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# The Effect of Polishing Techniques and Time on the Surface Characteristics and Sealing Ability of Resin Composite Restorations After One-year Storage

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### Clinical Relevance

The results of this study suggest that immediate polishing procedures can result in improved short-term surface smoothness results but do not influence smoothness or sealing ability after one-year storage.


## SUMMARY

**Since there is a lack of information on the surface properties of composite restorations achieved with standard polishing procedures after aging processes, this study evaluated the effects of immediate (IM) and delayed (DE) polishing on the surface roughness (Ra), microhardness (KHN) and microleakage (ML) of microfilled (Filtek A110) and hybrid (Filtek Z250) resin composites after one-year storage. Standardized preparations were made on the buccal surface of 256 bovine teeth, where half were restored with each composite. For each composite, the specimens were randomly allocated to two subgroups. The first group (IM) was polished immediately after gross finishing using three different systems/techniques (n=16): Sof-Lex, Flexicups and Flexicups + Jiffy Polishing Brush + Flexibuffs (sequential), then stored for three weeks in saline. The DE group was stored for two weeks, polished with the same systems and stored for one week. From each subgroup, eight specimens were assessed after three weeks regarding Ra, KHN and ML (baseline), and the eight remaining specimens were stored for one**


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**year before analysis. The data were analyzed ($\alpha$=0.05) with ANOVA, paired Student's *t*-test (Ra and KHN) or Kruskal-Wallis and Signed Rank tests (microleakage). After one year, microfilled resin composite specimens showed the lowest Ra and KHN (*p*<0.05). No difference in microleakage was observed among the different groups (*p*>0.05). The sequential technique provided the lowest roughness and Sof-Lex the lowest hardness (*p*<0.05). IM showed similar or better performance than DE for ML and Ra (*p*<0.05). In conclusion, aging increased the composites Ra and ML in all experimental conditions (*p*<0.05).**

## INTRODUCTION

Since Bowen[1] introduced resin composites into dentistry, the use of direct composite materials in the posterior region has revolutionized the delivery of minimally invasive treatment.[2] No other restorative material has been so modified and improved. Despite all initial inherent problems, the current status of composite restorations used in combination with the total acid-etch technique has made many dentists choose these materials, even for restoring areas of high occlusion stress, such as posterior teeth.[3-5]

Contemporary resin formulations provide improved strength, wear resistance, the preservation of sound dental structure and reinforcement of restored teeth, in addition to their aesthetic properties, which ultimately have led to improved clinical performance, as described in clinical trials.[6-10] However, different composite materials are expected to present differences in surface characteristics and polishability, which could ultimately contribute to longevity of the restoration. A highly polished surface is difficult to achieve due to factors such as differing amounts of filler particles, particle size and differences in hardness between filler particles and the matrix of the resin composite.[11-13] The polishing ability of composites varies depending on particle size.[14] Although microfilled composites are more easily polished than hybrid composites,[11,15] it is believed that hybrid composites may provide the best properties and clinical performance for both anterior and posterior restorations.[16-17]

The development of an optimal surface polish means a reduction in stain and plaque accumulation, minimization of wear effects and an enhancement in the definitive restoration's appearance.[2] In fact, important aspects, such as the marginal integrity, surface roughness and surface integrity, as well as the physicochemical properties of the material itself can affect plaque retention over restorations and are somewhat related to restorations' polishing procedures and restorative materials characteristics. Microleakage along the tooth/restoration interface may result in marginal staining, postoperative sensitivity, secondary caries and pulp irritation.[18] Likewise, residual surface roughness of restorations can directly influence plaque retention, which may result in superficial staining, gingival inflammation and secondary caries, compromising the clinical performance of restorations.[19-22] This means that the proper finishing and polishing of dental restoratives are critical clinical procedures that are not only for esthetics and longevity of restorations, but also for oral health.[23]

Different methods can be used for restorations' finishing and polishing;[21] however, there is a lack of consensus as to which material and technique provides the smoothest surfaces for composites,[15,24-25] and little research has been conducted on the influence of delay in polishing on surface roughness, hardness and the marginal sealing of composite restorations.[15,26-28] Still, there are no publications that address the effect of aging processes or long-term storage related to these properties.

