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SURFACE ROUGHNESS OF RESIN-BASED COMPOSITES SUBJECTED TO PROFESSIONAL PROPHYLAXIS

Rugosidade de superfície de resinas compostas após profilaxia profissional

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ABSTRACT

Aim: This study evaluated the effect of two prophylaxis methods over the surface roughness of different resin composites. **Materials and Methods:** Ten disc-shaped specimens (7 mm x 2 mm) were made for each composite tested: MH - microhybrid composite with regular viscosity (Opallis); NH – nanohybrid composite with regular viscosity (Vittra APS); BF – high-viscosity bulk fill composite (Opus Bulk Fill); MHF - microhybrid flowable composite (Opallis flow); and OS – nanohybrid one-shade composite with regular viscosity (Vittra Unique). Initial roughness (Ra) values were obtained from each sample, and then they were divided into two groups (n = 5) following the prophylaxis method: SB – prophylaxis with sodium bicarbonate powder (125µm grain) using an air-powder polishing device (30 s application distanced 10 mm with 2 bar); and PP – prophylaxis with pumice paste and rotatory brush (30 s, 3000 rpm and pressure of 150 g). After that, a new Ra measurement (Raf) was obtained, and the difference was calculated (ΔRa). Data were compared using Three-way ANOVA followed by Bonferroni teste and the Ra difference (ΔRa) was analyzed by Two-way ANOVA followed by the Tukey test ($p<0.05$). **Results:** MHF presented higher Ra values after receiving prophylaxis with SB, while for NH, the abrasion with pumice increased the Ra, and for the other groups, no differences were found. **Discussion:** Alteration promoted by prophylaxis is material dependent. **Conclusion:** Professional prophylaxis with a bicarbonate jet or abrasion with pumice-based paste can induce changes in the composites' roughness.

Keywords: Composite resins. Dental prophylaxis. Disease prevention. Surface properties.

RESUMO

Objetivo: Avaliar o efeito de dois métodos de profilaxia sobre a rugosidade superficial de diferentes resinas compostas. **Materiais e Métodos:** Dez amostras (7 mm x 2 mm) foram confeccionadas para cada resina testada: MH - resina microhíbrida (viscosidade regular - Opallis); NH – resina nanohíbrida (viscosidade regular - Vittra APS); BF – resina bulk fill (alta viscosidade - Opus Bulk Fill); MHF – resina fluida microhíbrida (Opallis flow); e OS – resina nanohíbrida camaleão (viscosidade regular - Vittra Unique). Os valores iniciais de rugosidade (Rai) foram obtidos para cada amostra e então subdivididas em dois grupos (n = 5) seguindo o método de profilaxia: SB – jato de bicarbonato de sódio (125µm, 30 s, 10 mm de distância, 2 bar); e PP – profilaxia com pasta de pedra-pomes e escova rotatória (30 s, 3000 rpm e pressão de 150 g). Após, uma nova medida de Ra (Raf) foi obtida, e a diferença calculada (ΔRa). Os dados foram analisados pelo teste ANOVA três fatores e teste de Bonferroni, e a diferença de rugosidade (ΔRa) pelo teste Anova dois fatores e teste de Tukey ($p<0,05$). **Resultados:** MHF apresentou maior rugosidade após profilaxia com jato de bicarbonato, enquanto para NH a abrasão com pedra pomes foi mais deletéria. Para os demais grupos não houve diferença. **Discussão:** A alteração na rugosidade promovida pela profilaxia é material-dependente. **Conclusão:** A profilaxia profissional com jato de bicarbonato ou abrasão com pedra-pomes induziu alterações na rugosidade das resinas.

Palavras-chave: Resinas compostas. Profilaxia dentária. Prevenção de doenças. Propriedades de superfície.

INTRODUCTION

The resin composites have emerged as a major milestone for Restorative Dentistry, allowing the restoration of cavities with an adhesive approach and attending to the philosophy of minimally invasive dentistry[1]. Besides, they can mimic tooth structures due to their mechanical, physical, and optical properties and also present high clinical longevity[2–4]. Although the main component of the composite resins is essentially the organic monomeric matrix, silanized inorganic fillers, and a photoiniciator system, there are several variations that directly interfere with their mechanical and physical properties, also influencing the quality and clinical success of the restorative treatment[5,6].

