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Effect of Whitening Mouthwashes on Hybrid Ceramic with Different Surface Treatments

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ABSTRACT

The purpose of this study is to investigate the effects of three whitening mouthwashes with various contents on hybrid ceramics with three different surface treatments in terms of color change.
Samples of 7x5x1 mm dimensions were prepared from hybrid ceramic blocks (Vita Enamic- VE). The surfaces of the samples were standardized with silicon carbide papers. The samples were randomly divided into 3 groups (Group C: no additional polishing, Group L: VE technical kit and Group G: glaze was applied) (n=24). All samples were kept in coffee for seven days after the initial colors were recorded. Following the second color measurement (ΔE_{001}), each group was divided into 3 subgroups and kept in whitening mouthwashes with different contents (Containing hydrogen peroxide, non-hydrogen peroxide and activated carbon) for 24 hours (n=8). The final color measurement was measured (ΔE_{002}). Color changes were evaluated according to CIEDE2000. Shapiro-Wilk, One way ANOVA and post hoc Tukey tests were used for statistical analysis of the data ($p<0.05$).
There was a significant difference in all groups for ΔE_{001}, with the highest in Group C (Group L and Group G, respectively). The mouthwashes showed similar color changes on VE with different surface treatments ($p\geq 0.05$). Group C showed a significantly higher ΔE_{002} value than Group G in containing hydrogen peroxide mouthwash.
Clinically acceptable color changes were observed in groups G and L after kept in coffee. After immersion in whitening mouthwash, all groups showed values below the threshold of perceptibility and acceptability (50:50% acceptability ΔE= 1.8, perceptibility ΔE=0.8).

Keywords: Hybrid ceramic, color change, surface treatments, whitening mouthwash

Introduction

Increase in aesthetic demand caused the development of Computer-Aided Design and Computer-Aided Manufacturing (CAD-CAM) technology which induced the use of various CAD-CAM materials (1, 2). As an alternative to machinable blocks, resin ceramic polymer-based materials have been introduced for use with CAD-CAM systems. The development of resin ceramic polymer-based materials, it is aimed to integrate the advantages of composite resin materials and dental ceramics (3, 4).

Vita Enamic (VE), introduced for this purpose, is called polymer infiltrated ceramic network (PICN) and consists of 2 interlocking phases, sintered feldspathic ceramic network and filler polymer material (5). It has been reported that due to their fine ceramic structures and polymer network, an elasticity close to dentin, high flexural strength and the ability to achieve high strength after adhesive bonding, thus minimally invasive restorations are applicable (6). Previous studies have documented that VE offers better marginal and internal adaptation than feldspathic ceramics (7). Resin composite blocks have a low index of brittleness; thus, resulting in better machinability and less wear on opposing teeth (8). In terms of color match, it has been stated that it offers material properties that are almost the same as natural tooth color. However, most resin-based restorations may experience discoloration due to the influence of different foods and beverages (9, 10).

This color change occurs duo to internal and/or external factors. Internal factors have been attributed to variation within the resin matrix. 'It occurs as a result of external factors, such as absorption of stain-forming beverages and colored solutions by materials, smoking and dietary habits, as well as poor oral hygiene (9, 11).

Surface finishing procedures have a significant impact on color change and the long-term success of restorations. It has been reported that rough surfaces cause increased discoloration of the

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restoration because of plaque retention and difficulty in cleaning (12, 13). Increasing use of CAD-CAM restorations, discs, polishing kits and polishing pastes have been developed to obtain smooth surfaces by mechanical polishing (14).

Replacing the discolored restoration is a costly treatment option to correct the aesthetic problem. Re-polishing and whitening approaches can be considered as less costly alternative treatments. Researchers reported that whitening treatments were effective in color change on colored CAD-CAM materials (15). Different chemical bleaching agents apply to remove discoloration (15, 16). Office type whitening products are usually procedures performed by the dentist. In addition, there are toothpastes, mouthwashes, chewing gums, gels and whitening strips that are easy to access and use, low cost and have a whitening effect (17).

