

# COLOR STABILITY OF A NANOFILLED RESIN: INFLUENCE OF POLISHING AND FINISHING AND FLUORIDE SOLUTIONS ACCORDING TO TIME

## ABSTRACT

**AIM:** The aim of the study was evaluate the finishing and polishing effect of the color stability of the composite resin Filtek Supreme XT, according to different fluoride solutions and time. **MATERIAL AND METHODS:** Specimens were prepared (n=140) with half of the samples finished and polished. The experimental groups were divided according to the presence or absence of finishing and polishing and immersion solutions (artificial saliva, sodium fluoride solution at 0.05% - manipulated, Fluordent Reach, Oral B, Fluorgard). The specimens remained in artificial saliva for 24 hours and were subjected to an initial color analysis using a spectrophotometer CIELab system. Then, they were immersed in the experimental solutions for 1 minute a day. The readings of the color change were made after 24 and 48 hours, 7, 14, 21, 30 and 60 days after the first immersion. The three-way mixed Analysis of Variance (ANOVA) ("finishing/polishing", "immersion medium" and "time") were performed. For multiple comparisons, the Sidak test for repeated measure was used, with a 5% level of significance. **RESULTS:** The finishing and polishing factor showed significant variability, independently of the immersion media ( $p<0.001$ ). **CONCLUSION:** Finishing and polishing procedures yielded better color stability to composite resin over time, regardless of the immersion media.

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## KEYWORDS

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## INTRODUCTION

Surface staining of composite resin restorations is related to intrinsic factors such as the material chemical composition, and extrinsic factors such as poor oral hygiene<sup>1</sup>, the routine use of fluoride mouthwash solutions, pigmented food intake<sup>1-4</sup> and the lack of finishing and polishing<sup>5-7</sup>.

Finishing and polishing procedures may influence the quality of the composite resin surface and they are effective ways to reduce the staining of the composites<sup>5-9</sup>. The probability of stain penetration into its resin matrix is lower in smoother and polished composite surface than in rough surfaces. High-quality finishing and polishing improve both the aesthetics and the longevity of composite restorations, whereas rough, poorly polished surfaces contribute to staining, plaque accumulation, gingival irritation, recurrent caries, and discoloration of the restoration<sup>10</sup>.

However, it is important to point out that children's dental treatment does not always permit implementing finishing and polishing procedures<sup>11</sup>. This inadequacy, associated to the patient's habits, such as poor oral hygiene and food with pigmented agents, in addition to the use mouthwash solutions, may affect the color stability of the anterior tooth restoration, one of the main reasons for replacing them<sup>12,13</sup>.

Regarding the mouthwash solutions, they can contain different percentages of alcohol and other ingredients such as detergents, emulsifiers, organic acids, dyes and solvents<sup>2</sup>, which can cause degradation and surface softening of the resin matrix, promote the wear of the material and change the color of composite resin<sup>14</sup>.

Therefore, the pediatric dentist should be apt to perform treatments that combine the preparation and maintenance of esthetic restorations, including the finishing and polishing procedures and the prevention of carious lesions of high-risk patients by establishing preventive methods, such as daily use of fluoride mouthwash.

The aim of this study is to evaluate the finishing and polishing effect and the different fluoride solutions on the color stability of a composite resin according to time.

## MATERIAL AND METHODS

This research consists of a double-blind experimental in vitro study. The dependent variable was the color stability and the independent variables were finishing/polishing, immersion medium and immersion time.

A nanofilled resin composite (Filtek Supreme XT, 3M ESPE, St. Paul, MN), shade B1E, was used in the preparation of the samples from a matrix of a two-part stainless steel, with four circular holes, 10 mm diameter

and 2 mm thick. A mylar matrix (K-Dent - Quimidrol, Com Ind. Importação Ltda, Joinville, SC, Brazil) and a glass plate were put on the surface of the composite resin. A 1kg stainless steel weight was applied for 30 seconds to drain the excess and leave the surface smooth and standardized<sup>15</sup>.

Afterward, the weight and plate glass were removed and light-polymerization was carried out for 40 seconds, using a halogen light curing light (XL 3000, 3M ESPE), with irradiance of 530mW/cm<sup>2</sup>, constantly monitored by a radiometer (Curing Radiometer Model 100, Demetron Research Corp., Danbury, CT, USA).

