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Original research

Evaluation of color stability of CAD/CAM materials polished with different systems*

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Purpose
The objective of this study was to investigate the color changes of various computer-aided design/computer-aided manufacturing (CAD/CAM) materials polished with different polishing systems and immersed in various colored drinks.

Materials and Methods
Three different resin-based CAD/CAM blocks (Cerasmart, Coltene Brilliant Crios, and SHOFU Block HC) were utilized. A total of 540 CAD/CAM blocks were prepared with a thickness of 2 mm and categorized into three main groups based on the polishing systems employed. The Sof-Lex, Identoflex, and Coltene Diatech polishing systems were administered to the materials. Subsequently, the specimens were further subdivided into three subgroups and immersed in three different colored solutions for one hour twice a day for 15 days. Filter coffee, cola, and distilled water served as the coloring agents. Color measurements were conducted at baseline and on Days 1, 7, and 15 using the VITA Easyshade compact spectrophotometer device.

Results
By the end of Day 15, Cerasmart specimens exhibited the least color change when immersed in coffee and distilled water, whereas Coltene specimens demonstrated the least color change when subjected to cola. Irrespective of the CAD/CAM blocks and polishing systems utilized, a statistically significant difference was observed among the beverages ($p<0.001$). Particularly, coffee induced a more pronounced color change compared to the other beverages ($p<0.001$).

Conclusion
The ΔE value increases proportionally with the duration of immersion in colored drinks. Specimens immersed in coffee displayed the highest color change for each CAD/CAM material.

Keywords: *CAD/CAM resin blocks, polishing systems, color change, coffee, beverage*

Introduction

With the increasing interest in aesthetic restorations, the dental industry has conducted more research in this field in recent years (1). As a result of the increased demand for aesthetic restorations, the use of ceramics in dentistry has also increased (2). To address this demand, computer-aided design/computer-aided manufacturing (CAD/CAM) systems were introduced in dentistry in the 1970s (3). The light transmission properties, color stability, and polishing properties of CAD/CAM materials, which are popular today for their aesthetic properties, remain controversial and are subject to ongoing research by scholars (4).

Ceramic is a restorative material that, owing to its aesthetic properties and biocompatibility, is currently the preferred material for dental restorations (5). Recent advancements in ceramics have resulted in materials with similar transparency and fluorescence to natural teeth, thanks to their improved optical properties (6). In addition to their aesthetic and mechanical proper-

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ties, color stability plays a crucial role in the long-term success of ceramic restorations (7). However, some ceramic materials have certain disadvantages, leading to the integration of advantageous qualities from ceramics and composites in newer materials. Thus, the binary network of ceramic and resin is less brittle and provides the desired edge stability (8).

Inadequate finishing and polishing processes or incorrect material selection may result in rough surfaces on ceramic restorations. Rough ceramic surfaces are more prone to external discoloration than smooth surfaces. Additionally, excessive plaque accumulation has been reported on rough surfaces, leading to periodontal damage and aesthetic issues (9,10). Ceramic restorations can be polished using various systems, including polishing kits, disks, rubber, cleaning-prophylaxis paste materials, and abrasive paper (11). The color properties of restorations may be influenced by the structure of the selected restorative materials, the finishing and polishing system used (12), or the exposure time to coloring agents (13,14).

In the present study, we aimed to investigate the effects of different polishing protocols on the color stability of various CAD/CAM restorative materials, testing two null hypotheses: first, that different solutions would not cause varying amounts of coloring on restorative materials, and second, that using different finishing and polishing systems for different CAD/CAM materials would not affect the color change properties of the materials. The null hypothesis is that there is no significant difference in the color stability of CAD/CAM restorative materials when exposed to different polishing protocols.

