Effect of Whitening Dentifrices on the Surface Roughness of Commercial Composites

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ABSTRACT

Purpose: Our study aimed to test the null hypothesis that whitening and non-whitening dentifrices affect similarly the surface roughness of commercial microhybrid composites, independent of the brushing time.

Materials and Methods: One hundred and ninety-two disc-shaped specimens of Filtek Z250 (3 M/ESPE, St. Paul, MN, USA) and Rok (SDI, Australia) were built up and randomly assigned to 24 groups, based on the dentifrices used (two whitening dentifrices: Colgate Max White—Colgate-Palmolive, São Bernardo do Campo, São Paulo, Brazil and Close Up Extra Whitening—Unilever, Brasil Higiene Pessoal e Limpeza Ltda, Ipojuca, Pernambuco, Brazil; and one non-whitening dentifrice: Colgate Total 12 Clean Mint—Colgate-Palmolive), and on the simulated brushing times (24 hours, 6, 12 and 24 months). The specimens were submitted to the toothbrushing regimens after which the surface roughness (Ra) was measured. Data was submitted to analysis of variance and Tukey test ($\alpha = 0.05$).

Results: The composite's surface roughness was significantly affected by the composites ($p = 0.0007$), the dentifrices ($p = 0.0001$), and the simulated brushing time ($p = 0.0001$). Higher roughness was observed when the whitening dentifrices were used and when the brushing time increased. Filtek Z250 was more affected than Rok, especially after 24 months of simulated brushing.

Conclusion: Whitening dentifrices produced higher surface roughness in the composites tested. The degree of surface compromising increased with brushing time and depends on the composite's microstructure and composition.

CLINICAL SIGNIFICANCE

Whitening dentifrices might produce rough surfaces in composite restorations, accelerating their degradation and causing biofilm retention.

(J Esthet Restor Dent 23:338–346, 2011)

INTRODUCTION

One of the main goals of dentistry is the control of infectious diseases, namely caries and periodontal disease, in both, individual and collective levels. For that goal to be successfully achieved, one might be able to cognitively interact with the patient, empowering him/her for dental hygiene actions. Dental hygiene by means of toothbrushing and flossing aims to disorganize the biofilm responsible for the disease.

In this sense, the use of dentifrices is key for the maintenance of the oral health. Fluoride dentifrices have been extensively shown to collaborate in caries

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 DOI 10.1111/j.1708-8240.2011.00426.x

reduction rates,[1] whereas dentifrices containing triclosan/copolymer help to prevent gingivitis and periodontitis.[2] Other therapeutic agents such as pyrophosphates and zinc citrate help to control tartar formation, and hypersensitivity might be controlled by dentifrices containing potassium nitrate.[3]

Along the last decade, dentifrices also became a means of whitening teeth, responding to the strong esthetic appeal worldwide. Whitening dentifrices are over-the-counter bleaching products, conceived for at-home tooth bleaching, with no dentist supervision.[4] Unlike the bleaching gels for home use, these dentifrices do not contain carbamide or hydroxide peroxide. Their bleaching mechanism is based on superficial stain removal by abrasives and on enzymatic breaking down of organic molecules present in the biofilm,[3,5,6] with no evidence of whitening internal discolorations.[6]

Abrasives present in dentifrices are inorganic particles that help disorganizing the biofilm over the tooth surface, removing stains and microorganisms. The most commonly used abrasives are silica and calcium carbonate. Abrasiveness is also the main mechanism of whitening dentifrices. Though, increasing abrasiveness might cause damage to hard and soft tissues, and also affect the surface polish of restorations.[7] The Council on Scientific Affairs of the American Dental Association (ADA) takes into account the degradation and the changes in hardness of enamel and dentin, as well as changes in the surface of dental materials as safety measures to release the ADA Acceptance Seal to whitening dentifrices.[3]

Dozens of dentifrices are commercially available in pharmacies and supermarkets, claiming to whiten teeth. On the other hand, little scientific information regarding their efficacy, safety, and effects on tooth structures and restorations exist. Wear of composite restorations might occur by long-term toothbrushing associated to highly abrasive dentifrices.[8] The loss of surface polish of the restorations causes gingival irritation, biofilm accumulation, and might accelerate the degradation of the restoration and compromise its esthetics,[8] producing the opposite result when it comes to cosmetics.

