Original Article

Effect of Polishing on the Surface Microhardness of Nanohybrid Composite Resins Subjected to 35% Hydrogen Peroxide: An *In vitro* Study

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Abstract

Aim: The use of bleaching agents, despite being a conservative treatment, can cause a decrease in the surface microhardness of dental resins, affecting their aesthetics and performance. The aim of this study was to evaluate the *in vitro* effect of polishing on the surface microhardness of nanohybrid composite resins that were subjected to bleaching with 35% hydrogen peroxide. **Materials and Methods:** This cross-sectional, *in vitro* experimental study consisted of 30 composite resin samples made according to ISO 4049-2019 and divided equally into two groups (A and B) which were subjected to 35% hydrogen peroxide bleaching. Group A was subjected to polishing procedure, whereas group B was the control group. The samples were stored in distilled water at 37°C for 24 h. The Vickers microhardness was determined with a load of 100 g-f for 10 s. The data were analyzed with Student's *t*-test for independent samples at a confidence level of 95%. **Results:** The surface microhardness of the group that was subjected to polishing (A) obtained a mean of 78.07 ± 7.96 HV, whereas for the group that was not subjected to polishing (B) the mean was 65.67 ± 5.22 HV. The difference between groups (A and B) was statistically significant ($P < 0.001$). **Conclusion:** Nanohybrid composite resins previously subjected to 35% hydrogen peroxide gel significantly increased their surface microhardness when subjected to polishing when compared with unpolished nanohybrid composite resins.

Keywords: *Hydrogen peroxide, nanohybrid resins, polishing, surface microhardness*

Introduction

Composite resins appeared in the 1960s as an alternative to acrylic resins and silicate cements. As the performance of composites has improved along with the increasing demand for aesthetic perfection, many dentists recommend the use of nanohybrid composite resins due to their high biocompatibility and physical properties such as increased wear resistance and surface hardness, as they consist of nanoparticles and ceramic metal fillers that enhance their surface to facilitate modeling and improve the aesthetic finish.[1,2] Microhardness of the composite resin surface is important for clinical success in dental restorations. The higher the microhardness of the restorative material, the better the resistance to wear and surface scratching.[3,4] It is therefore important to improve this mechanical property of the composite resin surface by polishing, as this procedure aims to eliminate rough surfaces that will eventually affect its resistance to chewing forces, as small surface reliefs can fracture and facilitate pigment retention and even facilitate the formation of secondary caries.[5-7]

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Throughout time, dentistry has sought to develop alternative techniques for aesthetic restorations in order to have teeth without pigmentation and not generate unnecessary wear in their structure. This has given rise to treatments such as enamel bleaching, which is a conservative, simple, relatively quick, and effective technique for modifying the "value" variable in the color of pigmented teeth, whether vital or endodontically treated, which can be carriers of physiological and pathological alterations.[8] However, some researchers report that the use of bleaching agents, despite being an efficient conservative treatment with predictable results, may cause morphological and microstructural changes in restorations as well as variations in their chemical composition that could affect the surface microhardness.[9,10] It is important to be aware of such effects, as the morphology and microhardness of the composite resin surface influence not only the aesthetic success, but also oral health.[11]

Therefore, the aim of this study was to evaluate the *in vitro* effect of polishing on the surface microhardness of nanohybrid composite resins that were subjected to bleaching procedure with 35% hydrogen peroxide.

Materials and Methods

Sample calculation and selection

This was a cross-sectional, analytical, *in vitro* experimental study. The universe consisted of 30 standardized nanohybrid composite resin samples (6 mm height × 6 mm diameter), which were prepared according to ISO (International Organization for Standardization) technical standard 4049:2019.[12]

The sample size was 15 composite resin samples per group and was calculated based on data obtained in a previous pilot study, in which the mean comparison formula was applied considering an $\alpha = 0.05$ and a statistical power $(1-\beta) = 0.8$, with variances $S_1^2 = 0.86$ and $S_2^2 = 0.94$. The distribution of samples was randomly assigned to the groups by a blinded laboratory assistant. Subsequently, the statistical analysis of results was also processed by a third blinded researcher. The groups were formed as follows:

Group A (*experimental group*): 15 polished nanohybrid composite resin samples, previously subjected to bleaching procedure with 35% hydrogen peroxide.