After placing a restoration, the steps of finishing and polishing the composite surface are essential to improve surface smoothness and decrease chemical degradation, thus contributing to an increase in procedure longevity[7]. Still, after receiving a restoration, maintenance appointments are indicated, and their frequency shall be established according to the risk of the patient to develop caries, erosive wear, or other diseases. Maintenance is very crucial in restorative treatment success since they are subject to abrasion from food and oral hygiene processes, as well as constant changes in pH and temperature and microbial chemical degradation by the action of the biofilm. During maintenance and/or preventive appointments, professional prophylaxis procedures are commonly performed to mechanically remove biofilm, calculus, and extrinsic stains, such as those from tobacco and pigments from the diet (coffee, wine, black tee, among others), from the tooth or the restorations surfaces[8–10].

Dental prophylaxis uses an insoluble abrasive with a higher hardness than that of the biofilm/calculus/stain; thus, the particles remove them by abrasion[11]. Among the commonly used techniques is the pumice slurry rubbed against the dental or restoration surface with the help of a rotatory brush or rubber cup and the air-powder polishing devices (APDs) coupled with sodium bicarbonate particles, which are propelled against the intended surface with a water jet[10–13]. Evidence shows that the APDs can reach some surfaces easier, such as fissures, occlusal pits, and subgingival regions, and therefore remove biofilm/calculus/stains quicker than the rotatory option[14]. However, the use of sodium bicarbonate APD can increase surface roughness, particularly over some restorative materials, such as composite resins and glass ionomer cements (GICs)[15–18]. Rougher surfaces predispose the increase of biofilm retention on restoration surfaces, and consequently increase the risk for the development of secondary caries, discoloration, and staining, thus compromising their final brightness and aesthetic appearance[14,15,19–21].

Therefore, the aim of this study was to evaluate the effect of two prophylaxis methods (pumice/rotatory brush and an APD device) over the surface roughness of different resin composite types. The null hypothesis tested was that the prophylaxis technique does not cause harm over the composite surface, regardless of their composition.

MATERIALS AND METHODS

Specimen Preparation

Ten disc-shaped specimens with 7 mm in diameter and 2 mm in thickness were made with each one of the following resin composites tested: MH - microhybrid composite with regular viscosity (Opallis, FGM, Brazil); NH – nanohybrid composite with regular viscosity (Vittra APS, FGM, Brazil); BF – high-viscosity bulk fill composite (Opus Bulk Fill, FGM, Brazil); MHF - microhybrid flowable composite (Opallis flow, FGM, Brazil); and OS – nanohybrid one-shade composite with regular viscosity (Vittra Unique, FGM, Brazil). Table 1 shows the composition of the composites tested. The sample size was determined considering the results presented by Wobido et al.[22], and defined using G*Power (version 3.1.9.2).

Each specimen was built with the help of a silicon mold containing an internal circular-shaped cavity with 7 mm x 2 mm (diameter x height), in which the composite resin was placed inside in a single increment. A Mylar strip was placed over the composite and pressed with a glass slide to remove bubbles and imperfections. The composite was then photocured with a LED blue light (1200 mW/cm², Optilight Max, Dabi Atlante, Brazil), for 40 sec. Irradiance was constantly checked with a radiometer (Light intensity radiometer, model 3K, Spirith Health). After cure, the samples were embedded in acrylic resin inside PVC tubes (6 cm in diameter and 1.5 cm in height) and polished to standardize the surface smoothness and parallelism. Polishing was made with silicon-carbide paper (grit #600, #800 and #1200, Extec Cor, USA) for 60 sec each, under water irrigation and at a controlled speed (300 rpm). One operator polished all the specimens and was blinded to the material that was being polished.

