

Effect of Staining and Bleaching on Surface Roughness of Different Nano Hybrid Resin Composite Materials

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الخلاصة

الاهداف: تهدف الدراسة الى تقييم آثار التصبغ بالقهوة والتبييض بنسبة ٣٠٪ بيروكسيد الهيدروجين على خشونة السطح لمادتي مركبة الراتنج نانو هجين . **المواد وطرائق العمل:** في هذه الدراسة التجريبية المختبرية ، تم تصنيع ٣٢ عينة قرصية من كل نوع من مواد مركبة الراتنج نانو هجين ، كل عينة قطرها ٥ ملم وارتفاعها ٢ ملم. تم تقسيم العينات لكل مادة بشكل عشوائي إلى أربع مجاميع فرعية (العدد = ٨). في المجاميع الفرعية الضابطة ، تم تخزين العينات في اللعاب الاصطناعي عند ٣٧ درجة مئوية لمدة أسبوع واحد، في المجاميع الفرعية للتصبغ تم تخزين العينات في محلول القهوة لمدة ٤٨ ساعة عند ٣٧ درجة مئوية ، في المجاميع الفرعية للتبييض والتبييض تم حفظ العينات في محلول القهوة لمدة ٤٨ ساعة عند ٣٧ درجة مئوية ثم تم تبييضها بنسبة ٣٠٪ بيروكسيد الهيدروجين ، في المجاميع الفرعية للتبييض تم تبييض العينات بـ ٣٠٪ بيروكسيد الهيدروجين. تم أخذ قياسات خشونة السطح لكل العينات لجميع المجاميع الفرعية. قياسات المجاميع الفرعية الضابطة تعتبر بيانات خط الأساس. **النتائج:** لم تتجاوز قياسات الخشونة السطحية لجميع عينات المجاميع الفرعية للمادتين المختبرة القيمة الحرجة ($R_a < 0,2 \mu m$) مع عدم وجود فرق معنوي بين جميع المجاميع الفرعية ($P > 0,05$). **الاستنتاجات:** لم تتأثر الخشونة السطحية لكلا مادتي مركبة الراتنج نانو هجين بالتصبغ بالقهوة ولا بالتبييض بنسبة ٣٠٪ بيروكسيد الهيدروجين.

ABSTRACT

Aims: The purpose of this study was to evaluate the effects of staining by coffee and In-office bleaching by 30% hydrogen peroxide on surface roughness of two different Nano Hybrid composite and Omnichroma resin-based composite. **Materials and Methods:** In this *in vitro* experimental study, 32 disc samples were fabricated from each type of the Nano-Hybrid resin composite materials, each sample measured 5 mm in diameter and 2 mm in height. The samples for each composite group were then sub-divided randomly into four sub-groups (n=8). In *control sub-groups*, samples were stored in artificial saliva at 37°C for 1 week. Samples of *Staining sub-groups* were stored in a coffee solution for 48h at 37°C. Samples of *Staining Bleaching sub-groups* were stained in a coffee solution for 48 h at 37°C then bleached with 30% H₂O₂. Samples of *Bleaching sub-groups* were bleached with 30% H₂O₂. The surface roughness measurements were taken for all samples of each sub-group; the measurements for control sub-groups considered as baseline data. Non-parametric tests were used for statistical analysis at P≤0.05. **Results:** The surface roughness measurements of all sub-groups for both tested materials didn't exceed the critical value ($R_a < 0.2 \mu m$) with no significant difference among all sub-groups ($P > 0.05$). **Conclusion:** Surface roughness of the two tested Nano-Hybrid resin composite materials were neither influenced by coffee staining nor by in-office bleaching with 30% H₂O₂.

Keywords: Resin composite, staining, bleaching, hydrogen peroxide, surface roughness, stylus profilometer.