Group B (*control group*): 15 unpolished nanohybrid composite resin samples, previously subjected to bleaching procedure with 35% hydrogen peroxide.

Sample characteristics and preparation

Samples of nanohybrid composite resin (Brillant NG, Coltene, Rio de Janeiro, Brazil) color A2 were used in this study. These were prepared with standardized molds of 6 mm diameter and 6 mm depth according to the ISO 4949-2019 Technical Standard[12] at the Operative Dentistry Laboratory of the Universidad Nacional Federico Villarreal, Peru. When sample was finished, a celluloid matrix was placed over the mold and a 1 mm thick microscope slide was placed on top of it to ensure that the upper and lower surfaces were parallel. The resin layers were light-cured from the top of the mold with a light emitting diode lamp (Bluephase N, Ivoclar Vivadent, AG, Liechtenstein) at a light intensity of 1200 mW/cm^2 for 20 s. The intensity was verified by a radiometer (Litex 682, Dentamerica, CA, USA).

Once the 30 smooth-surfaced nanohybrid composite resin samples were obtained, they were stored in an oven at 37°C for 24 h. The next day, all the specimens were treated with 35% hydrogen peroxide gel bleaching agent (Whiteness HP Maxx—FGM, Joinville, Santa Catarina, Brazil) in three applications of 15 min on the surface, according to the manufacturer's recommendation[13] [Figure 1]. Between each application, the samples were washed with distilled water and dried with sterile gauze for a total of 45 min per session.

After 24 h, group A was polished with a disc system (Sof-Lex, 3M ESPE, St Paul, SM, USA) from coarse to fine grain [Figure 2], whereas group B was not

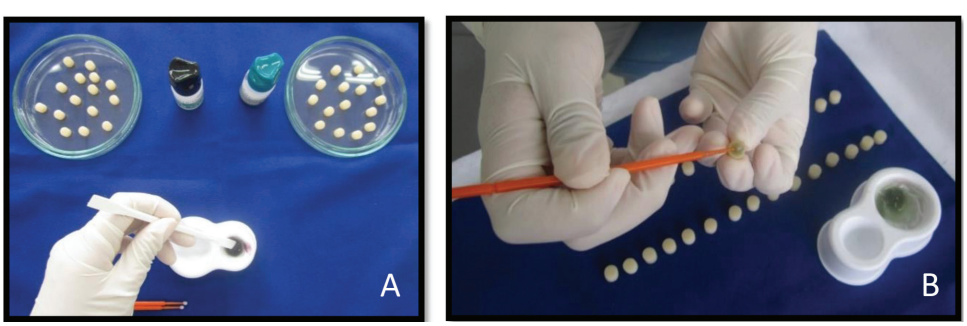


Figure 1: (A) Mixing procedure between 35% hydrogen peroxide and thickening agent. (B) Application of the bleaching agent on the surface of the resin samples