Table 1. Composition of the composite resins tested

Group	Composite	Characteristic	Composition
MH	Opallis (shade A2) FGM Dental Group	Microhybrid with regular viscosity	Organic matrix: BIS-GMA, BIS-EMA, UDMA, TEG-DMA, camphorquinone, accelerators, stabilizers and pigments. Filler: Barium glass-aluminum, silanized silicates, nanoparticles of silicon dioxide. Filler size: nanoparticles 40 nm–3μm, mean size 0.5μm Filler% (Wt): 78-80%
NH	Vittra APS (shade A2) FGM Dental Group	Nanohybrid, with regular viscosity	Organic matrix: UDMA and TEGDMA, photoinitiator composition (APS), co-initiators, stabilizer, silane, and pigments. Filler: Zirconia, silica. Filler size: 200 nm Filler% (Wt): 72 to 82%
BF	Opus Bulk Fill (Shade A2) FGM Dental Group	High-viscosity bulk fill	Organic matrix: TEGDMA, BIS- EMA, UDMA, photoinitiators and APS co-initiators Filler: Silica with urethane dimethacrylate, salinized silica dioxide, salinized barium glass, ytterbium fluoride. Filler size: non informed Filler% (Wt): 79%
MHF	Opallis flow (shade A2) FGM Dental Group	Microhybrid, with flowable viscosity	Organic matrix: Bis-GMA, TEGDMA, Bis-EMA, camphorquinone, accelerators, stabilizers and pigments. Filler: Barium glass-aluminum, silanized silicates, nanoparticles of silicon dioxide. Filler size between 0.05 to 5μm Filler% (Wt): 72%
OS	Vittra Unique (one-shade) FGM Dental Group	Composite with regular viscosity. Particle size not informed by the manufacturer	Organic matrix: mixture of methacrylate monomers. APS photoinitiator composition, co-initiators, stabilizers, and silane. Do not contain Bis-GMA or Bis-EMA. Filler: boro-aluminum-silicate glass Filler size: not informed Filler% (Wt): 72% to 80%

Bis-GMA: Bis-Phenol A di-Glycidyl Methacrylate; BisEMA: Bis-Phenol A di-Glycidyl Ethoxylated methacrylate; TEGDMA: Triethylene glycol dimethacrylate; UDMA: Urethane dimethacrylate

Initial roughness measurements (Ra)

After finishing and polishing, the initial roughness (Ra_0) values of each sample were obtained using a contact profilometer (Surftest SJ-410, Mitutoyo, Japan). The parameter Ra was used, and measurements were obtained using the cut-off of 0.08, length of 4.2 mm, and mean speed of 0.5 mm/s. Three measurements were obtained from each specimen, and their average was considered as the Ra value of the specimen. Specimens with a Ra value discrepant in 15% of the total mean value were replaced. One calibrated operator read the sample's surfaces and was blinded to the material.

Prophylaxis treatments

After the measurement of the Ra_0 values, the specimens from each composite group were allocated into two groups (n=5) according to the prophylaxis treatment performed: SB – prophylaxis with sodium bicarbonate powder using an air-powder polishing device; and PP – prophylaxis with pumice paste and rotatory brush.

For the SB group, a standard air prophylaxis unit (Jetflex I, Dentflex, Brazil) was used in the whole study. Sodium bicarbonate powder (extra fine grain - 125µm, Airon, Maquira, Brazil) was used to fill the powder chamber; the jet was directed towards the composite surface for 30s, distancing 10 mm of distance and pressure of 2 bar[22]. For the PP group, a slurry was made by mixing pumice and distilled water (proportion 1:1 in weight). The samples were brushed with a prophylaxis brush (Microdont, São Paulo, Brazil) for 30 s at 3000 rpm[22] and a pressure of 150 g. All samples were treated by the same trained operator. After treatments, the specimens were placed in an ultrasonic bath for 5 minutes to remove the excesses of the prophylaxis material and kept moist at 37º C for 24 h.

After the surface treatments, a new Ra measurement (Ra_f) was obtained from each sample using the same parameters as the initial measurements. The same operator did the final Ra measurements. The mean difference between the final and initial roughness was calculated by Delta Ra (ΔRa), using the formula: $\Delta Ra = Ra_f - Ra_0$.

Statistical analysis

Data from roughness analysis were checked for normality assumption (Shapiro Wilk test). Data from initial and final roughness analysis were subjected to ANOVA three-way evaluation, followed by the Bonferroni test ($p < 0.05$), and data from ΔRa evaluation was submitted to ANOVA two-way, followed by the Tukey test (p<0.05). All analyses were made with the Jamovi software (v. 1.8 - The jamovi project - 2021).

RESULTS

The Anova Three-way data analysis revealed that there were no significant differences in the prophylaxis factor (p = 0.115), while for the resin type and interactions between factors, significant differences were found (p < 0.001). Table 2 shows the results of the Anova 3-way test. Regarding the composite type, the flowable one presented higher Ra values, and regarding the time (initial x final), the roughness was higher after treatment. Table 3 shows the mean values and standard deviation found for all groups and the results of the Bonferroni test from the interactions among factors.

