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IN VITRO STUDY: SUSCEPTIBILITY TO PIGMENTATION OF DIFFERENT CERAMIC SURFACES

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ABSTRACT

The study was inspired by the chemical surface analysis of a pigmented ceramic sample of a clinical case, which was submitted to a surface study, by means of a chemical chromatographic and electronic microscope. We also performed an "in-vitro" quali-quantitative experiment with 200 ceramic surfaces made of lithium disilicate and feldspar. Which were divided into different surface variables. We also executed mathematical calculations in order to calculate the Delta-E-1976 indicator, which determines the difference of color in ceramic surfaces. In this sense, we analyzed the values obtained with standardized polarized photographs, before and after submerging them into different pigmentation containers for 20 days. These values were compared with visual tests. We performed the mathematical analysis by using the SPSS-22 statistical package.

KEYWORDS: resistance to ceramic staining, ceramic stain susceptibility, porcelain porosity

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INTRODUCTION

From the 1930s some odontology researchers began to analyze ceramic veneers. During the 1980s,the odontologists all over the world started to adhere such ceramic surfaces to patients' teeth[1-3]. Currently, we are aware that the clinical behavior of the porcelain veneers maintain a survival time range which varies from five to twenty years. On the other hand, the in-vitro studies demonstrate degradation of both mechanical and optical ceramics; the optical ones were submerged for 24 days in Coca-Cola liquid, coffee and grape juice[4]. In this context, the purpose of this study was to find the relation between the stain compounds and the ceramic surfaces.

MATERIAL AND METHODS

We applied the in-vitro non-experimental epidemiological design: Statistical comparison of two observations: (O1) Initial measurement of the experimental group after the application of an intervention program, by using the Cie-Lab-1976 system through standardized photography and visual analysis. This observation was collated with the control group observation (O2), final measurement of the experimental group, which received the intervention program by using the Cie-Lab-1976 system and the Delta-E calculation through the use of standardized photography, corroborated with the visual analysis[4]. The results of these observations were analyzed by the SPSS-22 statistical package.

This experiment was performed on 200 ceramic surfaces submerged for 20 days (1.6 years of contact in immersion liquids): group C in physiological serum; group GE1 in iodine; Group GE2 in wine; Group GE3 in Coca Cola; Group GE4 in Chlorhexidine. In each group we submerged 40 surfaces divided into 5 samples of each surface variable. The results were: feldspathic surfaces: Group FG, glazed; Group FP, polished; Group FF milled; Group FUS treated with ultrasound. Lithium disilicate surfaces: Group DG, glazed; Group DP, polished; Group DF,milled; Group DUS, treated with ultrasound.

For this measurement we took standardized photographs: Customized White Balance; DNG profile; shutter speed 1/125; diaphragm's opening F16; ISO sensor sensitivity 100; flash power 1/1, with polarized filter; focusing distance 30 mm.

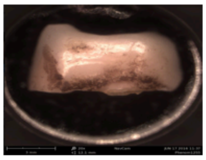
We calibrated the exposure with gray at 60 points with Lightroom 5 digital revelation; we obtained L * a * b * values with Color Think pro 3.0.3; we brushed the samples on both sides with Colgate toothpaste for 10 seconds each surface. The initial and final values provided the Delta-E calculation of each surface. These values determined perceptible color changes after the immersion in physiological saline serum, iodine, wine, chlorhexidine and Coca-Cola liquid. We corroborated such results by using the visual test.We used a Reflex XS photographic camera, Canon-Japan; 100mm. macro lens, Canon Ring flash; Polar Eyes (Bioemulation-USA); Adobe Lightroom 5 Software (Adobe, USA); chart-USA X-Rite Color; VitaCeramic and injection furnaces, Germany; Infinity m30 preheating oven (whimpmix, USA); Emax HO tablet Ceramic blocks of lithium disilicate (Ivoclar Vivadent, Germany); dentine BLeach-EmaxCeram®-feldspathic ceramic powder, (Ivoclar Vivadent, Germany), among other materials.

Before the experiment, we performed a pilot test in eighty surface samples: forty in disilicate and forty in feldspar, which are divided into four experimental groups: glazing, polishing, milling and ultrasonic tip treatment groups. We confirmed the absence of pigmentation in prepared zones, and in the unprepared zones we discovered pigmentation related to the porosity of the ceramic non-treated previously.

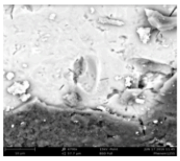
RESULTS

The chromatographic analysis showed the presence of carbon dioxide, iodine, bromine, barium and acetic acid in the figure 1.

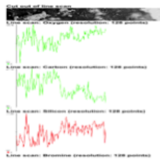
Figure 1. Chromatographic analysis showed the presence of carbon dioxide, iodine and acetic.



1) Presence of stain in the ceramic surface, from the clinical case that inspired this study.



2) Enlargement to 4,700 x, presence of porosity in the ceramic surface and its relation with the stain.



3) Analysis of elements evidencing the presence of Bromine.

Courtesy of Michael E. Vargas Vallejo and David Egas.

