EGYPTIAN
DENTAL JOURNAL
www.eda-egypt.org

Vol. 71, 1469:1476, April, 2025

Print ISSN 0070-9484 • Online ISSN 2090-2360

Fixed Prosthodontics and Dental Materials

Submit Date : 28-07-2024 • Accept Date : 26-03-2025 • Available online: 20-04-2025 • DOI : 10.21608/edj.2024.307799.3133

EFFECT OF DIFFERENT SURFACE TREATMENTS ON OPTICAL PROPERTIES OF CAD /CAM CERAMICS

Rasha Sayed Asaad* *and* Shereen Kotb Salem**

ABSTRACT

Objectives: To evaluate different surface treatments influence on optical properties of two CAD/CAM lithium silicate-based ceramics.

Materials & Methods*:* Sixty disc shaped samples (10 mm diameter x1mm thickness) were constructed and divided according to ceramic type into two groups (30 samples/group): **Group(LD):** Lithium disilicate. **Group (ZLS):** Zirconia reinforced-lithium silicate. Each group was divided into three sub-groups (10 samples/subgroup), according to the surface treatment: **(C)** Control, **(HF)** Hydrofluoric acid 9.5%, **(SB)** Sandblasting. Spectrophotometer was used to measure both Colour change (ΔE) & Contrast Ratio (CR). Universal adhesive was added to sub-groups **(HF)** & **(SB)** then (ΔE) & (CR) were measured for the new subgroups **(HFU & SBU)**. Finally, collected data were statistically analysed.

Results: (ΔE) showed significant increase within (LD) for both subgroups (HFU & SBU). ZLS (Subgroup SBU) showed a significantly higher ΔE compared to the other subgroups. In both groups, the highest ΔE was recorded for the (SBU subgroups). (CR) showed an insignificant difference within (LD) group. Only ZLS (HF) & (SB) subgroups recorded significant difference with all the other subgroups in both groups & insignificant difference with each other.

Conclusions: Etching or sandblasting without the use of universal adhesive didn't affect the colour of (LD) as ΔE lied in the range of clinical acceptance. Etching or sandblasting (LD) with or without the use of universal adhesive didn't affect its translucency. Etching (ZLS) with the use of universal adhesive didn't affect its colour nor its translucency.

KEY WORDS: Surface treatment, Lithium disilicate, Zirconia reinforced-lithium silicate, Translucency, Colour.

* Associate Professor, Fixed Prosthodontics, Faculty of Dentistry, Benha National University
** Professor, Fixed Prosthodontics, Faculty of Dentistry, October 6 University, Giza, Egypt

INTRODUCTION

Lithium silicate glass ceramics (LSC's) are considered an achievement due to their esthetics and mechanical properties in addition to their multiple clinical application. [1] CAD/CAM led to an evolution in the development of LSC's.[2] IPS e.max CAD was presented in 2005, with a well-accepted durable clinical serviceability.[3,4] Moreover, in order to enhance its mechanical properties, LSC's reinforced with 10 wt% zirconia ; VITA Suprinity was recently introduced.[5] LSC's CAD/CAM blocks are either pre-crystallized for faster milling or fully-crystallized to reduce heat treatment following the milling process and saves time for patients particularly in case of single appointment restorations. [2, 6, 7]

For a durable strong bond, various surface treatment protocols aroused for preparation of the internal surfaces of ceramic restorations, enhancing their chemical reactivity as well as the micro-mechanical retention with dental cements. Surface modifications can occur by mechanical, chemical or chemo-mechanical treatments. Acid etching, airborne particle abrasion (sandblasting) & diamond bur grinding, and tribochemical silica-coating are the representatives of these surface treatments respectively. [8-11]

The ceramic materials' chemical composition is responsible for their chemical reactivity to different acids; glass ceramics are more sensitive to acids, while polycrystalline ceramics are resistant to acids. [12] Hydrofluoric acid (HF) was employed for surface treatment of LSC's for generating a porous microstructure, but it showed skin penetrations and systemic toxicity. So, HF is advised to be applied outside oral cavity, then restorations should be ultrasonically cleaned and rinsed to ensure removal of acid remnants. [13] However, microscopically HF remnants were traced in ceramic surfaces even after rinsing. [14,15] So, to overcome any hazards, a substituent etching techniques have been introduced as a neutralizing agent that is applied on ceramics following HF etching in order to neutralize the residual acid and avoid any topographical alterations.[16,17]

