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# The Effect of Dental Bleaching on Surface Roughness and Microhardness of three Different Filler Types of Composites (An *in vitro* Study)

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## ABSTRACT

*Aim: This study looked at the effects of in-office bleaching on surface microhardness and roughness of three composite resin materials: Nano filled, Nano hybrid, and Supra-nano spherical resin composite.*

*Methods: A total eighty-four discs-like of nano filled, nano hybrid, Supra-nano spherical resin composite restorations were divided into two main groups for microhardness and surface roughness tests. Then, according to the type of composite, each main group was separated into three subgroups. Before and after bleaching with 32 percent hydrogen peroxide, the surface roughness and microhardness of all samples were assessed. The microhardness was measured by using Vickers tester, and a mechanical 2D profilometer surface roughness tester was used to measure the surface roughness. Repeated measures ANOVA and post hoc Tukey's test (alpha=0.05) were used to evaluate the data.*

*Results: After bleaching for surface roughness, the data demonstrates a statistically significant difference between the three tested groups, as well as a statistically significant difference between the three tested groups after bleaching for microhardness.*

*Conclusion: The application of bleaching substance increased the surface roughness and lowered the surface hardness of the three tested groups.*

**Key words:** Flash bleaching agent, Hardness, Surface roughness, Composite resin

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## INTRODUCTION

The appearance of teeth determines individual appearance. There are many factors that contributed the teeth appearance such teeth color, shape, position, and quality of the dental restorations [1,2]. Teeth color is one of many factors that determine individual satisfaction with their teeth appearance. Dental bleaching (teeth whitening) can be done by using many chemicals and natural materials. Generally, chemicals materials that used in dentistry for teeth whitening (dental bleaching) products are hydrogen peroxide and carbamide peroxide [3,4]. These materials bleach the teeth by releasing peroxide free radicals. Internal and external pigments of the teeth combine with these radicals and remove the pigments through an oxidative reaction [5,6]. But the use of these materials in teeth whitening procedure is currently still debatable because it might also affect the oral hard and soft tissues [7,8]. The use of these agents in high concentrations and for long periods might cause excessive teeth sensitivity and may harm the oral mucosa and gingiva [3,9]. Many Factors can affect the teeth whitening procedure like the type, concentration, and application duration of teeth whitening material, also, the light source and temperature factors [9]. Also, there are other factors that have the potential to inhibit the bleaching procedure like plaque and calculus.

There are many types of materials that use for tooth restorations, one of these materials is a composite resin. The composite resin is divided according to filler particles size into the traditional, small-sized filler, micro- sized filler, hybrid, and nano filled. Nano filled composite was introduced to the public for aesthetic demands with benefit on a glossy and smooth surface, so it is almost used for anterior teeth [10-12,2].

According to the polymerization process, the composite resin divided into chemical activated, light-activated and chemical-light activated (dual cure). Light Emitting Diode (LED) activated composite resin is a new technology to polymerize restoration materials in dentistry and has a positive effect compared to halogen light [2,10,11].

The chemical processes of bleaching agents may alter the clinical durability of dental composite restorations when they are used. Changes in the surface morphology, chemical, and physical properties of dental restorative materials were one of the side effects of bleaching agents. Surface microhardness is a physical property of a restorative material that indicates its resistance to indentation or penetration [13].

Much research has found mixed results when it comes to the impact of bleaching chemicals on the surface microhardness and surface roughness of dental composite resin, with some seeing a reduction in surface microhardness after applying bleaching agents [6,14,15]. Also, no changes in the surface microhardness after the application of bleaching agents were reported in some other studies.

The goal of the study was to see how dental bleaching affected the surface roughness and microhardness of three different types of composite fillers (Nano filled resin, Nano hybrid resin and Supra-nano spherical resin composite). The hypothesis tested was that there would be no effect of 32% hydrogen peroxide bleaching agent on surface roughness and microhardness of three different filler types resin composites.

## MATERIALS AND METHODS

The study protocol was approved by the Ethics Committee of College of Dentistry, University of Baghdad (290521).

