Effect of cigarette smoke on color stability of dental composites using spectrophotometer -an in vitro study.

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Abstract

Aim: To assess three dental composites color stability after they are exposed to brushing and cigarette smoke using spectrophotometer.

Materials and Methods: Twenty specimens were prepared for each type of restorative material used: nanohybrid (Tetric N-Ceram); hybrid (Z250-3M ESPE) and silorane-based microhybrid (Filtek P90-3M ESPE), which were divided into 2 groups ($n = 10$), according to the type of finishing/polishing received: Group 1 – papers with decreasing abrasive grit and Group 2 – polyester matrix (without polishing). After initial readouts of color (Easy Shade-VITA) specimens were subjected to action of smoke from 20 cigarettes, (Marlboro Red–Philip Morris). After each cigarette, the samples were submitted to brushing in a standardised device. After this, final readouts were taken to calculate change in color

(DE and DL) which were statistically analysed (2-way ANOVA, Bonferroni, and Student's-t tests respectively, $p < 0.05$).

Results: Tetric N-Ceram presented color change at clinically unacceptable levels (DE > 3.3) when the polyester strip was used for finishing, a result differing ($p < 0.05$) from those of the other composites, which presented no difference between them ($p > 0.05$)

Conclusion: Absence of polishing increases cigarette capacity to stain composites and surface roughness of composites, with exception of the silorane based type.

Statistical analysis used: (2-way ANOVA, Bonferroni, and Student's-t tests respectively, $p < 0.05$)

Keywords:Resin composite, Cigarette smoke, Color change, Polishing.

INTRODUCTION

Given that tobacco smoking is one of the main preventable causes of disease and death, the World Health Organization estimates that there are around 1 billion smokers worldwide [1].

[2]. Today's society places a great priority on physical beauty. Because of this gradual appreciation, many patients—smokers or not—now want a perfect smile in addition to a perfect body. Resin composite is the material of choice for direct repairs when aesthetics are important.

[3]External discolorations caused by stains and plaque accumulation are the first cause of color change; surface or subsurface alterations that promote surface deterioration and favor coloring agents adsorption—the penetration and reaction of coloring agents with the resin composite surface; and intrinsic discolorations caused by physical-chemical reactions in the deeper sections of the restorative material are the second and third main causes.[4] [5]Surface discoloration is a common consequence of coloring components penetrating foods and beverages such as coffee, tea, coffee, and red wine.[6, 8, 10, 11] as well as cola-based soft drinks.[8, 11] There is, however, a dearth of study on the effects of cigarette smoke on visually appealing restorative materials.[7;12], and [16] aesthetic properties, some drawbacks persist, most notably color instability.

The initial studies were conducted by Raptis et al.12, who found that composites exposed to 40 cigarettes' worth of smoke over time showed a noticeable change in color stability. Recent studies [15,16] have evaluated the effects of alcohol and cigarette smoke, demonstrating that the two drugs together may exacerbate the discoloration of restorative materials. The size, distribution, and volume of load particles, as well as the type of finishing and polishing techniques employed, are known to have an impact on surface roughness, which may delay staining [17, 18]. According to Sarac et al. [(19)], polishing would be better and there would be less color shift if the particle size was smaller.

Material & methods:

Table 1 displays the composites that were assessed.

Table 1: All the composite used in this study.

Material A2		Composition
Filtek Z 250	Hybrid composite	Bis-GMA, TEGDMA, UDMA, BisEMA, 60% of filler: zirconium/silica particles (0.01 mm–3.50 mm, mean size 0.6 mm,).
Tetric N-Ceram	Nano hybrid composite	Bis-GMA, UDMA, TEGDMA, BIS-EMA, 55–57% of filler: Barium glass, ytterbium trifluoride, mixed oxides and silica dioxide particles (0.04–3.0nm, mean size 0.7 nm)
Filtek P90	Micro hybrid composite	Hydrofobic silorane based matrix, 55% of fillers: quartz and yttrium fluoride particles (mean size 0.47 mm)

**Bis-GMA, bisphenol A-glycidyl dimethacrylate; Bis-EMA, bisphenol A-polyethylene glycol diether dimethacrylate; UDMA, urethane dimethacrylate; TEGDMA, triethylene glycol dimethacrylate.*