Materials and Methods

Preparation of the CAD/CAM blocks

In this study, three different types of CAD/CAM blocks were utilized: a hybrid ceramic [SHOFU Block CAD/CAM Ceramic-Based Restorative (SHOFU Dental Corp., Kyoto, Japan)], a hybrid nano-ceramic [Cerasmart Force Absorbing Hybrid CAD/CAM Block (GC Corp., Tokyo, Japan)], and a reinforced composite [Coltene Brilliant Crios (Coltene, Altstätten, Switzerland)]. To standardize the results, a single ceramic shade, A2, was chosen as it is commonly used clinically (15,16). Each group consisted of 20 specimens measuring 12×10×2 mm, cut from blocks (n=20) (17,18), resulting in a total of 540 CAD/CAM block sections prepared. Table 1 lists the materials used in the study, along with their respective manufacturing companies, contents, types, and lot numbers.

The specimens were cut at a low speed under water cooling at 2.3-mm intervals, taking into account that the thickness of the diamond cutting disk (Buehler, Lake Bluff, IL, USA) was also 0.3 mm (Isomet 1000, Buehler, Lake Bluff, IL, USA). CAD/CAM block sections were created to achieve a 2-mm thickness for each specimen (Figure 1). The upper surface of the specimens was then polished for 30 seconds with 1,200 grit SiC abrasive paper. A total of 180 specimens were prepared from each CAD/CAM block, resulting in a total of 540 specimens (N:540). Sixty specimens were prepared for each polishing system, with 20 specimens designated for each coloring drink

Polishing protocols

The CAD/CAM blocks were categorized into three main groups based on the polishing system used. The Sof-Lex Diamond Polishing System, Identoflex Diamond Ceramic Polishing System, or Coltene Diatech Shape Guard Polishing System were employed to treat the surfaces of the materials following the manufacturer's instructions. For the Sof-Lex Diamond Polishing System (3M ESPE, St. Paul, USA), a beige spiral was initially applied for 15 seconds, followed by a pink spiral for another 15 seconds under water cooling, using a slow-speed handpiece operating within the range of 15,000 to 20,000 rpm. For the Identoflex Diamond Ceramic Polish-

Table 1. *The materials used in this study.*

Material	Manufacturer	Type	Content	Lot Number
SHOFU Block CAD/CAM Ceramic-Based Restorative (A2 LT)	SHOFU Dental Corporation, Kyoto, Japan	Hybrid ceramic	UDMA, TEGDMA, Barium glass, Silica powder, Micro-fumed silica, Zirconium silicate	111501
Cerasmart Force Absorbing Hybrid CAD/CAM Block (A2 LT)	GC Corporation, Tokyo, Japan	Hybrid Nano-ceramic	Bis-MEPP, UDMA DMA, SiO_2, Barium glass	161003A
Coltene Brilliant Crios (A2 LT)	Coltene AG, Altstätten, Switzerland	Reinforced Composite	Bis-MEPP, UDMA, DMA, Amorphous SiO_2, Barium glass	H26421
Identoflex Diamond Ceramic Polishing System	KerrHawe SA	-	Diamond abrasive particles	6855499
Sof-Lex Diamond Polishing System	3M ESPE, St. Paul, USA	-	Al_2O_3, Diamond abrasives	N754512
Coltene Diatech Shape Guard Polishing System	Coltene, Altstätten, Switzerland	-	Diamond abrasive particles	428077

UDMA: Urethane dimethacrylate; TEGDMA: Triethylene glycol dimethacrylate; Bis-MEPP: 2,2-Bis (4-methacryloxy polyethoxy phenyl) propane; DMA: Dimethacrylate; SiO_2: Silicium oxide; Al_2O_3: Aluminium oxide

