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# Assessing the Surface Roughness of a Posterior Resin Composite: Effect of Surface Sealing

CYG Takeuchi • VH Orbegoso Flores • RG Palma Dibb
H Panzeri • EHG Lara • W Dinelli

### Clinical Relevance

Although the surface sealing of polymerized composites has been widely suggested, the use of surface sealants has not reduced the surface roughness of a posterior resin composite after simulated toothbrushing.

## SUMMARY

**This study assessed the *in vitro* influence of surface sealing on the surface roughness of a posterior resin composite before and after toothbrushing. Toward this purpose, 30 specimens (13 mm diameter x 1 mm high) were fabricated from Filtek-P60 resin composite and randomly assigned to three groups (n=10): a non-sealed control and two groups sealed with one of the tested materials—a surface-penetrating sealant (Protect-it!-PI) and a one bottle adhesive system (Single Bond-SB). The samples were subjected to a surface roughness reading to determine the initial roughness, then submitted to simulated toothbrushing with 35,600 cycles for 100 minutes. Specimens were then cleaned and a post-abrasion surface roughness reading accomplished. Means (µm), recorded before (B) and after (A) toothbrushing, and standard deviations were: Control—(B): 0.032 (±0.005), (A): 0.054 (±0.005); PI—(B): 0.034 (±0.005), (A): 0.060 (±0.034); SB (B): 0.031 (±0.004), (A): 0.047 (±0.007). Data were tabulated and submitted to two-way ANOVA. No statistically significant difference was observed when the control and experimental groups were compared. However, a significant difference ($p$<0.05) was found between the measurements performed before and after toothbrushing. Based on these results, it may be concluded that using both a surface penetrating sealant and a one bottle adhesive system did not provide the optimization of superficial integrity. The use of a dentifrice and toothbrush resulted in significant alterations to the surface smoothness of the resin composite.**

*Cristina Yoshie Garcia Takeuchi, DDS, post-graduate student, Department of Restorative Dentistry, Araraquara Dental School, São Paulo State University (UNESP), Brazil

Victor Humberto Orbegoso Flores, DDS, MS, PhD, research fellow, Araraquara Dental School, São Paulo State University (UNESP), Brazil

Regina Guenka Palma Dibb, DDS, MS, PhD, professor, Department of Operative Dentistry, Ribeirão Preto Dental School, University of São Paulo (USP), Brazil

Heitor Panzeri, DDS, MS, PhD, professor, Department of Dental Materials and Prosthodontics, Ribeirão Preto Dental School, University of São Paulo (USP), Brazil

Elza Helena Guimarães Lara, DDS, MS, PhD, professor, Department of Pharmaceutical Sciences, Pharmaceutical Sciences School, University of São Paulo (USP), Brazil

Welingtom Dinelli, DDS, MS, PhD, professor, Department of Restorative Dentistry, Araraquara Dental School, São Paulo State University (UNESP), Brazil

*Reprint request: R Humaitá, n° 1680 CEP: 14801-903, Araraquara-SP, Brasil; e-mail: cristakeuchi@yahoo.com.br

## INTRODUCTION

The advent of the acid-etching technique (Buonocore, 1955) and the further introduction of BIS-GMA resin composites (Bowen, 1956) has undoubtedly represented the most remarkable approaches in the outstanding progress of adhesive dentistry, as it has widened the scope in oral health care and has decisively prompted the development and optimization of innumerable restorative systems and techniques. Therefore, the indications and applicability of adhesive materials have been increasingly extended and widespread.

For more than 30 years resin composite has been employed in posterior teeth. Although the earliest formulations have yielded a number of problems, such as high polymerization shrinkage, marginal microleakage that invariably led to secondary caries, low wear resistance and loss of anatomic form, (Phillips & others, 1971; Phillips & others, 1973; Leinfelder & others, 1975), composites have recently experienced a notable improvement with their physical properties. However, despite advances, wear of composite materials still persists. Even after accomplishing appropriate finishing and polishing techniques, the surface exhibits microirregularities that inherently lead to material wear, deterioration and marginal infiltration, resulting mainly from the abrasive processes to which the restoration is subjected in the oral environment. Wear is, therefore, a complex process that involves several features—masticatory efforts, fatigue, friction, erosion and oral health care procedures that interact among themselves (Heath & Wilson, 1976; Araújo & Araújo, 1983; Knibbs & Pearson, 1984; Boghosian, Randolph & Jekkals, 1987; Pratten & Johnson, 1988; Dickinson & others, 1990; Leinfelder, 1991; Berastegui & others, 1992). Clinically, the wear of a restoration may result from centric and functional contacts, attrition of food bolus, interproximal contact areas, and toothbrushing (abrasion wear) through the mechanical action of the toothbrush and dentifrice (Kanter, Koski & Martin, 1982; Ehrnford, 1983; Goldstein & Lerner, 1991).

