EFFECT OF DIFFERENT POLISHING PROCEDURES ON COLOR STABILITY OF NANOCOMPOSITES IN DIFFERENT MOUTH RINSES

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Abstract

The aim of this in vitro study was to evaluate the effect of two polishing procedures on color stability of nanocomposites immersed in three mouth rinses.

One hundred twenty disc-shaped specimens (10x2mm) of nanocomposite Filtek™ Z350 XT, shade A3, were prepared. Specimens were distributed into 3 groups of 40 discs each: Group 1) Filtek™ Supreme XTE without polishing; group 2) Filtek™ Supreme XTE + Sof-Lex™ pop-on discs and group 3) Filtek™ Supreme XTE + PoGo® polishers. Initial color values were evaluated using the CIELAB scale. The discs in each group were randomly divided into 4 subgroups (n=10). Each subgroup was immersed in 20ml of mouth rinse for 12 hours, then removed and submerged in deionized water. Color values were remeasured.

The results didn't show any statistical significant difference between polished and unpolished samples whether immersed in artificial saliva or in Listerine®. For the specimens immersed in Cool Mint® Listerine® or in Enziclore, a statistically significant difference was observed between polished and unpolished specimens ($p < 0.05$).

Samples polished with Sof-Lex™ discs showed lower color alteration than samples polished with PoGo® polishers. Cool Mint® Listerine® (alcohol containing-mouthwash) and Enziclore (chlorhexidine-containing mouthwash) showed the highest value of discoloration but these differences were not visually perceptible.

Keywords: Nanocomposite - Sof-Lex™ discs - PoGo® polishers - color stability - mouth rinse - polishing techniques.

Résumé

Le but de cette étude *in vitro* était d'évaluer l'effet de deux techniques de polissage sur la stabilité de la couleur du nanocomposite immergé dans trois bains de bouche différents.

Cent vingt disques (10x2mm) de nanocomposite « Filtek XT™ Z350 », de teinte A3, ont été préparés. Les échantillons ont été répartis en 3 groupes de 40 disques chacun: groupe 1) « Filtek™ Supreme XTE » sans polissage; groupe 2) « Filtek™ Supreme XTE » + polissage à l'aide de disques « Sof-Lex™ » et groupe 3) « Filtek™ Supreme XTE » + polissage à l'aide des cupules « PoGo® ». Les premières valeurs de couleur ont été évaluées en utilisant l'échelle CIELAB. Les disques ont été maintenus à 37 °C tout au long de l'étude. Les disques de chaque groupe ont été divisés au hasard en 4 sous-groupes (n = 10). Chaque sous-groupe a été immergé dans 20 ml de bain de bouche pendant 12 heures, puis retiré et immergé dans de l'eau déminéralisée. Les valeurs de couleur ont été réévaluées.

Les résultats n'ont pas montré de différence statistiquement significative entre les échantillons polis et non polis immergés dans la salive artificielle ou dans la « Listérine® ». Pour les échantillons immergés dans du « Cool Mint® Listerine® » ou dans « Enziclore », une différence statistiquement significative a été observée entre les échantillons polis et non polis ($p < 0.05$). Une faible altération de la couleur a été observée dans les échantillons polis avec les disques « Sof-Lex™ » comparés à ceux polis avec les disques « PoGo® ». Des altérations de la teinte ont été observées avec le « Cool Mint® Listerine® » (contenant de l'alcool) et « l'Enziclore » (contenant de la chlorhexidine), mais ces différences ne sont pas visuellement perceptibles.

Mots-clés : résine composite – bain de bouche – polissage.

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Introduction

Color stability is the ability of any material to maintain its original color [1]. Tooth-colored restorations using resin composites have been extensively used in comparison with other material even for posterior teeth with great success [2]. Resin composite is the material of choice because of its excellent strength, adequate initial esthetics and adhesion to tooth structure [3]. However, discoloration can occur by three ways [4]:

-Extrinsic discoloration due to biofilm accumulation on the restoration surface.

-Intrinsic discoloration due to physic-chemical reactions inside the body of the restoration.

-Surface or subsurface changes with slight penetration and reaction of dye agents on the superficial layer of composite resin.

Furthermore, hydrophilic resins are more prone to dye penetration and staining than hydrophobic ones [4]. The low staining susceptibility may be related to a low water sorption rate of hydrophobic resins.