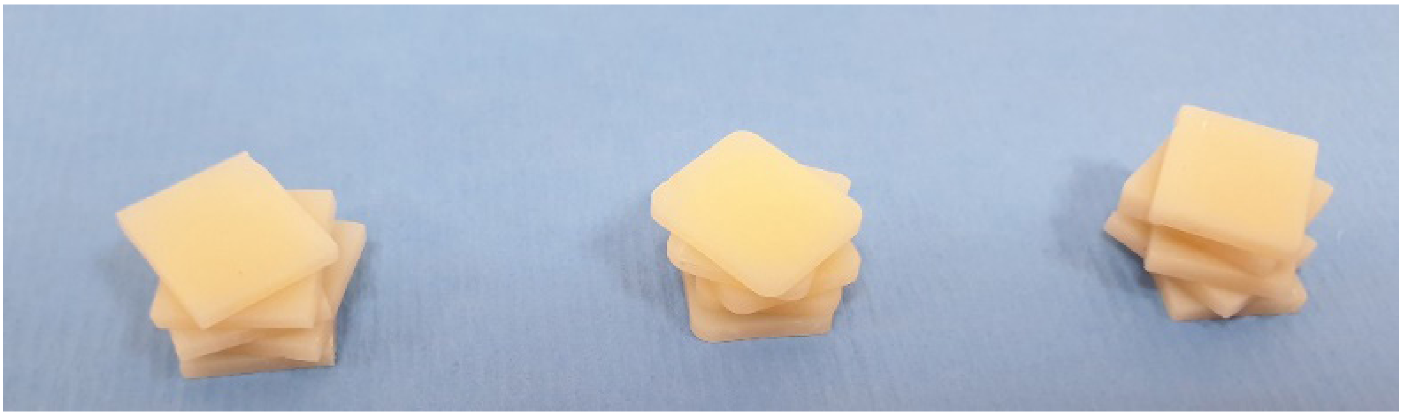

Figure 1. *Two mm thick CAD/CAM blocks.*

ing System (KerrHawe SA), the specimens underwent polishing for 30 seconds with a slow-speed handpiece under water cooling. Similarly, the Coltene Diatech Shape Guard Polishing System (Coltene, Altstätten, Switzerland) was employed. The polishing procedure involved using a purple spiral followed by a blue spiral for 15 seconds under water cooling with a slow-speed handpiece operating within the range of 10,000 to 12,000 rpm.

Color measurements

After the polishing process, the specimens were further divided into three subgroups and immersed in three different coloring drinks for 15 days: filter coffee, cola, and distilled water (control group) were used as the colorants. Initial color measurements were conducted using the spectrophotometer VITA Easyshade Compact (VITA Zahnfabrik, Bad Säckingen, Germany) on a white background. Following the initial measurements, the specimens were placed in opaque plastic containers, each container numbered according to the CAD/CAM material, polishing system, and beverage. The specimens were submerged in the beverages twice a day, morning and evening, for 1 hour each time, totaling 15 days. After each 1-hour immersion, the specimens were washed under running water for 1 minute and then returned to their respective storage containers. The distilled water in each storage container was replaced regularly to prevent bacterial contamination when the specimens were immersed in the coloring beverage. Color measurements of the specimens were performed on Days 1, 7, and 15 to assess color changes, ensuring consistent conditions: measurements were conducted in daylight, at the same time, in the same location, and under similar weather conditions. The Commission Internationale de l'Eclairage (CIE) recommends the use of three coordinates for evaluating color change in materials: L*, a*, and b*. The L* value indicates the lightness of an object, while a* measures redness (positive) or greenness (negative), and b* measures yellowness (positive) or blueness (negative). In our study, three repeated measurements were taken from each sample using the CIE L*, a*, and b* color measurement system, and an average value was recorded. Color differences were also calculated as ΔE values, with a value of ΔE ≥ 3.3 considered clinically unacceptable for color change, using the following formula: ΔE=[(ΔL)2+(Δa)2+(Δb)2] ½, (ΔL= L2*-L1*, Δa=a2*- a1* ve Δb=b2*-b1*) (15).

Statistical analysis

Statistical analysis was conducted using SPSS version 20.0 software (IBM Corp., Armonk, NY, USA). The normality of variable distributions was assessed using the Kolmogorov-Smirnov test. Continuous variables were presented as mean ± standard deviation (SD) or median (25th-75th percentile). For normally distributed numerical variables, differences among groups were analyzed using one-way analysis of variance (ANOVA), while the Kruskal-Wallis test was utilized for non-normally distributed numerical variables. Multiple comparisons were performed using the Tukey and Dunn tests. The Wilcoxon signed-rank test was employed for comparisons between dependent specimens. Comparisons between measurements at different time points were made using repeated measures ANOVA for normally distributed variables, and the Friedman bidirectional ANOVA for non-normally distributed variables. A p-value of <0.05 was considered statistically significant.

