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Chairside CAD-CAM milling materials optical properties: feldspathic versus lithium silicate

Materiale frezabile CAD-CAM: feldspatic versus litiu silicat

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Abstract

Background. Dental CAD-CAM technology has developed in the last three decades due to the evolution of dental materials and computer science.

Aims. The aim of the study was to evaluate the similarity of the color coordinates of different CAD-CAM milling materials with the corresponding tabs of the 3D Master shade guide.

Methods. Two different types of chairside CAD-CAM milling materials: feldspar ceramic (Vita Mark II - Vita) and zirconia-reinforced lithium silicate ceramic (Vita Suprinity - Vita) were used for this in vitro study. A group of 7 specimens of 1 mm thickness were cut for each type of material with a precision cutting saw. CIEL*a*b* color coordinates of each sample were determined with a dental spectrophotometer (Vita Easyshade - Vita) and compared to the color coordinates of a corresponding shade tab from a 3D Master shade guide, and the color differences CIE 76 (ΔEab) and CIE DE2000 (ΔE00), respectively, were calculated.

Results. Color differences (ΔEab and ΔE00, respectively) between the shade tab and the evaluated materials were 8.5 and 3.7 for Vita Mark II, 12.8 and 6 for Vita Suprinity High Translucent, and 33.3 and 12.7 for Vita Suprinity Translucent, respectively, way over the perceptibility and clinical acceptability thresholds.

Conclusions. In this study, a color difference above the limits of acceptability and perceptibility was found between each investigated material and the corresponding shade tab.

Key words: ceramic, feldspathic, lithium silicate, color, CAD-CAM

Rezumat

Premize. Tehnologia CAD-CAM utilizată în medicina dentară a cunoscut un progres important în ultimele trei decenii datorită evoluției materialelor dentare și a științei computerizate.

Obiective. Obiectivul studiului a fost de a evalua similaritățile dintre coordonatele cromatice ale diferitelor materiale frezabile CAD-CAM și eșantionul corespunzător din cheia de culori 3D Master.

Metode. Două tipuri diferite de materiale frezabile CAD-CAM: ceramica feldspatică (Vita Mark II - Vita) și ceramica de litiu silicat ranforsat cu zirconiu (Vita Suprinity - Vita) au fost utilizate pentru acest studiu in vitro. Un grup de 7 eșantioane de 1 mm grosime au fost tăiate pentru fiecare material în parte cu un microtom. Cu ajutorul unui spectrofotometru (Vita Easyshade - Vita) au fost determinate coordonatele cromatice CIEL*a*b* pentru fiecare material și comparate cu aceiași parametri ai eșantionului corespunzător al cheii de culori 3D Master și diferențele de culoare CIE 76 (ΔEab) și respectiv CIE DE2000 (ΔE00) au fost calculate.

Rezultate. Diferențele de culoare (ΔEab și respectiv ΔE00) dintre eșantionul din cheia de culori și Vita Mark II au fost de 8,5 respectiv 3,7, Vita Suprinity High Translucent de 12,8 respectiv 6 și Vita Suprinity Translucent de 33,3 respectiv 12,7, mult peste pragurile de perceptibilitate și acceptabilitate clinică.

Concluzii. În limita acestui studiu, între materialele investigate și eșantionul corespunzător din cheia de culori a fost găsită o diferență de culoare peste pragurile de perceptibilitate și acceptabilitate.

Cuvinte cheie: ceramică, feldspatic, litiu silicat, culoare, CAD-CAM

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Introduction

In the last 3 decades, computer aided design - computer aided manufacturing (CAD-CAM) technology has become indispensable for dental offices specialized in precise, highly aesthetic restorations, produced in a short time. The development of technology as well as modern high performance milling materials has contributed to this evolution (Davidowitz & Kotick, 2011).

Each year, new materials arise with improved properties and qualities, to resist and perform in the conditions of the oral cavity. The humidity, acidity and bacteria specific to the oral cavity have a destructive effect on restoration materials, comparable to that of masticatory forces (Egilmez et al., 2018; Skouridou et al., 2013).

Even if for a long time period only feldspar ceramic was used for the CAD-CAM technology, nowadays there are many other milling materials that can be used for this technology: glass ceramic (feldspar, reinforced with leucite, lithium silicate), oxide ceramics (magnesium, aluminum or zirconia), composite resins and hybrid ceramics (Conrad et al., 2007; Zaruba & Mehl, 2017; Tapie et al., 2015).