In an attempt to overcome this problem, using a thin layer of a low-viscosity resin over polymerized composite restoration has been investigated. The so-called surface-penetrating sealant or rebonding agent should be able to fill, by capillary action, the structural microdefects and microfissures that are formed during the insertion technique and finishing/polishing procedures. This approach is assumed to provide a more uniform, regular surface, thereby, enhancing surface smoothness. In addition, the coating resin would be capable of penetrating deeply into the interfacial microgaps, thus, providing improved marginal sealing especially in the dentin/cementum margins.

Although the properties of the latest posterior resin composites have been optimized, indeed, there is still a lack of studies reporting whether or not the surface integrity of such materials may be enhanced by the use of low-viscosity surface sealant. Moreover, although some studies have supported the idea that using specific surface-penetrating sealants is essential for an optimal resealing of polymerized resin composite restorations, a sufficiently low-viscosity resin agent with proper characteristics and formulation, even though not specifically developed for such purpose, could be successfully used as a surface sealant.

Taking this into consideration, this work assessed the influence of surface sealing on surface roughness of posterior resin composite before and after toothbrushing.

## METHODS AND MATERIALS

A total of 30 disks (13 mm diameter and 1 mm thick) were fabricated from Filtek P60 posterior resin composite (3M Dental Products, St Paul, MN, USA) using a *Teflon* matrix. The restorative material was inserted according to an incremental filling technique and light cured for 20 seconds each, as recommended by manufacturer's instructions, using a visible light-curing unit with 500mW/cm$^2$ output (XL 3000, 3M Dental Products). To assure the fabrication of specimens with highly regular surfaces before photo-polymerizing the last increment, a microscopic slide with a 1,650g weight was placed over the resin/matrix block in order to compact the material and provide a smooth, standardized surface. After 30 seconds, the weight was removed and the resin composite was light cured through the slide.

Resin composite samples were randomly assigned to three groups of equal size (n=10) according to the surface treatment: a non-sealed control group and two experimental groups in which the surface sealing was accomplished with one of the tested agents—a surface-penetrating sealant (Protect-it!-PI) (Pentron Inc, Wallingford, CT, USA) and a one bottle adhesive system (Single Bond-SB) (3M-ESPE Dental Products, St Paul, MN, USA). Table 1 lists the tested materials with their compositions, specifications and manufacturers.

For the sealed groups, both materials (Protect-it! and Single Bond) were applied following the same guidelines that were established for the surface sealing tech-

Table 1: *Materials Tested*

| Material | Category | Composition | Batch # |
|---|---|---|---|
| Filtek P-60 | Posterior resin composite | Zircon/Silica BIS-GMA, UDMA and BIS-EMA | 1KF, 0BR |
| Single Bond | Ethanol-and water-based, one-bottle adhesive system | Water/ethanol/HEMA, BIS-GMA, Dimentacrylate, Copolymers, Polyacrylic acid and Itaconic acid | 1FC |
| Protect-it! | Surface-penetrating sealant | BIS-GMA, UDMA, TEGDMA, THFMA, Photoinitiators, Accelerator, Stabilizer | 41205 |

nique: the resin composite surface was etched with a 37% phosphoric acid gel for 15 seconds, rinsed thoroughly for 15 seconds and the excess water removed with a mild oil-free air stream for 10 seconds. A uniform layer of the low-viscosity agent was applied over the etched area using a disposable microbrush with light scrubbing motion for 20 seconds, gently air-thinned for five seconds to assure an even distribution and light-cured for 20 seconds. It is important to emphasize that although Single Bond is an ethanol- and water-based one bottle adhesive system and, thereby, works best with some water present, the goal of this study was to assess the viability of using the one bottle adhesive system as a surface sealant. Therefore, Single Bond was applied following the same directions recommended for a surface-penetrating sealant.