Results

The ΔE values are presented in Tables 2-4. At the end of the 15th day, the specimens immersed in coffee using Identoflex Diamond and Sof-Lex Diamond polishing systems showed the highest color change with Shofu blocks, while those using the Coltene Diatech polishing system exhibited the highest color change with Coltene blocks. For specimens immersed in cola using Sof-Lex Diamond and Coltene Diatech polishing systems, the highest color change was observed with Cerasmart blocks, while the highest color change was noted with Shofu blocks using the Identoflex Diamond polishing system. In the control group, the highest color change was observed with Coltene blocks using the Identoflex Diamond polishing system, Cerasmart blocks using the Sof-Lex Diamond polishing system, and Shofu blocks using the Coltene Diatech polishing system.

At the end of the 15th day, a statistically significant difference was observed between the polishing systems used for Shofu blocks immersed in distilled water (p=0.02) and cola (p=0.002), whereas no significant difference was found between the polishing systems for Shofu blocks immersed in coffee (p=0.516). Similarly, a statistically significant difference was found between the polishing systems for Coltene blocks immersed in coffee (p=0.008), but not in cola (p=0.254). For Cerasmart blocks, no statistically significant

Table 2. *ΔE values obtained by color changes of CAD/CAM materials immersed in distilled water after applying different polishing systems (median, 25th-75th percentile, mean ± standard deviation).*

DISTILLED WATER		Day 1				Day 7				Day 15			
Material	**Polishing System**	**Median**	**(25th-75th)**	**Mean ±SD**	**p-Value**	**Median**	**(25th-75th)**	**Mean ±SD**	**p-Value**	**Median**	**(25th-75th)**	**Mean ±SD**	**p-Value**
SHOFU BLOCK HC	**IDENTOFLEX DIAMOND**	3.96	(3.07-5.38)	4.19± 1.26	0.616	1.79	(1.13-2.20)	1.76± 0.75	0.278	1.17	(0.80-2.18)	1.72± 1.44	0.02
	SOF-LEX DIAMOND	3.55	(2.03-5.38)	3.69± 1.76		2.42	(0.53-4.53)	2.55± 2.19		1.85	(1.06-3.86)	2.58± 1.81	
	COLTENE DIATECH	3.30	(2.56-4.56)	3.79± 1.97		2.23	(1.61-3.73)	2.71± 1.68		2.77	(2.28-4.06)	3.49± 1.98	
COLTENE	**IDENTOFLEX DIAMOND**	2.85	(2.23-6.41)	4.15± 2.68	0.001	3.85	(1.83-6.15)	4.19± 2.44	0.001	2.43	(1.38-4.36)	2.69± 1.72	0.126
	SOF-LEX DIAMOND	1.21	(0.88-2.17)	1.74± 1.44		2.27	(1.57-3.01)	2.36± 1.11		1.36	(1.00-2.09)	1.83± 1.36	
	COLTENE DIATECH	2.37	(1.41-3.26)	2.43± 1.13		2.05	(1.45-3.25)	2.38± 1.21		2.17	(1.63-2.90)	2.34± 1.33	
CERASMART	**IDENTOFLEX DIAMOND**	1.65	(1.06-2.94)	1.96± 1.15	0.003	2.73	(2.03-4.42)	3.19± 1.25	<0.001	1.32	(0.97-2.11)	1.61± 0.88	0.001
	SOF-LEX DIAMOND	1.99	(1.69-2.41)	2.03± 0.59		1.44	(1.06-2.14)	1.61± 0.84		2.23	(1.94-2.92)	2.47± 0.85	
	COLTENE DIATECH	3.04	(1.98-4.13)	3.08± 1.38		1.73	(1.11-2.14)	1.63± 0.68		2.41	(2.12-2.70)	2.37± 0.48	