Thus, this study aimed to evaluate the effect of whitening dentifrices on the surface roughness of two commercial microhybrid composites for up to 24 months simulated brushing times. The null hypothesis is that whitening and non-whitening dentifrices produce the same surface roughness over commercial composites after 24 months of simulated brushing.

MATERIALS AND METHODS

Eight specimens of the microhybrid composites Rok and Filtek Z250 were made per group. Information about both composites is shown in Table 1.

The specimens were built up by inserting 2-mm increments of the composite into a bipartite disc-shaped mold 6 mm in height and 5 mm in diameter. Polymerization was performed using a XL 3000 (3M/ESPE, St. Paul, MN, USA) tungsten-halogen light-curing unit with 16 J/cm^2 (600 mW/cm^2 for 27 seconds). The irradiance was measured after every five specimens with an analogical radiometer (Demetron, Danbury, CT, USA). Surface smoothness was given by the contact of the composite with the mylar strip. Following, the samples were stored in a light-free environment with distilled water for 24 hours at 37°C.

TABLE 1. Composites used in the study

Composite	Manufacturer	Batch no.	Organic matrix	Filler
Rok	SDI, Australia	051212	UDMA	Strontium-aluminum silicate, mean size of 1.2 μm; 70% vol., 77% wt.
Filtek Z250	3 M/ESPE, St. Paul, MN, USA	8NW	BisGMA, UDMA, BisEMA	Zirconium/silica, mean size of 0.6 μm; 60% vol., 82% wt.

 DOI 10.1111/j.1708-8240.2011.00426.x

TABLE 2. Dentifrices used in the study

Dentrifrice	Constituents	Manufacturer
Colgate Total 12 Clean Mint	1,450 ppm of fluoride, triclosan, water, sorbitol, silica dioxide (abrasive), sodium lauril sulfate, PVM/MA copolymer (gantrez), aroma, carrageenan, sodium hydroxide, titanium dioxide, sodium saccharin, sodium fluoride	Colgate-Palmolive, São Bernardo do Campo, São Paulo, Brazil
Colgate Max White	Sodium fluoride (1,450 ppm fluoride ion), sorbitol, water, hydrated silica (abrasive), PEG-12, sodium lauril sulfate, cocamidopropyl betaine, aroma, cellulose gum, tetrasodium pyrophosphate, sodium saccharin, hydroxypropyl methylcellulose, blue pigment 15	Colgate-Palmolive, São Bernardo do Campo, São Paulo, Brazil
Close Up Extra Whitening	Sodium monofluorophosphate (1,450 ppm fluoride ion), calcium carbonate (abrasive), water, sorbitol, silica (abrasive), sodium lauril sulfate, aroma, trisodium phosphate, titanium dioxide, cellulose gum, perlite, benzyl alcohol, sodium saccharin	Unilever Brasil Higiene Pessoal e Limpeza Ltda, Ipojuca, Pernambuco, Brazil

The initial surface roughness (Ra) of each specimen was obtained from three parallel measurements along a 2.5-mm length, using a SJ 201 Surface Roughness Tester (Mitutoyo, Kawasaki, Japan).

The specimens were brushed with two whitening dentifrices and one control dentifrice (Table 2) using a multi-station brushing device. Each specimen was brushed at a single station using a soft consistency, nylon-bristled toothbrush with 32 tufts and 60 bristles per tuft (Colgate Classic, Colgate, São Bernardo do Campo, São Paulo, Brazil). Brushing was performed with a brush-head load of 200 g and speed of 250 cycles/minute.