The number of samples used for 10 experimental condition was established at 14 (n=140). The samples prepared were randomly distributed in each experimental group.

Half of the sample was subjected to finishing/polishing procedures with aluminum oxide discs (Super-Snap, Shofu Dental Corp. Kyoto, Japan), 12 mm in diameter, in a decreasing granulation sequence, coupled to a counter-angle, at a low speed of 18,000 revolutions per minute. Each disk was used on the dampened surface for 15 seconds<sup>16</sup>.

For the finishing/polishing procedures, the samples were placed in a bipartite stainless steel matrix with height adjustment<sup>17</sup>, which prevented any contact of the finishing and polishing instruments with the matrix surface,

hence facilitating application.

During preparation, all the samples were marked in the back by the fitting of the two-part matrix, which served as a guide for the finishing/polishing procedures that were performed perpendicular to that marking<sup>7</sup>, with a standardized pressure of 2 kg.

Between one granulation and another, the samples were washed with air-water jets for 5 seconds, and at the end of the process were moved to the ultrasound (Ultrasonic Cleaner Plus 1440, Odontobrás - Doctors Trade in Eq - Dental Ltd., Ribeirão Preto, Sao Paulo, Brazil) containing water for 30 minutes, to remove possible debris deposited on the surface. The samples were immersed in artificial saliva and stored in a Bacteriological oven (EBC1-Odontobras - Comércio de Eq. Médicos-Odontológicos LTDA, Ribeirão Preto, SP, Brazil) and maintained at a temperature of  $37 \pm 1^{\circ}\text{C}$  for 24 hours.

In the staining process, the samples were immersed for a minute, daily, for 60 days, in different mediums: artificial saliva, 0.05% solution of sodium fluoride - manipulated, Fluordent Reach, Oral B and Fluoragard (Table 1). After immersion, the specimens were rinsed in running water, remaining in artificial saliva at  $37 \pm 1^{\circ}\text{C}$ .

For the artificial saliva group, the samples were kept at  $37 \pm 1^{\circ}\text{C}$ , with daily changes of the artificial saliva.

The staining procedures, for the different experimental groups, were repeated for 60 days.

Table 1. Tested Solutions.

Solution (Brand)	Composition	pH	Manufacturer	Lot
Artificial Saliva	KH <sub>2</sub> PO <sub>4</sub> , K <sub>2</sub> HPO <sub>4</sub> , KCl, NaCl, MgCl <sub>2</sub> .6H <sub>2</sub> O, CaCl <sub>2</sub> .2H <sub>2</sub> O, NaF, Sorbitol, Nipagin, Nipasol, Carboxymethyl Cellulose (CMC), Water.	7.0	Laboratory of Biochemistry of FCFRP-USP.	—
Manipulated sodium fluoride solution	0.05% of Sodium Fluoride solution	5.36	Santa Paula Pharmacy	—
Fluordent Reach	Water, Glycerin, Alcohol, Poloxamer 407, Methylparaben, Mint Flavor, Na <sub>2</sub> HPO <sub>4</sub> , Sucralose, NaH <sub>2</sub> PO <sub>4</sub> , Cetylpyridinium Chloride, 0,05% Sodium Fluoride (226ppm of fluoride), Propylparaben, Yellow Pigment, FD&C Blue n°. 1	6.96	Johnson & Johnson	1187B04
Fluorgard	Water, Sorbitol, Polysorbate 20, Potassium Sorbate, Sodium Biphosphate, Phosphoric Acid, 0,05% sodium Fluoride (226ppm of fluoride), Red Pigment, Flavor	4.13	Colgate	BR122A
Oral B	Water, Glycerin, PEG-40 Hydrogenated Castor Oil, Methylparaben, Flavor, 0,053% Monohydrated Cetylpyridinium Chloride, 0,05% Sodium Fluoride (226ppm of fluoride), Sodium Saccharin, Sodium Benzoate, Propylparaben, FD&C Blue n°. 1	5.41	Gillette	70338525 12

The color-change readings were made by Colorimetry Spectrophotometer (Color guide 45/0, PCB 6807 BYK-Gardner GmbH Geretsried Germany), with the variable wavelength ranging from 400nm to 700nm, by means of direct transmission, with standard lighting D65 on a white background<sup>16,18,19</sup>, by a properly calibrated tracer ( $\rho_L = 0.90$ ;  $\rho_a = 0.75$ ;  $\rho_b = 0.95$ ).

