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The Influence of Different Polishing Systems on the Surface Roughness and Microhardness of Nanocomposites after Exposure to Acid Drink

Bruna C. O. Lima[1], Carlize Vincenzi[1], Juliana Royer Heidmann[1], Glaucia M. B. Ambrosano[2], Virgínia Bosquiroli[3], Márcio J. Mendonça[3] and Veridiana Camilotti[3*]

[1]School of Dentistry, State University of Western Parana (UNIOESTE), Cascavel, Parana, Brazil.
[2]Departament of Social Odontology, School of Dentistry, State University of Campinas – FOP/Unicamp, Piracicaba, São Paulo, Brazil.
[3]Department of Restorative Dentistry, School of Dentistry, State University of Western Parana (UNIOESTE), Cascavel, Parana, Brazil.

Authors' contributions

This work was carried out in collaboration between all authors. Author VC designed the study, wrote the protocol, and wrote the first draft of the manuscript. Author GMBA performed the statistical analysis. Authors BCOL, CV and JRH managed the analyses of the study. Authors VB and MJM managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Aims: This in vitro study evaluated the surface roughness and microhardness of nanocomposites, after storage in acid solution for three months, with different techniques polishing systems.
Study Design: In vitro study.
Place and Duration of Study: Department of Restorative Dentistry, School of Dentistry, State University of Western Parana (UNIOESTE), Cascavel, Parana, Brazil, between June, and October, 2014.

**Corresponding author: E-mail: vericamilotti@hotmail.com;*

Methodology: A total of 280 specimens (4-mm in diameter, 2 mm thick) were fabricated for both tests (n=140 each test) in a plexiglass mold covered with a Mylar strip. After polymerization, specimens were divided into seven groups (n=20) according to the technique polishing systems: G1 – control group (no polishing treatment); G2 - Soft-Lex Discs; G3 - Diamont Master Discs; G4 - Po Go; G5 – Flexi discs; G6 – Enhance; G7 – Felt disks associated with diamond paste. All polishing systems were applied according to the manufacturers' instructions. The specimens were randomly divided into two groups according to the storage solution: a) distilled water and b) Coca-Cola classic, for a period of three months at 37℃. The surface roughness values were determined using a roughness test (initially and after three months). The microhardness measurements were performed using a digital microhardness tester (initially and after three months). The mean Ra and microhardness values were submitted to the LS means analysis and Tukey-Kramer test of 5%.
Results: There were no statistically significant differences between polishing systems in the roughness and microhardness of nanocomposites (p<0,05). The solution of Coca-Cola led to higher values of reduced surface roughness and microhardness values after 3 months of storage.
Conclusion: All polishing systems may be successfully used for polishing nanocomposites.

Keywords: Composite resin; dental polishing; surface roughness; microhardness.

1. INTRODUCTION

The search for esthetic materials has led to advances in the study of dental materials, especially composite resins, due to increased esthetic demands by patients, new developments in formulations and simplification of bonding procedures [1]. The composite resin used as an aesthetic restorative material is basically composed of an organic matrix and inorganic another. The organic matrix of composite resins is a mixture of methacrylate monomers with radicals. The main monomer is BisGMA developed by Bowen 40 years ago [2].

With respect to the inorganic matrix, the majority of composites can be found in the market micro-hybrid or hybrid and micro-particulates. The micro-particle composites have much charge is equal to 30% by volume with an average size of 0.04 micrometers. This gives the material a good polishing, but limited mechanical properties, which limits its indication only to regions where there incidence of masticatory forces. The hybrid composites have hybrid or micro-load volume of approximately 60% and average size of 0.6micrometres which ensures the material mechanical properties to withstand bending and compression stresses and the indication for anterior and posterior [3,4]. After the development of grinding technology to reduce the inorganic particles to a size less than 1 µm, the largest change in the systems of reinforcement of composites in recent years was to get particle sizes in the nanometer range (20 to 75 nm), whose surface was chemically treated with silane to avoid the formation of clusters. This technology enabled the inclusion of a volume (58.5%) similar to the proportion of glassy particles used inconventional composites and equivalence in physical properties [5].