Six grams of each dentifrice was mixed with 6 mL of distilled water forming a 1:1 wt:wt ratio slurry, in which the specimens were immersed during brushing. Five thousand, 10,000, and 20,000 cycles were performed to simulate 6, 12, and 24 months brushing time, respectively. The highest simulated brushing time was based on Tanoue and colleagues.[9] Each cycle was considered as a complete forward and reverse movement of 12 mm.

The specimens were washed in running water after brushing and blow-dried. Following each brushing time, the surface roughness was measured anew.

Four specimens per group were dried in silica gel at 37°C for 48 hours and gold sputter-coated at a current of 10 mA (SSD 050 Sputter Coater, Balzers, Liechtenstein) for observation in scanning electron microscope (SEM; XL 30, Phillips, Eindhoven, Netherlands), at 500× and 8,000× magnification.

Surface roughness data were submitted to three-way variance analysis and Tukey's test ($\alpha = 0.05$). Statistical analysis was made using the statistical package Statistix for Windows v.8.0 (Analytical Software, Tallahassee, FL, USA).

RESULTS

Variance analysis revealed statistically significant differences for the dentifrices ($p = 0.0001$), the composites ($p = 0.0007$) and the brushing simulated time ($p = 0.0001$). Significant interactions between dentifrice and brushing time ($p = 0.04$) and between composite and brushing time ($p = 0.004$) were also detected. Table 3 shows the Ra values of the composites after brushing.

The surface roughness increased with the increasing simulated brushing time (Figure 1). Both, Filtek Z250 and Rok presented similar roughness at baseline (24 hours), 6 and 12 months of simulated brushing. However, after 24 months, Filtek Z250's surface roughness increased significantly in comparison with Rok (Table 3 and Figure 1).

 DOI 10.1111/j.1708-8240.2011.00426.x

TABLE 3. Results of surface roughness (RA) of the composites tested considering the effect of dentifrices and simulated brushing time

Dentifrice	Composite	Time			
		24 hours	6 months	12 months	24 months
Colgate Total 12	Filtek Z250	0.06 (0.01)	0.07 (0.02)	0.09 (0.04)	0.09 (0.03)
	Rok	0.06 (0.01)	0.06 (0.01)	0.07 (0.02)	0.09 (0.02)
Colgate Max White	Filtek Z250	0.06 (0.01)	0.10 (0.05)	0.11 (0.06)	0.21* (0.11)
	Rok	0.06 (0.01)	0.08 (0.02)	0.11 (0.03)	0.12 (0.04)
Close Up Extra Whitening	Filtek Z250	0.06 (0.01)	0.10 (0.05)	0.11 (0.06)	0.21* (0.11)
	Rok	0.06 (0.01)	0.08 (0.02)	0.10 (0.03)	0.12 (0.04)

*Asterisks indicate statistically significant differences ($\alpha = 0.05$).

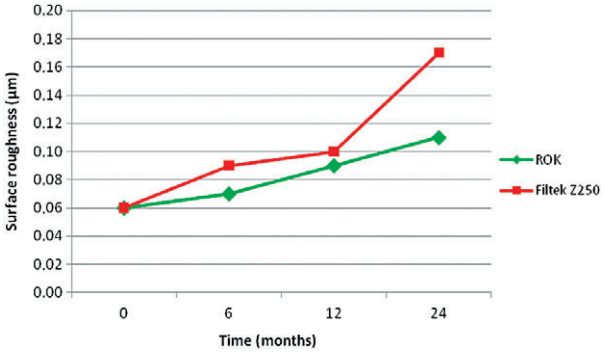

FIGURE 1. Surface roughness (Ra) of Rok and Filtek Z250 after simulated brushing times. Time 0 (zero) refers to the 24-hour evaluation.