### Preparation of resin samples

The research samples were 84 composite disks, these samples were divided into two main groups according to type of test; for each test 42 composite disks were used and these sample were divided into 3 subgroups according to type of composite, each group was 14 samples as follow:

- ✓ Group A: Nano hybrid resin composite Tetric N-Ceram from Ivoclar:
- ✓ Group B: Supra-nano spherical resin composite OMNICHROMA from Tokuyama.
- ✓ Group C: Nano filled resin composite type Z350XT from 3M:

Then the groups were tested as the following:

- ✓ Group A1R, B1R and C1R For Surface Roughness test before Hydrogen peroxide application.
- ✓ Group A2R, B2R and C2R For Surface Roughness test after Hydrogen peroxide application.
- ✓ Group A1M, B1M and C1M For Microhardness test before Hydrogen peroxide application.
- ✓ Group A2M, B2M and C2M For Microhardness test before Hydrogen peroxide application.

The research samples were prepared using a specially designed acrylic mold with dimensions 8mm in diameter and 2mm in thickness. A Mylar transparent matrix band was pressed on the mold after layering the composite resin material within the mold to obtain a smooth surface on the composite resin and prevent the creation of an oxygen-inhibited layer. The composite resin samples were then light-cured for 20 seconds at a right angle to the surface using an LED light cure unit (eighteeth, Changzhou Sifary Medical Technology Co., Ltd) with a light intensity of 1000 mW/cm2 that was measured by radiometer. Following the manufacturer's instructions, the group samples were polished using medium to superfine polishing disks (Sof-Lex TM, 3M ESPE, St. Paul, USA), To remove all debris, rinse with distilled water and clean with an ultrasonic instrument for two minutes. The prepared samples were maintained in distilled water at 37°C for 24 hours to ensure complete polymerization [6,16].

### Bleaching procedure

For each group, 32% Hydrogen Peroxide bleaching agent (Flash, Germany) was applied on the surface of the three types of composites for 15 minutes, three times in one session during the study with a thickness of 1mm (measured with a scaled periodontal probe) according to manufactural instructions to completely cover the sample surface. Distilled water will be used to rinse the samples after each bleaching procedure.

**Evaluation of surface microhardness and surface roughness**

The surface roughness and microhardness of all samples were determined 24 hours after polymerization, and after the bleaching process, the microhardness was measured using a Vickers indenter with a 100-gram force and a dwell duration of 15 seconds using Vicker's microhardness test (LARYEE, China). The indenter was placed on the upper surface of the composite disks, and three indentations were made in each sample, one mm apart from the disk edges and other indentations. The diameter of the indented rhombus was determined using the formula VH=F/d2 to determine the microhardness values at the three spots [17]. Finally, the mean of the three points was calculated and reported as the surface microhardness of each composite resin sample. A calibrated mechanical 2D profilometer surface roughness tester was used to assess the roughness of the surface (leeb 432A, Testcoat, USA) [18]. A diamond stylus with a diameter of 5m and a stylus angle of 90 was traversed in a length of 1.25mm and a cut-off length of 0.25 mm was employed on the profilometer to measure the (Ra) for each specimen according to ISO-DIN 4768 specification for surface roughness measurement. The average reading was taken after three measurements were taken in the middle of each sample at crossing directions with the use of a ruler [19].

**Statistical analysis**

Both Kolmogorov–Smirnov and Shapiro–Wilk tests were used to determine if the data from VHN and Ra before and after bleaching were normally distributed. The parametric analysis method was utilized since the data (N) were normally distributed. IBM Statistical Package for Social Sciences (SPSS) 26 Software for Windows was used to examine the data. At a significance level of 0.05, the data were subjected to a one-way analysis of variance (ANOVA) and Tukey's honest significant difference (HSD) tests.

## RESULTS

Tables 1 and 2 show the calculated means of VHNs and standard deviations (SD) before and after the bleaching procedure for all groups, whereas Tables 3 and 4 show the means and SD of Ra values before and after the bleaching process for all groups.