Table 1 displays the composites that were assessed. Each type of composite was used to create twenty test specimens in two increments using a Teflon matrix that was 8 mm in diameter and 2 mm thick. The final increment was covered with a polyester matrix, and a glass slide was placed on top of it to facilitate the flow of extra material and provide surface smoothness. Following this, the test specimens were light activated for 40 seconds in compliance with the manufacturer's instructions using a FLASHlite 1401, Discus Dental, Culver City, CA, USA – 1100 mW/cm2 light wavelength in the band between 460 and 480 nm. After the matrix was removed, the test specimens were separated into two groups (n = 10),

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According to the type of finishing/polishing performed: Group 1 – abrasive water papers (600, 800,1200 – Norton Abrasivos, Guarulhos, SP, Brazil); and Group 2 – without polishing, only the use of the polyester matrix at the time of obtaining the samples.. After fabrication, the samples were stored in distilled water at 378 for 24 h.

Initial color readouts (Spectrophotometer Easyshade, VITA Zahnfabrik, BadSa¨ckingen, Germany) readouts of the test specimens were taken. For color readouts, the test specimens were dried with absorbent paper, and placed on a standard white background. The observation pattern simulated for color readout followed the CIE L*a*b* system (Comission Internationale de I'E´ clairage). This consists of two axes, a* and b*, that have right angles and represent the dimension of tonality or color. The third axis is luminosity L*.This is perpendicular to the plane a* b*

Fig. 1 – (A) Smoking equipment used in the study. (B) Specimen put into the chamber using a supporting device.

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After this, the test specimens were submitted to the action of cigarette smoke. Therefore, a device was developed (Fig. 1) using a sectioned test tube, with a support at one end to fit in the cigarette, and on the other end, a cap fitted with a system that caused a negative pressure to aspirate the smoke released by the cigarette, thereby leading to impregnation of the restorative materials with the substances contained in the smoke, for the purpose of reproducing in vitro the conditions of a smoker's oral cavity. The test specimens were put into a chamber using a supporting device that would allow the samples to remain in a vertical position, so that the greater part of their surface would be exposed to the cigarette smoke. For each sample, 20 cigarettes (Marlboro Red, Phillip Morris) were used and each cigarette was burned in a standard time of 10 min.

After exposure to each cigarette, the test specimens were brushed, using a standardised device (Fig. 2) with the intention of eliminating excesses of substances from the smoke adhered to the test specimen surfaces. The device has an acrylic base with a sliding top surface, a central orifice for fixation of the test specimens, and a reservoir for depositing the dentifrice (Colgate Total 12 Colgate-Palmolive, Sa˜o Bernardo do Campo,Sa˜o Paulo, Brazil). The device was adapted to the supporting table of a paralellometer and the tooth brush heads (one for each sample) were coupled and fixed to the vertical rods of the paralellometer by means of a matrix made of colorless acrylic resin. The rod of the device was fixed to the paralellometer until the final stage of the experiment, in order to maintain the same position and standardise the brushing of all the test specimens. Each test specimen was brushed 10 times after each cigarette, with the top part of the device sliding in to and fro movements, thereby allowing the bristles to come into contact with the sample. After this, the test specimen was washed in running water, and put back into its respective receptacle containing water, until the next time it was exposed to smoke.

After the action of 20 cigarettes and subsequent brushing, the final color was taken.
The color stability of the materials was determined by the
calculation of DE, using the following formula:

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

where DL* = L*f L*i, Da* = a*f a*i and Db* = b*f b*i; where L* i, a* i and b* i are referred to as the initial color.measurement and L*f, a*f and b*f as the final color measurement.Values of DE 3.3 were considered clinically unacceptable(5).

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In order to illustrate the effect of cigarette smoke, one specimen of each group was photographed before and after cigarette smoke exposure.

