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DURABILITY OF REGAINED SURFACE SMOOTHNESS OF BLEACHED RESIN COMPOSITE BY SURFACE SEALANTS

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ABSTRACT

Aim: This study evaluated the effect of surface sealants and repolishing to regain surface smoothness of bleached micro hybrid resin composite, and how long this effect presented after aging processes by thermocycling and tooth brushing.

Materials and Methods: a total number of 120 micro hybrid resin composite disc specimens were prepared using Teflon mold (10x2 mm), then bleached using Opalescence Boost 40%. The specimens were divided into 3 groups: G I treated with Voco Easy Glaze surface sealant, G II treated with PermaSeal surface sealant, and G III repoloshed by OneGloss. Aging process (tooth brushing followed by thermocycling) was applied. Surface roughness was measured using profilometer after bleaching, treatment readings, and aging. The data were statistically recorded and compared at 5% level of significance.

Results: One Way ANOVA test showed significant decrease in (Ra) after treatment and aging for each group with the highest decrease was by Voco Easy Glaze, followed by PermaSeal and One Gloss. Kruskil wallis test showed significant decrease in surface roughness after treatment and aging. The aging showed statistically significant reincrease in roughness in all groups, and Voco Easy Glaze showed the least durability.

Conclusions: Surface Sealants application improved surface smoothness of bleached resin composite, and the durability of this smoothness is material dependent.

KEYWORDS: Bleached composite restorations, Surface Sealants, Surface roughness, tooth brushing aging.

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INTRODUCTION

Since a smile's look has a huge impact on daily living, specialists in the dentistry field favor composite restorations as their first choice since they combine good mechanical capabilities with aesthetically attractive appearance.[1] In parallel, dental bleaching techniques were generally known as a reliable, conservative, and efficient approach to treat discolored teeth. [2,3] Sometimes, bleaching performed on patients with composite restorations, [4] and the investigations have confirmed that the bleaching materials induce unwanted surface roughness to these restorations.[5,6] One of the primary determinants of esthetic success is the restorations' surface roughness since rough surfaces can lead to discoloration, bacterial accumulation, and diminished brightness.[7]

In order to maintain or enhance composite restorations, surface sealants have been manufactured. [8] Consequently, it has been suggested that surface sealants be used following the polishing process to prolong the life of restorations. [9] These liquid polishing solutions are low-viscosity, light-polymerized resin compositions with either no filler particles or very little of them. They offer a smooth, sealed surface. [10] Additionally, they encourage the capillary action to fill structural micro-defects and fissures to preserve surface smoothness and enhance wear resistance [11] [12] of the restorations.

Composite restorations (CRs) are subjected to a variety of environmental challenges in the oral cavity, including mechanical strains from chewing and chemical deterioration from acidic drinks and food particles, saliva, plaque, and oral enzymes. Consequently, surface deterioration of restorations is frequently noted. [13] The filler matrix interfaces may deteriorate due to cyclical temperature stresses, water, and other fluids. [14] Thermocycling, immersion in liquid media (ethanol or water), brushing simulation, and light aging were the most often utilized aging methods. [15] This study was designed in two phases; to evaluate and compare the effect of surface sealants and repolishing to regain surface smoothness of bleached resin composite, and then to test its durability after aging processes by thermocycling and tooth brushing. This study was conducted to test the null hypothesis that neither surface sealants nor repolishing affect surface roughness. Also, it was conducted to test the null hypothesis that aging had no effect surface roughness.

MATERIALS AND METHODS: (TABLE 1)

Sample Size Calculation:

The calculated sample size of this study was based for each group at 5% level of significance and 95% power using G Power 3 sample size calculator program. Also, it was based on maximum load between studied groups retrieved from previous research (Dede, et al, 2020), where effect size = 1.5, Z1-α/2 =1.96 and Z1-β=1.28. The calculated sample size was 40 specimens for each group. After that, Ethical approval for this study was declared by the Ethical Committee of Faculty of Dentistry, Mansoura University with approval number (A07060922).

A micro-hybrid RC (Opallis, FGM, Brazil), a chemically-activated bleaching system (Opalescence Boost, Ultradent, USA), a filled surface-sealant (Voco Easy Glaze, Voco GmbH, Germany), a unfilled surface-sealant (PermaSeal, Ultradent, USA), one-step resin composite polishing system (One-Gloss, Shofu, Kyoto, Japan), and a prophylactic toothpaste (Signal, Unilever, Switzerland) were employed in this study as shown in Table 1.

