JOURNAL OF OROFACIAL INVESTIGATION

Original Research

Surface roughness of enamel, dentin and a composite resin after using an experimental prophylaxis paste

Rugosidade de superfície do esmalte, dentina e resina composta após utilização de uma pasta Profilática experimental

Karen Pintado-Palomino[1], Raphael Jurca Gonçalves da Motta[1], Roberto Juns da Silva[1], Maria de Fátima Jurca da Motta[1], Camila Tirapelli[1]

[1] Department of Dental Materials and Prosthodontics, Ribeirão Preto School of Dentistry, USP - University of São Paulo, Ribeirao Preto, SP, Brazil.

Resumo

O estudo teve como objetivo avaliar uma pasta experimental contendo micro particulas de Biosilicato® como agente de polimento para esmalte, dentina e resina composta. As amostras foram preparadas e armazenadas em água destilada por uma semana (n=3- cada substrato). Depois, as amostras foram separadas aleatoriamente em 3 grupos de acordo com o protocolo de profilaxia(tratamentos): Grupo1: profilaxia com taça de borracha e pasta experimental com Biosilicato® ; Grupo 2: profilaxia com taça de borracha e pasta profilática comercial Herjos® e Grupo 3: profilaxia com jato de bicarbonato de sódio. A análise da rugosidade de superfície (SR) e microscopia eletrônica de varredura (SEM) foi realizada antes (t0) e após os tratamentos (t1). Em relação ao fator tempo (t0 x t1), o esmalte (0.16 x 0.57), dentina (0.23 x 1.5) e resina composta (0.12 x 0.86) do Grupo 3 apresentaram valores de t1 de SR estatisticamente diferentes ($p<0.05$) aos valores iniciais. Após o tratamento no Grupo 3, a alteração de SR na dentina (1.5) foi mais significante ($p<0.001$) que no esmalte (0.57) e resina composta (0.86). Em relação ao protocolo de profilaxia, houve diferença significante ($p<0.001$) entre os três Grupos para todos os substratos (esmalte, dentina e resina). Profilaxia com taça de borracha e pasta experimental de Biosilicato® não provocou alterações deletérias na rugosidade do esmalte, dentina e resina composta.

Key words: Materiais biocompatíveis; profilaxia dentária; propriedades de superfície

Abstract

The study aimed to evaluate an experimental paste containing Biosilicate® micron-sized particles as a polishing agent for enamel, dentin and composite resin substrates. Specimens were prepared and stored in distilled water for one week (n=30 for each substrate). Then, samples were randomly allocated in three treatment groups according to prophylaxis protocol: (Group 1) prophylaxis with rubber cup and experimental paste containing Biosilicate®; (Group 2) prophylaxis with rubber cup and commercial prophylaxis paste Herjos®; and (Group 3) prophylaxis with air-polishing device containing sodium bicarbonate powder. Surface roughness (SR) and scanning electron microscopy (SEM) analysis were performed before (t0) and after the treatments (t1) (five times with 30 days-interval). Regarding time factor (t0 x t1), enamel (0.16 x 0.57), dentin (0.23 x 1.5) and composite resin (0.12 x 0.86) from Group

3 showed SR values statistical different ($p<0.05$) when compared to baseline values. After treatment in Group 3, alteration of SR in dentin (1.5) was more significant ($p<0.001$) than enamel (0.57) and composite resin (0.86). Regarding prophylaxis protocol factor, there was statistical difference ($p<0.001$) when comparing Group 1 and Group 2 to Group 3 for all substrates. Prophylaxis with rubber-cup and an experimental Biosilicate® paste did not cause deleterious effect on SR of enamel, dentin and composite resin.

Key words: Biocompatible materials; dental prophylaxis; surface properties

INTRODUCTION

Removal of dental biofilm and extrinsic stains is required on most operative dentistry procedures. Conventional rubber cup prophylaxis and air powder polishing systems are commonly used to these aims. Bicarbonate jet procedure is particularly effective at removing these biofilms and stains[1]; however, this procedure also increases surface roughness and marginal degradation of restorations, resulting in the retention of biofilms, aesthetic damage, periodontal tissue irritation and loss of restoration durability [2, 3]. Although advances in composite resins have resulted in more resistant and durable restorative materials, their surface finishes can also deteriorate or even be destroyed by prophylaxis procedures [4].