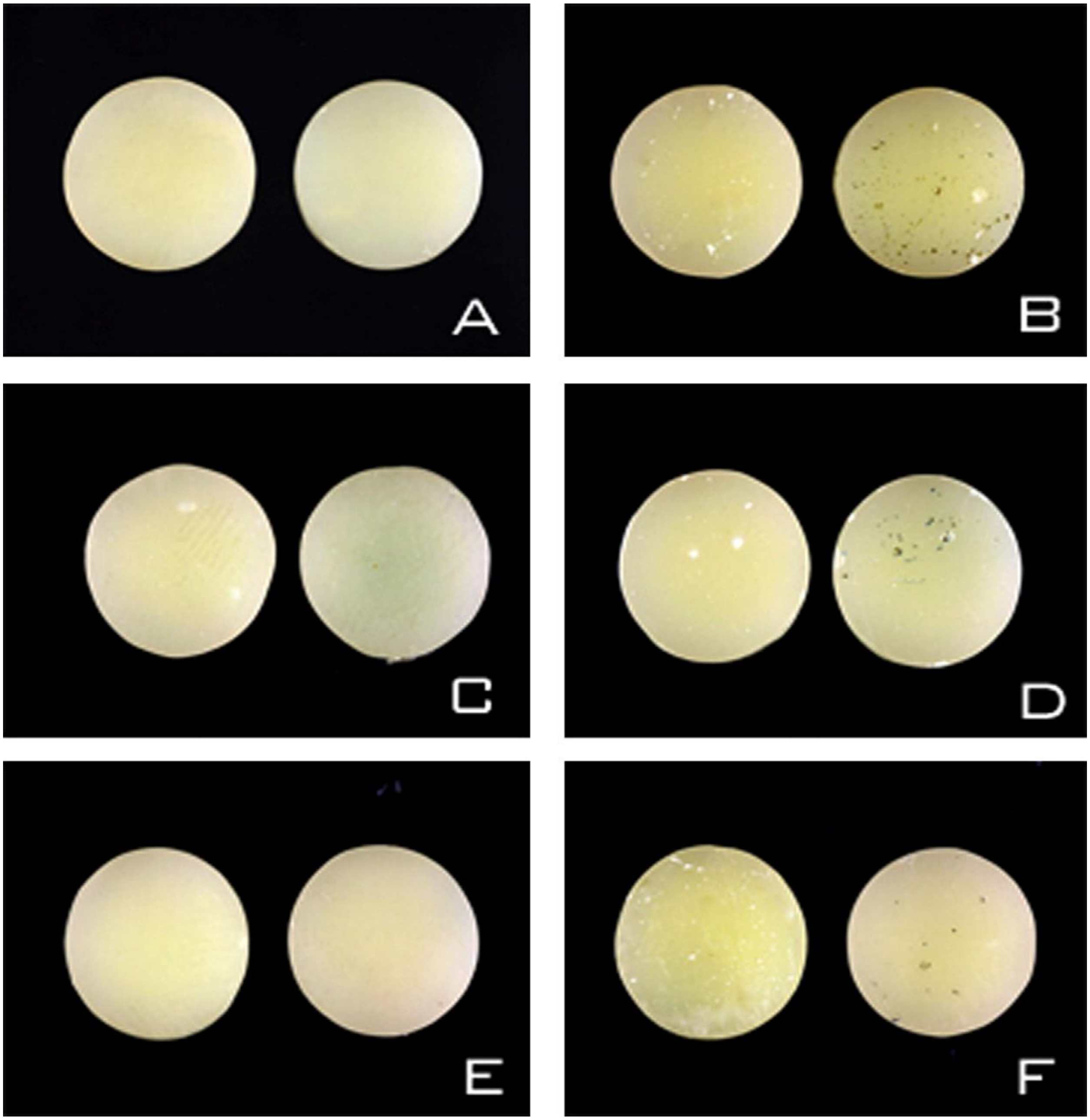

Fig. 3 – Specimens before and after cigarette smoke exposure. (A) Tetric N Ceram Polished with abrasive papers. (B) Tetric N Ceram Unpolished (polyester strip). (C) Filtek Z250 Polished with abrasive papers. (D) Filtek Z250 Unpolished (polyester strip). (E) Filtek P90 Polished with abrasive papers. (F) Filtek P90 Unpolished (polyester strip).