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INTRODUCTION

Resin composites are popular esthetic restorative materials used in dentistry for their excellent optical appearance, adequate strength, and their ability to be bonded to tooth structure [1]. When applying a composite restoration, one of the major objectives is to obtain restoration with smooth surfaces and without porosities; surface roughness is an important characteristic that determines the clinical success of the composite restorative materials as restorations with rough surfaces enhance plaque accumulation, discoloration, gingival irritation and secondary caries [2]. Oral environment and routine food habits can affect surface properties of resin composites and ultimately affect the durability of composite restoration in the long term. Also, some dental treatments like tooth bleaching can have a negative influence on resin composite restorations; tooth bleaching is a simplified and non-invasive approach for tooth whitening which is based mainly on oxidation by hydrogen peroxide or one of its precursors [3]. Resin composites are more susceptible to adverse changes by tooth bleaching compared to other tooth-colored restorative materials due to the presence of organic matrix in

their composition; peroxides in the bleaching agents might induce degradation of the polymer network of resin composites which may enhance surface roughness [4]. The response of resin composite restorations to whitening materials depends on several factors such as the type and percentage of both organic matrix and fillers of resin composites, concentration and application time of the bleaching agent [3].

There are many studies separately evaluated the effects of staining solutions and bleaching agents on surface roughness of different resin composite materials, but this study sought to evaluate the effect of staining by coffee and bleaching efficiency by 30% Hydrogen peroxide gel on surface roughness of two different Nano Hybrid resin composite materials. The tested hypothesis was that staining and bleaching with 30% H₂O₂ didn't affect on surface roughness of Nano Hybrid resin composite.

MATERIALS AND METHODS

Preparation of Samples

The study was approved by Research Ethics Committee board (University of Mosul, College of Dentistry, REC reference No. POP/S.14/6/20). The materials used in this study are shown in Table (1).

Surface Roughness of different Nano Hybrid resin composite materials

Table (1): Materials used in this study.

Material name	Type	Composition	Manufacture
Joyfil	Nano Hybrid universal composite	<u>Matrix:</u> BIS-GMA <u>Filler system:</u> Non- agglomerated 0.7 nm nano-silica filler in size and aggregated schott glass/silica nano-cluster filler. Range is 7 μm (74% w, 58.89% v)	3D Dental, USA
	Omnichroma	<u>Matrix:</u> 1,6(methacryl ethyloxycarbonylamino), UDMA, TEGDMA. <u>Filler system:</u> spherical silica-zirconia filler. Ranging from 0.2-0.6micron (Mean particle size is 0.3 μm (79% w, 68% v).	Tokuyama Dental, Japan
Dash Chairside whitening system	In-office chemical bleaching	30 % Hydrogen peroxide	Philips, USA

Resin composites (Joyfil Nano hybrid composite, 3D Dental, USA, and Omnicroma resin based composite, Tokuyama Dental, Japan) were used to fabricate 64 samples (32 samples for each Nano type). Samples of Joyfil resin composite were fabricated using shade A2, while the Omnicroma resin composite samples were fabricated using universal shade, as Omnicroma resin composite has a unique characteristic of having a universal shade. Polyurethane mold was used to fabricate the samples which measured 5 mm in diameter and 2 mm in height ^[4]. The Polyurethane mold was positioned on a transparent celluloid strip over a glass slab and filled with the tested material, then the surface of the mold was covered with another transparent celluloid strip and a glass slab ^[5]. The transparent celluloid strip will improve the surface

quality of the composite sample by limiting the oxygen inhibiting layer ^[6]. The mold was then compressed with A 500gm load for 30 seconds to allow the excess material to leak out and to obtain parallel surfaces ^[5]. The load was then discontinued and the sample was light-cured for 40 seconds using (LED light-curing unit, Blue phase, Woodpecker, China) with 1000 mW/cm² light intensity from the top and the bottom; distance between the light source and the specimen was standardized by holding the tip of the light curing unit in direct contact with the glass slab which was 1cm in thickness; after polymerization, samples were immersed in artificial saliva at 37°C for 24 hours ^[7]. The samples of each composite material were randomly divided into two major groups :

Group 1 : Joyfil resin composite. (32 samples).

Group 2: Omnichroma resin composite. (32 samples).

