SciForschen
Open HUB for Scientific Research
ISSN 2378-7090
International Journal of Dentistry and Oral Health
Research Article Volume: 2.5 Open Access

Effect of Air Polishing Procedure with Glycine and Bicarbonate Powders on Glass Ceramic and Composite Resin Surfaces

Mario F De Goes[1]*, Fabián Murillo-Gómez[1,2], Renally BW Lima[1] and Cristiana Godoy Sartori[1]

[1]*Department of Restorative Dentistry-Dental Materials Division, Piracicaba School of Dentistry-University of Campinas, Piracicaba, São Paulo, Brazil*
[2]*Department of Restorative Dentistry, School of Dentistry-University of Costa Rica, San José, Costa Rica*

***Corresponding author:** Mario Fernando de Goes, Department of Restorative Dentistry-Dental Materials Division, Piracicaba School of Dentistry-University of Campinas , Av. Limeira, 901 13414-903, Piracicaba, São Paulo, Brazil, Tel: 55-19-21065346; Fax: 55-19-34210144; **E-mail:** degoes@unicamp.br

Received date: 24 Feb 2016; **Accepted date:** 14 Mar 2016; **Published date:** 21 Mar 2016.

Citation: De Goes MF, Murillo-Gómez F, Lima RBW, Sartori CG (2016) Effect of air polishing procedure with glycine and bicarbonate powders on glass ceramic and composite resin surfaces. Int J Dent Oral Health 2(5): doi http://dx.doi.org/10.16966/2378-7090.191

Abstract

Objective: To evaluate the effect produced by air-polishing procedure using glycine and sodium bicarbonate-based powder on different restorative materials' surfaces.

Methods: There were used a nanofilled and nanohybrid composite resins and a glass-ceramic. Ten disks (n=10) of each material were made (6.5 mm × 0.5 mm). They were divided in 2 groups of 5 specimens each to be airpolished with sodium bicarbonateand glycine. The polishing procedure was performed at an angulation of 60°, 10 mm working distance, 10s and 4 bar pressure. A profilometer working at 0.5 mm/s was employed to evaluate roughness and a scanning electron microscope was used to evaluate surface morphology. Roughness was measured in all specimens before being polished to serve as control. All values were analyzed using ANOVA and Tukey test ($p<0.05$).

Results: Two-way ANOVA indicated that the factors "Restorative Material", "Polishing Powder" ($p<0.0001$) and also interaction between them were statistically significant. Nanohybrid composite treated with sodium bicarbonate (0.62 ± 0.20 μm) showed significantly higher roughness values than its control (0.37 ± 0.17)and also than the nanocomposite (0.16 ± 0.01 μm) and feldspathic ceramic (0.17 ± 0.05 μm) after treated with the same material ($p<0.05$). After treated with glycine the nanohybrid composite presented significantly lower roughness values (0.22 ± 0.07 μm) than when treated with sodium bicarbonate ($p<0.05$), and also it was not different from the nanocomposite (0.19 ± 0.05) and feldspathic ceramic (0.14 ± 0.02) after treated with the same material.

Conclusion: Sodium bicarbonate produced higher roughness values on the nanohybrid surface, and it also produced more morphological alterations on the two composite resins employed.

Keywords: Air polishing; Glycine powder; Sodium bicarbonate; Composite resin; Glass-ceramic

Introduction

Pressurized-air polishing system ejecting simultaneously water and abrasive powder is a less traumatic alternative method for removing supragingival extrinsic stains and bacterial deposits from teeth or restorative material surfaces when compared to rubber-cup polishing or to other invasive methods [1,2].

However, even air polishing may produce roughness on both tooth and restoration surfaces [3,4]. Surface damage of enamel, cement and restorative materials may accelerate biofilm accumulation and can cause aesthetic and gingival problems, depending on the abrasive powder employed, spraying time, working distance and angulation from the surface to be cleaned [5-8]. Although sodium bicarbonate powder has been largely used to perform air polishing procedure [9], concerns about gingival erosion have led to the recent development of a glycine-based powder. Considered as a highly water-soluble amino acid and presenting Morse hardness lower than that of $NaHCO_3$, glycine powder is considered clinically effective and it has a low abrasive effect on dental and restorative material surfaces [3,10-12].