Some dental practitioners prefer to apply a prophylaxis paste to polish the enamel surfaces after removing the calculus; nevertheless, depending on the method, an increase in the surface roughness can occur over time, along with the destruction of superficial tooth structures [4, 5]. During dental procedures, teeth with erosion, abrasion, abfraction lesions or restorations may also be polished inadvertently. Therefore, prophylaxis pastes can affect the surface roughness of enamel, exposed dentin, cementum and restorative materials, such as composite resins [5].

Polishing is a preventive procedure used to prevent the adhesion of bacteria that damage the dental and restoration surfaces. It can therefore be benefit from using smaller particles that produce smoother surfaces [6] and be able to remineralize dental tissues. In this sense, different studies have been conducted with Biosilicate®, a novel material based on micron-sized particles of bioactive glass-ceramic, because of features for bone tissue regeneration such as highly bioactive, non-cytotoxic and antibacterial properties [7]. Furthermore, Biosilicate microparticles can favor mineralization of dental tissues, by deposition of a hydroxicarbonateapatite (HCA) layer onto surfaces, improving their mechanical properties [8, 9] and promoting a desensitizing effect [10, 11]. Thus, this biomaterial could be advantage as a prophylactic paste.

This study aimed to evaluate the surface roughness of bovine enamel, dentin and composite resin after different prophylaxis methods. In particular, we tested and compared a conventional rubber cup prophylaxis with an experimental paste containing Biosilicate® with other prophylaxis methods. Our null hypothesis is that there will be no difference in surface roughness of the substrates of these three groups.

MATERIAL AND METHODS

Study design

The variable assessed in this vitro study was surface roughness with two factors of variation: 1) substrate, 2) prophylaxis methods and 3) and time factor. 90 specimens corresponded to enamel, dentin and composite resins substrates (30 for each one).

Sample preparation

Enamel and dentin specimens were obtained from permanent incisor bovine teeth stored in physiological saline solution at room temperature (24 °C ± 1 °C). We obtained the square enamel sections (4 mm × 4 mm × 3 mm) from the vestibular surface of the crown and the dentin sections (4 mm × 4 mm × 3 mm) from the cervical region of the root using carborundum disks in a low-speed dental handpiece (Dabi Atlante, Ribeirão Preto, São Paulo, Brazil) under refrigeration. Thickness and size of the flat specimens were checked with a micrometer (Mitutoyo, Tokyo, Japan). Then, they were embedded in acrylic resin (Jet Acrylic Resin, Clássico, São Paulo, Brazil). In order to create a planar, parallel and smooth surface, we polished the samples on a polishing device (Struers, Copenhagen, Denmark) under water-cooling using silicon carbide paper with grain sizes ranging from 300 to 2000.

Composite resin (Charisma, Heraeus Kulzer, Germany) specimens were prepared and formed in a custom-made polytetrafluoroethylene form (5 mm in diameter and 6 mm in depth); composite resin was placed into mold form and covered with acetate strips. It was light-cured for 40 seconds with a LED lamp (Optiligth LD Max, Gnatus, Ribeirão Preto, Brazil). Specimens also were polished using silicon carbide paper (grain 800, 1000 and 2000, successively).

Specimens were then stored at 36 ºC in 1.5 mL safe-lock individual, numbered tubes (Eppendorf Brazil, São Paulo, Brazil) containing distilled water.

Treatments

The prophylaxis treatments began one week after the sample preparation. The treatments were repeated five times on the same surface for each specimen with 30 days between each treatment.

Enamel, dentin and resin composite samples were divided into equal three groups according to the prophylaxis methods (Group 1, Group 2 and Group 3) (n = 10). The product used in this study are listed in Table 1.

Table 1- Composite resin, prophylaxis pastes and air polishing powder utilized in the study

Products	Composition	Manufacturer
Composite resin		
1. Charisma	Bis-GMA, TEGDMA, barium aluminum fluoride glass, high/dispersed silicon dioxide	Heraus Kulzer, Wehrheim, Germany
Prophylaxis pastes		
2. Experimental paste 1:1 (Biosilicate® and distilled water)	Particles of bioactive ceramic crystalline (1-10 μm) P_2O_5-Na_2O-CaO-SiO_2	Vitrovita, São Carlos, SP, Brazil
3. Herjos	Water, thickener, lauryl sulfate, calcium carbonate, pumice and artificial flavors.	Vigodent, S.A., RJ, Brazil
Polishing powder		
4. ProfiNeo	Sodium bicarbonate	Dabi Atlante, Ribeirão Preto, SP, Brazil