Besides the type of organic matrix and / or inorganic another factor of great importance incomposite resin restorations is the surface quality and final polishing. The presence of irregularities can influence the appearance, retaining plate, surface discoloration, gingival inflammation, the solubility of the organic matrix and the occurrence of recurrent caries [6]. Various finishing and polishing systems are available on the market, including abrasive diamond tips, silicon disks, aluminum oxide discs, abrasive rubbers, and several polishing pastes containing thin abrasive particles [7]. Recently, PoGo, which is a special mixture of silicones, and the specific composition and distribution of an abrasive particle one-step polishing system for resin composites, has been introduced. This is known as a "one-step polishing system," because contouring, finishing and polishing procedures can be completed using a single instrument [8].

The surface smoothness, chemical composition and stability in the oral environment are factors that directly interfere with the clinical durability of composite resin restoration [9,10]. The oral environment is a very humid environment susceptible to hydrolytic degradation, which is capable of causing the displacement of charged particles and residual monomers inside the polymer making the surface of the composite rougher [3,11]. Thus, whatever the resin composite composition may be, the physical property and degree of conversion must

guarantee the restorative material resistance to the action of solvents in the oral medium. In this connection, the pH of the oral medium and time of contact with the solution have a great deal of influence on the onset of degradation of the restoration surface. Acid solutions, with coca cola, cause erosion of the agent coating the filler particles of the resin composite, causing loss of composite hardness due to the hydrolysis that occurs at the dimethacrylate bond to the organic matrix [9]. This process can in the short or long period, result in damage to the polymer, modifying its chemical structure and physical [12]. Like this, the aim of this in vitro study evaluated the surface roughness and microhardness of nanocomposites, after storage in acid solution for three months, with different techniques polishing systems. The null hypothesis for the present study stated that there shall not be any difference in the polishing ability of either the tested polishing systems after storage Coca cola or distilled water for surface roughness and microhardness test.

2. MATERIALS AND METHODS

2.1 Preparation of the Specimens

One nanocomposites (Filtek Z350/ 3M ESPE) was used in this study. The finishing and polishing systems evaluated were Soft-Lex Discs (3M ESPE), Discos Diamont Master (FGM), Po Go (Dentsply); Flexi discs (Cosmedent); Enhance (Dentsply); Felt disks associated with diamond paste (FGM). Table 1 shows the composition and manufacturers of the polishing systems tested.

Table 1. The Composition and manufacturers' instructions of the materials Investigated

Material	Composition	manufacturers' instructions
NanocompositeFiltekSupreme (3 M ESPE)	Zirconia/silica cluster, 78.5% filler weight , filler volume 59,5%, average filler size 0.5 a 75 nm	Apply 2 mm increments and photopolymerize for 30 seconds
Soft-Lex Pop-On Discs (3 M ESPE)	Mediumaluminum oxide disc (40µm) Fine aluminum oxide disc (24µm) Ultra-finealuminum oxide disc (8µm)	Application of the disks in decreasing order of grain with intermittent pressure and low speed for 20 seconds. Prior to disk swapping, the specimens were washed with jets of air / water to remove polishing residues and dried with air jets and then polished with another disc of finer grain.
Diamont Master Discs (FGM)	Medium (29µm), Fine (14µm), Extrafine (5µm)	Application of the disks in decreasing order of grain with intermittent pressure and low speed for 20 seconds. Prior to disk swapping, the specimens were washed with jets of air / water to remove polishing residues and dried with air jets and then polished with another disc of finer grain.
PoGo (Dentsply)	Diamond coatedmicro-polisher	Applying pressure for 30 seconds and 10 seconds of intermittent gentle application.
Flexicups (Cosmedent)	Medium (blue) Extra-fine (pink)	Application of blue cup for 40 seconds. Application of air jet / water to remove polishing residues and dried with air jets and application of the cup pink for 40 seconds.
Enhance (Dentsply)	40µmaluminum oxide	Applyingpressure for 30 seconds
Diamond Flex (FGM)	Felt	Application of the felt disc was used in combination with a polishing paste applied on the surface of the body of the test piece at low speed for 60 seconds.
Excel® diamond paste	2-4µm	Application of the felt disc was used in combination with a polishing paste applied on the surface of the body of the test piece at low speed for 60 seconds.