Since air polishing method is becoming more popular, it is relevant to clarify the effect produced by different polishing powders on the most commonly used materials that may be exposed to this procedure, such as composite resins and ceramics, and also clarify if the effect they produce is the same for all kinds of restorative materials.

Scientific evidence regarding to the effect of bicarbonate and glycine powder on direct and indirect restorative materials surfaces is still quite scant, and no study has evaluated the impact of these powders on ceramic and composite resin surfaces simultaneously. So, the aim of this *in vitro* study was to examine the roughness and morphological effect produced by glycine and sodium bicarbonate based powder on two composite resins with different filler particle size and one glass-ceramic surfaces after an air polishing process.

Two null hypothesis were set in the present study. The first null hypothesis was that there will be no differences on the effect produced by both polishing powders on restorative materials' surface roughness. The second hypothesis set was that there will be no differenceson the behavior of restorative materials tested after both polishing treatments.

Materials and Methods

Two commercial composite resins (Filtek Supreme Ultra (nanocomposite)/ 3M/ESPE, St. Paul, MN; and IPS Empress direct (nanohybrid composite)/IvoclarVivadent, Schaan, Lichtenstein) and a feldspathic ceramic (Vitabloc Mark II/Vita, Bad Säckingen, Germany) were used (Table 1). Each commercial composite resin was dispensed into Teflon molds (6.5 ± 0.1 mm in diameter and 0.5 ± 0.05 mm in thickness) and immediately light-cured (Optilight Max, Gnatus, Brazil; light output: 600 mW/cm^2) for 20 seconds, following manufacturers' instructions.

Ten specimens of each nanocomposite and nanohybrid composite were isothermally conditioned at 35°C for 1 hour immediately after polimerization process. Cured specimens were retrieved, and stored for 24 hours at 100% relative humidity. Also, ten disc-shaped specimens (6.5 ± 0.1 mm in diameter and 0.5 ± 0.05 mm in thickness) were milled from feldspathic ceramic CAD/CAM blocks on an E4D Dentist System (D4D Technologies, LLC, Richardson, TX) using a custom-mill file. Both sides of each disk (composite resin and glass ceramic) were polished with 1000 grit sandpaper in order to calibrate inicial roughness for all materials. One specimen for each material was left untreated in order to serve as morphological control.

Air polishing process

Specimens from each material were divided in two groups of five specimens to be treated with two different abrasive powders: sodium bicarbonate (Polidental, Ind. E Com Ltda, SP, Brazil) and glycine-based powder (Clinpro Prophy Powder, 3M ESPE, Seefeld, Germany). All specimens were treated using a standard air polishing device (ProfiII Ceramic – DabiAtlante, RibeirãoPreto, SP, Brazil) at a working distance of 10 mm for 10 seconds and at an angulation of 60°. The working pressure was kept in 4.0 bar. All specimens were washed with tap water for 1 minute, ultrasonically cleaned in a water bath for 10 minutes, and air-dried.

Surface roughness measurement and scanning electron microscopy procedures

To measure the surface roughness of all specimens, a profilometer (Surcorder SE 1700, Kosaca Laboratory ltd, Tokio, Japan) with speed of 0.5 mm/s (0.25-mm cutoff) was used. All specimens were measured before being submitted to airpolishing procedure to record an initial roughness point for each one (control). For control and post polishment measuring, three measurements taken in different positions (left side, right side and the middle of the disk) were recorded automatically by the equipment, calculating then a surface roughness average (Ra) for each specimen. Finally a group average was obtained. Obtained data was analized by two-way ANOVAand Tukey test at significance level of 5%.

For SEM evaluation, all specimens were mounted on aluminum stubs, sputter coated with gold/palladium powder(SCD 050; Balzers, Schaan, Liechtenstein) and examined using a scanning electron microscope (JSM 5600LV;JEOL, Tokyo, Japan) operating at 15 kV.

Results

Both factors ("Restorative Material" ($p<0.0001$) and" Polishing Powder" ($p=0.0055$)) and also the interaction between them were statistically significant ($p<0.0001$). A summary of all surface roughness means is shown in table 2.