Current whitening agents have been marketed in various contents. The most used active ingredient is hydrogen peroxide. Oxygen molecules that emerge as a result of the disintegration of hydrogen peroxide penetrate the teeth, break down the pigmented molecules, and the whitening process occur (18). Another ingredient that has been introduced to the market recently is activated charcoal. Although activated charcoal is recommended by manufacturers in many areas related to oral health, scientific data is insufficient for its use as a whitening agent (19).

The aim of this study is to evaluate the effect of three bleaching mouthwashes with different contents (containing hydrogen peroxide, non-hydrogen peroxide, and activated carbon) in terms of color change in vitro, following the coloring of hybrid ceramics with three different surface treatments. The hypotheses to be tested that: 1) there would be no difference in discoloration among control group and polishing groups in coffee immersion, 2) there would be no difference in the effectiveness of whitening mouthwash between the control group and polishing groups.

Materials and Methods

The hybrid ceramics with three different surface treatments and three whitening mouthwashes with different contents were used in this study. The materials and their contents are given in Table 1. The experimental groups are conducted and schematized as shown in Figure 1.

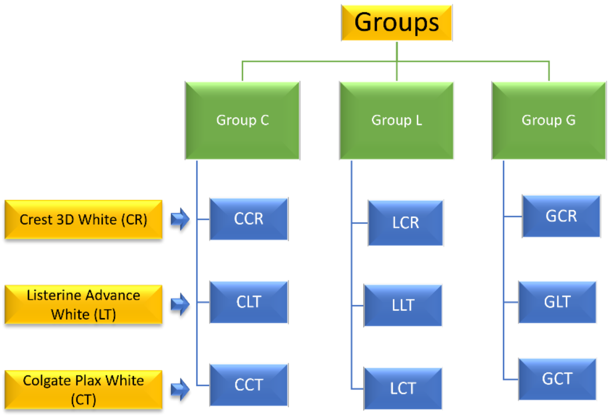

Fig. 1. Materials and Subgroups Used in the Study

Preparation of Samples: CAD-CAM hybrid ceramic blocks were sliced 1 mm thick under running water using a low-speed precision cutting device (Isomet 1000, Buehler, Lake Bluff, IL, USA) and a 1.0 ±0.05 mm thick diamond blade. Each sliced piece was divided into two with dimensions of 7x5x1 mm (n=72). Samples were sanded with 400, 600, and 1000-grit silicon carbide papers for 60 seconds under running water to establish a basic roughness in all experimental groups. The samples were ultrasonically cleaned with distilled water for 10 minutes and dried. Prepared samples were randomly divided into 3 subgroups (n=24).

Group C: No additional polishing or finishing.

Group L: According to the manufacturer's instructions, Vita Enamic Polishing Set (Technical Kit) was applied. This polishing kit was applied in 2 steps. In the first step, Pink Enamic polisher was applied at 10000 rpm. In the 2nd step, Gray Enamic polisher was applied at 10000 rpm (20).

Group G: Silane coupling agent (Ceramic Primer II; GC Corp) was applied to the surface of the samples and air dried. The surface was coated with a light curing agent (Optiglaze; GC Corp.) and polymerized for 8 minutes using a light curing device (Labolight Duo, GC Corp.).

Procedure: Baseline color measurements of the prepared samples were made with a spectrophotometer (Vita Easyshade Advance 4.0, VITA Zahnfabrik, Bad Säckingen, Germany) and L*, a*, b* values were recorded. Measurements were made by calibrating the device before each measurement and on a white background (L=53.5, a=3.2, b=12.8) in lighting conditions in D65 standards. All color measurements were made by a single operator.