After 24 hours of immersion in artificial saliva, the color measure of the samples (baseline) was performed. The subsequent color change readings were performed after 24 and 48 hours, 7, 14, 21, 30 and 60 days from the start of immersion.

The mean color ( $\Delta E$ ) of each group was calculated for the samples with and without finishing and polishing according to the

immersion solution and at different times. The color change value  $\Delta E^*$  was calculated according to the following formula<sup>20</sup>:

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

The normality and homoscedasticity preconditions were met. The sphericity was tested by Mauchly test and it was not assumed, so the correction factor Greenhouse-Geisser Épsilon was used. The three-way mixed Analysis of Variance (ANOVA) ("finishing/polishing", "immersion medium" and "time") were performed. For multiple comparisons, the Sidak test for repeated measure was used, with a 5% level of significance.

## RESULTS

The mean and standard deviation for color change ( $\Delta E$ ) according to time, finishing/polishing and immersion media are shown in Table 2.

On table 3 there is a summary of analysis of variances considering the repeated measures (time).

It can be verified the influence of time and finishing/polishing on color change.

On Figure 1 it can be observed the interaction of time and finishing/polishing (Sidak Post-Test).

It can be observed statistical difference on  $\Delta E$  between the different times only for the group without finishing and polishing.

On Table 4 there is the summary of analysis of variances considering the independent measures (Finishing/polishing and immersion media).

It can be verified the effect statistically significant of finishing/polishing on color change.

## DISCUSSION

Finishing and polishing are an essential procedure for obtaining an aesthetically acceptable restoration. The present study observed the influence of finishing/polishing with aluminum oxide discs on color stability of the Filtek Supreme XT composite resin, subjected to several immersion media. It was found that generally all groups that received this type of surface treatment showed lower color change values ( $\Delta E$ ) than those that did not receive finishing/polishing, independent of the immersion media they were exposed to (Table 2). Considering the time factor as repeated measure, the time associated with finishing/polishing, it can be verified difference statistically significant ( $p < 0.001$ ).

Analysing the independent factors, only finishing/polishing showed difference statistically significant on color stability values ( $p < 0.001$ ). Thus, the results showed the importance of the finishing and polishing procedure for the color stability of the studied resin composite.

Table 2. Mean and standard deviation for color change ( $\Delta E$ ) according to time, finishing/polishing and immersion media.

Color Change ( $\Delta E$ )		24 hs		48 hs		7 days		14 days		21 days		30 days		60 days		
Immersion media	Finishing/Polishing		Finishing/Polishing		Finishing/Polishing		Finishing/Polishing		Finishing/Polishing		Finishing/Polishing		Finishing/Polishing		Finishing/Polishing	
	with	without	with	without	with	without	with	without	with	without	with	without	with	without		
Artificial Saliva Manipulated	1,11±0,37	1,78±1,47	1,51±1,46	1,97±1,42	1,01±0,37	2,28±2,27	1,19±0,46	2,12±1,52	1,39±0,60	2,24±1,57	1,16±0,37	2,50±2,15	1,47±0,49	2,63±1,44		
Fluoride	1,12±0,36	1,74±1,48	1,11±0,47	1,44±0,52	0,99±0,34	1,48±0,44	1,48±1,46	1,99±0,88	1,15±0,44	2,13±0,75	1,68±1,88	1,85±0,68	1,32±0,46	2,12±0,95		
Oral B Fluorident	1,17±0,40	1,46±0,26	1,10±0,39	1,56±0,39	1,06±0,34	1,67±0,49	1,06±0,36	1,94±0,94	1,20±0,45	2,12±0,42	1,30±0,40	1,82±0,71	1,24±0,38	1,94±0,62		
Reach	1,13±0,34	1,22±0,23	1,14±0,37	1,44±0,34	1,92±2,50	1,40±0,27	1,07±0,52	2,26±1,41	1,11±0,35	2,51±1,04	2,05±2,27	2,58±1,16	1,10±0,54	3,46±2,85		
Fluogard	1,66±1,04	1,57±0,98	1,50±0,77	1,53±0,81	1,40±0,63	1,50±0,81	1,33±0,71	1,92±0,92	1,47±0,55	2,04±0,89	2,00±1,42	2,21±1,63	1,86±0,65	2,34±1,23		

Table 3. Summary of analysis of variances considering the repeated measures (time).