Roughness means of groups serving as control to sodium bicarbonate treatment (taken before polishing treatment), showed no statistical differences between materials, except for the nanohybrid composite (IPS Empress Direct) that presented statistically higher values ($p<0.05$) than the nanocomposite (Filtek Supreme Ultra). For the glycine groups, control measures demonstrated no statistical differences within the three materials (Table 2). Within the groups treated with sodium bicarbonate, nanohybrid composite roughness mean was statistically higher ($p<0.05$) than the nanocomposite and the feldspathic ceramic (Vitablock Mark II). For glycine treated groups, no statistical differences were detected ($p>0.05$).

For the nanohybrid composite just the sodium bicarbonate treatment rose the surface roughness compared to its control ($p<0.05$), while glycine treated group presented no significant difference with its control. On the other hand, both nanocomposite and feldspathic ceramic showed no statistical difference between their control and post-treatment groups for both polishing treatments ($p>0.05$).

Representative SEM photomicrographs of the control and treated specimens are shown in figures 1-3.

Figure 1a shows the typical morphological surface of nanocomposite (control), whereas figures 1b and 1c show the surfaces of nanocomposite after air polishing with glycine powder and sodium bicarbonate, respectively. Overall, it may be qualitatively observed that control surface seems to be less rough than that one polished with sodium bicarbonate but presented similar morphological surface to that one treated with glycine powder (Figures 1a-1c). Moreover, nanocomposite surface treated with glycine powder presented a smoother morphological surface than the one air-polished with bicarbonate powder (Figures 1b and 1c). It could also be observed that sodium bicarbonate produced small surface defects (a few filler particles were dislodged from the surface) on the nanocomposite surface, while glycine powder produced a surface pattern that may be characterized as a kind of "cleanliness", with composites´ nanofiller particles remaining on its surface.

Figure 2a exhibits the untreated nanohybrid composite surface (control), whereas figures 2b and 2c show nanohybrid composite surfaces after treated with glycine powder and sodium bicarbonate, respectively. It may be observed an irregular morphological surface of the control specimen with some visible scratches produced by the grit paper (Figure 2a). Nevertheless, the control surface was smoother than sodium bicarbonate treated surface (Figures 2a and 2c). However, the morphological aspect of the control surface revealed more irregularities than the one treated with glycine powder (Figures 2a and 2b). So, the surface of nanohybrid composite treated with glycine powder presented a smoother morphological surface than the one polished with sodium bicarbonate (Figures 2b and 2c). Also, it can be observed that the nanohybrid/sodium bicarbonate-treated surface, shows large surface depressions (a considerable quantitiy of filler particles were dislodged from the surface), while the glycine one, a smoother surface.

Material	Lot./Color	Composition*	Manufacturer
Filtek Supreme Ultra	N220206 Enamel A2	Bis-GMA, UDMA, TEGDMA, bis-EMA, fillers (non- aglomerated/ non-agregated 20 nm silica and 4-11 nm zirconia filler, aggregated zirconia/silica cluster filler.	3M ESPE St. Paul, MN, USA
IPS Empress Direct	R67351 Enamel A2	Dimethacrylates (UDMA, Bis-GMA, tricyclodocanedimethanoldimethacrylate), fillers 40-3000 nm (barium glass, ytterbium trifluoride, mixed oxide, silicon dioxide, and copolymer), additives, catalysts, stabilizers and pigments.	Ivoclar Vivadent, Schaan, Liechtenstein
Vitablock Mark II		SiO_2, Al_2O_3, Na_2O, K_2O, CaO, TiO_2	Vita, Bad Säckingen, Germany

Table 1: Restorative materials used in this study

*Bis-GMA: Bisphenol A diglycidyl ether dimethacrilate; UDMA: Urethane dimethacrylate; Bis-EMA: Ethoxylated bisphenol-A dimethacrylate; TEGDMA: Triethylene glycol dimethacrylate.