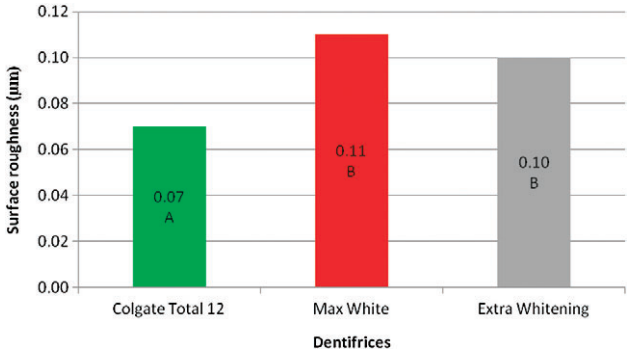

FIGURE 2. Surface roughness (Ra) produced by the dentifrices evaluated. Different letters indicate statistically significant differences.

The whitening dentifrices promoted significantly higher surface roughness on the composites surface (Figure 2).

SEM micrographs depicted different surface patterns for both composites following 24-months brushing with the dentifrices evaluated. Rok presented similar even surface patterns at baseline and after brushing for 24 months with Colgate Total 12 Clean Mint and Close Up Extra Whitening (Figures 3A–C). Colgate Max White, on the other hand, caused agressive surface wear of the composite matrix and partial filler exposure (Figure 3D). Filtek Z250 presented a smooth surface as a result from brushing with the non-whitening dentifrice (Figure 4B), whereas brushing with the whitening dentifrices produced a highly rough surface and filler exposure (Figures 4C and D). Brushing with Colgate Max White also caused dislodgement of the filler particles (Figure 4D), visualized as darker round spots on the composite surface.

DISCUSSION

Wear is a rather common long-term outcome in composite restorations, more associated to posterior restorations though. When it affects anterior restorations, it might produce esthetic uneasiness by losing of the surface polish and by exposure of the composite components that might incorporate external pigments from the biofilm in a rather rapid fashion. Toothbrushing is one of the mechanisms that impose this chemo-mechanical challenge to composite