This study evaluated the effects of different finishing and polishing techniques and time (immediate and delayed polishing) on surface roughness ($R_a$), microhardness (KHN), microleakage and sealing ability of two composites in an *in vitro* model after one-year storage in saline solution. The null hypothesis tested was that there are no differences caused by aging, polishing techniques, types of composites and polishing time on the surface texture, surface microhardness and sealing ability of resin composite restorations.

## METHODS AND MATERIALS

### Experimental Design

This *in vitro* study involved a complete, randomized and blinded design, considering two composites, three finishing and polishing techniques, the effects of immediate and delayed polishing and two occurrences of storage as factors under study. Surface roughness, microleakage and hardness were the dependent variables assessed.

Bovine teeth were restored with two different resin composites and finished and polished using different systems. One operator placed all the restorations with the same adhesive system (Single Bond, 3M ESPE, St Paul, MN, USA) and a microfilled (Filtek A-110, 3M ESPE) or a microhybrid resin composite (Filtek Z-250, 3M ESPE) (n=16). Specimens in which restorations were not finished and polished served as controls. All analyses were performed by a different examiner at baseline and after one-year storage in saline solution.

### Sample Preparation

For this study, 256 freshly extracted bovine incisors were selected, cleaned and stored in saline at 4°C until use. The teeth were sectioned 5 mm above and 5 mm below the cemento-enamel junction using a low-speed diamond-impregnated disk under water cooling followed by their embedment in cylindrical molds using acrylic resin. The buccal surface of each tooth was ground with a 180-grit silicon carbide paper under running water. Standardized Class V preparations were made on the exposed surface, with dimensions of 3 mm mesio-distally and occluso-gingivally, and 2 mm deep. The occlusal-cavosurface margin was located in enamel, while the gingival-cavosurface margin was in dentin. The specimens were kept hydrated in distilled water during all the steps. Randomization of the specimens to the experimental groups was as follows: 1) all specimens were numbered from 1 to 256 and listed in a computer program (Microsoft Office Excel 2003, Microsoft Co, Redmond, WA, USA); 2) the same program was used to generate 256 random numbers; 3) the specimens were re-ordered randomly according to random numbers; 4) 16 specimens each time, following the new random order created, were assigned to each one of the 16 experimental groups described below.

The cavity on each tooth was restored using the same adhesive system (Single Bond, 3M ESPE) either with a microfilled resin composite (Filtek A-110, 3M ESPE) or a microhybrid resin composite (Filtek Z-250, 3M ESPE) according to manufacturer's instructions. Shade B2 was selected for both composites to standardize the depth of cure, and the composite was placed in three increments with the cervical increment placed first. Transparent matrices were placed over the filled cavities and pressure was applied to extrude and then remove material excess. Each increment was cured for 20 seconds and the final restoration was cured for another 40 seconds.

The positive control groups for each composite (n=16) were evaluated without any finishing/polishing procedures and remained stored in saline solution at 37°C for three weeks. The solution was replaced twice a week. For the testing groups, transparent matrices were removed immediately after light-polymerization, and gross finishing was performed by grinding the specimens on 280-grit silicon carbide paper in one direction under running water. This procedure was carried out to simulate a fine diamond bur texture. Two negative control groups (n=16) were obtained with this gross finishing only. Results from both the positive and negative controls are presented and discussed elsewhere.[15]

Subsequently, all restored and finished specimens were randomly divided into 12 groups of 16 teeth and polished with: A) aluminum-oxide discs—Sof-Lex Pop On XT (3M ESPE); B) rubber-polishing cups—Flexicups (Cosmedent, Chicago, IL, USA) and C) the sequential use of rubber-polishing cups, a polishing brush—Jiffy Polishing Brush (Ultradent, South Jordan, UT, USA) and felt-polishing discs—Flexibuffs (Cosmedent). The materials were used according to manufacturers' directions. The systems were used in the same way (10 strokes and 20 seconds for each step) to allow for comparison. A polishing paste (Enamelize, Cosmedent) was used in sequences B and C. Table 1 provides additional information on the polishing systems and procedures.