The prophylaxis procedures were performed as follow:

- Group 1: 1 mL of Biosilicate®/ distillate water (1:1) paste was applied on samples surfaces with a microbrush applicator (Dentsply, Rio de Janeiro, Brazil). Then, a rotating rubber cup (Microdont, São Paulo, Brazil) in a slow-speed contra-angle handpiece (Dabi Atlante, Ribeirao Preto, Sao Paulo, Brazil) at 300 rpm and perpendicularly to the specimen surface rubbed the product for 30 seconds. A new rubber-cup was used for each procedure.

- Group 2: It was carried out the same procedure described for Group 1, except that we used the prophylaxis paste Herjos (Vigodent, S.A., Rio de Janeiro, Brazil).

- Group 3: Air-polishing system with sodium bicarbonate powder (ProfiNeo, Dabi Atlante, Ribeirao Preto, Sao Paulo, Brazil) was applied on the sample surfaces for 30 seconds. The nozzle orifice was placed in a perpendicular position to the surface at 10.0 mm away from the surface.

After each treatment, the specimens were washed with tap water and stored in individual tubes with fresh distilled water until the next treatment.

Measurements

Surface roughness

Surface roughness (Ra) was assessed quantitatively using a profilometer device (Mitutoyo, SJ201, Tokyo, Japan) (cut-off value of 0.08 mm). Three different spots were measured for each specimen before (t0) and after (t1) the successive five treatments.

Scanning electron microscopy

Representative composite resin, enamel and dentin specimens from each group were analyzed qualitatively before (t0) and after (t1) the treatments under scanning electron microscope (Superscan SS-550, Shimadzu, Japan). Previously, samples were dehydrated in a desiccator at 37°C for 24 h and gold-sputtered in a sputter coater device (Baltec SCD-050, Lichtenstein**)**. Scanning electron photomicrographs were taken at magnification of 1500X.

Statistical Analysis

Data from surface roughness showed normal (Shapiro Wilk test) distributions and were analyzed using paired Student´s t-test ($p<0.05$), in order to verify differences in the same sample before and after each moment of the treatment.

RESULTS

Analysis data revealed that air polishing method containing sodium bicarbonate powder (Group 3) caused significant more alterations ($p<0.001$) than conventional rubber-cup polishing method (with experimental Biosilicate® or prophylaxis commercial Herjos® paste) on all substrates and it affected the dentin more significantly ($p<0.001$) than enamel and composite resin. In addition, conventional rubber cup prophylaxis with an experimental paste containing Biosilicate® powder (Group 1) caused no significant alteration ($p>0.05$) in roughness surface of the substrates and showed similar behavior than the prophylaxis Herjos® paste (Figure 1).