 DOI 10.1111/j.1708-8240.2011.00426.x

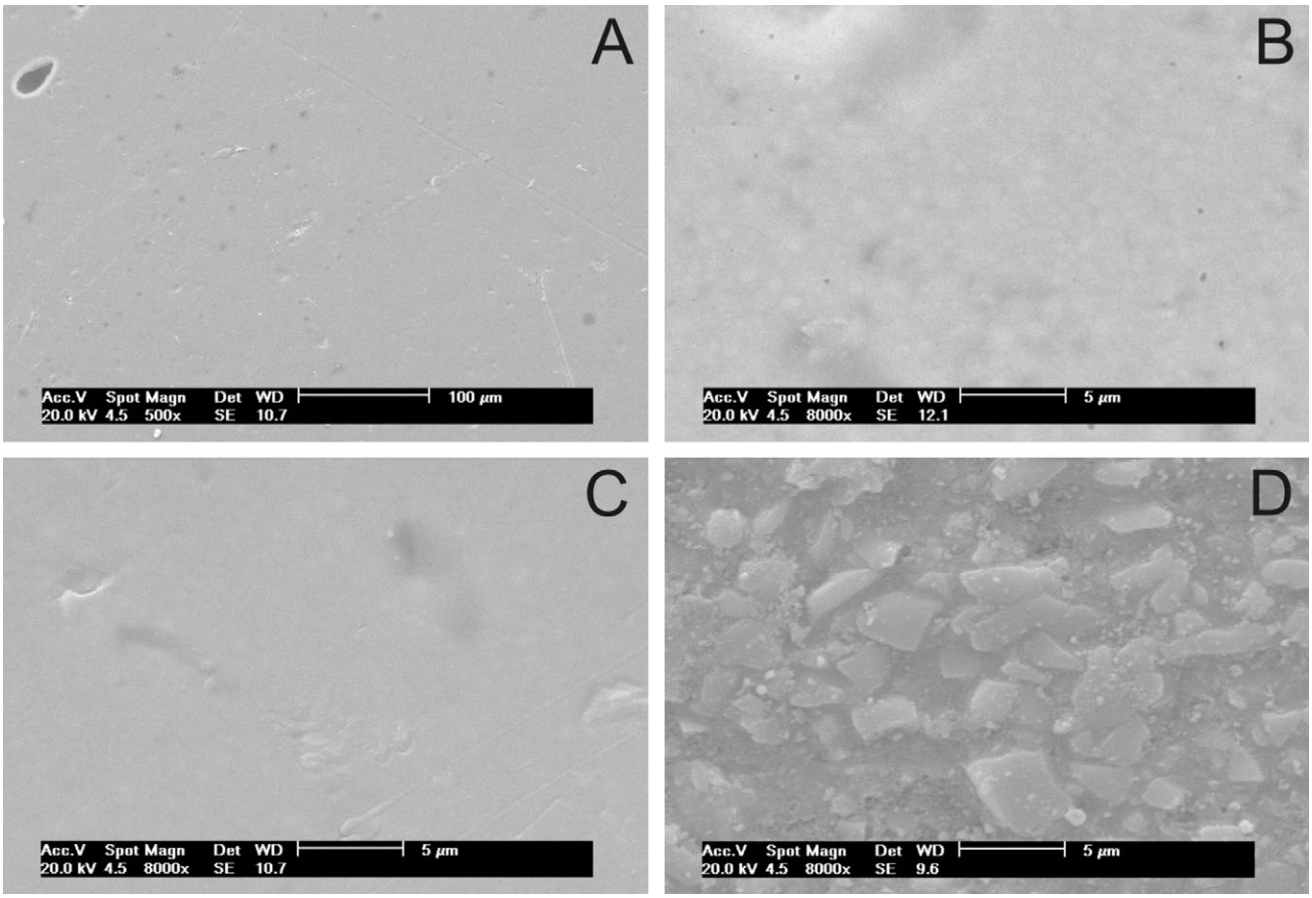

FIGURE 3. Scanning electron microscope micrographs of Rok: A, initial (500×); B, after brushing for 24 months with Colgate Total 12 Clean Mint (8,000×); C, after brushing for 24 months with Close Up Extra Whitening (8,000×); D, after brushing for 24 months with Colgate Max White (8,000×).

restorations and, in our study, toothbrushing with whitening dentifrices led to higher wear of the composites studied (Table 3 and Figure 2).

The abrasiveness of the slurry formed by the dentifrice during brushing is influenced by physical characteristics of the abrasive particles, namely shape, size, acuteness, hardness, and ductility.[10] It has been shown that coarse and irregular particles produce rougher surfaces and that the effect of the particle hardness is relative to the hardness of the composite's constituents.[10] Differences in abrasiveness between dentifrices also might occur as a result of the amount of abrasives, and produce variable levels of damage in dental structures and restorations.[11] Our results suggest that the presence of a higher amount of abrasives in whitening dentifrices, responsible for the whitening effect, also affect in a higher extent the surface roughness of the composites tested.

The composites were affected differently by the brushing simulation, with Filtek Z250 presenting rougher surface than Rok when brushed with the whitening dentifrices, especially after 24 months (Table 3 and Figure 1). Several factors affect the wear resistance of dental composites, and are related to properties of filler, matrix and the filler/matrix interface: content, shape, size, orientation, and distribution of the filler, hardness of the filler relative to the hardness of the abrasive, relative wear resistance of filler to the matrix, degree of conversion, quality of silane coating, and loading conditions during wear.[10,12]