Half of the groups were polished immediately after curing (IM), while the remaining half was polished within two weeks (DE). All the groups were stored in saline for a total of three weeks at 37°C prior to analyses. All the specimens underwent surface roughness evaluation, but just half were assessed regarding hardness and microleakage evaluations (n=8), and these results were previously presented and discussed.[15] Eight samples of each group were stored in saline at 37°C (solution replaced twice a week) to promote one-year aging and evaluated under the same conditions and methods used at the baseline evaluations.

### Assessment Procedures

Surface roughness ($R_a$) was measured using a profilometer (Surfcorder SE 1200, Kozaka Industry, Kozaka, Japan). Five readings were taken for each specimen on different locations and the $R_a$ value was calculated as the arithmetic average of these five readings. The equipment was periodically checked for performance, which consistently provided an accurate recording of the calibration block (3.10 ± 0.10 μm).

A Shimadzu HMV-2000 Hardness Tester (Shimadzu Co, Japan) with a Knoop diamond under a 25-g load for 30 seconds was used for the microhardness analysis (KHN). Five indentations were recorded for each spec-

Table 1: *Technical Profile of Polishing Systems and Details of Polishing Procedures*

| System/Manufacturer | Sequence of Use | Speed (rpm) | Condition |
|---|---|---|---|
| *Aluminum-oxide discs–* | | | |
| *Sof-Lex finishing system/3M ESPE* | | | |
| Medium (medium orange–29 μm) | 1 | 30,000 | Dry |
| Fine (light orange–14 μm) | 2 | 30,000 | Dry |
| Extra-fine (yellow–5 μm) | 3 | 30,000 | Dry |
| *Rubber-polishing cups–* | | | |
| *Flexicups/Cosmedent* | | | |
| Medium (blue) | 1 | 20,000 | Dry (polishing paste) |
| Extra-fine (pink) | 2 | 20,000 | Dry (polishing paste) |
| *Sequential technique* | | | |
| Rubber-polishing cup medium | 1 | 20,000 | Dry (polishing paste) |
| Rubber-polishing cup extra-fine | 2 | 20,000 | Dry (polishing paste) |
| Polishing brush–Jiffy/Ultradent | 3 | 30,000 | Dry (polishing paste) |
| Felt-polishing discs Flexibuffs/Cosmedent | 4 | 30,000 | Dry (polishing paste) |

imen, and the microhardness value was obtained as the average of these five readings.

Table 2: *Mean ± standard deviation of surface roughness (Ra-μm) of the different combinations of materials, polishing techniques and polishing times after one-year storage.*

| Resin Composite | Polishing Method | Polishing Time | |
|---|---|---|---|
| | | Delayed | Immediate |
| Microfilled | Rubber-polishing cups | 0.245 ± 0.03 Ab | 0.185 ± 0.05 Bbc |
| | Aluminum-oxide discs | 0.184 ± 0.05 Ab | 0.167 ± 0.05 Ac |
| | Sequential technique | 0.209 ± 0.09 Ab | 0.114 ± 0.02 Bd |
| Microhybrid | Rubber-polishing cups | 0.410 ± 0.09 Aa | 0.353 ± 0.18 Aa |
| | Aluminum-oxide discs | 0.162 ± 0.09 Ab | 0.206 ± 0.08 Ab |
| | Sequential technique | 0.150 ± 0.05 Ac | 0.143 ± 0.09 Ac |

*Upper case letters represent differences between delayed and immediate polishing; lower case letters represent differences among materials and techniques (p<0.05).*