Table 3. *ΔE values obtained by color changes of CAD/CAM materials immersed in filter coffee after applying different polishing systems (median, 25th-75th percentile, mean ± standard deviation).*

FILTER COFFEE		Day 1				Day 7				Day 15			
Material	**Polishing System**	**Median**	**(25th-75th)**	**Mean ±SD**	**p-Value**	**Median**	**(25th-75th)**	**Mean ±SD**	**p-Value**	**Median**	**(25th-75th)**	**Mean ±SD**	**p-Value**
SHOFU BLOCK HC	**IDENTOFLEX DIAMOND**	4.22	(3.87-4.58)	4.29± 0.71	0.086	7.27	(6.43-7.64)	7.01± 0.90	0.480	8.17	(7.24-8.51)	7.91± 0.83	0.516
	SOF-LEX DIAMOND	5.10	(4.24-6.15)	5.04± 1.25		6.60	(6.01-7.98)	7.09± 1.53		8.10	(6.78-9.76)	8.18± 1.57	
	COLTENE DIATECH	4.17	(3.79-4.98)	4.47± 0.89		6.45	(5.97-7.28)	6.66± 1.08		7.73	(6.98-8.07)	7.79± 1.24	
COLTENE	**IDENTOFLEX DIAMOND**	4.29	(3.61-4.65)	4.20± 0.70	0.028	6.13	(5.50-6.44)	5.99± 0.70	0.092	7.61	(6.92-8.03)	7.56± 0.76	0.008
	SOF-LEX DIAMOND	4.76	(3.77-6.12)	5.31± 3.24		6.52	(5.11-8.60)	7.10± 2.54		7.26	(5.91-9.48)	8.36± 2.93	
	COLTENE DIATECH	4.80	(4.06-5.27)	4.67± 0.75		6.57	(5.88-7.62)	6.78± 0.96		8.72	(7.97-9.73)	8.72± 0.96	
CERASMART	**IDENTOFLEX DIAMOND**	2.36	(1.82-5.37)	3.60± 2.42	0.377	5.44	(3.95-6.94)	5.57± 2.34	0.766	6.78	(4.73-8.61)	6.78± 2.49	0.360
	SOF-LEX DIAMOND	3.64	(3.18-4.65)	3.85± 0.81		5.63	(4.61-6.91)	5.72± 1.19		6.72	(5.99-8.52)	7.12± 1.38	
	COLTENE DIATECH	3.60	(3.06-3.95)	3.64± 0.69		5.32	(4.21-5.89)	5.10± 1.02		6.62	(5.96-7.14)	6.67± 0.87	

difference was found between polishing systems for specimens immersed in cola ($p=0.195$) and coffee ($p=0.360$).

When comparing the ΔE values of CAD/CAM blocks polished with Identoflex Diamond ($p=0.000$) and Coltene Diatech ($p<0.001$) polishing systems and then immersed in coffee, a statistically significant difference was observed between Day 1 and Day 15. However, no significant difference was found between Day 1 and Day 15 for Shofu ($p=0.342$), Coltene ($p=0.301$), and Cerasmart ($p=0.633$) blocks polished with the Identoflex Diamond polishing system and then immersed

Table 4. *ΔE values obtained by color changes of CAD/CAM materials immersed in cola after applying different polishing systems (median, 25th-75th percentile, mean ± standard deviation).*