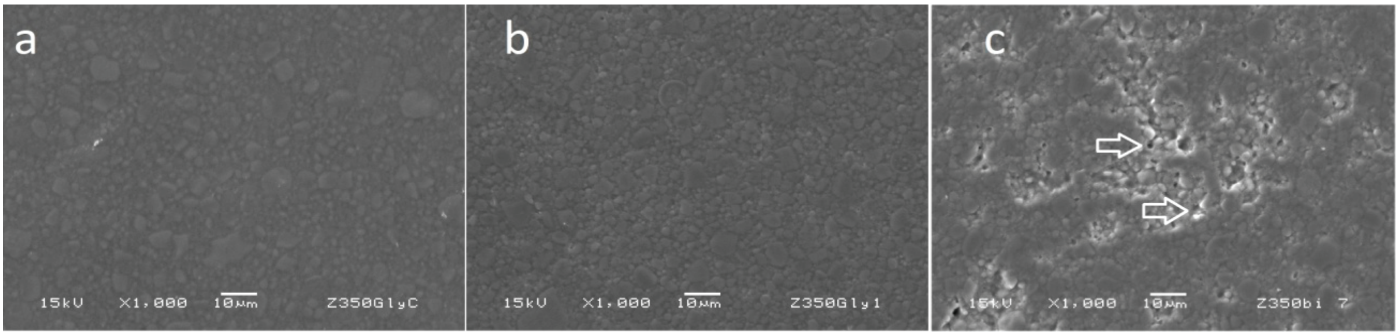

Figure 1: Typical SEM morphological surface images from: (a) Untreated nanocomposite surface (control); (b) Nanocomposite surface after treated with glycine powder; and, (c) Nanocomposite surface after treated with sodium bicarbonate. Note some filler-particles dislodged on the surface treated with sodium bicarbonate (arrows).

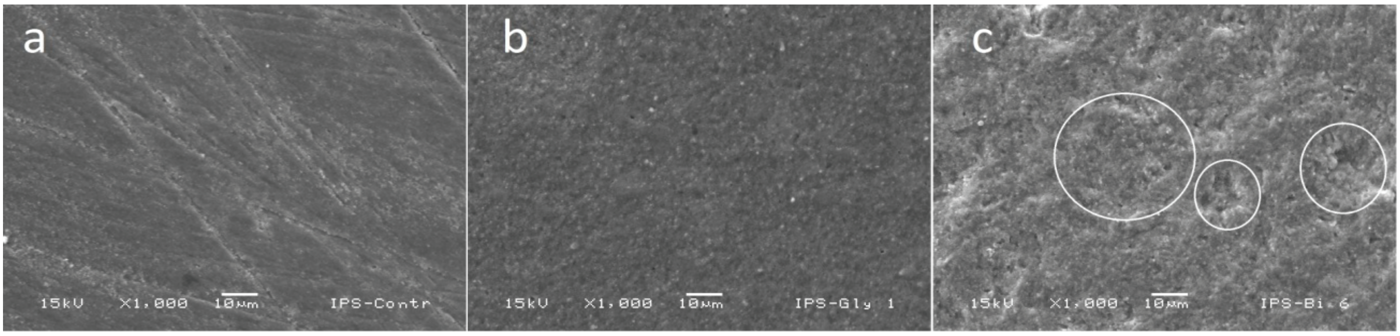

Figure 2: SEM morphological surface images from: (a) Untreated nanohybrid composite surface (control);(b) Nanohybrid composite surface after treated with glycine powder; and, (c) Nanohybrid composite after treated with sodium bicarbonate. Note the large surface defects produced on the surface treated with sodium bicarbonate (circles).