ISSN: 0975-3583, 0976-2833 || VOL 16, ISSUE 01, 2025

RESULTS:

3.1. Color stability

The results obtained for color change may be observed in Tables 2 and 3.

Table 2 – Means for DE values (2-way ANOVA, Bonferroni, p < 0.05).

Composite	Polished	Unpolished
Tetric N-Ceram	3.08 - 0.56^{aA}	3.39 - 0.63 ^{aA}
Z 250	1.87- 0.48 ^{aB}	2.11- 0.53 ^{aB}
P90	1.79- 0.44 ^{aB}	2.02-0.48 ^{aB}

Different uppercase letters in columns and lowercase letters in rows indicate statistically significant differences ($p < 0.05$)

As regards the DE values (Table 2), it was verified that all the groups presented change in color under the different experimental conditions, with the highest value being found for the composite Tetric N-Ceram, with statistically significant difference ($p < 0.05$) in comparison with the other materials, which showed statistical similarities between them ($p > 0.05$), at below critical levels (DE < 3.3). Tetric NCeram presented clinically acceptable color change levels (DE < 3.3) when the finishing used was abrasive paper, and clinically unacceptable conditions, (DE > 3.3) when the polyester strip was used.

As regards the analysis of DL (Table 3), a reduction was observed in the value of coordinate L* in all groups, under all experimental conditions, with statistically significant difference

($p < 0.05$) when the materials were compared, so that composite Tetric N-Ceram presented a greater change in DL than the other materials that were between them ($p > 0.05$). With regard to finishing procedures, a greater reduction in DL was verified when the polyester strip was used, with statistically significant results ($p < 0.05$) in comparison with the abrasive paper for the composite Tetric N-Ceram.

For the other materials, there was no significant difference ($p > 0.05$)

DISCUSSION: In this study, the effect of cigarette smoke on the color stability with different particles was analysed. It began with the hypothesis that cigarette smoke could produce a change in color irrespective of the finishing used on the sample. The study hypothesis could be partially accepted, because there was a change in color of the composites, however, finishing of the sample was the determinant factor for these alterations. It is known that color change may be caused by intrinsic factors such as chemical composition of the material, alteration in the matrix or in the matrix/load interphase [5,4]; and extrinsic factors related to dietary habits and sorption of coloring agents,[5] and it may also be related to the characteristics of the inorganic particles,[4,24]. There are not many studies in the literature that have standardised the manner of subjecting aesthetic restorative materials to cigarette smoke. Such studies have studied the effect of cigarette smoke without standardising the type of equipment used, number of cigarettes, smoke flow and time of the material exposure to the agent.[12,14–16,25]

In contrast to those previous studies, the design methodology of the present study was to use a small device with the capacity to receive one cigarette at a time, thereby allowing the cigarette smoke to pass over the test specimen in a standardised time interval and speed. This prevented the smoke from being dissipated into larger spaces, and avoid the influence of smoke simultaneously liberated by other cigarettes. After exposure to each cigarette, excessive deposits of smoke components adhered to the test specimen surfaces were observed, resulting in high color change values, which is not compatible with clinical reality, where the presence of saliva and tongue movements produce a certain form of cleaning of the teeth and restorations. Wasilewski et al.,16 reported very high DE (7.0–18.0) values and attributed these results to the sediments caused by the deposition of sugars and cocoa present in the composition of smoke. However, it was observed that in the composition of the cigarette there are various components also capable of causing this staining, such as coffee and tar, which is a viscous, black residue capable of becoming impregnated in the sample surface. With the aim of eliminating these superficial vestiges from the specimens after each cigarette smoked in a standardised manner, and considering that in a clinical situation, brushing forms part of patients' routine, the option was taken to use gentle brushing of the test specimens,because the influence of this association is also clinically relevant. The results obtained in the present study showed change in color under all experimental conditions. Cigarette smoke is composed of thousands of toxic substances such as carbon monoxide, carbon dioxide, nicotine, ammonia, nickel, arsenic and heavy metals.[26]

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In the present study, the DE values were clinically acceptable in the majority of groups (DE 3.3), justified by the brushing performed between one cigarette and another. This led to removal of the superficial alteration caused by the smoke, by means of light abrasion.
Tetric NCeram presented the highest DE values when compared with Filtek Z250 and Filtek P90. This change in color was also influenced by the surface finishing, considering that when the finishing was performed with abrasive paper, the color alteration levels were clinically acceptable (DE < 3.3); the same did not occur when the polyester strip was used, and clinically unacceptable conditions were presented (DE > 3.3).