Proper finishing and polishing are important steps in clinical restorative dentistry that enhance both esthetics and longevity of restorations [5]. Residual surface roughness may result in excessive plaque accumulation, gingival inflammation and increased surface staining [6]. Additionally, it might directly influence the wear behavior and marginal integrity of posterior composite resin restorations [7, 8].

Finishing is required to remove excess material and to adjust the occlusion. The final polishing reduces the remaining roughness [9] and eliminates the superficial resin layer which comes in contact with oxygen and does not polymerize. This resin layer has a direct effect on the staining ability of composite resin [10].

Mouth rinses are primarily used for controlling the progression of caries and periodontal diseases. These extrinsic factors can cause discoloration of resin composite [10, 11]. Previous studies have reported the effect of alcohol-containing, chlorhexidine gluconate-containing, and hybrid mouthwashes on the color stability of glass ionomers, compomers, and microhybrid resin-based composites [12, 13].

The aim of this *in vitro* study was to compare the effect of two polishing techniques on color stability of nanocomposites immersed in three commercially available mouth rinses.

The hypotheses tested in the study were:

1-The daily use of alcohol- or chlorhexidine-containing mouth rinses affects color stability of resin composite more than alcohol- and chlorhexidine-free mouth rinses.

2-A multistep polishing technique is better than a single-step polishing technique for color stability of nanocomposites.

Materials and Methods

One hundred twenty disc-shaped specimens (10x2mm) of nanocomposite Filtek™ Z350 XT (3M/ESPE, USA), shade A3, were prepared. The discs had smooth texture with no visible surface voids or bubbles. The materials used in the study are listed in the table 1.

Specimens were distributed into 3 groups of 40 discs each: Group 1) Filtek™ Supreme XTE without polishing; group 2) Filtek™ Supreme XTE + Sof-Lex™ pop-on discs and group 3) Filtek™ Supreme XTE + PoGo® (Dentsply) polishers.

Initial color values were evaluated using the CIELAB scale.

Three different mouth rinses were used (Table 2):

1-Listerine®.

2-Cool Mint® Listerine®.

3-Enziclore.

Discs preparation

A glass slide and polyethylene sheet were placed under the mold. Unset pastes were placed in the polytetrafluoroethylene (Teflon) mold (10x2.5mm). After filling the mold, a second polyethylene sheet and glass slides were placed over the filled mold and light pressure was applied. This method provided specimens with smooth surface. Unset material was cured with LED curing lamp Mectron, Italy (1.000mw/cm2) for 40 seconds on each side. The distance between the light and the specimen was standardized by using a 1mm glass slide.

Polishing techniques

In the group 1, after curing, the specimens were not submitted to any kind of finishing or polishing procedure (Table 3).

In group 2, specimens were polished with aluminum oxide- impregnated Sof-Lex™ discs at a low speed with light pressure for 20 seconds each, as recommended by manufacturer. Specimens were washed with water, air dried and then polished with another lower grit disc for the same period of time.

In group 3, specimens were polished with PoGo® polishing system at a low speed with light pressure for 30 seconds each, as recommended by the manufacturer.

After polishing, specimens were stored in artificial saliva in an incubator at 37° C for 24 hours.

Color evaluation

Baseline color measurements were performed with a spectrophotometer (Data color; SF 600; Plus-CT; USA) using CIE L*a*b*(Comission International l´Eclairage) system. The analyzed color parameters were the values for L*, a* and b*, where L* is the luminosity, a* represents the color variation between green-red and b* represents the color variation between blue-yellow.

The spectrophotometer was calibrated before each color analysis session of specimens in accordance with manufacturer's instruction.

For color analysis, each specimen was placed inside the central orifice of the white, opaque Teflon matrix. A mortise device was placed on the white Teflon,

Material	Manufacturer	Composition
Filtek™ Z350 XT (A3)	3M ESPE, St Paul, MN, USA	Matrix: Bis-GMA, UDMA, Bis-EMA, TEGDMA Filler: zirconia/silica Nanofillers of silicon (5–75 nm), zircon/silicon nanoclusters (0.6–1.4 μm) nanofiller 78.5% wt, 59.5% vol
Sof-Lex™ discs	3M ESPE St. Paul,MN, USA	Al2O3 flexible discs
PoGo® polishers	Dentsply Caulk, Milford, DE, USA	Cured composite of urethane dimethacrylate, fine diamond powder, silicon dioxide 7 μm, Al2O3

Table 1: Characteristics of the materials used in the study.