The two major groups of composite samples were further randomly subdivided into four sub-groups, each of which included 16 samples (8 samples of each type of composite material) as follow:

- ❖ **Control sub-group:** The samples were stored in artificial saliva at 37°C for 1 week, then the surface roughness measurements were taken and considered as baseline data.
- ❖ **Staining sub-group:** The samples were subjected to staining by coffee solution; the samples were incubated in coffee solution at 37°C for 48 h, then the surface roughness measurements were taken.
- ❖ **Staining Bleaching sub-group:** After staining with coffee for 48 h, the samples were subjected to chemical bleaching by 30% H₂O₂ gel; after that, the surface roughness measurements were taken.
- ❖ **Bleaching sub-group:** The samples were subjected to chemical bleaching by 30% H₂O₂ gel then the surface roughness measurements were taken.

Staining procedure

Specimens of Staining and Staining Bleaching sub-groups were stained by preparing a coffee solution by mixing (1.5 g) of coffee powder (Nescafe Classic, Nestle, Indonesia) in 120 ml of boiling

distilled water as per manufacturer's recommendation; after stirring, the solution was filtered using a filter paper and the specimens were immersed in the coffee solution and stored inside the incubator for 48 h at 37 °C [1]. After staining procedure, the specimens of Staining sub-groups were gently rinsed with distilled water and air-dried by triple syringe, dried be ready for taking surface roughness measurements, while the specimens of Staining Bleaching sub-groups were gently rinsed with distilled water and incubated again in artificial saliva at 37°C until performing bleaching procedure.

Bleaching procedure

Specimens of Staining Bleaching and Bleaching-sub-groups were subjected to bleaching using 30% hydrogen peroxide (Dash Chairside whitening system, Philips, USA). The bleaching material was applied with the syringe and uniformly spread on the surface of each specimen with the help of a cotton applicator. The specimens were subjected to bleaching for 3 times, each time for 15 minutes as manufacturer's instructions. At the end of bleaching procedure, specimens were washed under running water for 1 minute to eliminate the bleaching agent remnants from the sample surfaces and air dried before surface roughness measurements were taken.

Surface roughness measurement

Surface roughness measurement (Ra) in (µm) was performed for all specimens

Surface Roughness of different Nano Hybrid resin composite materials

using the contact method by Taylor-Hobson stylus profilometer. The R_a values of the control sub-group were taken first and considered as baseline data. During the measurement, the end of the profilometer device was in contact with the center of the sample and then the measurements were performed from a distance of 1 mm from the left and right sides of center of the sample for purpose of standardization; the mean of these three measurements was recorded as the surface roughness value of the sample [4].

Statistical analysis

Statistical analyses were performed using SPSS software (ver. 25 for Windows). Normality test confirmed that

data didn't follow normal distribution, so non-parametric tests were chosen. Friedman's test for related samples was used to test the significance for (R_a) values at $P \leq 0.05$ among the four sub-groups of the two tested materials. Mann-Whitney U Test for independent samples was used to compare the means of (R_a) values between every two similar sub-groups of the two tested materials.

RESULTS

The means of surface roughness (R_a) values in (μm) along with a standard deviation of the four sub-groups of the two Nano Hybrid resin composite materials are displayed in Table (2) and Figure (1).

Table (2): Descriptive statistic (Mean and standard deviation) of surface roughness (R_a) for all sub-groups of both tested materials.

Sub-groups	Joyfil composite Surface Roughness (R_a)		Omnichroma composite Surface Roughness (R_a)	
	Mean (μm)	Std. Deviation	Mean (μm)	Std. Deviation
Control	0.082	0.023928	0.086	0.031595
Staining	0.101	0.037201	0.075	0.028785
Staining Bleaching	0.109	0.051113	0.101	0.035963
Bleaching	0.078	0.034122	0.109	0.038707