Source	SS	df	MS	F	p	$\eta_p^2$	power
Time	43,554	4,170	10,444	10,319	<0,001	0,074	1,000
Time*Finishing/Polishing	21,388	4,170	5,129	5,067	<0,001	0,038	0,970
Time*Immersion Media	18,567	16,680	1,113	1,100	0,350	0,033	0,752
Time*Finishing/Polishing*Immersion Media	29,908	16,680	1,793	1,771	0,030	0,052	0,950
Error	548,699	542,110	1,012				

Figure 1. Interaction of time and finishing/polishing- FP (Sidak Post-Test).

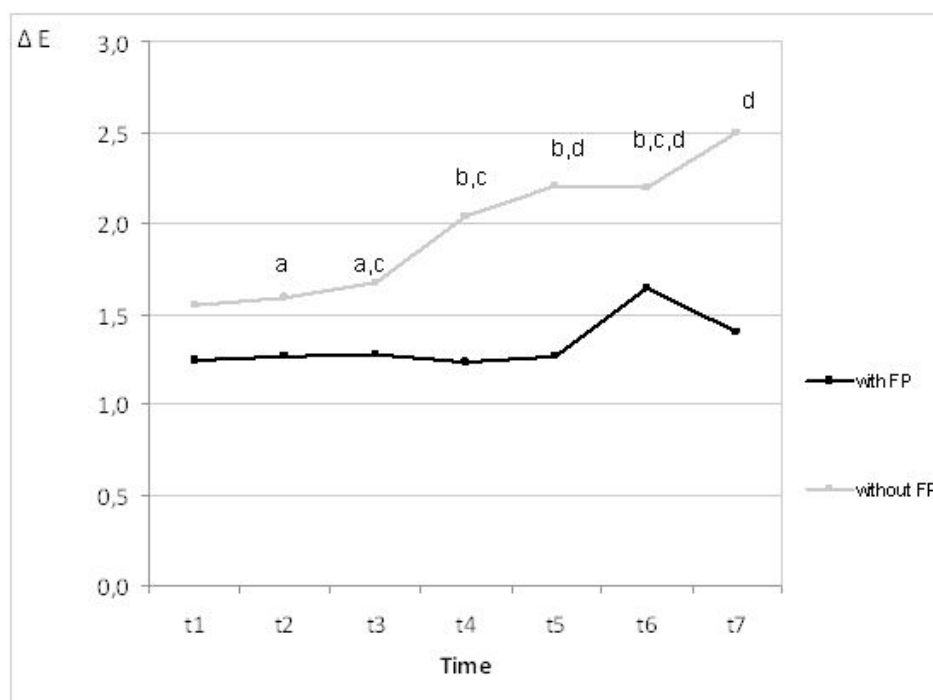


Table 4. Summary of analysis of variances considering the independent measures (Finishing/polishing and immersion media).

Source	SS	df	MS	F	p	$\eta_p^2$	power
Intercept	2658,357	1	2658,357	740,157	<0,001	0,851	1,000
Finishing/Polishing	98,112	1	98,112	27,317	<0,001	0,174	0,999
Immersion Media	13,064	4	3,266	0,909	0,461	0,027	0,283
Finishing/Polishing *Immersion Media	12,639	4	3,160	0,880	0,478	0,026	0,274
Error	466,910	130	3,592				

When the composite resins are polymerized in air, they exhibit a superficial layer whose polymerization is inhibited by oxygen. The use of the mylar matrix in the polymerization process results not only in a smoother surface, but also eliminates the non-polymerized layer of resin<sup>12</sup>. However, the area below the mylar matrix appears to have a lower degree of polymerization than the rest of the restoration, which increases its susceptibility to color change<sup>5,21</sup>. According to Anfe et al. (2011)<sup>22</sup>, composites with a low degree of conversion tend to present higher discoloration.