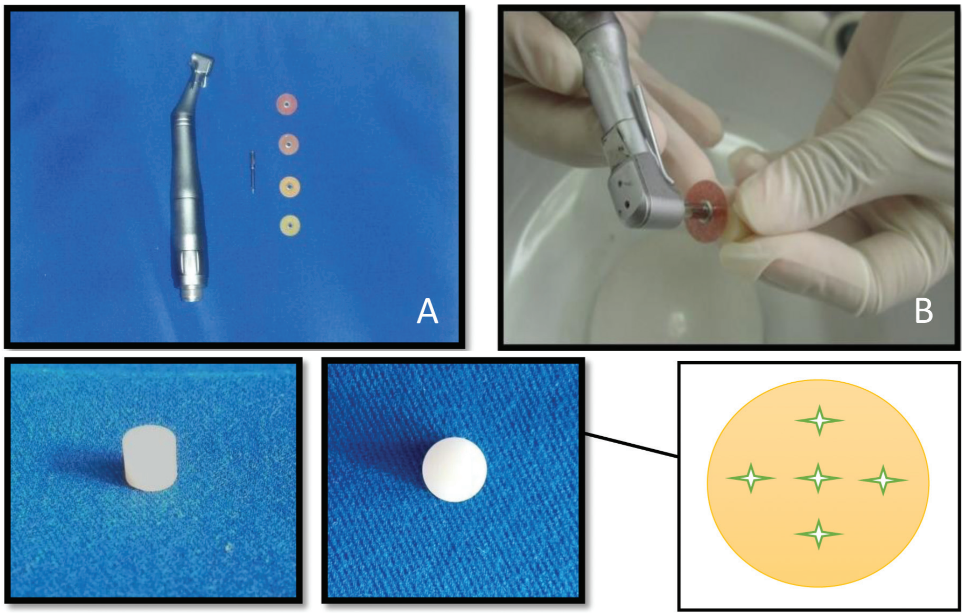


Figure 2: (A) Sof-Lex discs from coarse to fine grain. (B) Polishing of resin samples (experimental group).

polished. All samples were then stored in an oven with distilled water at 37°C for 24 h. After this time, surface microhardness tests were performed.

Surface microhardness test

Each composite resin sample was subjected to five indentations under a load of 100 g-f for 10 s in five different points with the same distance between them, maintaining a minimum distance of 1 mm from the sample margins. This was performed with a hardness tester (Leitz, W, Germany). The surface microhardness value [kg/mm^2 = HV (Vickers Hardness)] was determined by dividing the load applied on the surface of the indentation [Figures 2–4].

Statistical analysis

The collected data were entered into an Excel 2016 spreadsheet (Microsoft, Redmond, WA, USA) and then imported into SPSS (Statistical Package for the Social Sciences, Inc. IBM, NY, USA) version 24.0 for statistical analysis. For the descriptive analysis, measures of central tendency and dispersion such as mean and standard deviation were used. For the inferential analysis, the Shapiro–Wilk test was used to assess whether the data had a normal distribution, and the Levene homoscedasticity test was used to assess homogeneity of variances. For hypothesis testing, it was decided to use the parametric Student's *t*-test for independent samples. Differences were considered statistically significant at $P < 0.05$.

Results

After bleaching with 35% hydrogen peroxide gel in both groups, the nanohybrid composite resin group with polishing (experimental) presented significantly higher surface microhardness than the nanohybrid composite resin group without polishing (control) ($P<0.001$) [Table 1 and Graphs 1 and 2].

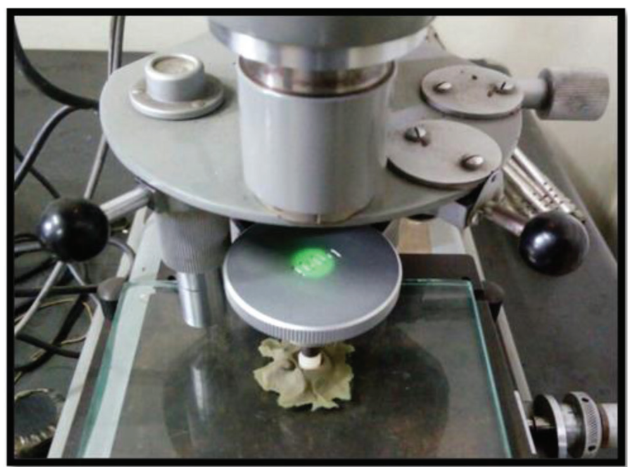


Figure 3: Durometer used for the Vickers microhardness test

Discussion

Advances in the field of restorative dentistry together with the aesthetic needs of patients have inevitably promoted the application of conservative, simple, relatively fast, and efficient alternative techniques, such as dental bleaching.