Following the baseline color measurement, all samples were kept in coffee in numbered flacon,

Table 1. The composition and Manufacturer of the Materials

Material	Composition	Manufacturer
Vita Enamic (VE)	UDMA, TEGDMA 86% feldspathic porcelain	VITA Zahnfabrik
Optiglaze	PMMA, MMA, Photoinhibitory, Silica	GC Corporation
Vita Enamic Polishing Set (Technical Kit)		VITA Zahnfabrik

at room temperature, for 7 consecutive days in order to color the samples. Coffee was prepared as 2 g (Nescafé Classic, Single Bags; Nestlé) in 200 ml of boiled water in accordance with the manufacturer's recommendation and was renewed daily. Color measurement was performed after all samples were washed under running water and dried at the end of 7 days.

To evaluate the effect of three whitening mouthwashes different contents (Table 2), samples from all groups were divided into 3 subgroups (n=8) (Fig. 1). The samples were kept in mouthwashes in flacon for 24 hours. The samples extracted from the solutions were washed under running water and dried before the final color measurement.

Evaluation of Color Change: Color changes were evaluated according to the formula CIEDE2000 (ΔE_{00}).

$$\Delta E_{00} = \sqrt{\left(\frac{\Delta L}{K_L S_L}\right)^2 + \left(\frac{\Delta C}{K_C S_C}\right)^2 + \left(\frac{\Delta H}{K_H S_H}\right)^2 + R_T\left(\frac{\Delta C}{K_C S_C}\right)\left(\frac{\Delta H}{K_H S_H}\right)}$$

The ΔL, ΔC, and ΔH in the formula describe the differences in lightness, chroma, and hue between two measurements, respectively. 'S' stands weight functions for chroma and hue. R_T: It is the cycle function that defines the amount of interaction between chroma and hue differences in the blue area in the CIE L*a*b color system. 'K' is parametric factor evaluated for lightness, chroma, and hue. In this study, it is accepted that K_L, K_C and K_H values are equal to “1” (11).

Statistical Analysis: Statistical analyzes were performed using the SPSS 21.0 (SPSS Inc. Chicago, IL, USA) program. The normality of data was checked with the Shapiro-Wilk test. One-way analysis of variance (ANOVA) with post-hoc Tukey test was conducted to determine color stability. Statistically significant level of $p<0.05$ was accepted.

Results

ΔE_{001} values formed after the samples were kept in coffee for seven days are shown in Table 3. Statistically, the highest color change was obtained in Group C. Group L showed a statistically higher value than Group G in terms of color change. Clinically acceptable color changes were observed in G and L groups evaluated in coffee immersion (50:50% acceptability ΔE_{00}= 1.8, perceptibility ΔE_{00}=0.8) (21).

ΔE_{002} values obtained after the groups were immersed in whitening mouthwashes are shown in Table 4. Among the groups in immersed the Crest, Group C exhibited the statistically highest ΔE_{002} value (p=0.018) and was not statistically different from Group L. In addition, while Group G showed the lowest ΔE_{002} value, no statistically significant difference was found between Group L and Group G. No statistically significant difference was found between groups immersed in LT and between groups immersed in CT.

There was no statistically significant difference between CR, LT and CT in Group G (p=0. 344). Although LT showed the highest ΔE_{002} value in the L group, there was no statistically significant difference between all groups (p=0.627). The highest ΔE_{002} CR was obtained in Group C, but there was no statistically significant difference between all groups (p=0.293).

After immersed in whitening mouthwashes, all groups showed values below the perceptibility and acceptability threshold value.