Table 3: *Mean ± standard deviation of microhardness (KHN) of the different combinations of materials, polishing techniques and polishing times after one-year storage.*

| Resin Composite | Polishing Method | Polishing Time | |
|---|---|---|---|
| | | Delayed | Immediate |
| Microfilled | Rubber-polishing cups | 50.93 ± 8.08 Ad | 46.84 ± 3.45 Bc |
| | Aluminum-oxide discs | 44.83 ± 2.15 Ae | 41.51 ± 3.42 Bd |
| | Sequential technique | 43.78 ± 3.06 Af | 47.34 ± 3.09 Ac |
| Microhybrid | Rubber-polishing cups | 110.78 ± 20.70 Aa | 103.64 ± 7.10 Ba |
| | Aluminum-oxide discs | 89.70 ± 6.05 Ac | 81.41 ± 5.79 Bb |
| | Sequential technique | 95.38 ± 7.63 Ab | 104.60 ± 12.30 Aa |

*Upper case letters represent differences between delayed and immediate polishing; lower case letters represent differences among materials and techniques (p<0.05).*

The specimens were subsequently sealed with two coats of nail varnish applied on the tooth, 1.5-mm short of the restoration's margins, which were to be exposed to dye. The specimens were then immersed in 1% aqueous basic fuchsin dye for 24 hours at 37°C. After removal from the dye solution, the teeth were cleaned and longitudinally sectioned through the restorations in a bucco-palatal plane with a diamond saw under water irrigation. The marginal sealing ability, indicated by the depth of dye penetration around the enamel (incisal) and dentin (gingival) margins, was evaluated under magnification (40x). A 0-3 scoring system was used to describe the severity of infiltration: 0 = no evidence of dye penetration, 1 = dye penetration to less than half of the cavity depth, 2 = dye penetration to the entire cavity depth and 3 = dye penetration to the axial wall and beyond.

### Statistical Analysis

One-year data were analyzed by three-way ANOVA followed by Tukey's test (microhardness and surface roughness) and Mann Whitney and Kruskal-Wallis (sealing ability). Data from microhardness and surface roughness were transformed by log. For comparisons between the baseline and one-year results, the Paired *t*-test and Wilcoxon Signed Rank test were used to analyze surface roughness and sealing ability, respectively. Since the one-year hardness evaluation was carried out in a different microhardness tester than that used in the baseline evaluation due to an equipment upgrade, no comparison between baseline and one-year data is presented. The computer system SAS/LAB (SAS system for Windows 9.0, SAS Institute Inc, Cary, NC, USA) was used and the significance level was established at 5%.

## RESULTS

The microfilled composite restorations showed the smoothest surfaces when immediate or delayed polished (Flexicups) ($p<0.05$—Table 2). The sequential technique showed better performance, decreasing surface roughness, except for the microfilled resin composite under delayed polishing ($p<0.05$—Table 2). However, the less efficient technique was the one that used rubber-polishing cups (Flexicups) ($p<0.05$—Table 2). Those restorations that were immediately polished showed lower $R_a$ compared to those polished after one-week's placement for microfilled composite, excluding when polishing procedures were carried out using Sof-Lex ($p<0.05$—Table 2).

In terms of microhardness, microfilled restorations showed lower microhardness when compared to microhybrid restorations ($p<0.05$—Table 3). The polishing technique that used rubber points presented the highest microhardness, except when immediate polishing of microfilled composite was accomplished ($p<0.05$). The use of aluminum-oxide discs (Sof-Lex) showed the weakest performance, as it decreased the microhardness of microhybrid restorations ($p<0.05$). Additionally, the overall results showed that immediate polishing promoted a hardness decrease (Table 3).

There were no significant differences among groups for microleakage results ($p>0.05$) for both enamel and dentin (Table 4). However, higher microleakage occurred in the dentin margins ($p<0.05$).