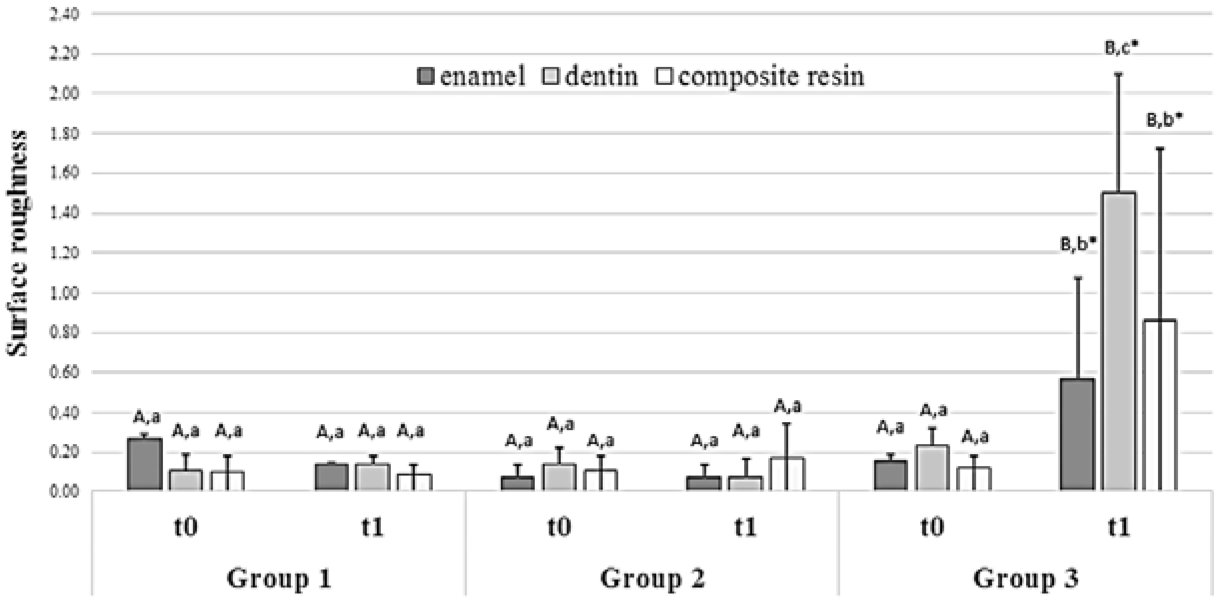

Figure 1- Enamel, dentin and composite resin surface roughness (Ra) before (t0) and after (t1) the treatment with different prophylaxis protocols. Different uppercase letters indicate statistical difference among the prophylaxis protocols. Different lowercase letters indicate statistical difference among the substrates. (*) shows statistical difference between t0 and t1 evaluation time (T Student test $p<0.05$).

The SEM images showed regular, smooth surfaces for untreated samples (Figure 2). After treatment, the Group 3-treated surfaces exhibited the greatest change. Substantial morphological changes were observed on dentin with opened dentin tubules and apparently erosion; however, it was possible to observe irregular and more porous surfaces of enamel and resin composite as well (Figure 3).

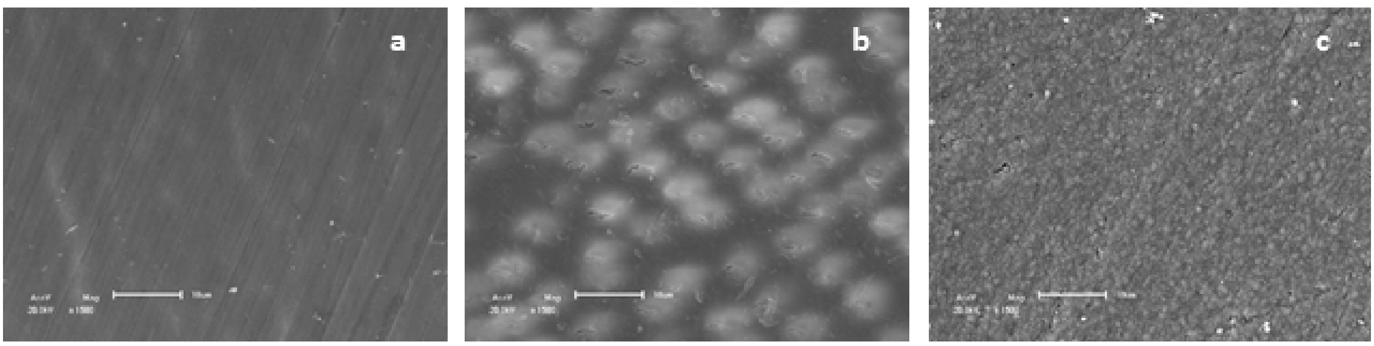

Figure 2 - SEM microphotographs of untreated samples. a. Enamel, b. Dentin and c. Composite resin.