Discussion

Based on the results of this *in-vitro* study, the first hypothesis that there would be no difference in discoloration among control group and polishing groups in coffee immersion was rejected. Statistically, in coffee immersion, the highest discoloration was obtained in control group, while the lowest was found in glaze group. Increasing patient awareness has led to a need not only for aesthetic materials close to tooth color, but also for materials that preserve this color. For this purpose, while materials are being developed every day, the surface treatments that can be applied are also developing. In this study, different polishing techniques were used, the technical polishing set that used in the laboratory and glaze

Table 2. Details of Tested Whitening Mouthwashes

Whitening mouth rinse	Composition	Company
Crest 3D White	Water, glycerin, hydrogen peroxide, propylene glycol, sodium hexametaphosphate, poloxamer 407, sodium citrate, flavor, sodium saccharin, citric acid	Procter & Gamble, Cincinnati, OH, USA.
Listerine Advance White	Aqua, Alcohol, Sorbitol, Tetrapotassium Pyrophosphate, Pentasodium Triphosphate, Citric Acid, Poloxamer 407, Sodium Benzoate, Eucalyptol, Thymol, Menthol, Sodium Saccharin, Sodium Fluoride, Tetrasodium Pyrophosphate, Propylene Glycol, Sucralose, Aroma, Disodium Phosphate.	Johnson& Johnson, Pomezia, Italy
Colgate Plax White & Charcoal Mouthwash	Aqua, Glycerin, Propylene Glycol, Sorbitol, Tetrapotassium Pyrophosphate, Polysorbate 20, Tetrasodium Pyrophosphate, Zinc Citrate, PVM/MA Copolymer, Aroma, Benzyl Alcohol, Sodium Fluoride, Sodium Saccharin, Bambusa Vulgaris Shoot Extract, Charcoal Powder, CI 15510, CI 17200, CI 19140, CI 42051.	Colgate-Palmolive, Guildford, GU2 8JZ.

application of VE. The results of this study showed that color stability is affected by surface finishing treatments similar to previous studies (4, 22).

Coffee is one of the most frequently used solutions in studies evaluating color stability. In the studies, it has been reported that a visible color change can be seen after 24 hours in VE samples dipped in coffee without a special surface treatment (23). In this study, immersion in coffee was used for 1 week, equivalent to 6 months of clinical aging (4, 10, 24). Paravina et al. determined the perceptibility and acceptability thresholds for the CIEDE2000 color formula as 0.8 and 1.8, respectively (21). In this study, only the discoloration of the Group C (ΔE =2.53) in coffee immersion was above the 50:50% acceptability threshold value.

Other studies supported that glazed groups show lower color change than other polishing techniques in terms of staining resistance and surface properties (14, 22, 25). Yilmaz et al. reported that after storage in methylene blue, glazed ceramics showed a statistically higher clinically acceptable range of color stability than ceramics polished using polish dots and polish paste (22). In a study, Kilinc et al. evaluated the optical properties of CAD-CAM materials with different finishing and polishing procedures and compared the manual polishing (Vita Enamic Technical Polishing Set for Vita Enamic) and glaze applications with the control group, which was not treated similarly to this study. They stated that glaze application was better in terms of color stability in VE material (25). In addition, in another study, the highest discoloring resistance was found in the glazed group compared to the unpolished control groups (14). Glaze was considered as the best way to achieve the smoothest surface (20). Different polishing techniques were investigated to create smooth surfaces in ceramic restorations, and it was stated that glaze application creates a smoother surface compared to other polishing methods (26, 27).

The staining resistance of resin ceramics polished with silicon carbide papers has been evaluated in several studies (4, 28, 29). However, this method is not possible in clinical practice. Other polishing methods used in the study could be applied to all restoration surfaces and gave more suitable results for clinical use in coffee discoloration.

Whitening mouthwashes contain various bleaching agents such as peroxides, sodium citrate, sodium hexametaphosphate, pyrophosphates and activated charcoal. These agents act either by bleaching or by removing and controlling the stain. The bleaching efficiency of hydrogen peroxide is supported in the literature (11, 30, 31). This agent, which is used both professional and self-applied, is a widely used bleaching agent (30, 31). Long-chain organic pigment molecules are separated into short-chain compounds with this oxidizing agent and bleaching is achieved. On the other hand, uncontrolled use of hydrogen peroxide in

Table 3. The mean and Standard Deviations of Δe_{001} Values (Mean±SD)