Some studies have reported that bleaching agents can cause microstructural changes and a decrease of the microhardness in restorative materials, as in the case of nanohybrid composite resin.[14,15] Surface microhardness is a mechanical property that determines the degree

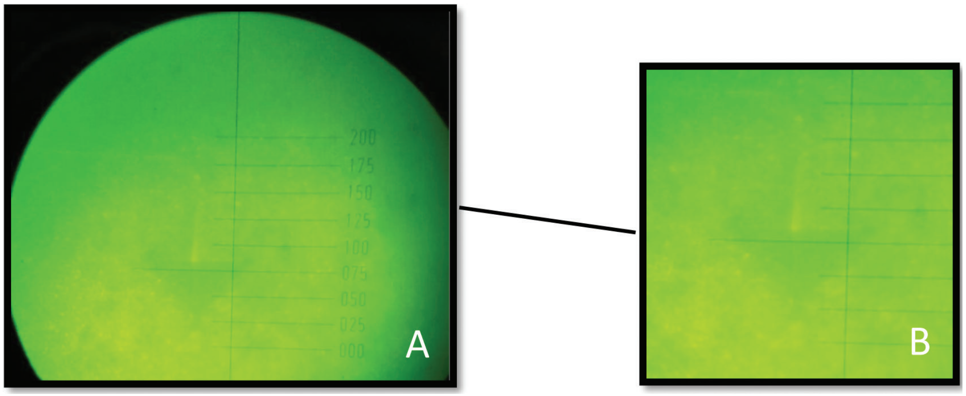


Figure 4: Observation of an indentation. (A) Panoramic view and (B) magnified view

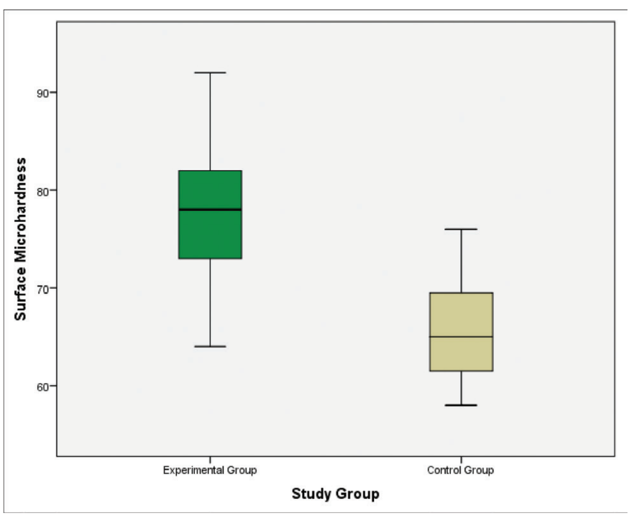
Table 1: Descriptive values of surface microhardness HV of the nanohybrid composite resin according to the study groups

Study groups	Mean	95% CI		SD	Minimum	Maximum	**P*-value
		Ll	Ul				
Experimental	78.07	73.66	82.47	7.96	64	92	<0.001**
Control	65.67	62.78	68.56	5.22	58	76	

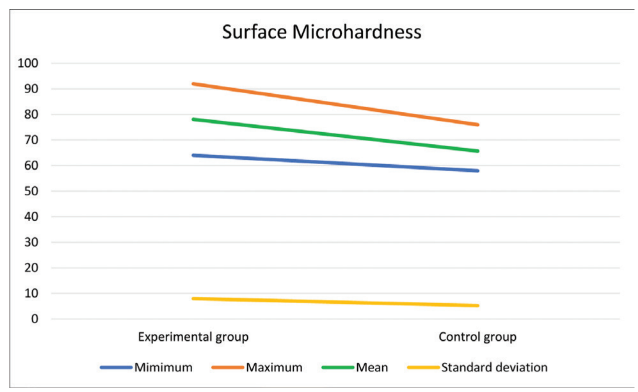
CI = confidence interval for the mean, Ll = lower limit, Ul = upper limit, SD = standard deviation

*Student's *t*-test for independent samples

**Very significant differences ($P < 0.01$)



Graph 1: Distribution of surface microhardness values (Hardness Vickers) of the nanohybrid composite resin after bleaching with and without polishing



Graph 2: Analysis of the surface microhardness values (Hardness Vickers) of the nanohybrid composite resin after bleaching with polishing (experimental group) and without polishing (control group)

of deformation in a material and its resistance to indentation, being of great importance in composite resins, since this property confers better resistance to wear and scratching.[4,5,7] For this reason, the purpose of this study was to evaluate the effects of polishing on the surface microhardness of nanohybrid composite resins previously subjected to 35% hydrogen peroxide gel.