Moreover, when the polymerization occurs using a mylar matrix, it results in a surface layer rich in resin matrix<sup>2</sup>. Depending on resin composition, the mylar matrix can increase the staining susceptibility, especially if the composite resin has great quantity of TEGDMA mixed with the Bis-GMA<sup>23</sup>. In this work, the resin composite studied was the Filtek Supreme XT (3M/ESPE), which is a nanofilled resin composite that contains 20nm particles of primary silica and silica/zirconia nanoclusters with size ranging from 0.6µm to 1.4µm and a resin matrix composed of BisGMA, BisEMA, UDMA, and TEGDMA<sup>18,24</sup>. Those properties of the material, seems to have conferred the greatest color change to the groups that did not receive finishing/polishing procedure. It occurs because the finishing and polishing process have a key role in the

reduction of color change susceptibility of the composite resin, removing the most superficial layer, rich in organic matrix. which is more vulnerable to abrasion and wear, making it more resistant to degradation by extrinsic factors<sup>10,25</sup>. Color change results similar to this study on the use of the mylar matrix were observed by Patel, et al.<sup>12</sup> (2004) and Shintani et al.<sup>26</sup> (1985). However, Bagheri et al.<sup>18</sup> (2005) did not observe a statistically significant difference with regard to the staining of the samples that did not receive surface treatment (mylar matrix) and those that received finishing and polishing with different types of materials.

On the other hand, Ferracane et al.<sup>27</sup> (1992), Nagem Filho et al.<sup>28</sup> (2003) and Turssi et al.<sup>29</sup> (2005) reported a contrary behavior to that observed in this study, with regard to the finishing and polishing procedures, emphasizing that this procedure allows the protuberance of particulates and cracks in the resin load-matrix union, facilitating the phenomena of surface degradation and discoloration.

In addition to the finishing and polishing procedures, another factor that should be considered is the influence of time on color stability of composite resin. In this study can be observed that the time had influence on color stability of samples without finishing/polishing independently of the immersion media studied ( $p < 0.001$ ). The

influence of time on the color stability of restorative materials subjected to several means of immersion as mouthwash, alcoholic beverages, coffee, tea and soda was also observed in some studies in the literature<sup>2,30</sup>.

Other factor considered in this study was the fluoride solution, which did not influence the color stability of resin studied ( $p = 0.461$ ), although the tested solution had different compositions and pHs. Catirse et al.<sup>31</sup> (2000), upon studying the effect of the same solutions used in this study on the translucency of the conventional ionomer glass cements, also did not observe statistical difference between them. On the other hand, Garcia et al.<sup>2</sup> (2002), upon investigating the influence of these solutions on the translucency of glass ionomer cements modified by resin, found that they promoted a translucency change, with Fluorgard responsible for the most considerable change.

The use of sodium fluoride solutions for daily rinses may exacerbate the external discoloration of the aesthetic restorative materials due to its chemical composition<sup>2</sup>.

Alcohol is usually added to the composition of mouthwash solutions, in addition to other ingredients such as detergents, emulsifiers, organic acids, dyes and solvents<sup>5</sup>. Given that mouthwash solutions are routinely used by patients, the dentists have a responsibility to determine where the chemical components of each solution may

affect the restorative materials commonly used in dental practice<sup>14</sup>. Thus, the professionals should be alert when indicating mouthwash solutions aiming to preventing interferences on the longevity of restorations.

Although color change statistically significance was observed for the groups studied without finishing and polishing, it was not clinically significant in the studied period (60 days), since  $\Delta E$  values less than 3.7 are considered clinically acceptable because they are not obvious to the human eye<sup>14,16</sup>. This fact shows us that for children patients with restorations made with the composite resin Filtek Supreme XT without finishing and polishing procedures, the prescription of any fluoride solutions would be possible, allowing for the remineralisation of dental structures, very important in the prevention of dental lesions and dental caries in Pediatric Dentistry, without much interference in their optical properties.

This in vitro study provided information on the color stability behavior of a composite resin subjected to various fluoride solutions and finishing and polishing procedures over time. With the obtained results, we intend to contribute to the professionals working with preventive and esthetics dentistry in order to alert them about the use of routine fluoride mouthwashes and its interference with the optical properties of restorative materials, as well as the importance of implementing



finishing and polishing procedures for the success and longevity of restoration.

### CONCLUSION

Finishing and polishing procedures yielded better color stability to composite resin over time, regardless of the immersion media.

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