Preparation of Specimens:

A total number of 120 standardized disc shaped specimens of RC were prepared in a specially designed cylindrical split Teflon mold with 10 mm in diameter and 2 mm in depth with the aid of glass slide and Mylar strip during curing process. Each disc was cured for 20 seconds with a blue LED light

TABLE (1) The materials used in the study

Material	Composition	Manufacturer	Batch No.
Opallis	Matrix: Bis-GMA, bis-EMA, TEGDMA, urethane dimethacrylate. Filler: Barium aluminum silicate, silicon oxide and nanoparticles, stabilizers, camphorquinone, accelerators, and pigments.	Opallis, EA2 shade, FGM, Joinville, SC, Brazil	060122
Opalescence Boost	Barrel 1: Sodium fluoride, potassium nitrate, potassium hydroide, Carbopol, glycerin, propylene, and glycol. Barrel 2: 40%hydrogen peroxide.	Ultradent Products, Inc, USA	BN47N
Voco Easy Glaze	Dipenta-erythritol pentacrylate (50 %), methyl methacrylate (25-50%), initiators (2.5-5%), nanofillers	Voco GmbH, Germany	2042137
PermaSeal	Bisphenol A-glycidyl methacrylate (60%), triethylene glycol dimethacrylate (40%), 1-dimethylaminoethyl metacrylate (3%)	Ultradent, USA	BKXGP
One-Gloss polisher	Silicone polishers impregnated with alumina	Shofu, Kyoto, Japan	0618249
Toothpaste	Calcium Carbonate, Sorbitol, Hydrated Silica, Aqua (Water) , Sodium Mono-fluoro-phosphate, Aroma (Flavor), Sodium Lauryl Sulfate, Cellulose Gum, Trisodium Phosphate, Sodium Saccharin, Potassium Citrate, Phenylcarbinol, Glycerin, Limonene, CI 12490	Signal, Unilever, Switzerland	

curing unit (O-lightII, Guilin Woodpecker, China) with additional 20 seconds light curing in direct contact of each specimen was done after removing the glass slide. [16]

The tested surface was finished using silicon carbide paper from the coarse to fine grit (400-600-800-1200) in the same direction and then polished by extra-fine sandpaper discs. After that, all specimens were stored in distilled water at 37 °c in the incubator (Incubator 1000, Heidolph, Schwabach, Germany) for 24 hrs and stored separately in labeled compartments of plastic containers.[17] All the specimens were subjected to chemical bleaching protocol following the manufacturer's instructions by application of 0.5-1mm thick layer of gel for 20 minutes on the surface of the specimen for three consecutive sessions for a total time of 60 minutes for each specimen. Then, the specimens were washed with distilled water, and stored in artificial saliva (Nile research center, Mansoura, Egypt); at 37ºC in the incubator until testing of specimens after 10 days.

After that, the specimens were randomly divided into 3 groups according to the treatment protocol; Group I in which Voco Easy Glaze was applied, Group II in which PermaSeal was applied to the specimens' surface, and Group III in which the specimens were repolished using One Gloss polishing system.

Applications of surface treatments protocols:

According to manufacturers' instructions, Voco Easy Glaze surface sealant was applied in a thin layer on the specimens' surface with a micro-brush, distributed on the whole surface, and agitated within 1 min to guarantee that an oxygen inhibition layer hadn't been formed. Then, all treated surfaces were light cured for 30 sec. PermaSeal surface sealant was performed after etching by 37% phosphoric acid and rinsing for 30 seconds and dried for 30 seconds. The sealant was applied and rubbed using a brush, gentle air was applied, and light cured for 20 seconds.

In Group III, the specimen's surfaces were repolished using cups of One Gloss by fixing the specimens in a specially designed rubber base mold. The repolishing was performed at a low-speed by using a contra angle handpiece attached to electric motor (Strong 204 Micromotor). Each specimen was repolished for 20 second using the polishing cup under water coolant, cleaned under running water, and gently dried with gauze.