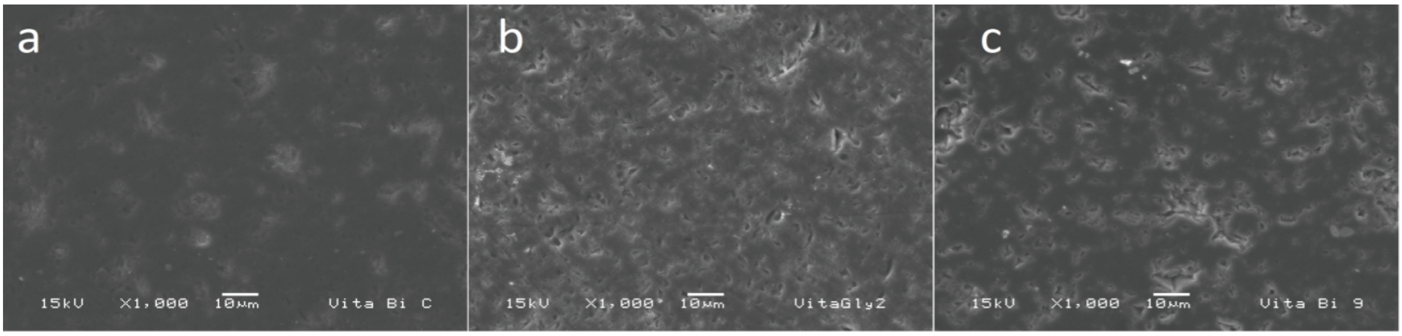

Figure 3: Typical SEM morphological surface image from:.(a) Untreated feldspathic ceramic surface (control); (b) Feldspathic ceramic surface after treated with glycine powder; and, (c) Feldspathic ceramic surface after treated with sodium bicarbonate.

On figure 3a, the typical morphological surface of feldspathic ceramic (control) can be seen, whereas figures 3b and 3c show the surfaces of feldspathic ceramic after air polishing with glycine powder and sodium bicarbonate, respectively. It could also be observed that control surface was smoother than the ones treated with both air polishing materials. The sodium bicarbonate and glycine powder airpolished surfaces presented similar morphological configuration and theyseem to have a "clean" or more regular aspect.

Discussion

The analyzed data in the present study indicated that both factors were statistically significant and also an interaction between them was detected. Pointing that differences were found between the effects produced by the two polishing powders and the behavior of the materials after both treatments, so both hypothesis must be rejected.

Air polishing procedure has been much utilized in the past years due to its effectiveness as a non-invasive prophylaxis method for periodontal treatment [7,11,13,14]. However, concern about its effect on dental structures and commonly used dental materials have grown, as all dental tissues and materials may suffer material loss after the application of this treatment [3]. Therefore, a certain amount of surface damage was expected when performing airpolishing procedure regardless of the polishing powder used, in accordance with previous works [8,10,12,14,15].

The obtained results suggested that the two air polishing powders produced different surface roughness values within the restorative materials, a fact confirmed by morphological observations where different surface patterns could be noted within the restorative materials tested (Figures 1-3).

Polishing Powder	Restorative Material		
	IPS Empress Direct	*Filtek Supreme Ultra*	*Vitablock Mark II*
Control-Sodium Bicarbonate	0.37 (0.17) Aa	0.18 (0.03) Ab	0.25 (0.14) Aab
Sodium Bicarbonate	0.62 (0.17) Ba	0.16 (0.01) Ab	0.17 (0.05) Ab
Control-Glycine	0.28 (0.06) Aa	0.24 (0.12) Aa	0.21 (0.05) Aa
Glycine	0.22 (0.07) Aa	0.19 (0.04) Aa	0.14 (0.02) Aa

Table 2: Surface roughness means (μm) and standard deviavion (in parenthesis) obtained from each tested restorative material when treated with two air polishing treatments (Sodium bicarbonate and Glycine powder) and their respective control group.
Same capital letters (column) and lowercase letters (row) represent no statistical difference by Tukey test ($p<0.05$).

Regarding surface roughness values, it could be noted that the nanohybrid composite resin (IPS Empress Direct) obtained significantly higher values than the nanocomposite resin (Filtek Supreme Ultra) and the feldspathic ceramic (these last two not different between them) when treated with sodium bicarbonate ($p<0.05$) (Table 2). Also, surface roughness mean obtained by nanohybrid composite resin was higher when treated with sodium bicarbonate than when glycine powder was employed ($p<0.05$). Thus, the highest roughness mean among all groups was obtained when nanohybrid composite resin was treated with sodium bicarbonate ($p<0.05$). This is in accordance with SEM images, where it could be observed profuse irregularities produced by sodium bicarbonate treatment (Figure 2c). A different morphological pattern could be noted on nanohybrid composite resin surface when treated with sodium bicarbonate and glycine. Glycine powder produced a more regular surface pattern than that produced by sodium bicarbonate (Figures 2b and 2c) and also smoother than the control group in which sanding marks appeared clearly (Figure 2a), but it can be said that this morphological difference between the control and glycine treated groups was not obtained on roughness values, as no statistical difference was detected between them. Pointing that glycine powder produced a kind of regularization on surface pattern for this material.