Authors such as Soares *et al.*[16] reported that the hydrogen peroxide-based bleaching agent acts as a powerful oxidant that releases free radicals with high chemical reactivity and diffusion capacity, capable of degrading the composite resin matrix. Furthermore, peroxides have been reported to induce the separation of the polymer chain that constitutes a composite resin, causing its double bonds to become vulnerable, resulting in a softening of the surface and deep layers of the restorative material, thus affecting the durability and clinical success of dental restorations.[16,17] In addition, Esmaeili *et al.*[17] stated that the mechanism of action of bleaching agents on tooth structures is based on the oxidation of dentin molecules, causing a change in color. From these statements, we can interpret that the oxidation reaction caused by the hydrogen peroxide-based bleaching agent interferes with the structural integration of composite resins, mainly influencing their organic matrix, facilitating water absorption and particle loss, as well as causing an alteration of the interface between the filler and the matrix, which would affect the topography of the resin surface and thus cause a decrease in the surface microhardness.

In contrast, Suárez and Lozano[18] reported that composite resin polishing can provide a smoother and more resistant surface to deformation and if this polishing is performed after 24 h of its photopolymerization, the surface microhardness values of the nanohybrid composite resins increase significantly. For this reason, in the present study, it was decided to polish the nanohybrid composite resin of the experimental group after 24 h of applying the bleaching agent.

Nanohybrid composite resins were considered as the unit of analysis because some intrinsic factors such as type, particle size, monomer composition, and filler content play a critical role in their clinical behavior. By having a higher inorganic filler loading justifies better performance in microhardness tests.[19] In addition, light-curing of the bleaching agent in contact with the resin was not included in the experimental design since numerous studies have shown that this procedure does not accelerate or improve the effect of the bleaching agent.[20,21]

As a limitation of this study, it is recognized that the results obtained cannot be reliably extrapolated to the clinical field, since the design of this research was *in vitro*. For this reason, it is advisable to perform randomized clinical trials related to the objective stated here. In addition, more comparative studies with the same proposed design involving microhybrid, incremental nanohybrid, and nanotechnology (Bulk Fill) composite resins are needed.[22]

The results of this study suggest an alternative to improve the surface microhardness property of nanohybrid composite resins after being subjected to a bleaching process, since the findings obtained allow recommending a polishing after the esthetic treatment to ensure the elimination of rough surfaces and small reliefs as a result of the action of the bleaching agent. This will contribute to greater durability of the nanohybrid composite resin, avoiding surface microfractures that facilitate pigment retention and/or the formation of secondary caries.

Conclusion

In summary, considering the limitations of the present *in-vitro* study, nanohybrid composite resins previously subjected to 35% hydrogen peroxide gel significantly increased their surface microhardness when subjected to polishing treatment, unlike those that were not polished.

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Nil.

Conflicts of interest

None to declare.

Authors contributions

They conceived the research idea (GGRV, JEMM), elaborated the manuscript (GGRV, JEMM, CFCR), collected, tabulated the information (GGRV, CFCR), carried out the bibliographic search (GGRV, MILC, ASAM), interpreted the statistical results and helped in the development from the discussion (CFCR, GGRV), he performed the critical revision of the manuscript (MILC, ASAM, LACG, CFCR). All authors approved the final version of the manuscript.

Ethical policy and institutional review board statement

This project is exempted from ethical approval because it was an experimental *in vitro* study.

Patient declaration of consent

Not applicable.

Data availability statement

The data that support the study results are available from the author (Dr César F. Cayo-Rojas, e-mail: cesarcayorojas@gmail.com) on request.

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