We submitted the experiment to a statistical analysis. The multiple regression analysis of surface variables (glazed feldspathic surfaces (DG)), glazed lithium disilicate ceramic surfaces (FP), polished feldspathic surfaces (DP), polished lithium disilicate ceramic surfaces (FF), milled feldspathic surfaces (DF), milled lithium disilicate surfaces (FUS), feldspathic surfaces treated with ultrasound tips (DUS), lithium disilicate surfaces treated with ultrasound tips; and, the immersion test variables (Physiological saline serum-group C; Wine-group E1; Iodine group- E2; Cola Drink-group E3; Chlorhexidine-group E4). This test verified that the corresponding crosses maintained perfect correlation strength with the gold standard (feldspathic surfaces glazed in physiological saline serum and lithium disilicate surfaces glazed in physiological saline serum). We confirmed that the multiple regression coefficient was: $r = 1$; determination coefficient $r^2 = 1$. Each one of the distinct independent variables reached 100% of the relation with the gold standard variable(Table 1).

Table 1. Summary of the model.

Summary of the Model

Model	R	R^2	Adjusted R^2	Estimation's Standard Error
1	1,000[a]	1,000	.	.

a. Predictors: (Constant), DELTA-E feldspathic surface milled in chlorhexidine (group E5);Delta-E feldspathic surface treated with ultrasound tip in chlorhexidine (group E5); Delta-E and milled feldspathic surface in saline serum (group C); Delta-E feldspathic surface glazed in iodine (Group E1).

When we analyzed the independent variables individually, each one of them explained the 100% of the variance of the dependent variable, because R^2 corrected = 100% (Table 2).

Additionally, we executed the ANOVA variance analysis in order to validate the multiple regression model of the experiment. The statistical significance corresponding to the probability value (f), confirmed the certainty of the H_0. Therefore, we state that the hyperplane defined by the regression equation gives a perfect regression line; under this, we disprove the hypothesis of this study (Table 3).

Table 2. Table of coefficients.

Table of Coefficients

Coefficients[a]

Model		Non-Standardized Coefficients B	Non-Standardized Coefficients Standard Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	83,267	,000		.	.
	DELTA-E MILLED FELDSPATHIC SURFACE IN SALINE SERUM (GROUP C)	-13,822	,000	-19,886	.	.
	DELTA-E MILLED FELDSPATHIC SURFACE IN WINE (Group E2)	-33,987	,000	-15,806	.	.
	DELTA-E MILLED FELDSPATHIC SURFACE IN COLA DRINK (Group E3)	-16,500	,000	-17,370	.	.
	DELTA-E MILLED FELDSPATHIC SURFACE IN CHLORHEXIDINE (Group E4)	2,936	,000	3,667	.	.

a. Dependent Variable: DELTA-E GLAZED FELDSPATHIC SURFACE IN SALINE SERUM (Gold Standard/Feldspathic Surfaces).

Source: *In-Vitro* Study: Susceptibility to Pigmentation of Different Ceramic Surfaces.

Table 3. The ANOVA test results.

Model		Sum of R^2	GL	Quadratic Average	F	Sig.
1	Regression	,644	4	,161	.	.[b]
	Residue	,000	0	.		
	Total	,644	4			

a. Dependent variable: DELTA-E glazed lithium disilicate in saline serum (GROUP C).

b. Predictors: (Constant), DELTA-E milled disilicate lithium surface in chlorhexidine (Group E5); DELTA-E polished disilicate lithium surface in chlorhexidine (Group E5); DELTA-E milled disilicate lithium surface of in wine (Group E2); DELTA-E lithium disilicate surface treated with ultrasound tip in Cola Drink (Group E3).

DISCUSSION

When we searched for literature on this subject and we reviewed it, we found out there are no similar works in any database. Everyone knows that complex events occur within the oral cavity, and over time, such actions may lead to changes in the color of biomaterials[5]. When we measured with spectrophotometers, the ambient light does affect measurements of surfaces and such light also influences the background on which surfaces are measured, regardless the color of such background[6,7]. The bibliographic references about this odontology topic show several Delta-E indicators, with a range that goes from 1.1 to 5.5[8]. The experiment showed the Delta-E indicator below 5.5. Some authors describe that wine pigments more than saliva, distilled water, coffee and tea; these results are in accordance with those obtained in this study[12]. Dondi et al. indicate that resistance to pigmentation decreases when we increase the percentage of large pores with an irregular internal structure. The pilot test verified the relation between porosity and resistance of pigmentation in ceramic after brushing and cleaning with toothbrush and toothpaste. A non-probabilistic study in ceramics with different physicochemical structure and composition, submerged in methylene blue for one day, generated the following results: the Ips Empress obtained the highest pigmentation (Delta-E 14.5); In Ceram 9.2; Procera 9.0. These high delta values differ from the values obtained in the current study[6].

CONCLUSIONS

The "in-vitro" study proved that the ceramic is not susceptible to pigmentation if it is treated carefully. Finally, we recommend experimental studies on other type of ceramic surfaces, emphasizing the fact that up to the present moment, there are no works similar to this current investigation.

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