Table 2. Description of solutions used with the pH value

Storage solution	pH	Composition	Manufacturer
Distilledwater	5,30	Distilled water	_____
Coca-cola Classic	2,73	Carbonated water, sugar, 2400 g, enough water to dissolve, caramel: 37 g, caffeine, 3.1 g phosphoric acid: 11 g, coca leaf: 1.1 g, kola nut: 0.37 g	Coca-Cola classic®/ Coca-cola LTDA

A total 280 specimens were fabricated for both tests (n=140 for each test) using a plexiglass well (4 mm in diameter and 2 mm thick) with a polyester strip (ProbemLtda, Catanduva, Brazil) was placed over the resin composite and finger pressure was applied with the aid of a 2 mm thick glass plate. The material was light activated for 30 seconds through the polyester strip, using a light unit (Elipar Free-Light 2/3M ESPE) with a power density of 1200 mW/cm2, gauged on a radiometer (L.E.D radiometer Demetron /Kerr, Middleton, USA).The curing light was placed perpendicular to the specimen's surface at or less than a distance of 1.0 mm. The curing light intensity was measured at 1200 mW/cm^2 and monitored with a light meter.

To reduce variability, all specimen preparation, finishing and polishing procedures were performed by the same operator. The specimens were examined for obvious voids, labeled on the bottom and randomly separated into seven treatment groups (n=40), according to the technique polishing systems (Table 1): G1 – Control group (no polishing treatment); G2 - Soft-Lex Discs; G3 - Diamont Master Discs; G4 - Po Go; G5 – Flexi discs; G6 – Enhance; G7 – Felt disks associated with diamond paste. All polishing systems were applied according to the manufacturers' instructions (Table 1). The specimens were randomly divided into two groups according to the storage solution: a) distilled water and b) Coca-Cola classic, for a period of three months at 37℃ (Table 2). The solutions were changed daily during this period.

2.2 Surface Roughness Test

The surface of the specimens were divided into two parts, the right part (marked a permanent marker of blue color) was intended for the surface roughness test and the other for the surface microhardness test. Both devices (Roughness meter and Microhardner) were calibrated to cover only half the surface of the specimens.

The surface roughness test was performed with a Rugosimeter (Surfcorder SE 1700) with a diamond tip 2 µm in diameter was used, which traversed a previously delimited surface (1.25 mm). Three successive measurements in different directions were recorded for all the specimens in each group. Average surface roughness (Ra) values were obtained.

2.3 Microhardness Test

On the left medial surface of each specimen, the Knoop hardness was determined using a microhardner machine (HMV 2000 Shimadzu). Indentations were made with a 50 g load applied for 15 seconds. Three consecutive and equidistant readings were obtained per specimen, and the microhardness value was obtained as the average of these findings.

2.3 Statistical Analysis

As the same test specimen was used for measuring the surface roughness and microhardness values for all the evaluated periods, the mixed model Maunchlysphericity test was applied by the PROC MIXED procedure for repeated measures of the SAS statistical program. The means of treatments were compared using the command LS means and Tukey-Kramer test. The level of significance considered was 5%.

*SAS Institute Inc., Cary, NC, USA, Release 9.1, 2008

3. RESULTS AND DISCUSSION

The average surface roughness values and standard deviation produced by different polishing systems are listed in Table 3 and 4.

3.1 Surface Roughness Test

Table 3 shows that in the initial period statistically significant lower values of roughness were found for control group and the highest values was significantly Masters for polishing discs. The other groups did not differ statistically among themselves. After 3-months of immersion in the control group continued to be the lowest roughness significantly followed by Soft-Lex discs. The other groups did not differ after three months of immersion in water.