ΔE_{001}	n	Mean ± SD
Group C	24	2.53±0.51[a]
Group L	24	1.71±0.37[b]
Group G	24	1.37±0.41[c]

*The superscript different lowercases indicate the statistically significant differences within columns

Table 4. The mean and standard deviations of ΔE_{002} values (Mean±SD)

ΔE_{002}	CR	LT	CT	p
Group C	0.49±0.11[a]	0.40±0.13	0.36±0.22	0.293
Group L	0.35±0.18[ab]	0.47±0.21	0.43±0.37	0.627
Group G	0.26±0.15[b]	0.37±0.11	0.37±0.23	0.344
p	0.018	0.38	0.88	

* The superscript different lowercases indicate the statistically significant differences within columns

whitening mouthwashes at home reserves some risks. Oxygen reagents derived from hydrogen peroxide are effective in the mechanism of chemical carcinogenesis and cause DNA damage (32). Generally, whitening mouthwashes contain low concentrations of hydrogen peroxide (17). Crest 3D White which was used in this study contains hydrogen peroxide. Mouthwashes contain phosphate-based whitening agents such as sodium hexametaphosphate and tetrasodium pyrophosphate (32) These phosphate materials added to mouthwashes have a strong binding affinity and act by desorbing the stain components (11). Listerine Advance White which was used in this study contains tetrasodium pyrophosphate. Activated charcoal is produced by partial oxidation of various materials as a natural method. Highly porous activated charcoal compounds, which have the ability to exchange ions through nanopores, can adhere to tooth enamel. Due to its capacity to adsorb stains on the tooth surface, it can remove coloring agents from the tooth (33).

The number of studies evaluating the color change of CAD-CAM materials of whitening mouthwashes is limited (34). In a study, the surface properties of CAD-CAM materials were evaluated as a result of immersion in mouthwashes, and that simulated with specifically whitening mouthwash both feldspathic ceramic and polymer-infiltrated ceramic mesh samples made the samples appear brighter, opaquer, and rougher (34).

The results obtained in the present study showed that both hydrogen peroxide-containing and non-hydrogen peroxide whitening mouthwashes can act as whitening agents in the short term. Based on the data obtained in this study, all whitening mouthwashes, regardless of their content, were effective as a whitening agent after coffee discoloration. ΔE_{002} values in all groups were below the threshold values of acceptability (1.8) and perceptibility (0.8). The second hypothesis that there would be no difference in the effectiveness of whitening mouthwash between the control group and polishing groups was partially accepted. In this study, more effective bleaching was obtained with the lowest ΔE_{002} value in the GCR group containing hydrogen peroxide, which was glazed. However, there was no statistically significant difference in the effectiveness of mouthwashes containing hydrogen peroxide and other mouthwashes in the glaze application groups. A recent study revealed few differences between the use of various non-hydrogen peroxide whitening mouthwashes and time intervals but showed no difference between the mouthwashes used in their effectiveness in teeth whitening (32). However, it has been stated that whitening toothpastes containing activated charcoal have whitening effectiveness by causing significant changes in tooth color (33). There was no study showing the effect of active charcoal-containing agents on restorative materials.

This study was designed and performed *in vitro* and has some limitations compared to clinical studies. The effects of saliva and aging effects of environmental factors on restorative materials have not been reflected in clinical practice. In the clinical situation, restorative materials are not constantly exposed to solutions. The exposure of the restoration to mouthwash may change under the influence of saliva; therefore, the effect of saliva may alter intraoral pH and/or environmental changes (35). It has been reported that the samples immersed in mouthwash for 12 hours is equivalent to 1 year of use (for 1 minute twice a day) (36). In this study, the samples were kept in mouthwash for 12 hours. The use of single type of material in a single color is a limitation for this study. In future studies, the color change and mouthwash use of CAD-CAM materials with different contents can be investigated by using different polishing systems.

Within the limitations of this study, the following results were obtained.