Also, Self-Etch Primers were proposed to substitute HF being less toxic but efficient in etching and priming. [18,19] Moreover, sandblasting is recommended as a surface treatment for various ceramics by forming microscopic surface irregularities. [9] Lately, universal adhesives have been introduced as alternatives to self-etch as well as etch-&-rinse adhesives. These universal adhesives overcome multiple steps required for the conventional ones, also their surface treatment for both restorations & teeth became easier & more time saving. [20] Many researchers investigated that these universal bonding agents can bond with tooth structures as well as ceramic restorations like zirconia & lithium disilicate as it contains a new type of MDP. [21,22] A lot of research have discussed the influence of universal adhesives on bond strength of ceramics. However, there is still inadequate information about the influence of these adhesives on the optical properties of various ceramic restorations.

The object's surface texture might crucially influence the ceramics' optical properties like color, translucency and opacity perception. As rough surfaces could permit light scattering more than smooth ones.[23] Therefore, the aim of this study was to investigate the effect of four surface treatment protocols on some optical properties of two CAD/CAM lithium silicate-based ceramics.

The null hypothesis of this study is that different surface treatments would not affect the optical properties of the tested ceramics.

MATERIALS AND METHODS

Study Design

In this research, sixty disc shaped samples (10 mm diameter x 1mm thickness) were constructed and equally divided into two different ceramic groups (30 samples/group): **Group (LD):** Lithium Disilicate (**IPS e.max CAD**, Ivoclar-Vivadent, Schaan, Liechtenstein), **Group (ZLS):** Zirconia reinforced-lithium silicate (**Vita Suprinity**, Vita Zahnfabrick, Bad Sackingen, Germany). Each group was randomly divided into three subgroups (10 samples/subgroup) according to performed surface treatment:**(C)** Control {no surface treatment}, **(HF)** Hydrofluoric acid 9.5%, **(SB)** Sandblasting. Then a spectrophotometer (VITA Easyshade Advance 4.0, Vita Zahnfabrick, Bad Säckingen, Germany) was used to record colour change(ΔE) & translucency {Contrast Ratio (CR)}.Then a universal adhesive (OptiBond™ eXTRa universal, Kavo Kerr) was added to sub-groups **(HF)** and **(SB)**. Finally (ΔE) & (CR) were measured for the new subgroups **(HFU & SBU)**. Collected data were statistically analysed.

Fabrication of Disc Samples:

To standardize the shape and thickness of the disc samples, a metal mold was constructed (10 mm diameter x 1mm thickness). Then a scan spray (Cerec Optispray, Sirona) was applied onto the top of metal mold to be scanned by inEos scanner (Sirona, Germany). Disc designing was done by a CAD software (Cerec inLab software). Milling of **(LD) & (ZLS)** A3 shade blocks was performed using Cerec inLab MC XL milling machine (Sirona, Germany).Thirty discs were obtained for each ceramic group. According to manufacturer instructions, **(LD)** discs were fully crystallized at 850˚C for thirty minutes while **(ZLS)** discs at 840˚C in a furnace (Programat P500, Ivoclar Vivadent, Schaan, Liechtenstein). Finally, all discs were cleaned through steam followed by air dryness.[24] Polishing was performed using 600, 1000, 1200 grit wet silicon carbide papers (Klingspor abrasives Inc. Hickory. NC), respectively under constant water irrigation.[25]

Surface treatment:

Sub-group (HF): Discs were etched with 9.5% HF acid gel (Bisco,USA) following the instructions of the manufacturer for 20 sec. for both (LD) & (ZLS), then rinsed for 1 min. , cleaned ultrasonically for another 1 min. and finally air dried.[26]

Subgroup (SB): Discs were sandblasted for 20 sec. using 50-µm Al_2O_3 at a pressure 2.8 bars, at a distance 10 mm (perpendicular to the treated surface) utilizing a sandblasting device (prep star. Danvell instrument. CA. USA).[27] Then all discs were ultrasonically cleaned for 3 min. and left to dry.