Mouth rinses	Manufacturer	Chemical composition	Ph
Listerine®	Johnson & Johnson	Eucalyptol, menthol, methyl salicyclate, thymol	5.0
Cool Mint® Listerine®	Johnson & Johnson	Water, alcohol, sorbitol, propyl alcohol, poloxamer 407, benzoic acid, sodium saccharine, eucalyptol, flavour, thymol, methyle salicyclate, menthol, sodium benzoate	3.7
Enziclore	Platinium pharmaceuticals	Benzydamine hydrochloride,chlorhexadine gluconate	5.8

Table 2: Mouth rinses used in the study.

which was positioned over the specimen to standardize the contact of the tip from the spectrophotometer to the specimen surface at a 90° angle.

Forty specimens of each group were randomly divided into 4 subgroups (n=10). Details of subgroups are given in table 4. Subgroups G1, G5, G9 were stored in artificial saliva; other subgroups were immersed in 20 ml of respective mouth rinses for 12 hours (Table 4), equivalent to the use mouthwashes twice per day for 1 year [14]. Specimens were kept at 37°C throughout the study, and mouth rinses were shaken every hour to provide homogeneity. After 12 hours, the specimens were removed, submerged in deionized water and color values were remeasured. The total color variation is ΔE. It was calculated according to the following equation:

ΔE*ab = [(ΔL*)2 + (Δa*)2+ (Δb*)2]1/2

Statistical analysis

The statistical analysis was performed using a software program (SPSS for Windows, version 16.0, Chicago, IL, USA). The alpha error was set at 0.05.

Kruskal-Wallis test and Tukey's honest significance test for multiple comparisons were conducted to explore significant changes in color (ΔE) among the groups.

Results

No statistically significant differences were found between polished (G5, G9), (G6, G10) and unpolished (G1, G2) subgroups immersed in artificial saliva and Listerine®, respectively. After immersion, there was no color alteration. Furthermore, no significant difference was observed between both polishing procedures ($p>0.05$) as shown in table 5.

In cool Mint® Listerine®, a statistically significance difference was found between polished (G7, G11) and unpolished (G3) subgroups ($p \leq 0.05$). Unpolished subgroup (G3) displayed color changes after immersion whereas in polished subgroups (G7, G11) the color was stable.

In Enziclore mouthwash, all samples showed color changes after immersion and a statistically significant difference was found among unpolished (G4) and both polished subgroups (G8, G12). The subgroup polished with Sof-Lex™ discs showed lower color alteration compared to subgroup polished with PoGo® polishers. Furthermore, unpolished subgroups (G4) showed the highest degree of color alteration.

Discussion

The present study evaluated the effect of two different polishing techniques on the color stability of nanocomposite specimens immersed in three commercially available mouth rinses.

The effectiveness of surface finishing and polishing techniques is of fundamental importance for any restoration [15]. These procedures are commonly required after placement of direct composite resin-based restorations since they minimize the retention of plaque and stains and other problems resul-

Groups	N	Polishing procedures
1	40	Mylar® strip (polyester matrix)
2	40	Sof-Lex™ pop-on discs (coarse, medium, fine, extra fine)
3	40	PoGo®

Table 3: Groups distribution according to polishing procedures.

Polishing techniques	Immersion medium			
	Artificial saliva	Listerine®	Cool Mint® Listerine®	Enziclore
Mylar® strip	G_1	G_2	G_3	G_4
Sof-Lex™ pop-on discs	G_5	G_6	G_7	G_8
PoGo® polishers	G_9	G_{10}	G_{11}	G_{12}

Table 4: Characteristics of the subgroups.

Polishing procedures	Immersion medium	Mean ± SD
Mylar strip (polyester matrix)	Artificial saliva	1.161±0.195
	Listerine®	1.124±0.181
	Cool Mint® Listerine®	1.918±0.091
	Enziclore	2.387±0.395
Sof-Lex™ pop-on discs	Artificial saliva	1.124±0.181
	Listerine®	1.124±0.181
	Cool Mint® Listerine®	1.113±0.216
	Enziclore	1.124±0.181
PoGo® polishing disc	Artificial saliva	1.124±0.181
	Listerine®	1.124±0.181
	Cool Mint® Listerine®	1.113±0.216
	Enziclore	2.236±0.272

Table 5: Means of color change values observed for the different groups.

ting from the exposure of rough surfaces to the oral environment.