Aging with Simulated Tooth brushing and thermocycling:

At Mansoura University's Faculty of Engineering, Department of Mechanics and Power, a specially developed brushing simulation equipment was created. Its purpose was to provide a uniform force that a toothbrush (Pro-Health Clinical Battery Toothbrush, Oral-B, Braun, Frankfurt, Germany) would apply to the tooth paste slurry. Supported by an adjustable digital timer. The apparatus was linked to the digital display situated at its base. The duration of brushing was changed to 30 minutes, or 8000 cycles. Lastly, each specimen was completely cleaned with running water to remove any remaining paste, and then it was placed back into artificial saliva at 37ºC in the incubator. The specimens were then all heated to a temperature of between 5°C and 55°C for 10,000 thermal cycles in a thermocycling system, with a dwell time of 30 seconds and a transfer time of 15 seconds. (SD Mechatronic thermocycler, Germany).

Evaluation of surface roughness:

Measuring Surface roughness applied using the profilometer device with stylus contact (Surftest Sj-210, Mitutoyo, Corp, Kawasaki, Japan). The roughness average (Ra) is the arithmetical mean value of the movement of the profile stylus over the specimen's surface. Five points were determined on the top surface for measuring (Ra) of the specimen. Surface roughness was recorded at baseline after bleaching, after resurfacing, and after aging. Each specimen was stored in the artificial saliva at 37°c in an individual labeled container to be tested in between this study steps. All the collected data were undergone statistical analysis utilizing the Windows version of the Statistical Package of Social Science (SPSS) application (Standard version 26). The 5% level is the set threshold of significance (p-value). When the $p \leq 0.05$, the results were deemed significant.

RESULTS

As shown in Table 2, One Way ANOVA test revealed statistically significant differences between different stages of treatment and aging ($P \leq 0.001$) (Figure 1). In the same group, paired t test showed that there was statistically significant decrease between treatment-baseline and statistically significant increase between treatment-aging. Regarding percent of change, Kruskil Wallis test showed statistically significant differences between all the groups for all the stages of treatment and aging ($P \leq 0.001$), Table (3) and Figure (2).

The roughness showed statistically significant improvement (decrease) ($p>0.005$) after application of treatment on the specimens of all the study groups, with the highest decrease was shown by Voco Easy Glaze, followed by PermaSeal and the lowest decrease by One Gloss polishing system. Also, the aging processes produced a statistically significant increase in roughness ($p>0.005$) in all groups; Voco Easy Glaze showed the least durability against aging processes in comparison to other groups. Although the roughness was increased by aging processes in all groups, it showed a statistically significant decrease ($p>0.005$) in comparison to after bleaching in all groups.

TABLE (2) Surface roughness of each group during all stages of the study

	Voco Easy Glaze	PermaSeal	Polishing system
Baseline	0.435± 0.05	0.428 ± 0.04	0.387± 0.05
After treatment	0.297± 0.03 ≠	0.318 ± 0.05 ≠	0.337± 0.04 ≠
After aging	0.352±0.03 €	0.345 ± 0.04 €	0.365±0.04 €
Repeated measured ANOVA (F)	160.9	369.4	28.08
P value	≤0.001*	≤0.001*	≤0.001*

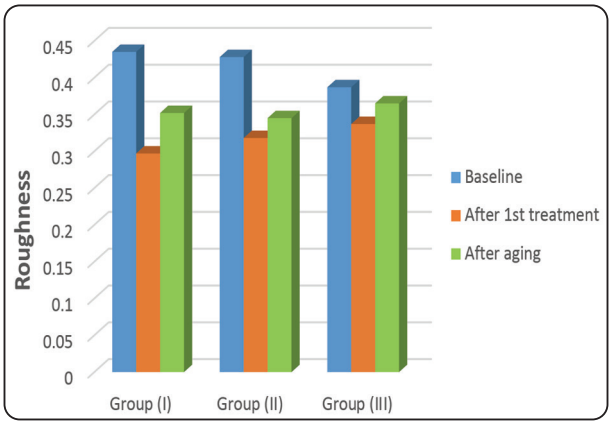

Fig. (1) Mean roughness at baseline, after treatment and after aging among different groups

TABLE (3) The comparison between different groups regarding surface roughness change