COLA		Day 1				Day 7				Day 15			
Material	**Polishing System**	**Median**	**(25th-75th)**	**Mean ±SD**	**p-Value**	**Median**	**(25th-75th)**	**Mean ±SD**	**p-Value**	**Median**	**(25th-75th)**	**Mean ±SD**	**p-Value**
SHOFU	**IDENTOFLEX DIAMOND**	3.99	(3.18-6.32)	4.66±2.16	0.001	2.07	(1.45-3.82)	2.80±2.08	0.487	3.14	(2.25-4.63)	3.34±1.34	0.002
	SOF-LEX DIAMOND	2.99	(2.41-3.98)	3.86±2.35		2.67	(1.17-3.42)	2.27±1.23		1.80	(1.24-2.59)	2.02±1.05	
	COLTENE DIATECH	1.80	(1.60-3.83)	2.60±1.70		1.56	(1.09-3.05)	2.05±1.23		1.72	(1.15-2.98)	2.16±1.30	
COLTENE	**IDENTOFLEX DIAMOND**	1.29	(0.96-1.93)	1.43±0.64	<0.001	4.03	(3.61-4.42)	4.02±0.58	<0.001	1.69	(1.23-2.24)	1.79±0.77	0.254
	SOF-LEX DIAMOND	3.46	(2.58-4.63)	3.67±1.21		1.61	(1.14-2.31)	2.05±1.34		1.74	(1.32-2.20)	1.99±1.09	
	COLTENE DIATECH	2.23	(1.55-2.88)	2.46±1.17		1.74	(1.17-2.93)	2.04±1.21		1.43	(0.81-2.08)	1.46±0.68	
CERASMART	**IDENTOFLEX DIAMOND**	1.72	(1.28-3.20)	2.09±1.10	<0.001	3.64	(2.75-4.60)	3.84±1.57	<0.001	2.21	(1.59-3.23)	2.52±1.19	0.195
	SOF-LEX DIAMOND	4.46	(3.67-5.14)	4.39±0.93		1.92	(1.28-2.62)	1.90±0.78		2.74	(2.41-3.35)	2.88±0.59	
	COLTENE DIATECH	2.97	(2.28-4.08)	3.56±1.63		1.65	(1.11-2.89)	1.95±1.04		2.18	(1.73-4.31)	2.76±1.38	

in cola. For Shofu blocks polished with the Sof-Lex Diamond polishing system and then immersed in cola, there was no statistically significant difference between Day 1 and Day 15 (p=0.74). However, a statistically significant difference was observed between Days 1 and 15 for Coltene and Cerasmart blocks (p<0.001). Additionally, no statistically significant difference was observed between Day 1 and Day 15 for Shofu (p=0.142) and Cerasmart (p=0.342) blocks polished with the Coltene Diatech polishing system and then immersed in cola. Conversely, a statistically significant difference was noted between Day 1 and Day 15 for Coltene blocks (p=0.005).

The evaluation of color changes of the specimens on Day 15 revealed a statistically significant difference among the beverages, regardless of the CAD/CAM blocks and polishing systems used (p<0.001). In pairwise comparison, the coffee beverage, in particular, induced a higher color change than the other beverages, and this difference was statistically significant (p<0.001).

Discussion

In the present study, our first null hypothesis that "different solutions could not cause different amounts of coloring on restorative materials" is rejected. All CAD/CAM materials used in this study exhibited different ΔE values in different solutions (cola, coffee or distilled water). The highest color change was seen in specimens that immersed in coffee. Our second null hypothesis that "using different finishing and polishing systems for different CAD/CAM materials would not affect the color change properties of the materials" is confirmed. In this study, the color change of CAD/CAM materials was affected by the time period of measurement and the coloring agent.

Finishing and polishing processes applied to the surface of materials affect the structure, roughness, and brightness of the surface. A successful finishing and polishing system increases the color stability of the restoration and affects its long-term clinical success (10,19). It is reported that the rough surfaces of ceramic restorations increase plaque retention and the material undergoes discoloration due to the difficulty of cleaning (20,21). Sagsoz *et al.* (22) investigated that the coloration resistance of four different CAD/CAM ceramics and three resin-ceramics polished with different polishing techniques. They applied glaze to only one ceramic restorative material and polished other materials with ceramic and composite polishing kits. The authors concluded that ceramic materials polished with an appropriate polishing system had sufficient resistance to coloring solutions. Similar to this one, in our study, we observed no significant difference between the polishing systems in terms of coloration resistance.