Following the surface treatment, the specimens were stored in distilled water at 37°C for seven days. The samples were then subjected to a one-minute cleansing in ultra-sound with distilled water and 1% detergent added and carefully rinsed, blotted with absorbing paper and air dried for 15 seconds (Working Draft for Wear Test by Tooth Brushing, 1996). Samples were then subjected to a surface roughness reading to determine the initial roughness in a roughness meter (Prazis RUG 03 Digital Roughness Meter, ARO-Argentina). Each specimen was carefully fixed with wax on a metallic support, with the needle situated at the extremity of the equipment's arm positioned on the sample surface and programmed to trace a course of 4.8 mm, providing the first measure. Two additional measurements were accomplished by rotating the disk through at an angle of 90°, and the average (*Ra* initial-μm) was obtained from the three values. This measure was defined as an average of the pick-up arm's distances over and below the central line adopted for reference (Leitão & Hegdahl, 1981).

After the surface roughness reading, the samples were prepared for the wear test. For purposes of the study, each resin composite disk was individually fixed on the center of a *Plexglass* plate by adding a drop of acrylic resin monomer (JET, Clássico, 05458-001, Sao Paulo, SP, Brazil) on its surface and pressing the specimen against the plate for 10 seconds. The *Plexglass* plates were constructed with the dimensions required by the toothbrushing equipment: 50 mm large, 20 mm wide and 3 mm thick (Figure 1).

*Plexglass* patterns, designed with the same dimensions as the resin composite disks, were also prepared to act as a reference for the wear test. It has been advocated that, due to its highly homogenous composition, *Plexglass* ensures increased reliability to the

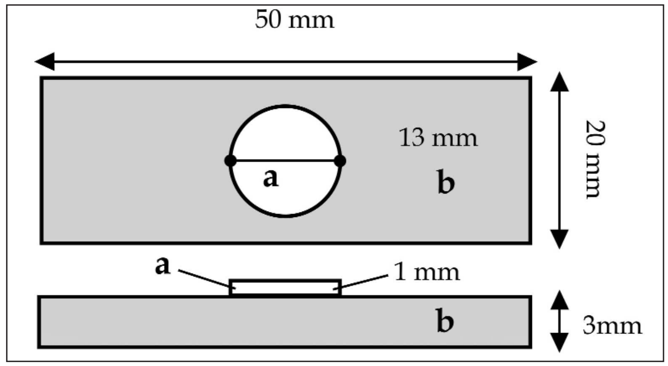


Figure 1:

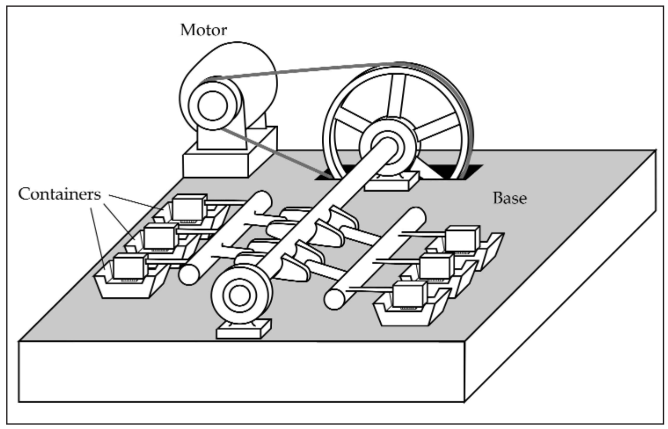


Figure 2:

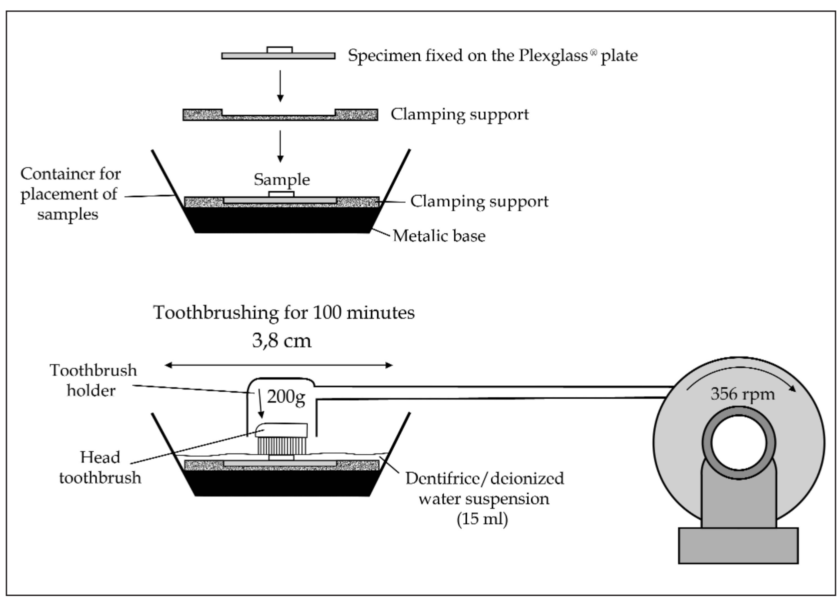


Figure 3:

results as it enables wear to be evaluated whether or not the specimens were subjected to uniform wear during simulated toothbrushing (Ramos, Palma Dibb & Lara, 1999).