Surface roughness is the major contributor for extrinsic discoloration of resin composite restorations. This property is closely related to the organic matrix, inorganic filler composition of the composites in addition to the finishing and polishing techniques.
In our study, unpolished sample surfaces were smoothen against the polyester matrix; they appeared more polished because these surfaces are rich in organic polymer matrix. They tend to absorb more water and become more prone to staining [16 - 18].
The single-step PoGo® system was applied with no surface pretreatment. The corresponding specimens displayed more color changes in comparison with samples polished with Sof-Lex™ discs. Similar results were obtained by Yap et al. [13]. These authors stated that higher surface roughness values were obtained with PoGo® polishers in comparison with the Sof-Lex™ discs and that rough surfaces were more prone to staining [4].
In the multiple-step technique, polishing points or burs are used in sequential order of decreasing abrasiveness, favoring the final surface texture. This scenario does not occur with the one-step technique [1, 14].
The effect of staining solutions on color changes of composite resin-based may be material-dependent, and the staining susceptibility of a restorative material may be attributed to its resin matrix or filler type.
Asmussen [19] reported that mouth rinses with high alcohol content might soften the composite resin material.

Ethanol has a softening effect on BIS-GMA based polymers. Gürgan et al. [14] showed that irrespective of alcohol concentration, both alcohol-containing and alcohol-free mouth rinses could affect the hardness of resin-restorative materials. Our study showed statistically significant differences in color change values among alcohol-free, alcohol-containing, chlorhexidine-containing mouth rinses and artificial saliva. The color changes were mostly observed in samples immersed in the alcohol- and the chlorhexidine-containing mouth rinses.
Villalta et al. [20] have shown that low pH and alcohol concentration of solutions might affect the surface integrity of composite resins and cause staining. In the present study, there was a statistically significant difference regarding color change values between the alcohol-free mouth rinse, i.e. Listerine® and distilled water and alcohol-containing and chlorhexidine-containing mouth rinses (Cool Mint® Listerine® and Enziclore), but this difference was not visually perceptible.

Color stability of a material can be evaluated by various methods. It involves subjecting the specimens to a colorant and evaluating the change in color over a period of time. The evaluation of color can be done either by visual assessment or by instrumental methods.
Variability of the results by visual assessment can arise due to several factors including the observed object, illuminant position relative to the observer and to each other, color characteristics of the illuminant, metamerism, fatigue, aging and emotional state of the observer [21]. Since instrument measurements can eliminate subjective interpretation of visual color comparison, spectrophotometers and colorimeters are more widely used today. These instruments use the CIE L*a*b* (CIELAB) color system, which was developed in 1978 by the "Commision Internationale de L'Eclairage" for characterizing color for human perception.
The CIE L*a*b* (CIELAB) color space is a uniform three dimensional color order system. The color difference ΔE represents the relative color changes that are observed for the materials after treatment or between time periods. Um and Ruyter [22] suggested that a perceptible discoloration must be referred to as acceptable up to a value .E=3.3 while Gulern [23] stated that a value of 3.7 should be considered as visually perceptible. The color change observed in our study was not visually perceivable since the obtained ΔE*ab was 3.3.

Conclusion

Understanding the property of color stability and the comparative analysis of various restorative materials will help a clinician to choose the materials as per the diet.
Within the limitations of the study, we can conclude that:

- Nanocomposites multistep polishing procedures with Sof-Lex™ discs promoted greater staining resistance than single-step polishing technique with PoGo® polishers.
- Cool Mint® Listerine® (alcohol-containing) and Enziclore (chlorhexidine-containing) mouth rinses showed the highest value of discoloration as compared to Listerine® (non-alcohol-containing mouth rinse) and artificial saliva. However, these differences were not visually perceptible.

Furthermore, future *in vivo* studies should consider longer periods of immersion to determine the effect of the two different polishing procedures on staining potential of nanocomposites when using different types of mouth rinses.

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