**Surface microhardness**

The collected hardness data revealed significant differences between all test groups before bleaching ($p<0.000$) and after bleaching ($p<0.000$) using a one-way ANOVA analysis. For all groups before bleaching, the HSD test revealed a highly significant difference between A1M

**Table 1: Minimum, maximum, means and (SD) of surface microhardness for all three groups before bleaching.**

| N | | Mean | Std. Deviation | Std. Error | Minimum | Maximum |
|---|---|---|---|---|---|---|
| A1M | 14 | 40.06786 | 3.710387 | 0.991643 | 31.55 | 45.5 |
| B1M | 14 | 43.38857 | 3.974656 | 1.062271 | 36.82 | 48.9 |
| C1M | 14 | 59.42286 | 5.475583 | 1.463411 | 50.83 | 68.53 |
| Total | 42 | 47.62643 | 9.593658 | 1.480334 | 31.55 | 68.53 |

**Table 2: Minimum, maximum, means and (SD) of surface microhardness for all three groups after bleaching.**

| Groups | N | Mean | Std. Deviation | Std. Error | Minimum | Maximum |
|---|---|---|---|---|---|---|
| A2M | 14 | 23.7471 | 4.46912 | 1.19442 | 17.51 | 32.84 |
| B2M | 14 | 32.9879 | 4.82345 | 1.28912 | 25.01 | 39.56 |
| C2M | 14 | 45.3207 | 4.26561 | 1.14003 | 39.09 | 53.62 |
| Total | 42 | 34.0186 | 9.97422 | 1.53906 | 17.51 | 53.62 |

**Table 3: Minimum, maximum, means and (SD) of surface roughness for all three groups before bleaching.**

| N | | Mean | Std. Deviation | Std. Error | Minimum | Maximum |
|---|---|---|---|---|---|---|
| A1R | 14 | 0.469 | 0.055416 | 0.014811 | 0.389 | 0.549 |
| B1R | 14 | 0.475 | 0.068463 | 0.018298 | 0.335 | 0.572 |
| C1R | 14 | 0.46579 | 0.050076 | 0.013383 | 0.384 | 0.573 |
| Total | 42 | 0.46993 | 0.057183 | 0.008824 | 0.335 | 0.573 |

**Table 4: Minimum, maximum, means and (SD) of surface roughness for all three groups after bleaching.**

| | N | Mean | Std. Deviation | Std. Error | Minimum | Maximum |
|---|---|---|---|---|---|---|
| A2R | 14 | 0.6745 | 0.039481 | 0.01055 | 0.613 | 0.755 |
| B2R | 14 | 0.7541 | 0.036744 | 0.00982 | 0.688 | 0.811 |
| C2R | 14 | 0.8151 | 0.052543 | 0.01404 | 0.703 | 0.899 |
| Total | 42 | 0.7479 | 0.072049 | 0.01111 | 0.613 | 0.899 |

and C1M groups (p=0.000) and B1M and C1M groups (p=0.000). There was also a significant difference between the A1M and B1M groups (p=0.133). In addition, the HSD test revealed a highly significant difference between A2M, C2M (p=0.000) and B2M, C2M (p=0.000) groups. After bleaching, there was also a significant difference between the A2M and B2M groups (p=0.000).

**Surface roughness**

When the collected Ra values were analyzed using One-way ANOVA, there were no significant differences between the groups before bleaching (p< 0.915) and highly significant differences (p< 0.000) after the bleaching process. HSD test showed highly significant difference between A2R, B2R groups (p=0.000) and A2R and C2R groups (p=0.000). Also, a significant difference between B2R, C2R groups (p=0.002) after bleaching.

## DISCUSSION

In ordinary dental practice, restoring damaged teeth with modern resin composites was a common procedure. Contemporary resin composites have made significant advances not only in their chemical formula but also in their application processes, which can closely replicate both surface and optical tooth features [20]. However, some in-office procedures, such as bleaching, may have a negative impact on these characteristics [15]. Normally, to improving teeth esthetics a short-term approach used like dental bleaching. There are a variety of in-office and at-home bleaching products on the market today; however, carbamide and hydrogen peroxide-based gels are the most typically used in in-office bleaching procedures. Even though bleaching treatment appears to be simple for patients, some authors have found adverse effects on existing dental restorations as well as oral and dental tissues. The bleach products' potency and acidity could be the main causes of the bleaching treatment's negative effects [21]. Resin composites are the most used direct cosmetic tooth replacement material when compared to dental amalgam and glass-ionomer. These materials offer a wide range of clinical applications in addition to their acceptable mechanical and esthetic endurance [20].

On the one hand, dental composites' surface roughness increases the risk of dental caries and periodontal disease through influencing the adhesion and retention of dental plaque [22,23]. Surface roughness influenced the color, gloss, and staining susceptibility of resin composite restoratives [24].

