed greater color stability than mechanical polishing application applied to both zirconia-enhanced lithium silicate (Vita Suprinity) and lucite-reinforced feldspathic ceramic (GC Initial® LRF BLOCK). However, mechanical polishing applied to feldspathic ceramic (Vita® Mark II) showed greater color stability than glaze application alone.

Vasiliu et al. evaluated the effect of thermocycle, surface treatments, and microstructure on translucency, opacity, and surface roughness on CAD/CAM and heat-pressed glass-ceramic (47). In the study, Vita Mark II, Vita Surinity and IPS E.max CAD with CAD/CAM material and Vita PM9 FP, IPS E.max Press and Celtra Press CLSP as heat pressed material were used. Samples were prepared at a thickness of 1.5 ± 0.03 mm. Manual polishing was applied to half of the prepared samples and glaze was applied to the other half. After basic measurements for optical and roughness parameters, the samples were aged in 10,000 thermocycles in distilled water. As a result, the researchers found that the surface treatments of manual polishing and glaze had a significant effect on translucency and opacity and surface roughness ($p< 0.05$), and the translucency and opacity values differed significantly between heat-pressed and CAD/CAM ceramics before and after thermocycle ($p<0.05$), $p< 0.001$) reported that. The loss of translucency and opacity was most noted for heat-pressed Celtra Press CLSP and Vita Suprinity CAD/CAM. In addition, microstructural analyzes revealed that glass surfaces are more affected by thermocycler, especially for Vita Suprinity and Celtra Press CLSP. Polished and glazed IPS E.max Press was the least affected by the thermocycle. The optical properties of Vita Suprinity were the most affected by the processes we applied similarly in our study.

The results of our study showed that all CAD/CAM ceramic materials tested displayed color changes when bracket bonding and surface treatments were applied. The MII polishing group showed higher color stability than the glaze group. Glaze groups showed higher color stability for GC LRF and VS ceramics. VS ceramics showed significantly lower color stability in both glaze and polishing groups, even prior to manual polishing or reglazing. When different ceramics of the same brand, i.e. VS and MII ceramics, are evaluated within themselves, significantly different color changes are observed. The highest color stability in all conditions was found in MII ceramics. Regardless of surface treatments, VS ceramics showed discoloration just below the clinically detectable level ($\Delta E = 3.4$) even after bracket removal.

Clinicians should inform patients with aesthetic ceramic restorations, especially in the anterior region, about the effects of orthodontic applications, especially patients with restorations made from VS ceramics. To meet the demands of orthodontic patients on this subject, more studies should be conducted to investigate the color stability of CAD/CAM aesthetic ceramic materials. Before starting orthodontic treatment, clinicians should know the type of restoration materials present in the patient's mouth and apply surface treatment accordingly. Intraoral manual polishing may be recommended, since removing the restoration and putting it back after glazing is expensive in terms of time, cost, and effort. However, to improve the color stability of CAD/CAM aesthetic ceramic materials, the structure of the relevant materials should be developed by the manufacturers.

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