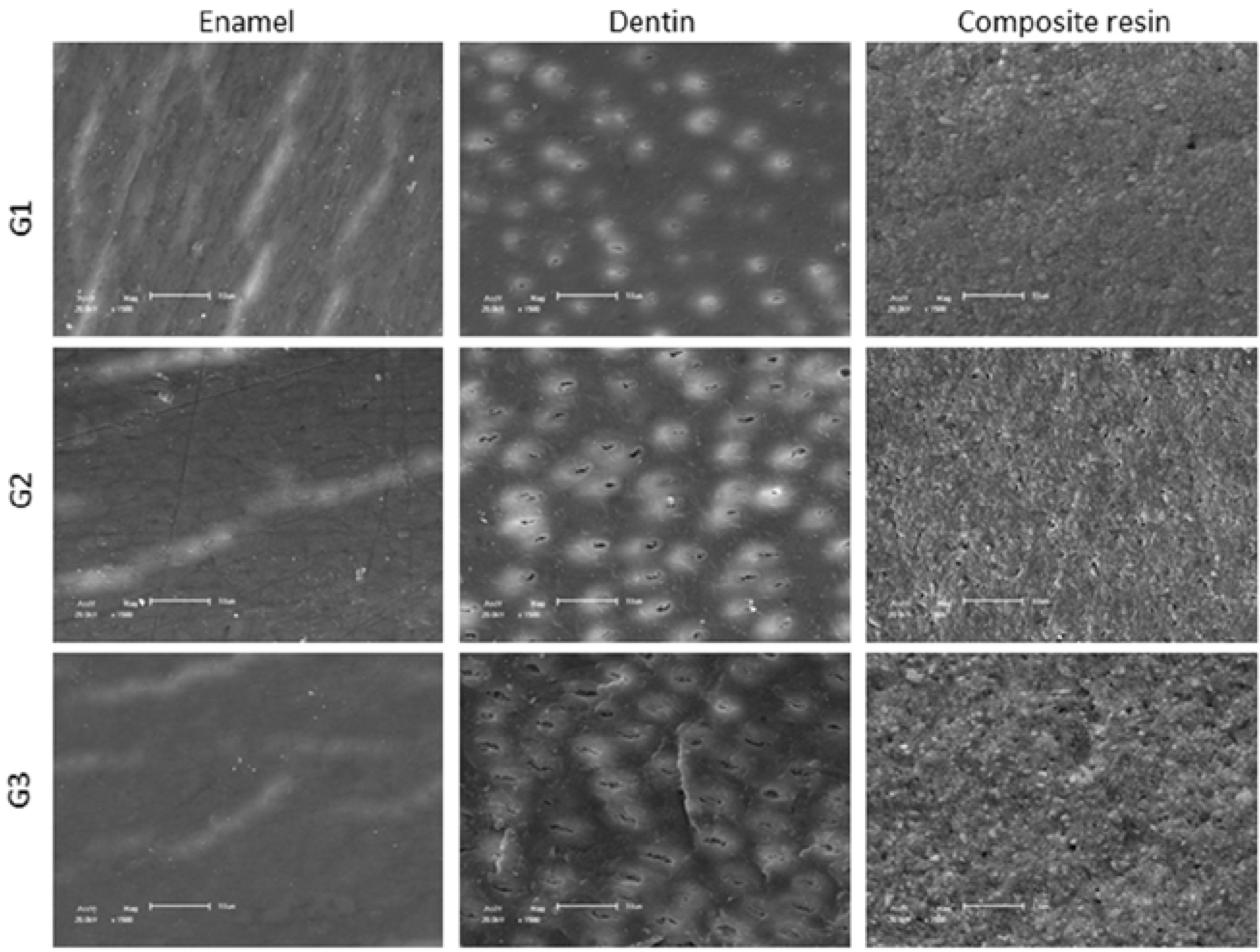

Figure 3 – SEM microphotographs after different prophylaxis protocols.

DISCUSSION

Practitioners have used air polishing method as an alternative to conventional mechanical polishing with rubber cup and paste by the reduced time and operator fatigue [12]. To remove plaque biofilm and stains, air polishing system applied a slurry of pressurized air (400–800 MPa) and abrasive powder with or without water (100-500 MPa) over dental surface.

Sodium bicarbonate based-powder (NaHCO3) is the most widely used with a particle size less than 200 µm [13]. Despite the efficacy of air polishing with sodium bicarbonate for tooth stain and supragingival plaque biofilm removal [1], side effects also have been related on dental hard tissues and restorative materials, even after only one treatment on the surface.

In this study, we proposed Biosilicate® - a novel bioactive glass ceramic - as polishing powder. Biosilicate® contains rounded, fully crystalized and highly bioactive microsized particles (10 µm) based on $23.75Na_2O–23.75CaO–48.5SiO_2–4P_2O_5$ (wt.%) composition [7] and presents important futures to be consider for a polishing material: antibacterial activity [14], dentinal tubule occlusion capability [15] and desensitizing effect [10].