Table 2. Results of the Anova three-way evaluation

	Sum of Squares	**df**	**Mean Square**	**F**	**p**
Resin	0.184	4	0.046	27.886	< .001
Prophylaxis	0.004	1	0.004	2.538	0.115
Time	0.266	1	0.266	161.135	< .001
Resin ✻ Prophylaxis	0.089	4	0.022	13.482	< .001
Resin ✻ Time	0.127	4	0.032	19.258	< .001
Prophylaxis ✻ Time	0.004	1	0.004	2.176	0.144
Resin ✻ Prophylaxis ✻ Time	0.090	4	0.023	13.673	< .001
Residuals	0.132	80	0.002		

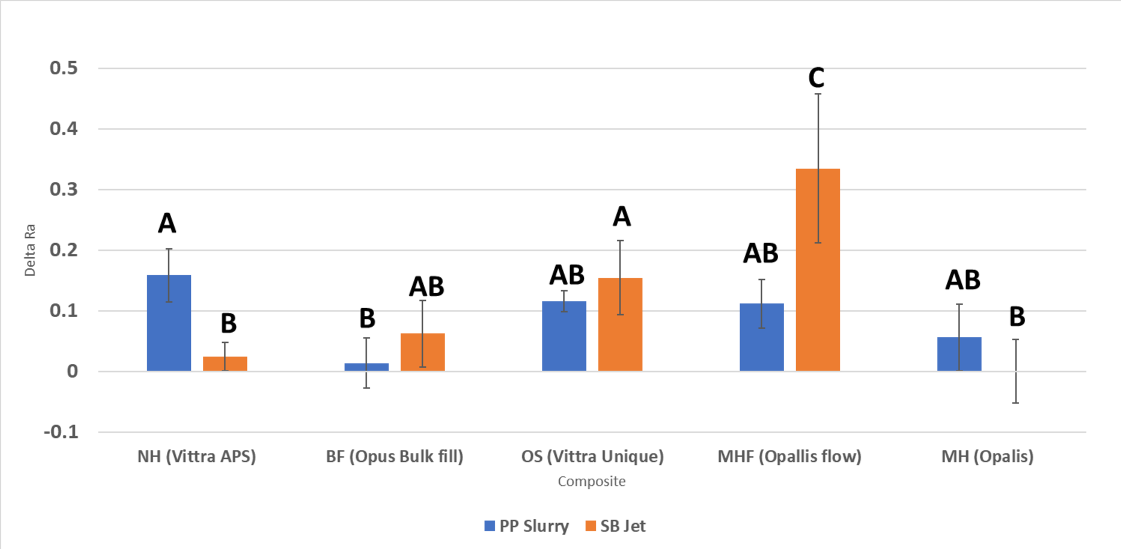
Table 3. Mean (± standard deviation) of Ra values and results of the Bonferroni test

	SB Jet		PP	
Composite	*Ra0*	*Raf*	*Ra0*	*Raf*
MH (Opallis)	0.300 (±0.007) Aa	0.300 (±0.046) Aa	0.299 (±0.007) Aa	0.356 (±0.050) ABa
NH (Vittra APS)	0.283 (±0.006) Aa	0.307 (±0.023) Aa	0.282 (±0.006) Aa	0.440 (±0.041) Ab#
BF (Bulk)	0.295 (±0.004) Aa	0.357 (±0.053) ABa	0.295 (±0.006) Aa	0.309 (±0.038) Ba
MHF (Flow)	0.314 (±0.017) Aa	0.649 (±0.109) Cc#	0.314 (±0.020) Aa	0.426 (±0.052) Ab
OS (Unique)	0.256 (±0.018) Aa	0.410 (±0.075) Bb	0.252 (±0.015) Aa	0.367 (±0.010) ABb

Uppercase letters show differences between composites within the same treatment and time. Lowercase letters show differences between the initial and final (Ra0 x Raf) conditions within the same composite and treatment. Symbol (#) shows differences between treatments (SB x PP) considering the same composite and time.

Regarding the Ra difference (ΔRa) there was a significant difference between the composites ($p < 0.001$), with the flowable composite presenting higher ΔRa values compared with all others. Regarding the surface treatments, there was no significant difference ($p = 0.150$) between the prophylaxis with sodium bicarbonate powder using an air-powder polishing device (SB) and the prophylaxis with pumice paste and rotatory brush (PP). The interaction between composites and surface treatment revealed significant differences ($p > 0.001$), and the results of the Tukey test are presented in Figure 1. The nanohybrid composite (Vittra APS) was more resistant to jet abrasion (SB) than to the use of slurry with the rotatory brush (PP), while for the flowable composite, the inverse was observed. For the one-shade composite, when using the PP treatment, there was no difference was observed with the other composites tested, but when subjected to the abrasive Jet (SB group), higher roughness was observed compared with the microhybrid one (Opalis).