Initially, for highly aesthetic cases, feldspar ceramic was mainly used because of its optical characteristics. The mechanical properties of this ceramic (flexural strength of 154 MPa) (1) were considered acceptable, with a 10-year survival rate of 90% (Fasbinder, 2016; Reiss & Walther, 2000), but ceramic fracture was considered the main factor of restoration failure (Donovan, 2008; Horvath, 2016). To solve this problem, in 2006 a reinforced ceramic was developed (Emax CAD - Ivoclar Vivadent, Liechtenstein, Germany - lithium silicate glass ceramic), capable of resisting higher forces of 360-400 MPa (2). Moreover, in 2013 a zirconia reinforced lithium silicate ceramic (Vita Suprinity - Vita, Bad Säckingen, Germany), with a flexural strength of 420 MPa (3), was introduced in the medical field.

However, with the evolution of mechanical properties, the optical properties of chairside CAD-CAM milling materials changed. Introducing different components to increase the resistance of the material, such as zirconia, affected the translucency of the restorative materials, and in conjunction, the whole optical perspective.

The aim of the study was to evaluate the correspondence of the color coordinates of different CAD-CAM milling materials with the tabs of the 3D Master shade guide with the same designation.

The null hypothesis was that there were no differences between the color coordinates of chairside CAD-CAM milling materials and the correspondent shade tabs.

Material and methods

An in vitro study was conducted using two different types of chairside CAD-CAM milling materials: feldspar ceramic (Vita Mark II - Vita, Bad Säckingen, Germany) with SiO_2: 56-64%, AI_2O_3: 20-23%, Na_2O: 6-9%, K_2O: 6-8%, CaO: 0.3-0.6% and TiO_2: 0.0-0.1%, and zirconia-reinforced lithium silicate ceramic (Vita Suprinity - Vita, Bad Säckingen, Germany) with ZrO_2: 8-12%, SiO_2: 56-64%, Li_2O: 15-21% and others > 10%, high translucent (HT) and translucent (T).

a) Specimen preparation

For each material, seven 2M2 shade specimens were cut at 1 mm thickness with a precision saw (IsoMet 1000 - Buehler) using a diamond cutting blade for hard brittle materials and structured ceramics (IsoMet Diamond Wafering Blade, 5 in, 15LC - Buehler) at a speed of 100 rotations per minute.

To reach the desired thickness (±0.01mm), the samples were measured with an electronic micrometer and polished using sandpaper (Klingspor) with increasing grits (P240, followed by P400, P800, P1000 and P1200).

b) Determination of color coordinates and calculation of color differences

For each specimen, the CIEL*a*b* (L* - luminosity values, a* - chrome on the red-green scale, and b* - chrome on the yellow-blue scale) optical parameters were determined with a dental spectrophotometer (Vita Easyshade - Vita). Each measurement was repeated three times and a mean value was obtained for each optical parameter of each specimen. The same CIEL*a*b* optical parameters were determined ten times and an average value was obtained for the 2M2 shade tab of Vitapan 3D Master (Vita) shade guide.

Differences in color: DE_{ab} and DE_{00} were determined between the specimens and the shade tab using the following formulas:

$$\Delta E_{ab}{}^{*}=\sqrt{(\Delta L^{*})^{2}+(\Delta a^{*})^{2}+(\Delta b^{*})^{2}}$$

where ΔL* is the difference in lightness, Δa* is the difference in redness-greenness, and Δb* is the difference in yellowness-blueness.

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

The weighting functions S_L, S_C, S_H adjust the total color difference for variation in perceived magnitude with variation in the location of the color difference pair in L', a', and b' coordinates. The parametric factors K_L, K_C, K_H are correction terms for variation in experimental conditions.

The values were compared with the acceptability threshold (AT) and perceptibility threshold (PT). For ΔE_{ab}, PT 1.2, and AT 2.7 were considered, whereas for ΔE_{00}, values were 0.8 for PT and 1.8 for AT (Paravina et al., 2015).

Results

The color coordinates of the chairside CAD-CAM milling materials investigated in this study are presented in Table I.

For Vita Mark II, L* ranged from 84.9 to 87.3 with a mean value of 86.6, a* ranged from -0.6 to 0.4 with a mean value of -0.5, and b* ranged from 15.6 to 16.1 with a mean value of 15.9.

For Vita Suprinity Translucent, L* ranged from 82.7 to 83.5 with a mean value of 83, a* ranged from 3.6 to 4.3 with a mean value of 4.2, and b* ranged from 51.4 to 53.3 with a mean value of 52.7.