In this study, we rejected the null hypothesis since there were difference in surface roughness among the groups. The results of this study revealed that Biosilicate® paste did not affect the surface roughness of the substrates showing a significant difference ($p<0.0001$) when comparing to air polishing with sodium bicarbonate. This difference may be explained because bioactive glass material is capable to achieve a smoother surface by calcium phosphate layer formation on dentin surface [16] due to its ability to react with body fluids (saliva) to deposit hydroxycarbonate apatite (HCA). For resin composites, it is not expected that bioactive particles will have an effect; however, on dentin and enamel, it is possible to hypothesize that a regenerating activity might facilitate the smoother, more mineralized surface observed after dental prophylaxis or polishing treatments.

The effect on enamel surface roughness depends on the abrasiveness powder [17] and the presence of caries lesion [18]. In this study, only sodium bicarbonate powder affected the sound enamel. This finding are in agreement with previous study that showed more damage in enamel surface roughness after bicarbonate use when compared to other powders [19]. Moreover, in this study when comparing the prophylaxis methods, conventional rubber cup method seems to be less deleterious. Similarly, Fratolin et al. [17] showed that air-polishing treatment causes enamel surfaces significantly rougher than the corresponding-cup polishing.

About the effect on dentin, some studies in vitro [20-22] have indicated that powder containing sodium bicarbonate may be not safe for using on exposed dentin. The abrasion depths occurred by bicarbonate powder increase disproportionately causing considerable substance loss [20] and volume [22]. In a recent study, Buhler et al. [21] related that sodium bicarbonate powder causes a significantly higher increase surface roughness compared to others, still either powder increases the surface alterations by an increase in treatment time, a decrease in working distance and an angulation of 45°. In this current study, air polishing containing sodium bicarbonate affected significantly the dentin increasing its roughness surface. Dentin is considered less hard than enamel due to different composition and internal microstructures; therefore, it is justifiable dentin has been more affected.

Furthermore, literature has related the effects of air polishing powders on esthetic restorations, including glass ionomers, porcelain, and composites [12]. In particular, sodium bicarbonate powder in air polishing generates the highest surface roughness [3] and produces some defect depths at the resin composite-dentin interface [23]; therefore, authors suggested caution or complete avoidance of use. As expected, the results of our study also showed an increase surface roughness of composite resin by sodium bicarbonate powder use but significantly lower than the dentin. Most likely because of structural differences: dentin is a multitubular tissue composed of 70% inorganic material, 18% organic matrix and 12% water (wt. %), whereas resin composites are usually composed of organic matrix (40%), inorganic filler (60%) and a coupling agent to bond the filler to the organic matrix.

To minimize the adverse effects of polishing powders and gain some advantages such as more smooth and remineralized surfaces, researchers have developed bioactive glasses materials for prophylaxis and polishing uses. These materials have been tested and compared with other prophylaxis products presenting better results. In an in vitro study, Sauro et al. [13] showed that bioactive glass used both with air polishing systems and as prophy-pastes with rotary rubber instruments were the most effective to reduce the dentine permeability. In addition, in in vitro conditions, bioactive glass material powder with different particles size induced dentin remineralization through a 7-day period of artificial saliva [16]. In a clinical study [24], bioactive glass powder air polishing had a significant longer term desensitizing effect and provided more comfort during the procedure, whereas the sodium bicarbonate powder tended towards increasing dentine sensitivity. Still, the bioactive glass was more efficient in stain removal than sodium bicarbonate due to bioactive glass particles have greater density and a more spherical aspect ratio than the sodium bicarbonate. In addition, sodium bicarbonate and bioactive glass react differently with the exposed dentin surface, since bioactive glass is able to create a smear layer more compact and resistant to the acid attack [13].

In this study, we proposed Biosilicate® - a novel bioactive glass ceramic - as polishing powder. Biosilicate® contains rounded, fully crystalized and highly bioactive micron-sized particles (10 μm) based on $23.75Na_2O–23.75CaO–48.5SiO_2–4P_2O_5$ (wt.%) composition [7]

and presents important futures to be consider for a polishing material: antibacterial activity [14], dentinal tubule occlusion capability [15] and desensitizing effect [10].

In this study, we rejected the null hypothesis since there were difference in surface roughness among the groups. The results of this study revealed that Biosilicate® paste did not affect the surface roughness of the substrates showing a significant difference ($p<0.0001$) when comparing to air polishing with sodium bicarbonate. This difference may be explained because bioactive glass material is capable to achieve a smoother surface by calcium phosphate layer formation on dentin surface [16] due to its ability to react with body fluids (saliva) to deposit hydroxycarbonate apatite. For resin composites, it is not expected that bioactive particles will have an effect; however, on dentin and enamel, it is possible to hypothesize that a regenerating activity might facilitate the smoother, more mineralized surface observed after dental prophylaxis or polishing treatments.