Colour Measurement Test

Using the spectrophotometer, samples were scanned & CIELAB colour parameters within the visible spectrum 380-780 nm were calculated. The 3 coordinate values (L, a, b) of the CIELAB colour system were measured. ΔE was calculated to assess surface treatment of different subgroups, using the following formula.[28]

$$\Delta E\ (L^*, a^*, b^*) = ([\Delta L^*]^2 + [\Delta a^*]^2 + [\Delta b^*]^2\ )^{1/2}$$

Where,

ΔL^* represents, difference in L between the control group & the tested subgroup

Δa^* represents, difference in a between the control group & the tested subgroup

Δb^* represents, difference in b between the control group & the tested subgroup

Translucency test: Contrast Ratio (CR):

The L*, a* and b* were recorded for each disc by placing the probe tip on the central part.[29] For reliability, probe tip was positioned similarly on each sample. These measurements were repeated three times for each sample. The samples were positioned against white and black backgrounds. Figure (1).

For standardization, the device was calibrated before each measurement. The (CR) was calculated according to the following equations:

The spectral reflectance (Y) was calculated as follows: [30]

Y= [(L*+16)/116]³ X 100.

Registered readings on white (Yw) & black (Yb) backgrounds were utilized as follows: [30]

CR= Yb/Yw.

(CR) values range : (0 = transparent object) – (1 =opaque object).

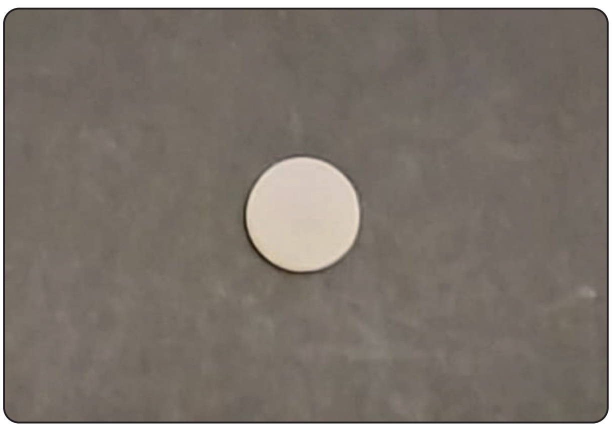

Fig. (1) Ceramic sample on a black background for translucency measurement

Following the Colour Measurement & (CR) Test

For Sub-groups (HF) & (SB):

The (OptiBond™ eXTRa universal, Kavo Kerr) adhesive was applied for 20 sec. & thoroughly air dried. The adhesive was light cured for 10 sec. Then ΔE & CR were measured for the samples of both subgroups after the addition of the adhesive creating two new subgroups **(HFU & SBU)**, respectively.

Statistical Analysis

The analysis of data was carried out using the IBM SPSS version 25 statistical package software. Normality of the data was tested using the Shapiro Wilk test. Data were expressed as mean ± SD. Analyses were done between all groups using One Way Anova test followed by post hoc LSD analysis between each two groups. P-value less than 0.05 were considered statistically significant.

RESULTS

Change in colour results:

The change in colour of different groups after being subjected to different surface treatments are represented in table (1), figure (2). Results showed a significant increase in (ΔE) within LD group when subjected to surface treatment with **HF+Universal adhesive, {subgroup HFU** (4.1)**} as well as with Sandblasting+Universal adhesive {subgroup SBU** (4.4)**}** compared to acid etched LD subgroup. Sandblasted (SB) LD subgroup showed an insignificant difference in ΔE compared to other LD subgroups. For ZLS group, the subgroup treated with **Sandblasting + Universal adhesive (subgroup SBU)** showed a significantly higher ΔE (6.7) compared to the other subgroups. In both groups, the highest ΔE was recorded for the subgroups treated with **Sandblasting + Universal adhesive (SBU subgroups).**

TABLE (1) Means & standard deviations (SD) values of ΔE of different groups.