Aging of the specimens caused an increase in surface roughness, considering all experimental conditions,

Table 4: *Microleakage results after one-year storage for enamel and dentin margins according to the combination of materials, polishing techniques and polishing times.*

| Resin Composite | Polishing Method | Enamel Margins | | Dentin Margins | |
|---|---|---|---|---|---|
| | | Polishing Time | | Polishing Time | |
| | | Delayed | Immediate | Delayed | Immediate |
| Microfilled | Rubber-polishing cups | 2.0 (1.75 ± 0.46) | 2.0 (1.87 ± 0.64) | 2.5 (2.37 ± 0.74) | 2.0 (2.25 ± 0.71) |
| | Aluminum-oxide discs | 2.0 (1.62 ± 1.06) | 0.5 (0.75 ± 0.89) | 2.5 (2.12 ± 0.99) | 1.0 (1.37 ± 0.91) |
| | Sequential technique | 2.0 (1.62 ± 0.74) | 2.0 (1.57 ± 0.53) | 2.5 (2.00 ± 1.20) | 2.0 (2.14 ± 0.90) |
| Microhybrid | Rubber-polishing cups | 0.5 (0.75 ± 0.89) | 1.0 (1.12 ± 0.83) | 1.0 (1.13 ± 0.64) | 2.0 (2.00 ± 0.76) |
| | Aluminum-oxide discs | 1.0 (1.00 ± 0.93) | 1.0 (1.29 ± 0.76) | 1.0 (1.38 ± 1.06) | 1.0 (1.00 ± 0.58) |
| | Sequential technique | 2.0 (2.12 ± 0.83) | 2.0 (2.10 ± 0.35) | 3.0 (2.63 ± 0.74) | 1.0 (1.75 ± 1.35) |

*Values are Median (Mean ± SD). Groups are not statistically different (Kruskal-Wallis test–p>0.05).*

Table 5: *Comparisons between baseline and one-year storage for surface roughness, enamel and dentin microleakage results according to the combination of materials, polishing techniques and polishing times.*

| Resin Composite | Polishing Method | Polishing Time | Surface Roughness (Ra-μm) | | Enamel Microleakage | | Dentin Microleakage | |
|---|---|---|---|---|---|---|---|---|
| | | | Evaluation Period | | Evaluation Period | | Evaluation Period | |
| | | | Baseline | 1 Year | Baseline | 1 Year | Baseline | 1 Year |
| Microfilled | Rubber-polishing cups | Delayed | 0.18 ± 0.04 A | 0.25 ± 0.03 B | 1.0 (1.25 ± 0.71) A | 2.0 (1.75 ± 0.46) A | 2.5 (1.85 ± 1.36) A | 2.5 (2.37 ± 0.74) A |
| | | Immediate | 0.19 ± 0.05 A | 0.19 ± 0.05 A | 1.0 (1.00 ± 0.60) A | 2.0 (1.87 ± 0.64) B | 2.5 (2.12 ± 1.13) A | 2.0 (2.25 ± 0.71) A |
| | Aluminum-oxide | Delayed | 0.14 ± 0.04 A | 0.18 ± 0.05 B | 0.0 (0.50 ± 0.76) A | 2.0 (1.62 ± 1.06) B | 1.0 (1.50 ± 1.07) A | 2.5 (2.12 ± 0.99) A |
| | | Immediate | 0.14 ± 0.02 A | 0.17 ± 0.05 A | 0.5 (0.62 ± 0.74) A | 0.5 (0.75 ± 0.89) A | 2.0 (1.87 ± 0.83) A | 1.0 (1.37 ± 0.91) A |
| | Sequential technique | Delayed | 0.13 ± 0.03 A | 0.21 ± 0.09 B | 0.5 (0.62 ± 0.74) A | 2.0 (1.62 ± 0.74) B | 3.0 (2.87 ± 0.35) A | 2.5 (2.00 ± 1.20) A |
| | | Immediate | 0.09 ± 0.02 A | 0.11 ± 0.02 B | 1.0 (0.75 ± 0.71) A | 2.0 (1.57 ± 0.53) A | 2.5 (2.25 ± 0.89) A | 2.0 (2.14 ± 0.90) A |
| Microhybrid | Rubber-polishing cups | Delayed | 0.27 ± 0.06 A | 0.41 ± 0.09 B | 0.0 (0.25 ± 0.46) A | 0.5 (0.75 ± 0.89) A | 2.5 (2.25 ± 0.89) B | 1.0 (1.13 ± 0.64) A |
| | | Immediate | 0.21 ± 0.03 A | 0.35 ± 0.18 B | 1.0 (0.75 ± 0.70) A | 1.0 (1.12 ± 0.83) A | 2.5 (2.25 ± 0.89) A | 2.0 (2.00 ± 0.76) A |
| | Aluminum-oxide | Delayed | 0.12 ± 0.03 A | 0.16 ± 0.09 A | 0.0 (0.37 ± 0.52) A | 1.0 (1.00 ± 0.93) A | 1.5 (1.75 ± 0.89) A | 1.0 (1.38 ± 1.06) A |
| | | Immediate | 0.15 ± 0.03 A | 0.21 ± 0.08 B | 1.0 (0.87 ± 0.83) A | 1.0 (1.29 ± 0.76) A | 1.0 (1.62 ± 0.92) A | 1.0 (1.00 ± 0.58) A |
| | Sequential technique | Delayed | 0.11 ± 0.02 A | 0.15 ± 0.05 B | 1.5 (1.12 ± 0.64) A | 2.0 (2.12 ± 0.83) B | 3.0 (2.50 ± 0.92) A | 3.0 (2.63 ± 0.74) A |
| | | Immediate | 0.13 ± 0.03 A | 0.14 ± 0.09 A | 1.0 (0.87 ± 0.64) A | 2.0 (2.10 ± 0.35) B | 3.0 (2.87 ± 0.35) B | 1.0 (1.75 ± 1.35) A |