Conversely, SEM images for nanocomposite resin revealed almost no morphological differences between the control and the surface treated with glycine powder (Figures 1a and 1b). In the other hand, nanocomposite resin surface treated with sodium bicarbonate showed some irregularities and some filler particles dislodged. So, based on morphological analysis it could be suggested in general, that surface damage was higher for nanohybrid composite resin than for nanocomposite resin when using both air polishing powders, being more aggressive sodium bicarbonate for both nanohybrid and nanocomposite resins. Even though based on roughness values, it can be seen that just sodium bicarbonate produced a higher surface roughness for the nanohybrid composite (compared to nanocomposite) while the glycine produced no statistically different effect on this task for this two materials. Giacomelli et al. [12] found that sodium bicarbonate produced greater defects on nanocomposite resin than glycine powder, and thus being in accordance with the present findings.This fact can signalize that glycine powder produces less surface erosion than sodium bicarbonate, probably due to the smaller particle size of glycine, which is around 4 times smaller than sodium bicarbonate and the low abrasive characteristics of the crystal-particle present on glycine powder [15]. That difference in particle size and the lower density of glycine particles when compared with sodium bicarbonate powder may produce lower kinetic energy when glycine powder strikes material surface [14,16] and also it may cause less aggressive effect on gingival [14]. Those issues are in accordance with previous studies [3,4,12,17-19].

Nevertheless, sodium bicarbonate produced significantly higher roughness values than glycine powder just for nanohybrid composite resin. For nanocomposite resin there were no differences between both polishing powders' means. This can suggests that this nanocomposite resin is more resistant to wear effect than nanohybrid composite resin. Previous studies have reported lower properties for some nanohybrid composites compared with nanocomposite resins, maybe due to the incorporation of pre-polymerized resin fillers and also some bigger particles that could produce greater surface defects and roughness when submitted to wear [20,21]. In the case of nanohybrid composite resin (IPS Empress Direct) the filler particle size is between 40-3000 nm while for nanocomposite resin (Filtek SupremeUltra) is between 4-20 nm. Another possible factor that makes nanohybrid composite resin less resistant to wear is that it has less percentage of filler content than the nanocomposite resin used. Literature has reported that composites having more filler percentage will be stronger, stiffer and tougher [22].

To the author´s knowledge, no other study evaluated the effect of sodium bicarbonate and glycine powder on ceramic material. In the present work, a feldspathic material was tested along with two composite resins. When sodium bicarbonate was employed, feldspathic ceramic presented lower roughness values compared with the nanohybrid composite resin, but not different from the nanocomposite resin (Table 2). This points that roughness effect produced by sodium bicarbonate on feldspathic ceramic was similar to the one observed on nanocomposite resin, and that happened maybe due to their similar high wear resistance [22]. Also it could be inferred that because ceramic surface is harder than the two powders particles, no major morphological alteration occurred in that material (Figure 3).

When ceramic was air polished with glycine, it presented statistically not different roughness mean when compared with the two composite resins (Table 2). In fact, glycine produced similar roughness effect within the three materials. Thus, it can be inferred that glycine powder produced less roughness regardless of the material employed. Conversely, sodium bicarbonate produced higher roughness values and more aggressive morphological alterations on nanohybrid composite resin, when compared with the other materials used in this study. This can signalize that sodium bicarbonate roughness effect may be material-dependent.