Concerning methodology, we considered some points in the study design. The study compared various types of surfaces; including enamel, dentin and a composite resin because in accordance with previous studies, polishing/ prophylaxis procedures affect the root surface [25], enamel [17, 19] and restorative materials [26]. We measured surface roughness, which is commonly used to quantify the surface deviations [21], because it represents the main variable for evaluating dental polishing materials [6, 27]. Additionally, we measured surface roughness over successive treatments since dental clinicians recognize these types of procedures as preventive protocols for the control of caries and periodontal disease that should be performed annually or biannually [28]. On the other hand, despite of SEM imagens show morphological characteristic of specimens after the prophylactic methods, another type of evaluation should be made to corroborate a formation of a layer of HCA, i.e., SEM-EDS, SAED –TEM, Confocal Raman.

Nevertheless, other aspects of polishing material should be also considered in clinical situations. Since acidity and abrasivity of oral care products and abrasivity by tooth brushing may increase the abrasion of dental tissues [18], it would be recommended to use in polishing procedure some product with low abrasivity and capable to remineralize dental tissues. In addition, future studies will explore vehicles for polishing pastes containing bioactive materials and their regenerative effects on dentin and enamel.

Considering the methodology employed and the limitation of this in vitro study, we concluded that conventional prophylaxis rubber-cup with Biosilicate® paste can use for dental prophylaxis/ polishing since it caused no deleterious effect on surface roughness of enamel, dentin and composite resin. Air polishing with sodium bicarbonate powder increases the surface roughness of enamel, dentin and composite resin, affecting more significantly the dentin.

ACKNOWLEDGMENTS

The authors are grateful to FAPESP (São Paulo Research Foundation # 2010/12032-6, # 2011/19567-5, # 2011/07039-4, # 2012/08312-9 and # 2013/07793-6) for the financial support of this study.

REFERÊNCIAS

1. Samra AP, Ribeiro DG, Borges CP, Kossatz S. Influence of professional prophylaxis on reducing discoloration of different aesthetic restorative materials. J Dent. 2012;40 Suppl 2:e71-6.

2. Soares CJ, Pereira JC, Souza SJ, Menezes MS, Armstrong SR. The effect of prophylaxis method on microtensile bond strength of indirect restorations to dentin. Oper Dent. 2012;37(6):602-9.

3. Salerno M, Giacomelli L, Derchi G, Patra N, Diaspro A. Atomic force microscopy in vitro study of surface roughness and fractal character of a dental restoration composite after air-polishing. Biomed Eng Online. 2010;9:59.

4. Yap AU, Wu SS, Chelvan S, Tan ES. Effect of hygiene maintenance procedures on surface roughness of composite restoratives. Oper Dent. 2005;30(1):99-104.

5. Yurdaguven H, Aykor A, Ozel E, Sabuncu H, Soyman M. Influence of a prophylaxis paste on surface roughness of different composites, porcelain, enamel and dentin surfaces. Eur J Dent. 2012;6(1):1-8.

6. Gaikwad RM, Sokolov I. Silica nanoparticles to polish tooth surfaces for caries prevention. J Dent Res. 2008;87(10):980-3.

7. Crovace MC, Souza MT, Chinaglia CR, Peitl O, Zanotto ED. Biosilicate® — A multipurpose, highly bioactive glass-ceramic. In vitro, in vivo and clinical trials. J Non-Cryst Solids. 2016;432, Part A:90-110.

8. Pinheiro H, Lopes B, Klautau E, Cardoso J, Silva B, Cardoso P. Influence of Bioactive Materials Used on the Dentin SurfaceWhitened with Carbamide Peroxide 16%. Mat Res. 2010; 13(2): 273-8.

9. Pintado-Palomino K, Tirapelli C. The effect of home-use and in-office bleaching treatments combined with experimental desensitizing agents on enamel and dentin. Eur J Dent. 2015;9(1):66-73.

10. Tirapelli C, Panzeri H, Lara EH, Soares RG, Peitl O, Zanotto ED. The effect of a novel crystallised bioactive glass-ceramic powder on dentine hypersensitivity: a long-term clinical study. J Oral Rehabil. 2011;38(4):253-62.