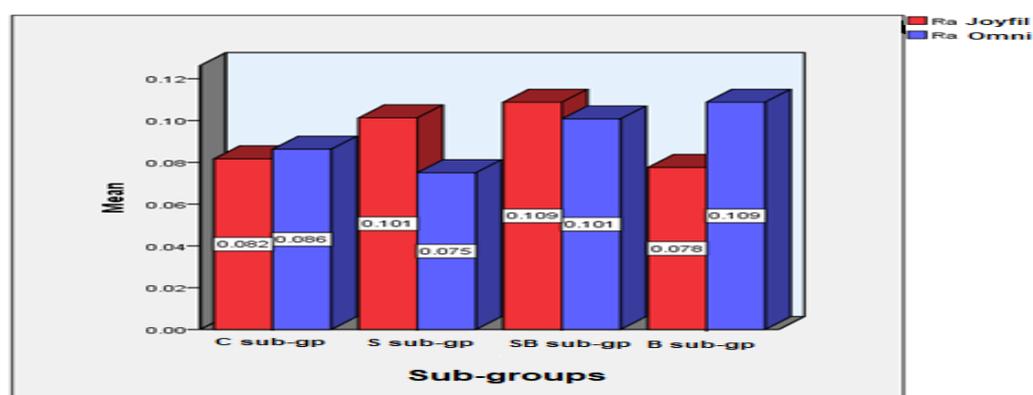


Figure (1): Mean of (R_a) values of all sub-groups for both Joyfil and Omnichroma resin composite materials. (C sub-gp: Control sub-gp, S sub-gp: Staining sub-gp, SB sub-gp: Staining Bleaching sub-gp, B sub-gp: Bleaching sub-gp).

The Mean of Roughness values (R_a) of all sub-groups of the two tested materials didn't exceed the critical limits ($R_a < 0.2 \mu m$). Friedman's test of related

samples revealed that surface roughness differences were statistically insignificant ($P > 0.05$) among all sub-groups of both tested materials as seen in Table (3).

Table (3): Friedman's test compares the (R_a) values among all sub-groups of both tested materials.

Test	Joyfil Nano Hybrid composite		Omnichroma resin base composite	
	Test statistic	Sig	Test statistic	Sig
Related-Samples Friedman's Two-Way Analysis of Variance by Ranks	3.115	0.374	4.325	0.228

Mann-Whitney U Test for independent samples was used to compare the Means of (R_a) values between each similar two sub-groups of both Joyfil and Omnichroma resin composite samples. The

result showed that there were no significant differences between (R_a) Mean values of all sub-groups for both tested materials ($P > 0.05$) as seen in Table (4).

Table (4): Mann-Whitney U Test Compares the (R_a) Mean values of each similar two sub-groups for both tested materials.

(R_a) of Sub-groups of Joyfil and Omnichroma resin composite	Test statistic	Sig
(R_a) of C sub-gp (Joyfil) and (R_a) of C sub-gp (Omni)	34.000	0.878
(R_a) of S sub-gp (Joyfil) and (R_a) of S sub-gp (Omni)	18.000	0.161
(R_a) of SB sub-gp (Joyfil) and (R_a) of SB sub-gp (Omni)	29.500	0.798
(R_a) of B sub-gp (Joyfil) and (R_a) of B sub-gp (Omni)	45.500	0.161

(C sub-gp: Control sub-gp, S sub-gp: Staining sub-gp, SB sub-gp: Staining Bleaching sub-gp, B sub-gp: Bleaching sub-gp).

DISCUSSION

This study examined the influence of staining by coffee and bleaching by 30% H_2O_2 on surface roughness of two different Nano Hybrid resin composite materials. Coffee was selected in the present study because it is a very frequently consumed beverage. Also, tooth bleaching has become a routine treatment in common dental practice, so the effect of bleaching agents on morphological and surface texture of composite restorative materials

should also be considered [8]. Resin composites have a biphasic nature (composed of a resin matrix and filler particles) and the type of resin matrix has been shown to play an important role in water sorption from different beverages and staining solutions; increase in water sorption can decrease the life of resin composite by expanding and plasticizing the resin component, hydrolyzing the silane and causing microcracks formation at the interface between the fillers and the matrix