Ceramics	HF	SB	HFU	SBU
Li Disilicate	2.6[a] (0.22)	3.3[a,b] (0.16)	4.1[b] (0.29)	4.4[b] (0.32)
Zr Li Silicate	3.8[b] (0.19)	3.4[a,b] (0.19)	2.5[a] (0.47)	6.7[c] (0.26)

Different letters denote significant difference

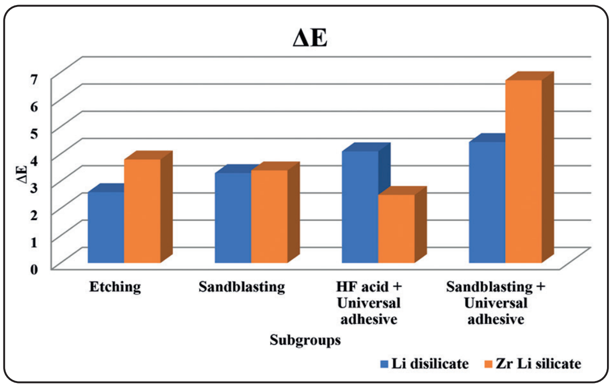

Fig. (2) Bar chart representing ΔE of different subgroups

Translucency results (Contrast ratio):

Contrast ratio results showed an insignificant difference within (LD) group. Only ZLS (etched) (HF) & (sandblasted) (SB) subgroups recorded significant difference with all the other subgroups in both groups & insignificant difference with each other representing the highest CR, 0.84,0.85, respectively. table (2), figure (3).

TABLE (2) The mean, standard deviation (SD) values of CR of different groups.

Ceramics	Control	HF	SB	HFU	SBU
Li disilicate	0.73[a] (0.06)	0.68[a] (0.02)	0.7[a] (0.03)	0.63[a] (0.04)	0.7[a] (0.02)
Zr Li silicate	0.71[a] (0.02)	0.84[b] (0.02)	0.85[b] (0.02)	0.7[a] (0.03)	0.7[a] (0.04)

Different letters denote significant difference

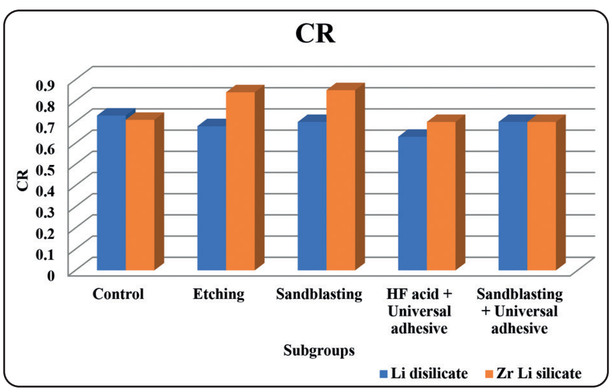

Fig. (3) Bar chart representing CR of different subgroups

DISCUSSION

The current study investigated the effect of different ceramic surface treatments on change in colour & translucency of two glass ceramics with different compositions. **Soares et al 2021**,[31] found insufficient data recording the interaction of surface treatment on ΔE and translucency, as morphological surface changes might alter light pathway and degree of light absorption.[32] Samples thickness was adjusted to 1mm as this is the maximum accepted thickness of a ceramic laminate veneer[33,34] Etched surfaces were copiously rinsed after etching to remove any white deposits representing remnants of remineralized salts, to exclude their effect on the ceramics' shade.[31] Measuring ΔE was done using a spectrophotometer which can detect colour changes undetectable by the human eye.[35] Optibond eXTRA Universal was used as it was claimed by the manufacturer that it can be used on any substrate instead of silane & primer.

Glass ceramics optical properties are specified according to their type, microstructure, porosities, thickness, and crystalline structure & content, grain size &, degree of pigmentation as well as amount and size of surface defects and porosities.[31,36-39] Thus, the microstructure, surface texture, and thickness of a ceramic restoration greatly influence its photometric characteristics. Light attenuation through ceramic restorations might lessen bonding to light cured resin cement, reducing restoration's durability.[23, 32]

Etching LD samples resulted in the lowest ΔE compared to other surface treatments, although there was no significant difference with sandblasted LD subgroup. The ΔE was clinically unacceptable when etching or sandblasting were combined with universal adhesive indicating that using the universal adhesive negatively affected the shade of LD but it had no effect on their translucency.