Table 3. Mean values and standard deviations of groups for surface roughness (Ra)

Time	Groups	Storage solution	
		Distilled water	Coca-cola®
24h	Flexi cups	*0,239 (±0,031) Abcd	*O,263(±0,048) Aa
	Enhance	0,274 (±0,04) Aab	*0,269 (±0,038) Aa
	PoGo	0,245 (±0,046) Abc	*0,256 (±0,024) Aa
	Soft-Lex	0,215 (±0,022) Acd	*0,247 (±0,028) Aa
	Diamond Flex	0,269 (±0,025) Aab	*0,237 (±0,024) Aa
	Diamont Master Discs	0,309 (±0,034) Aa	*0,228 (±0,029) Bab
	Control group	0,192 (±0,018) Ad	*0,182 (±0,023) Ab
Threemonths	Flexi cups	0,315 (±0,023) Aa	0,350 (±0,025) Aa
	Enhance	0,318 (±0,035) Aa	0,341 (±0,032) Aa
	PoGo	0,287 (±0,047) Aab	0,327 (±0,022) Aa
	Soft-Lex	0,239 (±0,019) Bbc	0,334 (±0,031) Aa
	Diamond Flex	0,310 (±0,027) Aa	0,324 (±0,019) Aa
	Diamont Master Discs	0,325 (±0,035) Aa	0,322 (±0,043) Aa
	Controlgroup	0,233 (±0,016) Ac	0,313 (±0,013) Ba

*Means followed by different letters (uppercase letters in the horizontal and vertical solution compared within each material and time) differ among them (p≤0.05).*Differs from the second time within the same solution and material (p ≤ 0.05).*

Table 4. Mean values and standard deviations of groups for surface microhardness test

Material	Storagesolution	Time	
		24h	Three months
Flexicups	Água	58,53 (±2,75) Aa	29,21 (±7,98) Ba
	Coca-cola	55,53(±3,44) Aa	24,81(±5,34) Bb
Enhance	Água	57,36 (±3,56) Aa	28,53 (±6,35) Ba
	Coca-cola	58,6(±4,66) Aa	23,01(±6,59) Bb
PoGo	Agua	54,08(±6,29) Aa	31,42(±5,32) Ba
	Coca-cola	53,06 (±7,68) Aa	25,52(±4,67) Bb
Soft-Lex	Agua	56,36(±3,29) Aa	29,56(±6,64) Ba
	Coca-cola	59,05(±5,18) Aa	23,54(±4,73) Bb
Diamond Flex	Água	57,96(±3,01) Aa	28,20(±9,12) Ba
	Coca-cola	58,38(±4,84) Aa	22,92 (±3,47) Bb
Diamont Master Discs	Água	59,24(±3,90) Aa	28,62 (±7,89) Ba
	Coca-cola	56,87 (±4,58) Aa	22,72 (±6,11) Bb
ControlGroup	Água	61,71 (±9,04) Aa	30,62 (±6,46) Ba
	Coca-cola	60,86 (±6,85) Aa	24,15 (±6,33) Bb

Means followed by different letters (uppercase letters in the horizontal and vertical solution compared within each material and time) differ among them (p≤0.05). There was no significant difference between the materials (p=0.2821)

On coca-cola solution in the initial period the significantly lower values of roughness were found for the control group, while the other study groups did not differ statistically among themselves. After 3-months of immersion in Coca-Cola were not significant differences between all groups.

In the analysis of the evaluation period, we determined that the solution to water there was no statistically significant differences between the materials, except for Cosmedent which showed higher values of roughness statistically significant after three months of immersion when compared to the initial period. For the solution coca-cola, all materials showed significant increase in roughness values after three months of immersion.

Comparing the effect of solution on the values of roughness, there was no significant influence of the groups evaluated according to the type of solution store. With the exception of the polyester strip that had higher values of roughness significantly in the solution of cola after three months of immersion compared with water for the same period of evaluation. By that way the null hypothesis was rejected.

3.2 Microhardness Test

The average microhardness values and standard deviations produced by groups evaluated are listed in Table 4. According to the microhardness values, no statistically significant differences were observed between the polishing systems (p=0.2821). After the 3-month storage period in coca-cola all polishing systems presented significantly softer surfaces in comparison with the 24 hour samples ($p \leq 0.05$). On the other hand, for the surface microhardness, no significant alteration was detected when 3-month storage period in distilled water.