In recent years, new-generation CAD/CAM blocks have been developed, combining the high bond strength and low abrasiveness properties of composite resins with the durability and color stability properties of dental ceramics (23). Samra *et al.* (24) evaluated the coloration of five different aesthetic restorative materials immersed in coffee for 15 days. In this study, the IPS Empress 2 ceramic material showed less color change compared to other direct (Tetric® Ceram) and indirect (Targis, Resilab Master, belleGlass HP) composite materials.

The clinical success and long-lasting use of ceramic restorations is related to the color stability of the restorations in addition to their aesthetic and mechanical properties. The deterioration in the color of the restoration leads to patient dissatisfaction (25,26). Prolonged exposure of restorations to agents such as coffee, tea, red wine, chlorhexidine, or bleaching agents causes discoloration (27- 29). The ΔE value is accepted as 0 when the colors remain stable after the materials are exposed to the coloring agent. The color change of the material is clinically noticeable, if the ΔE value is ≥3.3 (30,31).

Quek *et al.* (32) immersed their direct composite, indirect composite, and CAD/CAM composite materials in tea, coffee and red wine for seven days. The highest rate of color change was observed in the specimens immersed in red wine. In our study, similar to this study, cola caused less color change than coffee. Colombo *et al.* (33) examined the color changes of CAD/CAM zirconia ceramic specimens immersed in cola and coffee. As a result of keeping the specimens in cola for a week, no significant color change was observed in any of the restorative materials used (ΔE <3.3). However, the specimens that were immersed in coffee showed a visible color change (ΔE ≥3.3). In our study, a similar result was obtained. This can be attributed to the higher temperature of the coffee compared to cola. Coffee that prepared at 80ºC can accelerate plasticization by affecting the monomer structure of composite materials. In this way, it may sensitize the materials to coloring agents and cause the absorbed and adsorbed colorants to affect the matrix structure of the material.

Atay *et al.* (34) examined the color changes and surface properties of feldspathic ceramics immersed in distilled water, coffee, red wine, and cola. According to the results of this study, the holding time of the specimens in coloring drinks and the applied surface procedures had certain effects on the color stability of the materials. Furthermore, Kanat-Ertürk (35) polished ceramic materials by applying different finishing systems (glaze: IPS Ivocolor Glaze, Vita Akzent Plus and mechanical polishing: DFS Diamon GmbH, Silco-pol) and, then, immersed the specimens in tea and coffee to examine their color stability. Considering the holding times of the specimens in beverages, for all polishing system groups, holding the specimens in tea resulted in higher ΔE values than holding them in coffee. This may be due to the tannin in the tea beverage. Both tea and coffee drinks contain acids (36). The beverages used in our study contained acid similar to this study. However, the lower color change observed in the materials immersed in cola compared to those immersed in coffee may be explained by the fact that cola contains few low-polarity coloring agents.

Barutçugil *et al.* (37) examined the color change of three different CAD/CAM materials (Lava Ultimate, Cerasmart, and VITA Enamic) in three different beverages (distilled water, red wine, and coffee). At the end of Day 30, VITA Enamic showed the highest ΔE value (ΔE 3.6) among the specimens that were immersed in coffee, while the Lava Ultimate showed the highest ΔE value (ΔE: 3.5) among the specimens that were immersed in red wine. The Cerasmart showed the least color change in both red wine and coffee. Similar to this study, in our study, among the specimens that immersed in coffee, Cerasmart was the least colored material, which may be related to the contents and filler amounts of the materials.