Etching of ZLS resulted in ΔE exceeding the clinically acceptable change (ΔE<3.7 units).[36] Combined surface treatments of ZLS samples showed significantly higher translucency compared to single treatments, indicating that the universal adhesive was capable of masking the effect of etching as well as sandblasting of ZLS on both colour & translucency, except when the universal adhesive was used on sandblasted samples, which failed to produce clinically acceptable ΔE, but improved their translucency. It was confirmed by many researchers that high ΔE was displayed when roughness increased.[40-43] They reported that selective removal of the ceramic glassy (vitreous) matrix by HF etching or sandblasting lead to a rougher surface due to the exposure of crystalline structures revealing an amorphous microstructure with many porosities.[44]

The needle-like crystalline microstructure of ZLS which is 4-8X less than that of LD permitted the existence of a great amount of glass content as a surrounding matrix, which was attacked by HF as well as sandblasting. But sandblasting caused lower translucency compared to etching with HF. Researchers,[31,45,46] attributed this to the force of bombardment of the aluminium oxide particles while sandblasting causing a less regular removal of the vitreous matrix compared to HF etching.[45-47] **Soares et al 2021,**[31] recorded that silane was not able to hide the surface effect of sandblasting & that sandblasting resulted in higher surface alteration of ZLS than the HF.

The null hypothesis was rejected as the surface treatment technique of the two selected glass ceramics affected the two examined optical properties.

CONCLUSIONS

Within the limitations of this investigation, it could be concluded that:

1. Etching or sandblasting without the use of universal adhesive didn't affect the colour of LD as ΔE lied in the range of clinical acceptance.
2. Etching or sandblasting LD with or without the use of universal adhesive didn't affect its translucency.
3. Etching ZLS with the use of universal adhesive didn't affect its colour nor its translucency.

RECOMMENDATIONS

1. To keep the colour & translucency of Lithium disilicate ceramic, it is recommended to be etched with HF or sandblasted but without adding universal adhesive Optibond eXTRA Universal.
2. To keep the colour & translucency of Zirconia reinforced-lithium silicate ceramic, it is recommended to be etched with HF followed by the addition of the universal adhesive Optibond eXTRA Universal.

REFERENCES

1. Holand W, Beall GH. Glass-ceramic technology: John Wiley & Sons; 2019.
2. Lubauer J, Belli R, Peterlik H, Hurle K, Lohbauer U. Grasping the Lithium hype: insights into modern dental Lithium Silicate glass-ceramics. Dent Mater 2022;38(2): 318-332.
3. Rauch A, Reich S, Dalchau L, Schierz O. Clinical survival of chair-side generated monolithic lithium disilicate crowns: 10-year results. Clin Oral Investig 2018;22(4):1763-1769.
4. Willard A, Chu T-MG. The science and application of IPS e. Max dental ceramic. Kaohsiung J Med Sci 2018;34(4): 238-242.
5. Phark JH, Duarte Jr S. Microstructural considerations for novel lithium disilicate glass ceramics: a review. J Esthet Restor Dent 2022;34(1):92-103.
6. Marchesi G, Camurri Piloni A, Nicolin V, Turco G, Di Lenarda R. Chairside CAD/ CAM materials: current trends of clinical uses. Biology 2021;10(11):1170.
7. Huang S, Li Y, Wei S, Huang Z, Gao W, Cao P. A novel high-strength lithium disilicate glass-ceramic featuring a highly intertwined microstructure. J Eur Ceram Soc 2017;37(3): 1083-1094.
8. Bajraktarova-Valjakova E, Grozdanov A, Guguvcevski L, Korunoska-Stevkovska V, Kapusevska B, Gigovski N. Acid etching as surface treatment method for luting of glass-ceramic restorations, part 1: acids, application protocol and etching effectiveness. Open Access Maced J Med Sci. 2018;6(3):568-573.

9. Borges GA, Sophr AM, De Goes MF, Sobrinho LC, Chan DC. Effect of etching and airborne particle abrasion on the microstructure of different dental ceramics. J Prosthet Dent 2003;89(5):479-488.

10. Ho GW, Matinlinna JP. Insights on ceramics as dental materials. Part II: chemical surface treatments. Silicon 2011;3(3): 117-123.