The highest color change in the coffee dipping process was found in Group C, and the lowest in Group G.

In coffee immersion, only the control group showed ΔE values above the acceptability threshold.

Although whitening mouthwashes had different contents, they provided whitening in all groups.

Color change was observed below the acceptability and perceptibility thresholds in all groups after dipping in whitening mouthwashes.

References

1. Miyazaki T, Hotta Y, Kunii J, Kuriyama S, Tamaki Y. A review of dental CAD/CAM: current status and future perspectives from 20 years of experience. Dent Mater J. 2009;28(1):44-56.
2. Sadowsky SJ. An overview of treatment considerations for esthetic restorations: a review of the literature. J Prosthet Dent. 2006;96(6):433-42.
3. Awada A, Nathanson D. Mechanical properties of resin-ceramic CAD/CAM restorative materials. J Prosthet Dent. 2015;114(4):587-93.
4. Stawarczyk B, Sener B, Trottmann A, Roos M, Oezcan M, Hämmerle CH. Discoloration of manually fabricated resins and industrially fabricated CAD/CAM blocks versus glass-ceramic: effect of storage media, duration, and subsequent polishing. Dent Mater J. 2012;31(3):377-83.
5. He L-H, Swain M. A novel polymer infiltrated ceramic dental material. Dent Mater. 2011;27(6):527-34.
6. Dirxen C, Blunck U, Preissner S. Clinical performance of a new biomimetic double network material. Open Dent J. 2013;7:118.
7. Özarslan MM, Büyükkaplan UŞ, Barutcigil Ç, Arslan M, Türker N, Barutcigil K. Effects of different surface finishing procedures on the change in surface roughness and color of a polymer infiltrated ceramic network material. J Adv Prosthodont. 2016;8(1):16.
8. Ruse N, Sadoun M. Resin-composite blocks for dental CAD/CAM applications. J Dent Res. 2014;93(12):1232-4.
9. dos Santos Bertoldo CE, Miranda DA, Souza-Junior EJ, Baggio FH, Aguiar DANLL, Lovadino JR. Evaluation of surface roughness and color stability of direct resin composites after different polishing protocols. Int J Dent Clin. 2011;3(3):4-7.
10. Arocha MA, Mayoral JR, Lefever D, Mercade M, Basilio J, Roig M. Color stability of siloranes versus methacrylate-based composites after immersion in staining solutions. Clin Oral Investig. 2013;17(6):1481-7.
11. Harorlı OT, Barutcigil Ç. Color recovery effect of commercial mouth rinses on a discolored composite. J Esthet Restor Dent. 2014;26(4):256-63.
12. Haralur SB. Evaluation of efficiency of manual polishing over autoglazed and overglazed porcelain and its effect on plaque accumulation. J Adv Prosthodont. 2012;4(4):179-86.
13. Aykent F, Yondem I, Ozyesil AG, Gunal SK, Avunduk MC, Ozkan S. Effect of different finishing techniques for restorative materials on surface roughness and bacterial adhesion. J Prosthet Dent. 2010;103(4):221-7.
14. Sagsoz O, Demirci T, Demirci G, Sagsoz NP, Yildiz M. The effects of different polishing techniques on the staining resistance of CAD/CAM resin-ceramics. J Adv Prosthodont. 2016;8(6):417-22.
15. Alharbi A, Ardu S, Bortolotto T, Krejci I. In‐ office bleaching efficacy on stain removal from CAD/CAM and direct resin composite materials. J Esthet Restor Dent. 2018;30(1):51-8.
16. Türkün LŞ, Türkün M. Effect of bleaching and repolishing procedures on coffee and tea stain removal from three anterior composite veneering materials. J Esthet Restor Dent. 2004;16(5):290-301.
17. Lima FG, Rotta TA, Penso S, Meireles SS, Demarco FF. In vitro evaluation of the whitening effect of mouth rinses containing hydrogen peroxide. Braz Oral Res. 2012;26:269-74.
18. Greenwall L. Bleaching techniques in restorative dentistry: An illustrated guide: CRC Press; 2001.
19. Brooks JK, Bashirelahi N, Hsia R-c, Reynolds MA. Charcoal-based mouthwashes: a literature review. Br Dent J. 2020;228(4):290-4.
20. Fasbinder DJ, Neiva GF. Surface evaluation of polishing techniques for new resilient CAD/CAM restorative materials. J Esthet Restor Dent. 2016;28(1):56-66.
21. Paravina RD, Ghinea R, Herrera LJ, Bona AD, Igiel C, Linninger M, et al. Color difference thresholds in dentistry. J Esthet Restor Dent. 2015;27:S1-S9.