11. Pintado-Palomino K, Peitl Filho O, Zanotto ED, Tirapelli C. A clinical, randomized, controlled study on the use of desensitizing agents during tooth bleaching. J Dent. 2015;43(9):1099-105.

12. Graumann SJ, Sensat ML, Stoltenberg JL. Air polishing: a review of current literature. J Dent Hyg. 2013;87(4):173-80.

13. Sauro S, Watson TF, Thompson I. Dentine desensitization induced by prophylactic and air-polishing procedures: an in vitro dentine permeability and confocal microscopy study. J Dent. 2010;38(5):411-22.

14. Martins CH, Carvalho TC, Souza MG, Ravagnani C, Peitl O, Zanotto ED, et al. Assessment of antimicrobial effect of Biosilicate® against anaerobic, microaerophilic and facultative anaerobic microorganisms. J Mater Sci Mater Med. 2011;22(6):1439-46.

15. Tirapelli C, Panzeri H, Soares RG, Peitl O, Zanotto ED. A novel bioactive glass-ceramic for treating dentin hypersensitivity. Braz Oral Res. 2010;24(4):381-7.

16. Wang Z, Jiang T, Sauro S, Wang Y, Thompson I, Watson TF, et al. Dentine remineralization induced by two bioactive glasses developed for air abrasion purposes. J Dent. 2011;39(11):746-56.

17. Fratolin MM, Bianco VC, Santos MJ, Rizkalla AS, Santos GC. The effect of prophylactic powders on the surface roughness of enamel. Compend Contin Educ Dent. 2014;35(9):e31-5.

18. Kielbassa AM, Gillmann L, Zantner C, Meyer-Lueckel H, Hellwig E, Schulte-Mönting J. Profilometric and microradiographic studies on the effects of toothpaste and acidic gel abrasivity on sound and demineralized bovine dental enamel. Caries Res. 2005;39(5):380-6.

19. Castanho GM, Arana-Chavez VE, Fava M. Roughness of human enamel surface submitted to different prophylaxis methods. J Clin Pediatr Dent. 2008;32(4):299-303.

20. Sahrmann P, Ronay V, Schmidlin PR, Attin T, Paqué F. Three-dimensional defect evaluation of air polishing on extracted human roots. J Periodontol. 2014;85(8):1107-14.

21. Bühler J, Schmidli F, Weiger R, Walter C. Analysis of the effects of air polishing powders containing sodium bicarbonate and glycine on human teeth. Clin Oral Investig. 2015;19(4):877-85.

22. Tada K, Kakuta K, Ogura H, Sato S. Effect of particle diameter on air polishing of dentin surfaces. Odontology. 2010;98(1):31-6.

23. Shimizu Y, Tada K, Seki H, Kakuta K, Miyagawa Y, Shen JF, et al. Effects of air polishing on the resin composite-dentin interface. Odontology. 2014;102(2):279-83.

24. Banerjee A, Hajatdoost-Sani M, Farrell S, Thompson I. A clinical evaluation and comparison of bioactive glass and sodium bicarbonate air-polishing powders. J Dent. 2010;38(6):475-9.

25. Petersilka GJ, Bell M, Mehl A, Hickel R, Flemmig TF. Root defects following air polishing. J Clin Periodontol. 2003;30(2):165-70.

26. Pelka MA, Altmaier K, Petschelt A, Lohbauer U. The effect of air-polishing abrasives on wear of direct restoration materials and sealants. J Am Dent Assoc. 2010;141(1):63-70.

27. Moëne R, Décaillet F, Andersen E, Mombelli A. Subgingival plaque removal using a new air-polishing device. J Periodontol. 2010;81(1):79-88.

28. Azarpazhooh A, Main PA. Efficacy of dental prophylaxis (rubber cup) for the prevention of caries and gingivitis: a systematic review of literature. Br Dent J. 2009;207(7):E14; discussion 328-9.

Corresponding author:
Karen Pintado-Palomino
Department of Dental Materials and Prosthodontics,
Ribeirão Preto School of Dentistry, University of São Paulo.
Avenida do Café s/n, Bairro Monte Alegre.
Postal Code: 14040-904.
Ribeirão Preto, SP, Brazil.
Tel.: +55-16-33150479.
E-mail: karenpintado@usp.br