11. Oliveira-Ogliari A, Vasconcelos CS, Bruschi RC, Gonçalves AP, Ogliari FA, Moraes RR. Thermal silicatization: a new approach for bonding to zirconia ceramics. Int J Adhes Adhes 2014;48 :164-167.

12. Della Bona A. Bonding to ceramics: scientific evidences for clinical dentistry: BDJ 2010;209(2):99.

13. Ozcan M, Allahbeickaraghi A, Dündar M. Possible hazardous effects of hydrofluoric acid and recommendations for treatment approach: a review. Clin Oral Invest 2012;16(1):15-23.

14. Canay S, Hersek N, Ertan A. Effect of different acid treatments on a porcelain surface. J Oral Rehabil 2001;28(1): 95-101.

15. Leite FP, Özcan M, Valandro LF, Cunha Moreira CH, Amaral R, Bottino MA. Effect of the etching duration and ultrasonic cleaning on microtensile bond strength between feldspathic ceramic and resin cement. J Adhes 2013;89(3): 159-173.

16. Sriamporn T, Kraisintu P, See LP, Swasdison S, Klaisiri A, Thamronganankul N. Effect of different neutralizing agents on feldspathic porcelain etched by hydrofluoric acid. Eur J Dent 2019;13(1):75-81.

17. Panah FG, Rezai SM, Ahmadian L. The influence of ceramic surface treatments on the micro-shear bond strength of composite resin to IPS Empress 2. J Prosthodont 2008;17(5):409-414.

18. Lopes GC, Perdigão J, Baptista D, Ballarin A. Does a self-etching ceramic primer improve bonding to lithium disilicate ceramics? Bond strengths and FESEM analyses. Oper Dent 2019;44(2):210-218.

19. Tribst JP, Diamantino PJ, de Freitas MR, Tanaka IV, Silva-Concílio LR, de Melo RM. Effect of active application of self-etching ceramic primer on the long-term bond strength of different dental CAD/CAM materials. J Clin Exp Dent 2021;13(11): e1089-e1095.

20. Kim JH, Chae SY, Lee Y, Han GJ, Cho BH. Effects of multipurpose, universal adhesives on resin bonding to zirconia ceramic. Oper Dent. 2015; 40(1):55-62.

21. Yoshida F, Tsujimoto A, Ishii R, Nojiri K, Takamizawa T, Miyazaki M. Influence of surface treatment of contaminated lithium disilicate and leucite glass ceramics on surface free energy and bond strength of universal adhesives. Dent Mater J. 2015; 34(6): 855-862.

22. Xie H, Li Q, Zhang F, Lu Y, Tay FR, Qian M. Comparison of resin bonding improvements to zirconia between one-bottle universal adhesives and tribochemical silica coating, which is better? Dent Mater 2016; 32(3): 403-411.

23. Villarroel M, Fahl N, De Sousa AM, De Oliveira OB Jr. Direct esthetic restorations based on translucency and opacity of composite resins. J Esthet Restor Dent 2011; 23(2):73-87.

24. Swank h, Motyka NC, Bailey CW, Vandewalle KS. Bond strength of resin cement to ceramic with simplified primers and pretreatment solutions. Gen Dent 2018; 66(5):33-37.

25. Salem A, Mohsen C. Effect of surface treatments on color of machinable ceramics. J Mod Res 2021;3(1): 10-14.

26. Ren DF, Luo XP. Effect of hydrofluoric acid etching time and resin bonding on the flexural strength of lithium disilicate glass ceramic. Zhonghua Kou Qiang Yi Xue Za Zhi / Chinese journal of stomatology. 2013; 48(8):462-466.

27. Kara HB, Dilber E, Koc O, Ozturk AN, Bulbul M. Effect of different surface treatments on roughness of IPS Empress 2 ceramic. Lasers Med Sci 2012; 27(2):267-272.

28. Chu SJ, Devigus A, Paravina RD, Mieleszko AJ. Fundamentals of Color: Shade Matching and Communication in Esthetic Dentistry. Quintessence Pub. Co., 2011; 2nd ed.

29. Karaarslan ES, Bulbul M, Yildiz E, Secilmis A, Sari F, Usumez A. Effects of different polishing methods on color stability of resin composites after accelerated aging. Dent Mater J 2013;32(1):58-67.