The simulated toothbrushing apparatus was the Pepsodent type (Figure 2) developed at the Precision Workshop at the University of Sao Paulo, Brazil. Earlier investigations have described this equipment as a valuable tool to provide precise, well-controlled toothbrushing (Vieira, 1960; Vieira & Phillips, 1960; Lara, 1988; Ramos & others, 1999; Chimello & others, 2001; Wang, 2001).

For each sample, a Kolynos toothbrush with soft bristles (Kolynos do Brasil Ltda, Osasco, SP 06020-170, Brazil) was used. As abrasive agent, a suspension of dentifrice Kolynos (Kolynos do Brasil Ltda, Osasco, SP, 06020-170) and deionized water were prepared in a 1:1 rate at room temperature. Both slurry and toothbrush heads were replaced for every new sample.

The equipment allowed simultaneous toothbrushing of six samples: five resin composite disks and one Plexiglass pattern. The composite specimens were randomly assigned to groups of equal size and individually fixed with wax in a clamping support positioned inside the containers and fully covered with 15 ml of the dentifrice/water suspension (Figure 3). Before the wear test began, the equipment was calibrated to level the toothbrush bristles parallel to the sample surface, thereby, providing uniform toothbrushing (Harrington & others, 1982). Afterwards, toothbrushing was accomplished at a frequency of 356 rpm with horizontal movements of the toothbrush heads under a 200g weight and a traveled course of 3.8cm. Each group of specimens was subjected to a 100-minute simulated toothbrushing that performed a total of 35,600 brushings per test. This interval is reported to correspond to a two-year toothbrushing exposure (Phillips & Van Huysen, 1948) provided by an individual with good oral health care (Vieira, 1960).

Following the wear test, the samples were carefully cleaned, as previously described, and submitted to a post-abrasion surface roughness reading. Each specimen was tested for the first reading: three measurements were provided and the average (*Ra* final-µm) was calculated. However, at this time, the equipment's arm was positioned in such a way that the tracing direction was perpendicular to the direction of the toothbrushing, with the aim of registering the undulations caused by the abrasion procedure. The roughness meter detected the surface irregularities transverse to matrix direction that correspond to peaks, valleys and waves produced by the toothbrushing.

Furthermore, the dentifrice was assessed for its abrading degree at the laboratory of Pharmaceutical Sciences Department at the Pharmaceutical Sciences School, University of Sao Paulo. The analysis of the wear suffered by the material during toothbrushing consisted of weighing the specimens in an analytic electronic balance (Ohaus Corporation, Union, NJ, USA) before and after the toothbrushing test to calculate the mass difference in grams. The average mass loss was 14.52 mg, which corresponds to a low abrading level (Working Draft for Wear Test by Tooth Brushing, 1996).

The collected data were submitted to two-way ANOVA at 5% significance level.

## RESULTS

The analysis of data revealed a statistically significant difference ($p<0.05$) between the measurements performed before and after the wear test, with increased roughness recorded after toothbrushing.

Means and standard deviations are shown in Table 2.

As the tested conditions were compared, no statistical difference was noticed among the groups.

## DISCUSSION

The findings of the conducted research disclosed that toothbrushing provided a significant increase in surface roughness of the resin composite. These results are similar to those reported by Goldstein and Lerner (1991) and Chimello and others (2001), who noticed surface alteration on the specimens after toothbrushing. Roughness may be influenced by different features, such as the amplitude of the traveled course of the toothbrush, the weight applied on the toothbrush head and the dentifrice abrading degree and temperature (Heath & Wilson, 1976). Moreover, it has been demonstrated that the dentifrice rate in the suspension and toothbrushing speed may lead to surface alteration (Ehrnford, 1983). Taking this into consideration, in the present study, the same brand of dentifrice and toothbrush were employed in all tests and the above factors were assessed in order to standardize the experiment and evaluate solely the influence of the surface sealants on surface texture.