*Values are Mean ± SD for Ra data, or Median (Mean ± SD) for microleakage data (n=8). Groups identified by different upper case letters are significantly different (p<0.05).*

with statistically different results ($p<0.05$) in 8 of the 12 groups studied (Table 5). Additionally, there was a significant increase ($p<0.05$—Table 5) in surface roughness when delayed polishing of microfilled composites was performed.

In enamel margins, the aging process caused a decrease in marginal sealing in nearly all experimental conditions ($p<0.05$—Table 5). The microhybrid composite polished with the sequential technique showed the highest microleakage scores after aging ($p<0.05$). In dentin margins, polishing time was significant for the microhybrid composite when considering delayed polishing with Flexicups or immediate polishing when using the sequential technique ($p<0.05$—Table 5).

## DISCUSSION

Although there are still limitations in the survival rates of composite restorations, long-term studies have shown that these restorations perform adequately in small- to moderate-sized cavities, even in areas of high occlusal stress, such as posterior teeth.[8,29-30] Associated with esthetic and adhesive advantages, these findings deeply influence the decision-making process regarding materials and treatments in clinical practice.

The clinician's objective when placing esthetic restorations is to achieve the smoothest surface to minimize plaque and stain retention.[31] Composites are finished and polished to establish a functional occlusal relationship and a contour that is physiologically in harmony with supporting tissues.[17] In addition, proper contour and high gloss give the desired appearance of natural tooth structure that patients want.[23] Thus, it is important to determine which finishing and polishing system offers the best results for maintaining esthetic restorations.

In clinical practice, some functional adjustments are necessary in nearly all restorations. In this study, finishing was carried out with standardized 280-grit silicon carbide paper under running water to simulate the texture of a fine diamond bur, therefore producing specimens with similar surface characteristics before applying the tested polishing procedures/conditions.[15] Several studies agree that flexible aluminum-oxide disks are the best choice for providing the lowest roughness on composite surfaces.[32-34] Their efficacy, however, depends on the anatomical form and accessibility of the restoration surface to be polished. Therefore, the use of specialized shapes of abrasive instruments is usually necessary in clinical practice to attain the best results. The authors of this study have shown that the use of a sequential polishing technique carried out with rubber-polishing cups, polishing brushes and felt polishing discs presented similar results when compared to using aluminum-oxide disks,[15] suggesting that the use of other techniques can improve polishing in areas that are difficult to access with aluminum-oxide discs. After one-year storage, the sequential technique still exhibited comparable or better results than standard techniques, corroborating baseline findings where the use of a sequential technique was proposed as an alternative to aluminum-oxide disks in areas where discs may not reach.