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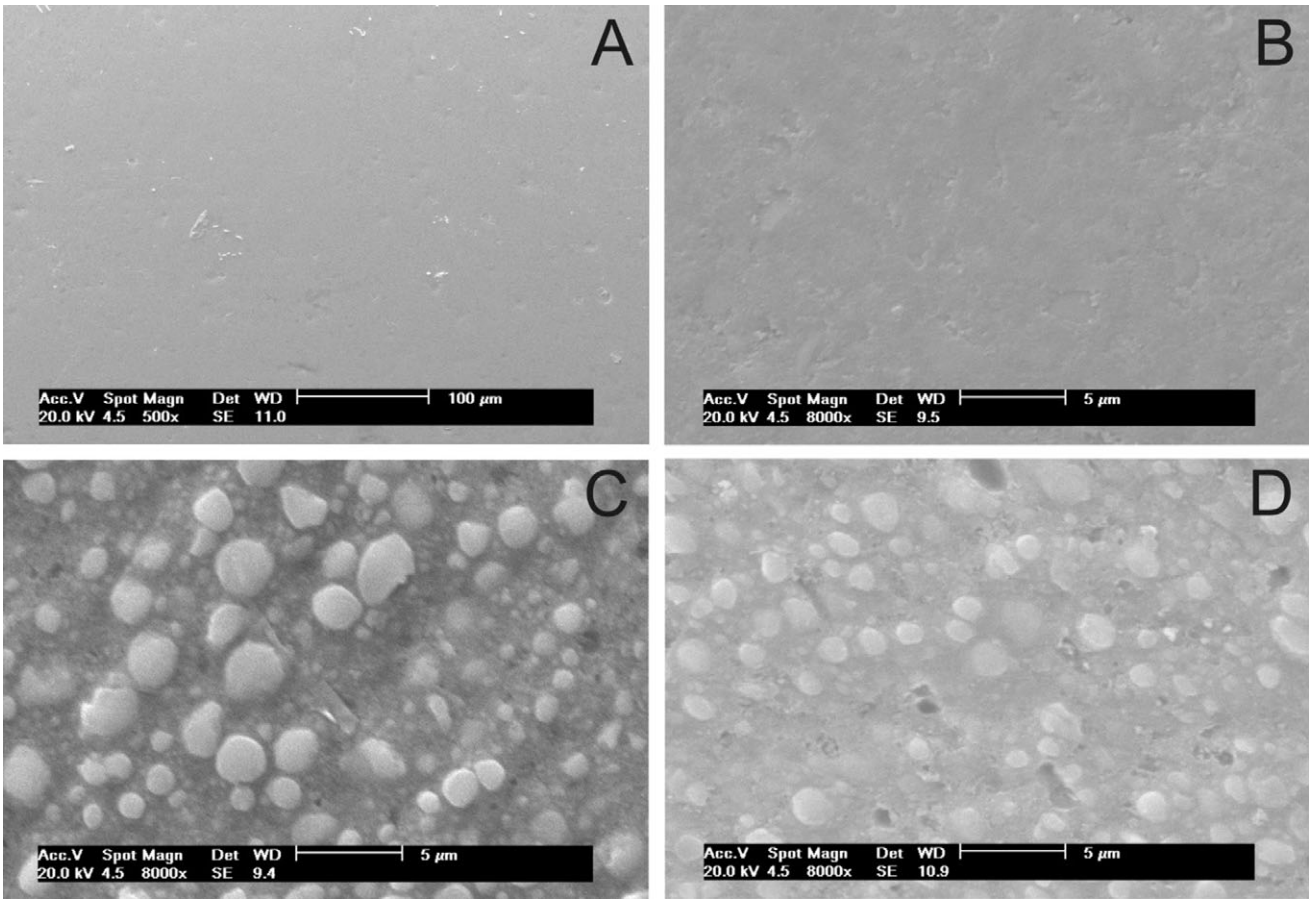

FIGURE 4. Scanning electron microscope micrographs of Filtek Z250: A, initial (500×); B, after brushing for 24 months with Colgate Total 12 Clean Mint (8,000×); C, after brushing for 24 months with Close Up Extra Whitening (8,000×); D, after brushing for 24 months with Colgate Max White (8,000×).