Median (Min-Max)	**Voco Easy Glaze**	**PermaSeal**	**Polishing system**	**Kruskil wallis test**	**P value**
Difference between baseline and treatment	-0.13 (-0.21 - -0.01)	-0.12 (-0.16 - -0.05)	-0.04 (-0.15 - -0.02)	KW=47.5	≤0.001*
In-between groups comparison	P1=0.002*, p2≤0.001*, p3≤0.001*				
Difference between treatment and aging	0.04 (0.01-0.15)	0.02 (0.01-0.05)	0.02 (0.00-0.12)	KW=11.21	≤0.001*
In-between groups comparison	P1=0.015*, p2=0.003*, p3=0.149				
Difference between baseline and aging	-0.10 (-0.17 -0.0)	-0.085 (-0.14 - -0.03)	-0.02 (-0.15 - 0.09)	KW=39.0	≤0.001*
In-between groups comparison	P1=0.628, p2≤0.001*, p3≤0.001*				
p1: compare group (I) and (II), p2: compare group (I) and (III), p3: compare group (II) and (III)					

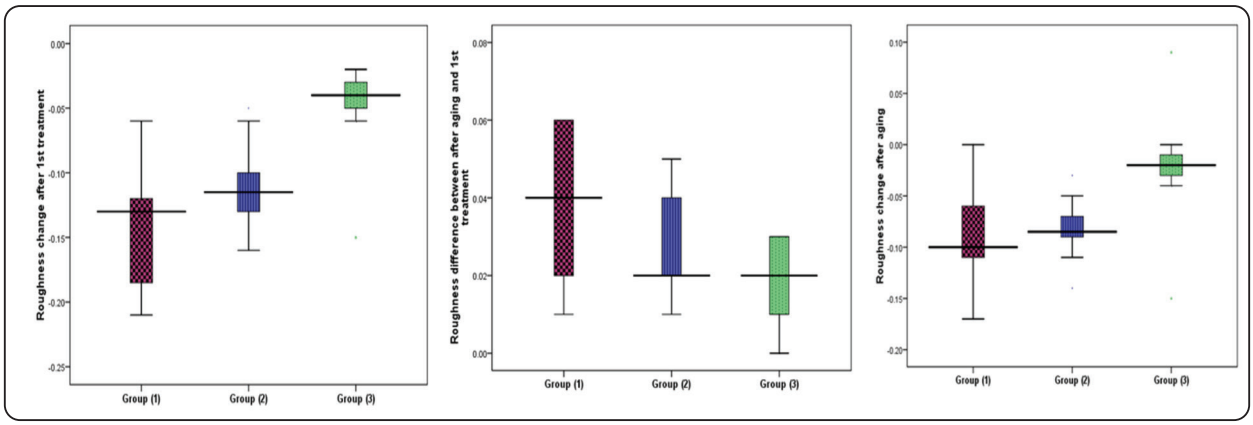

Fig. (2) Box plots for median roughness change during all phases of this study between the studied groups

DISCUSSION

One of the safest and most efficient cosmetic dental procedures is in-office dental bleaching for stained teeth.[18] A high hydrogen peroxide concentration (35–40%) is used in in-office bleaching to effectively remove discolorations. Tooth whitening and the release of stain-containing molecules are caused by an increase in the quantity of oxygen-free radicals. The detrimental effects of bleaching on dental restorations remain a topic of discussion despite their rising popularity.[19] Because resin composite restorations have favorable adhesion and cosmetic qualities, they are often utilized in dental procedures. To reduce coloring and plaque deposition, the smoothest surface must be created after using these products. Additionally, a natural-looking tooth that is the patient's preference is created by a proper counter and a lot of shine.[20]

Consequently, in order to determine whether to replace or maintain the restoration, it is required to assess surface roughness after dental bleaching. The effects of bleaching on RCs are contingent upon several variables, including resin composition, the makeup of the bleaching gel, and the frequency and length of the bleaching agent's exposure.[21] It has been noted that high hydrogen peroxide percentages can result in etching-like patterns and rough surfaces.[22] There are some worries that the surface quality of composite resin restorations may be harmed and the roughness may worsen even at low concentrations of peroxide. [19]