In another study, Alp *et al.* (38) applied different surface finishing and polishing procedures (glazing or polishing) to CAD/CAM monolithic glass ceramics and, then, applied coffee thermocycles to materials. In this study, the color change of the specimens after the coffee thermocycles, except for the mechanically polished lithium disilicate glass ceramics, was lower than the clinically acceptable values. The authors concluded that there was an interaction between the CAD/CAM materials and the surface procedures applied to these materials in terms of the amount of coloration of the materials. Unlike the aforementioned authors, we found that the coloration of specimens that were immersed in coffee was higher than clinically acceptable values in our study. This can be attributed to the fact that the CAD/CAM blocks used in our study were selected from hybrid ceramics. In addition, the utilization of different devices for color measurement might have caused discrepancies between the two studies. Shiozawa *et al.* (17) used three different CAD/CAM blocks and immersed the materials in water, coffee and curry for 1 month. The ΔE values of all CAD/CAM blocks after curry and coffee immersion increased with increasing immersion periods, while those after water immersion barely increased. In our study, similarly, the color change was higher in the specimens immersed in coffee compared to the specimens immersed in water. In addition, the amount of coloration increased as the immersion time increased. The immersion time of the material in the beverage, the amount of coloring agent in the content of the beverage, the acidity and temperature of the beverage are all effective in the formation of higher coloration rate of the specimens.

Conclusion

The samples immersed in coffee exhibited the highest color change values in our study. Polishing CAD/CAM materials with the Identoflex Diamond, Sof-Lex Diamond, and Coltene Diatech systems affected the color changes of the samples in different beverages to varying degrees. The rate of color change of the samples increased with the duration of time in the solution. Irrespective of the polishing system used, the Shofu Block, Cerasmart, and Coltene exhibited similar color changes at the end of Day 15.

Türkçe öz: *Farklı Cila Sistemleri Uygulanan CAD/CAM Materyallerinin Renk Stabilitelerinin İncelenmesi. Amaç: Bu çalışmanın amacı, farklı CAD/CAM materyallerin farklı cila sistemleriyle cilalanmasının ardından, renklendirici içeceklerde bekletilerek materyallerde meydana gelen renk değişiminin incelenmesidir. Gereç ve Yöntem: Çalışmamızda, üç farklı rezin içerikli CAD/CAM blok Cerasmart, Coltene Brilliant Crios ve SHOFU Blok HC kullanıldı. Bloklardan 2 mm kalınlığında, toplamda 540 adet örnek hazırlandı (n=20). Çalışmada kullanılacak olan CAD/CAM bloklar uygulanacak olan cila sistemine göre 3 ana gruba ayrıldı. Materyallere uygulanacak olan yüzey bitirme ve cilalama sistemleri Sof-Lex Diamond Polishing System, Identoflex Diamond Ceramic Polisher ve Coltene Diatech Polishers'dir. Cilalama prosedürünün arkasından örnekler tekrardan 3 alt gruba ayrıldı ve 3 farklı renklendirici solüsyonda 15 gün süresince sabah akşam olmak üzere günde 2 kez 1'er saat bekletildi. Çalışmada kullanılan içecekler filtre kahve, kola ve distile su olarak belirlendi. Renk ölçümleri başlangıç, 1., 7. ve 15. günlerde VITA Easyshade Compact spektrometre cihazı kullanılarak yapıldı. Bulgular: 15. günün sonunda Cerasmart örnekleri kahve ve damıtılmış su için en düşük renk değişimini gösterirken Coltene örnekleri kola için en düşük renk değişimini gösterdi. Kullanılan CAD/CAM blokları ve cilalama sistemlerinden bağımsız olarak içecekler arasında istatistiksel olarak anlamlı fark bulundu (p<0,001). Özellikle kahve diğer içeceklere göre daha belirgin renk değişimine neden olmuştur (p<0,001). Sonuç: Genel olarak, örneklerin içeceklerde bekletilme süresinin artması ile ΔE değerlerinin arttığı görüldü. Her bir CAD/CAM materyali için en yüksek renk değişim oranı kahvede bekletilen örneklerden elde edildi. 15. günün sonunda kahve ve suda bekletilen örneklerde Cerasmart numuneleri, kolada bekletilen örneklerde ise Coltene numuneleri en düşük renk değişim oranını sergiledi. Anahtar Kelimeler: CAD/CAM rezin blok, kola, kahve, renk değişimi, kahve, içecek*

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