22. Yılmaz C, Korkmaz T, Demirköprülü H, Ergün G, Özkan Y. Color stability of glazed and polished dental porcelains. J Prosthodont. 2008;17(1):20-4.
23. Barutçugil Ç, Bilgili D, Barutcigil K, Dündar A, Büyükkaplan UŞ, Yilmaz B. Discoloration and translucency changes of CAD-CAM materials after exposure to beverages. J Prosthet Dent. 2019;122(3):325-31.
24. Sarikaya I, Güler AU. Effects of different surface treatments on the color stability of various dental porcelains. J Dent Sci. 2011;6(2):65-71.
25. Kilinc H, Turgut S. Optical behaviors of esthetic CAD-CAM restorations after different surface finishing and polishing procedures and UV aging: An in vitro study. J Prosthet Dent. 2018;120(1):107-13.
26. Al Ben Ali A, Kang K, Finkelman MD, Zandparsa R, Hirayama H. The effect of variations in translucency and background on color differences in CAD/CAM lithium disilicate glass ceramics. J Prosthodont. 2014;23(3):213-20.
27. Al-Wahadni A, Muir Martin D. Glazing and finishing dental porcelain: a literature review. J Can Dent Assoc 1998;64:580-3.
28. Acar O, Yilmaz B, Altintas SH, Chandrasekaran I, Johnston WM. Color stainability of CAD/CAM and nanocomposite resin materials. J Prosthet Dent. 2016;115(1):71-5.
29. Stawarczyk B, Liebermann A, Eichberger M, Güth J-F. Evaluation of mechanical and optical behavior of current esthetic dental restorative CAD/CAM composites. J Mech Behav Biomed Mater. 2016;55:1-11.
30. Joiner A. Whitening toothpastes: a review of the literature. J Dent. 2010;38:e17-e24.
31. Tredwin C, Naik S, Lewis N, Scully C. Hydrogen peroxide tooth-whitening (bleaching) products: review of adverse effects and safety issues. Br Dent J. 2006;200(7):371-6.
32. Ntovas P, Masouras K, Lagouvardos P. Efficacy of non- hydrogen peroxide mouthrinses on tooth whitening: An in vitro study. J Esthet Restor Dent. 2021;33(7):1059-65.
33. Ghajari MF, Shamsaei M, Basandeh K, Galouyak MS. Abrasiveness and whitening effect of charcoal-containing whitening toothpastes in permanent teeth. Dent Res J. 2021;18.
34. Lee JH, Kim SH, Yoon HI, Yeo ISL, Han JS. Colour stability and surface properties of high- translucency restorative materials for digital dentistry after simulated oral rinsing. Eur J Oral Sci. 2020;128(2):170-80.
35. Sulaiman TA, Abdulmajeed AA, Shahramian K, Hupa L, Donovan TE, Vallittu P, et al. Impact of gastric acidic challenge on surface topography and optical properties of monolithic zirconia. Dent Mater. 2015;31(12):1445-52.
36. Soygun K, Varol O, Ozer A, Bolayir G. Investigations on the effects of mouthrinses on the colour stability and surface roughness of different dental bioceramics. J Adv Prosthodont. 2017;9(3):200-7.