The organic matrix of Rok is composed exclusively by UDMA (Table 1), which is less viscous and more flexible than BisGMA, producing higher cross-linkage and hardness than the later.[13,14] On the other hand, besides UDMA, Filtek Z250 is also composed by a BisGMA and BisEMA copolymer (Table 1). BisGMA is stiffer than UDMA and generates a more rigid polymer, with less double bond conversion, though. Therefore, copolymers containing BisGMA tend to present lower hardness, which is directly related to the degree of conversion, and higher water sorption.[14,15] BisEMA is a recently introduced analog of BisGMA that allows for a higher double bond conversion while transforming the polymer into a more flexible and less stiff resin.[15,16]

Composites presenting large[17] and irregular-shaped filler particles[18] have been related to lower wear resistance than the ones presenting small and round-shaped particles. The latter allow higher filler packing ratio compared with the former, which is highly related to the mechanical resistance of composites.[19,20] However, in our study the composite containing the larger (Table 1) and irregular-shaped particles (Rok) was more resistant to wear, especially when brushed with the whitening dentifrices. Also, its filler particles were not exposed when it was brushed with one of the whitening dentifrices (Close Up Extra Whitening) (Figure 3C), as opposed to the other composite (Figure 4C), which leads to the conclusion that the UDMA-based matrix of Rok plays an important role for its wear resistance.

Some authors consider the filler/matrix interface as a third phase of the composite.[21] This interface is

 DOI 10.1111/j.1708-8240.2011.00426.x

designed to chemically bond the matrix to the filler through a bifunctional organosilane.[20,21] It is also a site where microcracks may form and a path through which water may penetrate, degrading the composite.[22,23] According to Whitehead and colleagues,[24] the surface of composites becomes susceptible to crack formation and propagation resulting from mastication. Therefore, it is fair to assume that the filler exposure caused by brushing with whitening dentifrices (Figures 3 and 4) accelerates the degradation of the composites, compromising the surface polish and inducing surface staining.

After the 24 months of brushing time with the whitening dentifrices, the surface integrity of Filtek Z250 was compromised, revealing a groovy surface with exposure of filler particles (Figure 4C) and loose particles (Figure 4D). Despite the increasing roughness of Rok as brushing time increased, filler exposure was noticed only after brushing with Colgate Max White (Figure 3D). This dentifrice was the most aggressive (Figure 2), exposing the filler of both composites, and should be avoided for more than 12 months when the patient possesses composite restorations.

In several societies the concept of a beautiful smile with white, proportional, and aligned teeth is a strong synonym of success and social acceptance. The demand for white teeth created an entire market of over-the-counter products. The legislation of some countries considers dentifrices that claim to whiten teeth as cosmetics rather than medical devices, meaning that no restriction is made to their access by individuals. Also, advertisement regulations are more lax than if they were considered medical devices.[4] Indeed, no information about adverse effects on dental structures and restorations were found associated to the whitening dentifrices tested in this study.

CONCLUSION

Whitening dentifrices are more detrimental to the surface of the composites than non-whitening dentifrices. The degree of surface compromising increased with brushing time and depends on the composite's microstructure and composition. Manufacturers should inform consumers about the adverse effects of whitening dentifrices on dental restorations.

DISCLOSURE

The authors do not have any financial interest in any of the companies whose products are discussed in this paper.