Figure 1. Difference of roughness (means and standard deviation) with the results of Tukey test



DISCUSSION

The prophylaxis with pumice slurry or air-powder polishing system is both effective professional techniques for plaque and stain removal, without detrimental effects to the tooth structure or gingival tissues when correctly used[23]; however, little evidence is available regarding the effects of these methods on the surface of composite resins. Regarding the comparison between the prophylaxis methods tested, the present results indicate that the abrasion with pumice paste was more deleterious than the SB air-polishing device for the nanohybrid composite, white for the one-shade composite (Vitra Unique) and the flowable one, both prophylaxis methods were deleterious to the surface, increasing final roughness (Table 3). These results indicate that using sodium bicarbonate jet or abrasion by brushing with pumice paste can change the surface roughness of the tested composites, but these induced negative effects depend on the type of material.

It is suggested that the composite surface roughness is related to the size, hardness, and amount of fillers, which influence the mechanical properties of the resin composites[21]. The lower amount of filler in the flowable composite tested, associated with great variance between filler size (0.05 to 5µm -Table 1), might be responsible for these results, as during abrasive events, the organic phase of the composites is usually removed or worn first, leaving the inorganic particles protruding from the surface and resulting in a rougher profile[7]. The microhybrid flowable composite (Opallis flow) tested showed an even higher variation (ΔRa) when treated with the SB air-polishing device, possibly due to the lower volume of fillers compared to the other materials tested, thus decreasing the material resistance to wear. Still, this was the only one without UDMA in its composition, which might have also contributed to the results found in this study. It is suggested that urethane-base (UDMA) composites perform significantly better in terms of wear resistance than those which were BisGMA-based[24]. Clinically, restorations made with this flowable composite, such as class V cavities, fissures and pit sealants, and even restoration repairs, shall benefit from additional polishing after prophylaxis.

Still, the nanohybrid also increased in surface roughness after treatment with PP slurry, considering the comparison between initial x final condition, although when comparing with all composites, this difference was less significant (Fig 1). This can be explained by the lower amount of fillers (72 to 82%) compared with the BF (79%) and MH tested (78 to 80%). Interestingly, the single-shade composite (OS) presented alteration in the final roughness for both treatments (Table 3), and, when treated with the SB Jet, was less resistant than the microhybrid and the nanohybrid composites in the same treatment condition, indicating that the absence of silicate or zirconia fillers could diminish its wear resistance. Regarding this one-shade composite tested, this is a material recently launched in the market with the promise to optically mimic tooth color with a single material, without the need for layering technique, thus facilitating the restorative procedure. There are a few studies in the literature with this type of material, indicating favorable aesthetical results, the ability to mimic tooth color and opacity (so-called chameleon effect), and satisfactory mechanical properties[25–27]. When submitted to prophylaxis with SB jet, it presented higher Ra values than the nanohybrid and the microhybrid composites in the same condition, indicating that its monomeric composition or filler content is less resistant to abrasion, and as it is indicated mainly for aesthetic regions, it could benefit from an additional finish/polishing after prophylaxis to improve the surface roughness.

The surface texture of composites plays a significant role in biofilm formation, and it is reported that when the surface roughness is around 0.15μm, bacterial adhesion is reduced[28]. Still, rougher surfaces cause a significant impact on the composite aesthetic properties, compromising gloss and color stability and increasing the risk of discoloration[29,30]. Additionally, the human tongue is sensitive enough to detect even a slight surface roughness change of 0.3 μm, making a smooth surface more comfortable for patients[31]. All final values were above this limit, indicating the need for additional polishing of the surface previous prophylaxis treatments.

In this study, prophylaxis was performed after finishing and polishing the samples. It should be considered that, while in function, the composites are subject to aging processes due to the constant changes in pH and temperature, chemical degradation by the action of the biofilm, and water sorption due to contact with the saliva, among other factors[32–34]. All of these can induce an increase in surface roughness and also decrease its resistance to abrasive wear; therefore, the damage induced by the professional prophylaxis found in this study could be even higher over aged composites. Clinically, the dentist shall be aware of this effect, and a re-polishing of the surface of restorations after professional prophylaxis procedures is indicated.

CONCLUSION

Considering the limitations of this study, it can be concluded that professional prophylaxis with a bicarbonate jet or abrasion by brushing with a pumice-based paste can induce changes in the roughness of composite resins, depending on the type of material. The flowable and the one-shade composite presented greater surface roughness alteration after prophylaxis.

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CONFLICT OF INTERESTS

The authors declare that they have no conflict of interest.

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