Since it indicates the brightness of the samples, the position L * is crucial to the processing of the data. Because there are far more rods (cells) involved in black and white vision than cones (cells) involved in color vision, the human eye can detect changes in this axis more clearly than on the a* and b* axes. Consequently, color stability and clinical success depend critically on any loss of brightness.[27] All of the groups showed a decrease in the parameter L* in the axes analysis, indicating that smoke exposure darkened the samples and decreased luminosity. This is consistent with the in vitro study by Mathias et al.15, which discovered that cigarette smoke decreased the luminosity of resin composite specimens.
When comparing the materials, the current study also revealed significant differences in this coordinate. The composite Tetric N-Ceram showed a greater change in luminosity than the other composites, and this change was also greater when the polyester strip was used. Furthermore, the results were statistically significant ($p < 0.05$) when compared to abrasive paper finishing. Regarding finishing techniques, there were no appreciable differences for the other materials. ($p > 0.05$). The fact that samples submitted to finishing with polyester presented greater alteration than those that were polished with abrasive paper may be explained due to the greater homogeneity of the sample surface after polishing with abrasive papers, leaving it more regular (particularly with regard to distribution of the particles). Furthermore, the polyester strip produced a smoother surface in comparison with those after finishing and polishing procedures,[19] however, Shintani et al.,[28] demonstrated that light polymerisation under pressure, which may be exerted by the polyester strip, produced a superficial layer rich in organic matrix with a reduced quantity of load particles. Other studies [10,29] have also shown that smother composite surfaces are not necessarily more resistant to staining, as proved in this study. Thus, the surface would become unstable and could more easily absorb the pigments The composite Filtek P90, indicated for posterior restorations, presented lower color change values. This may be explained by the nature of the organic matrix in comparison with methacrylate-based composites. Furuse et al.,[30] evaluated the color stability and brightness of silorane and methacrylate- based composites submitted to accelerated artificial ageing. According to the authors the silorane-based composite presented the best behaviour and stability of brightness and color.
The silorane matrix has increased hydrophobicity due to the presence of siloxane, which provides the material with insolubility,[31] and results in a very low tendency to lead to exogenous

pigmentation. This fact has important clinical consequences, such as stability when under hydrolytic attack by water and saliva,[32] since the sorption of these elements may lead to greater degradation of the polymeric chain, and possibly to the reduction in the properties of the material.[33] The greater change in color of the composite Tetric NCeram, in comparison with the other composites cannot be justified by some change in particle size, as the composite Z250 (microhybrid) underwent less change in color than Tetric N-Ceram (nanohybrid); or even the differences in the organic matrix composition (Bis GMA, UDMA, Bis EMA), as they both present the same composition. The only component that differentiates these composites is the type of particle. Filtek Z250 has rounded zirconium and silicone particles, whereas, Tetric-Ceram barium glass particles and it has been suggested that composites with barium glass particles are more susceptible to water sorption.[34] Barium glass also allows less light refraction, resulting in a lower luminosity,[35] which could explain the results found for Tetric N-Ceram.[38] Because the polishing processes would remove the rich layer of superficial polymer matrix that this unpolished surface presents, it is often smoother than polished surfaces.[39] The lack of polishing was found to increase the ability of cigarettes to stain all composites except P90. The goal of the current in vitro study was to demonstrate how easily composites could be stained by cigarette smoke. This would help dentists choose the best material for smokers, ensuring that restorations would last longer and avoiding premature replacement for aesthetic reasons.

5. Clinical significance

For smoking patients, greater color stability of restorations may be possible with the right material selection and surface finishing techniques.

Conflict of interest statement

We wish to confirm that there are no known conflicts of interest and there has been no significant financial support for this work that could have influenced its outcome.

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