Hardness, on the other hand, refers to the ability of restorative composite resin materials to withstand mechanical degradation in service; however, the size and amount of filler in the material can affect this ability [25,26].

Bleaching agents can influence the microhardness and surface roughness of restorative materials, bleaching agents may produce a decrease in surface hardness and an increase in surface roughness [16,27]. So, the goal of this in vitro investigation was to see how a bleaching agent affected the surface hardness and roughness of three different types of resin composites.

**Microhardness evaluation**

**Effect of Bleaching materials**

According to the findings of this study, the null hypothesis was rejected, because the in-office bleaching resulted in a highly significant decrease in composite resin surface microhardness for all groups, which is consistent with the findings of Kamangar et al, who found a decrease in composite resin surface microhardness after bleaching with a higher concentration of Hydrogen peroxide [28]. Also, the findings of this study came in agree with the finding of Mohammadi et al., 2019, and disagree with findings of studies by Yap and Wattanapayungkul which reported that no significant difference was observed in microhardness levels of resin materials after applying (CP at 35% and HP at 35%) in-office bleaching.

The free radicals created by hydrogen peroxide may cause the separation of polymer chains and the breakage of double bonds in the composite resin structure, resulting in a decrease in surface microhardness. Free radicals also cause microcracks at the resin-filler contact [29].

In this study, the higher concentration of HP in the in-office bleaching procedure resulted in a greater drop in the surface microhardness of composite resins, which might be explained by an increase in the disintegration of composite resin material [6,30,31].

According to Alkahtani's research, having a higher proportion of TEGDMA in a resin composite can reduce surface microhardness. Due to the integration of TEGDMA diluent monomers in the resin matrix, the resin matrix may become less resistant to bleaching agents, and the softening of resin composite material may be increased [32].

The influence of bleaching agents on the surface properties of composite resins varies depending on the type of bleaching agent, the time it is applied, and the substrate [33]. Because bleaching agents impact the resin matrix, composite resins with a small matrix volume are less sensitive to bleaching agent adverse effects [6,33].

**Surface roughness evaluation**

The average roughness (Ra), which represents the arithmetical average value of all absolute distances of the roughness profile from the center line within the measuring length, was used to characterize surface roughness [34].

Due to the increase in surface porosity and loss of material mass the surface was noted to be rough, in addition to water sorption, that cause color change and resin morphology dimensional alterations [35,36].

A study stated that the roughness will not contribute to plaque accumulation if a surface has a roughness value less than 200 nm (0.2µm) but plaque accumulation will be unavoidable if the value is higher [37]. Other studies stated that if the surface roughness of the restorative material was ≤ 1 µm this value considered to be an acceptable value [38,39].

A resin matrix and filler particles are the biphasic nature of resin composites. The type of resin matrix has been shown to play an important role in water sorption from different beverages and staining solutions; increased water sorption can decrease the life of resin composites 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 s [40].

In the current investigation, the null hypothesis was rejected, because the using 32 percent HP in-office bleaching resulted in a larger rise in the surface roughness of composite resins, which may be explained by the bleach compromising the structural integrity of the composite surfaces, and these findings came in agree with the previous studies [1,16,41], and disagree with the findings of other studies [42,43]. Some authors have reported degradation of the resin matrix and resin–filler bonds in the presence of bleach [44,45], and Steinberg et al. [46] supported it, stating that in the presence of acidic and oxidizing bleaching chemicals, resin composite surfaces are susceptible to chemical erosion.

Bleaching agents should not be used indiscriminately in patients' mouths, according to the findings of this study, and teeth with extensive tooth-colored restorations should be avoided or at least protected. Patients should be advised that tooth-colored restorations may lose their physical properties because of the bleaching procedure. The composite restoration may need to be replaced because of these consequences, which could contribute to increased adherence of cariogenic bacteria, surface wear rate, stain absorption, and likely marginal/edge strengths of these restorations.

## CONCLUSIONS

Within the limits of the present in vitro study, it can be concluded:

- ✓ In-office bleaching material caused significant decrease in microhardness of the three types of composites.
- ✓ Bleaching by 32% hydrogen peroxide caused significant increase in surface roughness.

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