The effectiveness of surface finishing and polishing procedures is of fundamental importance for any restoration [13]. These procedures are commonly required after placement of direct composite resin restorations since they minimize the retention of plaque and stains and other problems resulting from the exposure of rough surfaces to the oral environment [14]. Composites are finished and polished to establish a functional occlusal relationship and a contour that is physiologically in harmony with supporting tissues [15]. Thus, it is important to determine which finishing and polishing system offers the best results for maintaining esthetic restorations.

In the present study, the group that achieved the highest surface smoothness was the control group, this result corroborates with the findings of Yazici [15], where the polishing with the polyester strip obtained the lowest values of surface roughness. Even if care is taken in the placement of the matrix, removal of excess material and recontouring of restorations are frequently necessary. However, these procedures significantly increase surface roughness. Thus, a large number of polishing techniques is available for composites [14].

After 3-months of immersion in the control group continued to be the lowest roughness significantly followed by Soft-Lex discs. The other groups did not differ after three months of immersion in water, with the exception of Flexi cups. This result disagrees with Cenci [16] have shown after one-year storage in distilled water, the sequential technique still exhibited comparable or better results than standard techniques. These results deferred, since the authors used longer immersion and also a microhybrid resin composite. The microhybrid composite were irregular-shaped particles, which complicates the finishing and polishing procedures. Since the composite nanoparticles used in this study presents filler particles that promote more regular surface acting as a facilitator for all polishing techniques, on the other hand, both in this study as the work of Cenci [16] flexicups showed the highest values of roughness after immersion in water.

After 3-month storage period in distilled water still smoothest surface in all the composite groups tested followed by Soft-Lex discs. The other groups did not differ significantly among themselves after 3-months of storage in water [17]. The influence of the initial finishing method on final surface roughness increased as the number of subsequent polishing steps decreased. The influence of the finishing method on surface roughness after polishing was strongest with Soft-Lex, agreement with the results of this study.

After 3-months of immersion in Coca-Cola were not significant differences between all groups for roughness test and all differ significantly with the initial period. Coca-cola Classic® (pH 2, 68) to present in its composition the phosphoric acid solution is considered a high-powered dental erosion [18]. The period of immersion associated with low pH and the presence of a strong acid may have been the factors that caused the loss of filler particles in the composite resin evaluated for all techniques of polishing, caused significant increase in the values of surface roughness and reduced statistical in microhardness values [19].

The relative importance of a microhardness test shows the fact that it gives information as to the mechanical properties of the material. No other significant difference in microhardness was observed among the different polishing systems tested agreement with the results of Korkmaz [6]. The hardness results indicate that the storage period presented a significant detrimental effect on the surfaces of the composites. As a probable consequence, the inorganic particles are no longer provided with a stable structure, which could predispose to filler dislodgment and elution [20]. The hardness results indicate that the storage period presented a significant detrimental effect on the surfaces of the composites. As a probable consequence, the inorganic particles are no longer provided with a stable structure, which could predispose to filler dislodgment and elution. Therefore, one could expect that the decreased surface hardness should be accompanied by increased surface

roughness. Indeed, water sorption reduces the hoop stresses around fillers, which facilitates the plucking-out of particles. Nonetheless, although filler leaching probably occurred during the storage period, composite resin showed no significant alteration in surface roughness between the periods before and after the immersion ($p \leq 0.05$). Corroborating this finding, Tuncer et al. [21] reported that, the microhardness values were significantly different from the initial values after immersion in coca cola solution.

This study demonstrated that the use of the technique carried out with polishing abrasive erasers (one or more steps) showed similar results to testing surface roughness and microhardness when compared to the use of aluminum oxide discs in the two assessment periods suggesting that the use of alternative techniques of a polishing step can improve in areas that are difficult to access with aluminum oxide discs.

4. CONCLUSION

Within the limitations of this study, it is possible to conclude that:

1. The smoothest surfaces were produced with Mylar strips
2. Values of roughness, there was no significant influence of the groups evaluated according to the type of solution store
3. There were no statistically significant differences between polishing systems
4. Surface microhardness, no significant alteration was detected when 3-month storage period in distilled water.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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