Changes in hardness may reflect the state of the setting reaction of a material and the presence of an ongoing reaction or maturity of the restorative material.[26,35] In this experiment, all the evaluations were conducted after one-year storage in saline at 37°C for all specimens. In this way, the maturity of the composites was common at the evaluation time, and any differences in hardness could be attributed to the effects of the polishing procedures at both intervals. If the polishing procedure is completed prior to completing resin composite maturation, the restoration could be more susceptible to thermal insults, which could result in lower surface hardness.[36-37] In the current study, in terms of overall results, the specimens with delayed polishing showed lower hardness results compared to specimens that were polished immediately. This may be explained by the loss of surface properties after polymerization using delayed polishing procedures. Additionally, after one-year storage, the immediate polishing group showed lower surface roughness, except for the sequential technique. The microfilled composite exhibited lower hardness than the microhybrid composite, which was expected, since microfilled composites usually have lower filler contents and present smaller filler particles and, therefore, result in some reduction in their mechanical properties, such as surface hardness and flexural strength.[15,38]

The thermal insults produced by rotational instruments during finishing and polishing procedures can somewhat affect marginal sealing of the restorations.[27,39] The results of the current study show that, after one year, there were no differences among the groups. A reasonable explanation is that the storage period compromised adhesion between the composite and cavity walls, possibly due to adhesive degradation.[40-43] This degradation could be responsible for overcoming differences among the groups observed in the baseline results.[15]

The moment when polishing procedures should be carried out remains controversial. While some manufacturers claim that finishing and polishing could be done after removal of the matrix or five minutes thereafter, some authors have suggested that, if these procedures are delayed for 24 hours or more, better marginal sealing could be obtained, as the immediate finishing and polishing could cause flow of the composites due to thermal insults of polishing.[44] Since the composite polymerization reaction may not be complete in less than 24 hours and water sorption would continue to occur, the hygroscopic expansion of composites[37,44] could result in a reduction in microleakage.[45] In this way, delayed polishing procedures could compromise the marginal sealing obtained with the hygroscopic expansion of the composite and adhesive system, resulting in an increase in microleakage due to the stresses generated by the procedures.[27] Immediate finishing and polishing could also compromise the initial marginal sealing; however, hygroscopic expansion could somehow compensate for the damage caused by immediate polishing.[15,27]

In terms of microleakage, the aging process in water has been shown to not have an effect on resin composites,[5,46-47] yet there is a reduction in adhesive resistance after long periods of storage, related to adhesive system hydrolysis.[40,42] Morphological studies indicate that the resin and collagen matrix may suffer degradation from storage.[48-49] Even though enamel adhesion is considered more safe and stable than dentin,[50] the current study showed failure regarding marginal sealing for enamel margins and in nearly all experimental conditions, which means that water caused damage in enamel margins as well as in dentin.

Despite several limitations in these *in vitro* studies, especially when correlating with the oral environment,[51] some experimental designs may be used to simulate *in vivo* conditions in *in vitro* methodologies. In this way, the aging of specimens is important not only to compare the different materials and techniques, but also to estimate the materials' survival. The results of this study reject the hypothesis that the aging process would not have a negative influence on the tested properties, as it caused an increase in surface roughness in all experimental conditions and in enamel microleakage, depending on the group studied. Polishing procedures can be carried out immediately after restoration placement without a negative influence on surface roughness, surface hardness or the sealing ability of composite restorations. Therefore, immediate polishing is recommended, since this procedure reduces the number of clinical sessions and brings more comfort and satisfaction to the patient.

## CONCLUSIONS

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

1. Immediate polishing resulted in similar or higher marginal sealing and surface smoothness compared to delayed polishing.
2. The different polishing techniques influenced the hardness and roughness values, with Sof-Lex discs producing the lowest hardness values and Flexicups producing the highest surface roughness. Use of the sequential technique led to lower surface roughness and greater hardness and was not influenced by polishing time (delayed or immediate).
3. The aging process produced a drawback on the sealing ability and surface roughness of both composites under study.

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