For Vita Suprinity High Translucent, L* ranged from 81.7 to 82.1 with a mean value of 81.9, a* ranged from -0.5

Table I
Optical parameters for Vita Suprinity Translucent (VS T), Vita Suprinity High Translucent (VS HT) and Vita Mark II (VM II)

	L*			a*			b*		
Sample number	VS T	VS HT	VM II	VS T	VS HT	VM II	VS T	VS HT	VM II
1	82.7	81.9	86.5	4.3	-0.3	-0.5	53.3	33.0	15.7
2	83.2	82.0	87.2	4.3	-0.2	-0.5	53.2	32.5	16.0
3	83.0	82.1	86.7	4.3	-0.5	-0.5	53.1	31.6	16.1
4	82.7	81.8	86.9	4.1	-0.1	-0.6	51.9	32.0	15.6
5	83.5	82.0	84.9	3.6	-0.2	-0.4	51.4	32.1	15.7
6	83.0	81.9	87.3	4.3	-0.1	-0.5	52.8	32.9	16.0
7	83.1	81.7	86.8	4.3	-0.4	-0.4	53.1	31.3	15.9
Average	83.0	81.9	86.6	4.2	-0.3	-0.5	52.7	32.2	15.9

to -0.1 with a mean value of -0.3, and b* ranged from 31.3 to 33 with a mean value of 32.2.

For the 2M2 shade tab, L* ranged from 79.1 to 79.2 with a mean value of 79.2, a* ranged from 1.1 to 1.2 with a mean value of 1.1, and b* ranged from 19.6 to 19.8 with a mean value of 19.7.

Color differences (DE_{ab} and DE_{00} respectively) between the shade tabs and the evaluated materials were 8.5 and 3.7 for Vita Mark II, 12.8 and 6 for Vita Suprinity High Translucent, and 33.3 and 12.7 for Vita Suprinity Translucent, respectively, way over the perceptibility and clinical acceptability thresholds (Fig. 1).

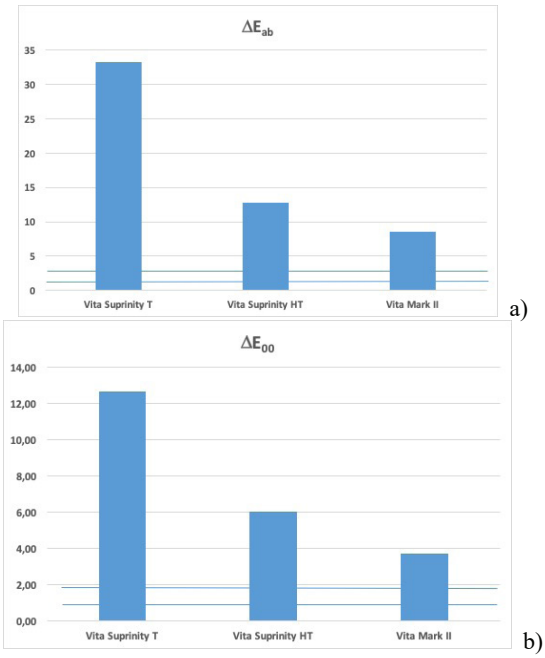

Fig. 1 – Color differences for the investigated materials: a) DE_{ab} b) DE_{00}

Discussions

The null hypothesis was rejected, since there were color differences between the shade tab and the evaluated materials.

It seems that various materials have different optical parameters, even if they have the same color designation. The color parameters of the feldspar ceramic were more similar to those of the shade tab, compared to the lithium silicate ceramic.

Vita Mark II is available in 10 shades of Vitapan Classical and 10 shades of Vitapan 3D Master, while Vita Suprinity is available in only 7 shades of Vitapan Classical and 6 shades of Vitapan 3D Master. Even so, Vita Suprinity has 2 variants of translucency: translucent (T) and high translucent (HT).

The visual determination of the dental color, using different shade tabs from a shade guide, can be challenging for clinicians. Using the Vitapan 3 D Master shade guide, the color samples feature an equidistant distribution in the color space in accordance with scientific principles, which adds superior precision to shade matching if proper handling is ensured.

After milling, a CAD-CAM restoration has to be glazed and individualized with different pigments, to mimic the natural look. For the present study, no other material (glaze or pigment) was used to alter the surface of the samples. Even so, there are studies which highlight the factors that can alter the final color of the restoration: different glazing methods and repeated firings (Yılmaz et al., 2014), finishing procedures of the surfaces of the restoration (Özarslan et al., 2016; Sarac et al., 2006a; Sarac et al., 2006b).