Roughness effect on feldspathic ceramic produced by both polishment powders was similar (Table 2), same case of nanocomposite resin. Bearing in mind that post treatment roughness values obtained by them were between 0.14 (± 0.02) and 0.19 (± 0.05) μm (Table 2), it can be inferred that they had an acceptable performance when submitted to both powders, as they are in the "safe range" of roughness to avoid high surface bacterial accumulation, according to one *in vitro* study that suggested this safe range to be around 0.20 μm [23]. In the other hand the nanohybrid composite resin presented post treatment roughness values significantly higher than 0.20 μm after treated with sodium bicarbonate (Table 2).

In general it could be suggested that glycine powder caused less surface damage than sodium bicarbonate. Various studies referred that glycine powder is efficient in plaque removal and producing less damage to dental and gingival structures [8,14-16,18]. Other previous works in the other hand, found that less surface damage caused by glycine powder may be associated with limited plaque and staining removal in contrast with more efficient performance of sodium bicarbonate on this task, leading to a recommendation of incrementing time in procedure employing glycine powder [3]. In the present work, airpolishing was performed for 10s and plaque removal was not evaluated. Therefore no data regarding plaque removal effectiveness can be drawn from the present work, so future investigations evaluating plaque removal and surface damage together, should be encouraged. Also, knowledge about other aspects associated with airpolishing using both powders could be also extended such as dental sensitivity [24], dentin-restorative material bonding affectation [25] and effect on titanium implant abutments [17] for example.

Within the limitations of this *in vitro* study, it could be concluded that glycine powder had better performance than sodium bicarbonate air polishing on the nanohybrid composite surface. The surface roughness mean values (Ra) presented by nanocomposite material and feldspathic ceramic were significantly lower ($p<0.05$) compared with nanohybrid composite roughness values when sodium bicarbonate powder was employed. Also, glycine powder produced no significantly different roughness values between the three tested materials ($p>0.05$). Nanocomposite resin and feldspathic ceramic did not differ significantly among themselves ($p>0.05$). Glycine powder produced less aggressive morphological alterations on both composite resins than sodium bicarbonate, while in feldspathic ceramic no significant morphological differences were observed between the two powders employed.

Conclusion

This study showed that glycine powder produced less aggressive morphological alterations on both composite resins than sodium bicarbonate, while in feldspathic ceramic no significant morphological differences were observed between the two powders employed. Sodium bicarbonateair polishing produced higher roughness values on the nanohybrid surface, and it also produced more morphological alterations on the two composite resinsemployed.

Clinical Relevance

Scientific rationale

The effective use of air polishing method for supragingival extrinsic stains and biofilm removal in comparison with rubber-cup polishing or to other invasive methods has been established. This study clarifies the effect produced by air polishing using sodium bicarbonate and glycine powder on direct (composite resin) and indirect restorative (glass-ceramic) materials surfaces.

Clinical findings

Glycine-based powder air polishing produces a less aggressive effect than sodium bicarbonate-based powder on dental materials' surfaces.

Practical implications

Glycine powder air polishing can be used for clinical prophylaxis procedure without produce significant surface damage on commercial composite resin and glass-ceramic.

Acknowledgements

The authors want to dedicate this paper to the memory of Dra. Anadelia Borges Soares and thank her for her invaluable support in the present investigation.