30. Comba A, Paolone G, Baldi A, Vichi A, Goracci C, Bertozzi G, Scotti N. Effects of substrate and cement shade on the translucency and color of CAD/CAM lithium-disilicate and zirconia ceramic materials. Polymers 2022; 14(9): 1778.

31. Soares EJ, Oliveira RF, Silame FD, Tonani-Torrieri R, Franca R, Pires-de-Souza FD. Color Stability, Translucency, and Wettability of a Lithium Disilicate Dental Ceramics Submitted to Different Surface Treatments. Int J Prosthodont Restor Dent 2021; 11(1):4-8.

32. Pacheco RR, Carvalho AO, André CB, Ayres APA, de Sá RBC, Dias TM, Rueggeberg FA, Giannini M. Effect of indirect restorative material and thickness on light

transmission at different wavelengths. J Prosthodont Res 2019;63(2):232-238.

33. Turgut S, Bağış B, Korkmaz FM. Do surface treatments affect the optical properties of ceramic veneers? J Prosthet Dent 2014;112(3):618-624.

34. Turgut S, Bagis B, Ayaz EA. How will surface treatments affect the translucency of porcelain laminate veneers? J Adv Prosthodont 2014;6(1):8-13.

35. Perroni AP, Kaizer MR, Della Bona A. Influence of light-cured luting agents and associated factors on the color of ceramic laminate veneers: A systematic review of in vitro studies. Dent Mater 2018;34(11):1610-1624.

36. Yildirim B, Recen D, Simsek AT. Effect of cement color and tooth shaded background on the final color of lithium disilicate and zirconia-reinforced lithium silicate ceramics: An in vitro study. J Esthet Restor Dent 2021;33(2):380-386.

37. Vasiliu RD, Porojan SD, Birdeanu MI. Effect of thermocycling, surface treatments and microstructure on the optical properties and roughness of CAD-CAM and heat-pressed glass ceramics. Materials 2020;13(2):381.

38. Porojan L, Vasiliu RD, Birdeanu MI. Surface characterization and optical properties of reinforced dental glass-ceramics related to artificial aging. Molecules 2020;25(15):3407.

39. Al-Johani H , Julfikar Haider J, Silikas N, Satterthwaite J. Effect of surface treatments on optical, topographical and mechanical properties of CAD/CAM reinforced lithium silicate glass ceramics Dent Mater 2023; 39(9):779-789.

40. Haralur SB, Raqe S, Alqahtani N, Alhassan Mujayri F. Effect of hydrothermal aging and beverages on color stability of lithium disilicate and zirconia-based ceramics. Medicina 2019;55(11):749.

41. Dos Santos DM, Da Silva EVF, Watanabe D. Effect of different acidic solutions on the optical behavior of lithium disilicate ceramics. J Prosthet Dent 2017;118(3):430-436.

42. Palla ES, Kontonasaki E, Kantiranis N. Color stability of lithium disilicate ceramics after aging and immersion in common beverages. J Prosthet Dent 2018;119(4):632-642.

43. Motro PFK, Kursoglu P, Kazazoglu E. Effects of different surface treatments on stainability of ceramics. J Prosthet Dent 2012;108(4):231-237.

44. França R, Bebsh M, Haimeur A. Physicochemical surface characterizations of four dental CAD/CAM lithium disilicate based glass ceramics on HF etching: An XPS study. Ceram Int 2020;46(2):1411-1418.

45. Lima CM, da Silva NR, Martins JD. Effect of different surface treatments on the biaxial flexure strength, Weibull characteristics, roughness, and surface topography of bonded CAD/CAM silica-based ceramics. Dent Mater 2021;37(3):e151-e161.

46. Dilber A, Yavuz T, Kara HB. Comparison of the effects of surface treatments on roughness of two ceramic systems. Photomed Laser Surg 2012;30(6):308-314.

47. Carneiro CMA, Paulart MM, Correr GM, da Cunha LF, Diógenes AN, Gonzaga CC. Translucency parameters of different CAD/CAM ceramics for monolithic restorations. Cerâmica 2023; 69 (391): 248-253.