REFERENCES

1. Cury JA, Tenuta LMA, Ribeiro CCC, Paes Leme AF. The importance of fluoride dentifrices to the current dental caries prevalence in Brazil. Braz Dent J 2004;15:167–74.
2. Teles RP, Teles FRF. Antimicrobial agents used in the control of periodontal biofilms: effective adjuncts to mechanical plaque control? Braz Oral Res 2009;23(Suppl 1):39–48.
3. American Dental Association. Whitening toothpastes. J Am Dent Assoc 2001;132:1146–7.
4. Demarco FF, Meireles SS, Masotti AS. Over-the-counter whitening agents: a concise review. Braz Oral Res 2009;23(Suppl 1):64–70.
5. Lima DANL, Faria e Silva AL, Aguiar FHB, et al. In vitro assessment of the effectiveness of whitening dentifrices for the removal of extrinsic tooth stains. Braz Oral Res 2008;22:106–11.
6. Sarrett DC. Tooth whitening today. J Am Dent Assoc 2002;133:1535–8.
7. Kodaka T, Kuroiwa M, Okumura J, et al. Effect of brushing with a dentifrice for sensitive teeth on tubule occlusion and abrasion of dentine. J Electron Microsc 2001;50:57–64.
8. dos Santos PH, Pavan S, Consani S, et al. In vitro evaluation of surface roughness of 4 resin composites after the toothbrushing process and methods to recover superficial smoothness. Quintessence Int 2007;38:247–53.
9. Tanoue N, Matsumura H, Atsuta M. Analysis of composite type and different sources of polymerization light on in vitro toothbrush/dentifrice abrasion resistance. J Dent 2000;28:355–9.
10. Turssi CP, Purquerio BM, Serra MC. Wear of dental resin composites: insights into underlying processes and assessment methods—a review. J Biomed Mater Res B Appl Biomater 2003;65B:280–5.
11. Lambrechts P, Debels E, Van Laduyt K, et al. How to simulate wear? Overview of existing methods. Dent Mater 2006;22:693–701.

 DOI 10.1111/j.1708-8240.2011.00426.x

12. Atai M, Yassini E, Amini M, Watts DC. The effect of a leucite-containing ceramic filler on the abrasive wear of dental composites. Dent Mater 2007;23:1881–7.
13. Asmussen E, Peutzfeldt A. Influence of UEDMA, BisGMA e TEGDMA on selected mechanical properties of experimental resin composites. Dent Mater 1998;14:51–6.
14. Barszczewska-Bybarek IM. Structure-property relationships in dimethacrylate networks based on Bis-GMA, UDMA and TEGDMA. Dent Mater 2009; 25:1082–9.
15. Sideridou I, Tserki V, Papanastasiou G. Study of water sorption, solubility and modulus of elasticity of light-cured dimethacrylate-based dental resins. Biomaterials 2003;24:655–65.
16. Ogliari FA, Ely C, Zanchi CH, et al. Influence of chain extender length of aromatic dimethacrylates on polymer network development. Dent Mater 2008;24:165–71.
17. Moraes RR, Ribeiro DS, Klumb MM, et al. In vitro toothbrushing abrasion of dental resin composites: packable, microhybrid, nanohybrid and microfilled materials. Braz Oral Res 2008;22:112–8.
18. Turssi CP, Ferracane JL, Vogel K. Filler features and their effects on wear and degree of conversion of particulate dental resin composites. Biomaterials 2005;26:4932–7.
19. Sabbagh J, Ryelandt L, Bachérius L, et al. Characterization of the inorganic fraction of resin composites. J Oral Rehabil 2004;31:1090–101.
20. Rodrigues-Junior SA, Scherrer SS, Ferracane JL, Della Bona A. Microstructural characterization and fracture behavior of a microhybrid and a nanofill composite. Dent Mater 2008;24:1281–8.
21. Wilson KS, Zhang K, Antonucci JM. Systematic variation of interfacial phase reactivity in dental nanocomposites. Biomaterials 2005;26:5095–103.
22. Ferracane JL. Hygroscopic and hydrolytic effects in dental polymer networks. Dent Mater 2006;22:211–22.
23. Bagheri R, Tyas MJ, Burrow MF. Subsurface degradation of resin-based composites. Dent Mater 2007;23:944–51.
24. Whitehead SA, Shearer AC, Watts DC, Wilson NHF. Surface texture changes of a composite brushed with tooth whitening dentifrices. Dent Mater 1996;12: 315–8.

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This article is accompanied by commentary, Effect of Whitening Dentifrices on the Surface Roughness of Commercial Composites, Gisele F. Neiva, DDS, MS
DOI 10.1111/j.1708-8240.2011.00427.x

 DOI 10.1111/j.1708-8240.2011.00426.x