A rough surface may decrease the wear resistance of the restorative material and significantly increase the number of sites on the restoration's surface that are prone to accumulating bacterial biofilm, which inherently leads to a greater incidence of oral diseases apart from making the restorations more susceptible to stain-

Table 2: *Initial and Post-Abrasion Surface Roughness Means (µm) and Standard Deviation for the Tested Conditions*

| Group | Before | After |
|---|---|---|
| Control | 0.032 (±0.005)[a] | 0.054 (±0.005)[b] |
| Single Bond | 0.031 (±0.004)[a] | 0.047 (±0.007)[b] |
| Protect-it! | 0.034 (±0.005)[a] | 0.060 (±0.034)[b] |

Same letters indicate statistical similarity ing and loss of brilliance (Lutz, Setcos & Phillips, 1983; Pratten & Johnson, 1988).

The surface sealing technique was proposed in an attempt to eliminate the microfissures and irregularities that resulted from removing several surface particles or microfractures on the enamel/adhesive interface caused by polymerization shrinkage or finishing and polishing. Surface sealants were specifically developed to provide an increase in wear resistance and optimize the marginal sealing of resin composites applied to posterior teeth (Dickinson & Leinfelder, 1993). Clinical trials have reported a significant increase in marginal integrity and wear resistance (Dickinson & others, 1990; Dickinson & Leinfelder, 1993). In addition, *in vitro* investigations have concluded that resealing restoration margins may optimize restorations' marginal sealing (Ramos & others, 2000).

Studies (Torsteson, Brännstrom & Mattson, 1985; Reid, Saunders & Chen, 1991) have suggested coating polymerized resin composite with different materials, such as adhesive system or fissure sealants. However, studies have also postulated (Tjan & Tan, 1991) that using any low-viscosity resin system as a surface sealant would provide an incomplete wetting and may not yield the required effectiveness in enhancing surface integrity by sealing structural microdefects due to improper fluidity (poor wettability) disparities in formulation, diluents (ethanol/water or acetone), viscosity modifiers (materials with or without filler particles) and curing mechanisms. Since the degree of penetration of surface sealants relies upon their viscosity and the ability to wet and spread over an etched surface, the efficiency of these materials depends on how deep they penetrate into microcracks before polymerization is completed.

Accordingly, some authors (Dickinson & others, 1990; Dickinson & Leinfelder, 1993) have suggested that a specially formulated surface-penetrating sealant might be desirable in order to optimize the depth of penetration into the debonded surface and ensure complete wetting and the consequent sealing of microdefects. The first surface–penetrating sealants (SPS) were developed and made commercially available in the early 1990s. The use of these agents provided optimal performance, mainly in enhancing marginal integrity (Ramos & others, 2000). However, their efficiency in improving the wear resistance of resin composites is still controversial (Ramos & others, 1999). Apart from this, the use of a specific surface sealant inevitably results in additional cost for both the clinician and patient, and this needs to be considered. As a result, the conducted investigation assessed whether using an adhesive system would lead to results similar or comparable to those reached by the surface-penetrating sealants as regards surface roughness.

In this study, the surface sealants yielded a performance similar to the surface roughness of the resin composite assessed before and after surface sealing. Likewise, no difference was observed when the experimental groups were compared to the non-sealed control. These findings corroborate those by Ramos and others (1999) that reported tested surface sealants did not interfere with the degree of wear and surface roughness of resin composite. Such results could possibly be ascribed to the extremely thin layer of surface sealant that solely fills the most superficial defects of resin composite without providing an adequate overall surface covering (Bertrand & others, 2000). Besides, polymerization failure of the sealant may occur in the presence of oxygen (Rueggeberg & Margeson, 1990). As a result, it can be easily removed by the action of saliva, food, brushing, antagonistic surfaces or other agents (Bertrand & others, 2000).

The constant improvement of dental materials may result in the development of resin systems with appropriate flow rate and properties that perform the role of the surface-penetrating sealants with the same efficiency at no additional cost to clinician or patient. Nevertheless, further research is necessary to confirm this assumption. Moreover, studies must also be focused on the long-term evaluation of sealed posterior composite restorations in order to provide the clinician with guidelines for a proper indication and correct handling of such restorations.

## CONCLUSIONS

The results of this study may conclude that:

1. Using surface penetrating sealant and one bottle adhesive system did not provide optimal superficial integrity;
2. Using dentifrice and a toothbrush resulted in considerable alterations on the surface smoothness of the resin composite.

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