In this study, two different commercial types of sealants were tested; the first one was filled type (Voco Easy Glaze), and the second one was unfilled (PermaSeal) to investigate the filler existence to be a reason for choosing the surface sealant. Because the current mechanical brushing simulation approach standardized the distance and applied force on the specimens, it was easy to simulate the regular toothbrushing process." The force of 2N, or 204 g, was employed in this investigation and it presents in accordance with the ISO guidelines. The range of wear specified by ISO is 50 to 250.[23] Dentifrices' abrasiveness is measured by a process called Relative Dentin Abrasivity (RDA), which is crucial in preventing tooth discoloration from outside sources. It is advised by ISO that toothpaste RDAs not exceed 250. Signal dentifrice, which has an RDA value of 50 and is regarded as a low abrasive dentifrice, was utilized in this investigation.[24] To make the specimens more akin to actual clinical practice, they were brushed for thirty minutes. In actuality, brushing for 30 minutes might be comparable to brushing for a full year. If it were assumed that three times a day, 120 seconds would be the optimal amount of time to brush, which

would translate to six seconds per day for tooth surface brushing. [24]

During preparation of the study specimens, one surface of resin composite specimens was finished using silicon carbide paper from the coarse to fine grit in the same direction and then polished by extra-fine sandpaper discs. This is because no RCs in oral cavity left without finishing and polishing or left with polished surface made by Mylar strip. ***Alawjali*** and ***Lui*** demonstrated that Mylar strips generate weak RCs surface can be accounted for by the presence of a layer that forms on the surface of the repair that is rich in the composite resin matrix. Additionally, it has been demonstrated that surfaces with less hardness are produced by the polishing done with the Mylar strip (as opposed to abrasive polishing methods).[25] Consequently, the tougher filler particles will be able to stay in touch with the surface during polishing since the composite resin matrix will have been removed by finishing and polishing. [26]

Depending on the outcomes of this study, the null hypothesis was rejected and surface roughness decreased significantly in all tested groups after SSs and repolishing applications. The improvement in smoothness by mechanical repolishing was due to removing irregularities in the bleached surface leading to better smoother surface. This improvement by repolishing is in agreement with the study made of ***Rodrigues et al***. who reported that repolishing after bleaching improved RC smoothness.[16]

The smoothness restored by SSs was due to that they can fill the structural micro-defects and micro-fissures by the capillary effect, thereby providing a more uniform, regular surface.[27] Another reason may explain this improvement is that the sealant substance is polymerized without creating an oxygen inhibitor layer and showed a conversion rate of 80%. [28] ***Attar et al***. concluded that all of the examined samples' surface roughness was decreased by applying surface sealants after the samples had been polished. [29] Also, ***Cilli et al.***, shown that the sealed group had less surface roughness than the unsealed group at every brushing stage. [30] **Perez *et al***. determined that applying surface sealant reduced the composites' surface roughness and declared that surface sealant is an important technique for producing a polished surface. [31] ***Dede et al.*** also documented that the use of sealant agent decreased the roughness values of nanohybrid composites compared with conventional polishing. The results of this study were inconsistent with the results of the study by ***Bagis et al.*** who concluded that the using surface sealants may have no benefit in improving surface roughness.[32]

By comparing the two sealants, it was found that Voco easy glaze had better smoothness results than PermaSeal. When PermaSeal was rubbed vigorously on the surface of the RC with the applicator tip according to the manufacturer instructions, and this may lead to higher incorporation of air bubbles in the sealant. The presence of bubbles and application of air jets prior to curing can create surface irregularities.[33] In addition, differences in the composition and thus differences in the viscosity, flow rate, and penetration capacity of the surface sealants used may lead to differences in their results. The results also showed that mechanical repolishing had the lowest effect in restoring smoothness. These results may be related to One gloss system that used in this study may associated with implementation of pressure during application.[34]

As regards the aging phase, the result showed significantly increasing in surface roughness. These results were consistent with the results of study by ***Khalaj et al.*** who showed that the surface roughness increased after artificial aging processes, but this amount of increase was not statistically significant. Another study by ***Halis et al.*** concluded that application of surface sealant gave smoother surface to CRs even after toothbrushing.[35] In spite of Voco

easy glaze showed the best smoothness, it had the least durability after aging. This might be due to that Voco easy glaze is a filled sealant but PermaSeal is unfilled. When filler was added to the sealant, its performance worsened when compared with PermaSeal after thermocycling and toothbrushing.[36] This sealant's organic matrix may have worn out, causing the filler to lose or protrude, giving the surface a rougher texture.[36]

CONCLUSIONS

- Surface sealant application could improve surface smoothness of CR.
- The durability of SS is affected by aging processes.
- PermaSeal showed higher durability than Voco Easy Glaze.

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