References

1. Gutmann ME (1998) Air polishing: a comprehensive review of the literature. J Dent Hyg 72: 47-56.
2. Darby ML, Walsh MM (2010) Management of extrinsic and intrinsic stains. In: Dental Hygiene theory and Practice. 3rd edition, Saunders, St. Luis 511-528.
3. Pelka MA, Altmaier K, Petschelt A, Lohbauer U (2010) The effect of air –polishing abrasives on wear of direct restoration materials and sealants. J Am Dent Assoc 141: 63-70.
4. Engel S, Jost-Brinkmann PG, Spors CK, Mohammadian S, Müller-Hartwich R (2009) Abrasive effect of air-powder polishing on smoothsurface sealants. J Orofac Orthop 70: 363-370.
5. Arabaci T, Ciçek Y, Ozgöz M, Canakçi V, Canakçi, CF, et al. (2007) The comparison of the effects of three types of piezoelectrics ultrasonic tips and air polishing system on the filling materials: An *in vitro* study. Int J Dent Hyg 5: 205-210.
6. Pikdoken ML, Ozcelik C (2006) Severe enamel abrasion due to misuse of an air polishing device. Int J Dent Hyg 4: 209-212.
7. Petersilka GJ, Schenck U, Flemmig TF (2002) Powder emission rates of four air polishing devices. J Clin Periodontol 29: 694-698.
8. Petersilka GJ, Bell M, Mehl A, Hickel R, Flemmig TF (2003) Root defects following air polishing. J Clin Periodontol 30: 165-170.
9. Johnson WW, Barnes CM, Covey DA, Walker MP, Ross JA (2004) The effects of a commercial aluminum airpolishing powder on dental restorative materials. J Prosthodont 13: 166-172.
10. Petersilka GJ, Bell M, HäberleinI, Mehl A, Hickel R, et al. (2003) *In vitro* evaluation of novel low abrasive air polishing powders. J Clin Periodontol 30: 9-13.
11. Petersilka GJ, Steinmann D, Häberlein I, Heinecke A, Flemmig TF (2003) Subgingival plaque removal in buccal and lingual sites using a novel low abrasive air-polishing powder. J Clin Periodontol 30: 328-333.
12. Giacomelli L, Salerno M, Derchi G, Genovesi A, Paganin PP, et al. (2011) Effect of air polishing with glycine and bicarbonate powders on a nanocomposite used in dental restorations: An *in vitro* study. Int J Periodontics Restorative Dent 31: e51-e56.
13. Flemmig TF, Arushanov D, Daubert D, Rothen M, Mueller G, et al. (2012) Randomized controlled trial assessing efficacy and safety of glycine powder air polishing in moderate-to-deep periodontal pockets. J Periodontol 83: 444-452.
14. Petersilka G, Tunkel J, Barakos K, Heinecke A, Häberlein I, et al. (2003) Subgingival plaque removal at interdental sites using a low abrasive airpolishing powder. J Periodontol 74: 307-311.
15. Petersilka G, Faggion CM Jr, Stratmann U, Gerss J, Ehmke B, et al. (2008) Effect of glycine powder air-polishing on the gingiva. J Clin Periodontol 35: 324-332.
16. Flemmig TF, Hetzel M, Topoll H, Gerss J, Haeberlein I, et al. (2007) Subgingival debridement efficacy of glycine powder air polishing. J Periodontol 78: 1002-1010.
17. Cochis A, Fini M, Carrassi A, Migliario M, Visai L, et al. (2013) Effect of air polishing with glycine powder on titanium abutment surfaces. Clin Oral Implants Res 24: 904-909.
18. Khalefa M, Finke C, Jost-Brinkmann PG (2013) Effects of air-polishing devices with different abrasives on bovine primary and second teeth and deciduous human teeth. J Orofac Orthop 74: 370-380.
19. Salerno M, GiacomelliL, Derchi G, Patra N, Diaspro A (2010) Atomic force microscopy *in vitro* study of surface roughness and fractal character of a dental restoration composite after air-polishing. Biomed Eng Online 9: 59.
20. Blackham JT, Vandewalle KS, Lien W (2009) Properties of hybrid resin composite systems containing prepolymerized filler particles. Oper Dent 34: 697-702.
21. Ernst CP, Brandenbusch M, Meyer G, Canbek K, Gottschalk F, et al. (2006) Two-year clinical performance of a nanofiller vs a fine-particle hybrid resin composite. Clin Oral Investig 10: 119-125.
22. Ferracane JL (2011) Resin composite-State of the art. Dent Mater 27: 29-38.

23. Bollen CM, Lambrechts P, Quirynen M (1997) Comparison of surface roughness of oral hard materials to the threshold surface roughness for bacterial plaque retention: a review of the literature. Dent Mater 13: 258-269.
24. Banerjee A, Hajatdoost-Sani M, Farrel S, Thompson I (2010) A clinical evaluation and comparison of bioactive glass and sodium bicarbonate air-polishing powders. J Dent 38: 475-479.
25. Frankenberger R, Lohbauer U, Tay FR, Taschner M, Nikolaenko SA (2007) The effect of different air-polishing powders on dentin bonding. J Adhes Dent 9: 381-389.