The samples used for this study had a flat surface to avoid the "edge loss errors". These errors occur when some of the radiation reflected by the convex buccal surface of the tooth does not reach the flat active part of the spectrophotometer. This kind of error is amplified by the translucency of the tooth or restoration material as well (Paravina et al., 2007). This could be a reason for the discrepancies between the optical parameters of the shade tabs and the materials selected for this study.

Conclusions

1. In this study, the optical parameters of chairside CAD-CAM milling materials are different from those of the corresponding shade tab.
2. Feldspar ceramic was more similar to the shade tab than lithium silicate ceramic.

Conflicts of interests

None

Acknowledgments

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References

Davidowitz G, Kotick PG. The use of CAD/CAM in dentistry. Dent Clin North Am. 2011;55(3):559-570. doi: 10.1016/j.cden.2011.02.011.

Egilmez F, Ergun G, Cekic-Nagas I, Vallittu PK, Lassila LVJ. Does artificial aging affect mechanical properties of CAD/CAM composite materials. J Prosthodont Res. 2018;62(1):65-74. doi: 10.1016/j.jpor.2017.06.001.

Skouridou N, Pollington S, Rosentritt M, Tsitrou E. Fracture strength of minimally prepared all-ceramic CEREC crowns after simulating 5 years of service. Dent Mater. 2013;29(6):e70-e77. doi: 10.1016/j.dental.2013.03.019.

Conrad HJ, Seong WJ, Pesun IJ. Current ceramic materials and systems with clinical recommendation: a systematic Review. J Prosthet Dent. 2007; 98(5):389-404. DOI:10.1016/S0022-3913(07)60124-3.

Zaruba M, Mehl A. Chairside systems: a current review. Int J Comput Dent. 2017;20(2):123-149.

Tapie L, Lebon N, Mawussi B, Fron Chabouis H, Duret F, Attal JP. Understanding dental CAD/CAM for restorations--the digital workflow from a mechanical engineering viewpoint. Int J Comput Dent. 2015;18(1):21-44.

Fasbinder DJ. Clinical performance of chairside CAD/CAM restorations. Send to J Am Dent Assoc. 2006;137 (suppl):22S-31S.

Reiss B, Walther W. Clinical long-term results and a 10-year Kaplan-Meier analysis of Cerec restorations. Int J Comput Dent. 2000;3(1):9-23.

Donovan TE. Factors essential for successful all-ceramic restorations. J Am Dent Assoc. 2008;139 suppl:14S-18S.

Horvath SD. Key parameters of Hybrid Materials for CAD/CAM - Based Restorative Dentistry. Compend Contin Educ Dent. 2016;37(9):638-643.

Paravina RD, Ghinea R, Herrera LJ, Bona AD, Igiel C, Linninger M, Sakai M, Takahashi H, Tashkandi E, Perez Mdel M. Color difference thresholds in dentistry. J Esthet Restor Dent. 2015;27(Suppl 1):S1-S9. doi: 10.1111/jerd.12149.

Yılmaz K, Gonuldas F, Ozturk C. The effect of repeated firings on the color change of dental ceramics using different glazing methods. J Adv Prosthodont. 2014;6(6):427-433. doi: 10.4047/jap.2014.6.6.427.

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):16-20. doi: 10.4047/jap.2016.8.1.16.

Sarac D, Sarac YS, Kulunk S, Ural C, Kulunk T. The effect of polishing techniques on the surface roughness and color change of composite resins. J Prosthet Dent. 2006a;96(1):33-40. DOI:10.1016/j.prosdent.2006.04.012.

Sarac D, Sarac YS, Yuzbasioglu E, Bal S. The effects of porcelain polishing systems on the color and surface texture of feldspathic porcelain. J Prosthet Dent. 2006b;96(2):122-128. DOI:10.1016/j.prosdent.2006.05.009.

Paravina RD, Majkic G, Imai FH, Powers JM. Optimisation of Tooth Color and Shade Guide Design. J. Prosthodont. 2007;16(4):269-276. DOI:10.1111/j.1532-849X.2007.00189.x.

Websites

(1) Vita mark II. Flexural strength. Available online at: https://www.vita-zahnfabrik.com/en/VITABLOCS-Mark-II-25030,27568.html. Accessed on 11 September 2018.

(2) Emax CAD mechanical properties. Available online at: http://www.ivoclarvivadent.com/en/p/all/ips-emax-system-dentists/ips-emax-cad-chairside Accessed on 11 September 2018.

(3) Vita Suprinity: mechanical properties. Available online at: https://www.vita-zahnfabrik.com/en/VITA-SUPRINITY-PC-44049.html Accessed on 11 September 2018.