which may increase surface roughness [9]. The increase in fluid uptake (water sorption) was attributed to the incorporation of hydrophilic monomers in the resin matrix. Bis-GMA and TEGDMA are hydrophilic monomers due to the presence of hydroxyl group in their chemical structure; in contrast, (UDMA) is less hydrophilic with low water sorption than Bis-GMA and TEGDMA, so it's more resistant to staining and solubility and changes in surface texture [1]. The surface roughness of restorative materials has been a major concern for researchers and clinicians because it is an important clinical property with a confirmed effect on dental esthetics and oral health. The surface roughness (R_a) value measured in μm and the acceptable threshold of (R_a) is believed to be 0.2 μm ; increasing in superficial roughness of restorative materials beyond the critical value (0.2 μm) is considered clinically relevant because this will increase the risk of extrinsic staining, plaque maturation, gingival inflammation and periodontal disease [5]. Although Bis-GMA and TEGDMA are present in both tested materials, the surface roughness values after immersion the samples of both Joyfil and Omnicroma in coffee Dolution didn't exceed the critical limit ($R_a < 0.2 \mu\text{m}$) with no intergroup and intragroup statistical significant differences ($P > 0.05$) and these results coincided with the results obtained by Tuncer *et al* and Gül *et al* [2,8] who also concluded that staining by coffee didn't increase the surface roughness of

composite samples. These results may be attributed to low water sorption rate or low resin content for these two materials. With respect to filler system, resin composites with high filler loading and small filler size are expected to have good characteristics and more resistant to degradation and changes in surface topography with less response to staining solutions and bleaching agents [10]. Another explanation is that coffee staining solution is not acidic and has high pH when compared to other staining solutions like cola and red wine, so it didn't induce resin degradation and changes in surface roughness.

The consequences of bleaching procedures on resin composites surface topography have been assessed in many studies; the resin matrix of resin composites has shown to be highly susceptible to softening and undergo alteration induced by bleaching agents compared to other restorative materials; hydrogen peroxide (H_2O_2) generates free radicals which have an extensive ability for diffusion and penetration the surface of composite restorative materials then producing degradation of polymer network, so a resin composite with higher resin content is expected to be more pronounced to degradation by bleaching materials [8]. Also, the effect of high energy free radicals liberated from peroxides at the resin-filler interface might cause complete or partial filler-matrix detachment and water uptake that accelerates the hydrolytic degradation of resin composites leading to more

separation and debonding of filler particles and ultimately increased surface roughness of restorative material [11]. Gül *et al* [8] reported that bleaching procedures caused a significant increase in surface roughness in tested samples and referred this result to degradation of the composite resin matrix. In contrast, studies were done by Yikilgan *et al*, Bahari *et al* and Varanda *et al* [4,5,12], summarized that bleaching agents have no significant effect on surface roughness of resin composite materials. These results came in agreement with the present study that bleaching by hydrogen peroxide has induced a slight increase in surface roughness, but this increase was clinically and statistically irrelevant as ($R_a < 0.2 \mu\text{m}$) and ($P > 0.05$). These results revealed that hydrogen peroxide didn't influence changes in surface properties in Nano Hybrid resin composites due to less degradation of the resin matrix. The silica Nanoparticles contained in both tested materials can also contribute in resistance to surface roughness of resin composites after bleaching procedure; this coincided with the finding by Dogan *et al* [13] who affirmed that glass particles containing barium are more susceptible to hydrolytic attack than quartz or silica. Taking into consideration these results, the tested hypothesis that staining and bleaching didn't affect surface roughness of Nano Hybrid resin composite was accepted. A comparison between the two tested materials about roughness values was irrelevant as ($P > 0.05$), so both materials are

good choices to be used for patients who will undergo bleaching treatments in the future.

Some limitations of this study can be pointed out that this is an *in vitro* study and it was not possible to directly mimic the oral conditions, so the effect of staining and bleaching products on surface roughness of restorative materials under *in vitro* conditions may be different from that under *in vivo* conditions.

CONCLUSION

Within the limitations of this study, it may be concluded that staining by coffee and bleaching by 30% hydrogen peroxide didn't induce obvious changes in surface roughness of both Joyfil and Omnicroma resin composite materials.

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