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Research Article

Comparison of Different Bleaching Treatments Effect on Micro Hardness of Four Different Aged Composites

Alireza Danesh Kazemi,[1] and Najmeh Johar[1,*]

[1]Operative Dentistry Department, Shahid Sadooghi University, Yazd, IR Iran

[*]*Corresponding author*: Najmeh Johar, Operative Department, School of Dentistry, Shahid Sadooghi University, Yazd, IR Iran. Tel: +98-9193422940, E-mail: najmejohar@gmail.com

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Abstract

Background: In this study, four different types of composite samples were aged then exposed to 16% carbamide peroxide and 40% hydrogen peroxide, and the results were compared to a control group.

Objectives: The aim of this study was to investigate variations of micro hardness in types of composite materials after bleaching treatments and comparison of hardness in types of composites.

Methods: From each composite, (Z100, Z250, Z350, P90) 36 composite discs were prepared with dimensions of up to 3 × 8. The samples went through the aging process for four weeks, and then they were placed in a thermocycling device for 5000 cycles. The composite samples were divided to duodenary three subgroups and each subgroup was exposed to different bleaching treatments including: 1. untreated control group, 2% - 35% hydrogen peroxide (Office B.) and 3% - 16% carbamide peroxide (Home B.). After 14 days of treatment, micro hardness of composite samples (Vikers) was evaluated. The obtained data were analyzed via Analysis of Variance (ANOVA) and Tukey tests and significance level was determined as 0.05.

Results: The mean values of VHN after home bleaching treatment in composite Z100 (163.0), Z250 (100.4), Z350 (116.7) and P90 (80.0) were different from non-treated group including Z100 (146.8), Z250 (84.0), Z350 (110.4) and P90 (76.8), yet this difference was not significant. While in the after office bleaching treatment, the results of mean value were as follows, Z100 (163.0), Z250 (100.4), Z350 (116.7), P90 (80.0) Z100 and Z350; a significant increase in hardness was seen in both groups.

Conclusions: Aged composite bleaching leads to an increase or no change in microhardness compared to the control group that depends on the type of restorative material and bleaching agent. Meanwhile, in the composite examined in this study, the highest rate of microhardness was related to composite Z100 and subsequently Z350 and the lowest rate was related to both composites Z250 and P90.

Keywords: Composite, Bleaching, Aging, Carbamide Peroxide, Hydrogen Peroxide

1. Background

Paying attention to teeth has increased remarkably. In 2011, an article was published, that stated 21% of Americans are dissatisfied with the color of their teeth and 28% of Americans are dissatisfied with the appearance of their smile (1). Various methods have been developed to improve smile appearance with one of the most common methods being the application of bleaching agents to correct the color and to make the teeth brighter (2). Bleaching has some advantages such as availability of materials, low cost, high safety and low complications and is used widely in beauty treatments (3).

Bleaching methods are divided to two main categories: at the clinic and at home. Regarding the method performed at home, the materials are prescribed by a dentist and are used by the patient at home inside a special tray, and these materials mainly contain hydrogen peroxide up to 10% and carbamide peroxide up to 16% (or higher concentration) (4). Regarding the method performed at the clinic, materials containing high concentrations of hydrogen peroxide (35% -30%) and/ or 35% carbamide peroxide are used for faster outcome (4).

The basis of all bleaching methods is similar and includes the use of peroxide compounds or its derivatives such as carbamide peroxide. These substances are oxidizers and produce free radicals during decomposition (5). Stain removal is done often by shortening these colored molecules via oxidation together with breaking the conjugated bonds by OH and OOH radicals, so that molecules with lower molecular weight reflect less light (6).

Many people of the society have repaired teeth. It has been reported that about 40% of people have at least one repair in their mouth (7). Also, composites, as tooth isochromatic materials, have been welcomed by the public and are used widely in dental restoration (5). Thus, it is necessary to investigate the treatment effect of bleaching on composite properties in order to select the best treatment for the patients.

Bleaching agents that are in contact with composite restorations can affect organic and inorganic structure of the composite and cause a chemical change, this issue can affect the durability of the clinical restoration (8).

The bleaching agents with high oxidative capacity in contact with organic molecules are able to harm the composite matrix polymer network and make this material susceptible to degradation (9). Also the changes in the inorganic phase content will change the surface and physical properties of the substance (9).

The presence of bacteria and their products, large forces of chewing, warm liquids and constant change of pH in the mouth has made this environment one of the hardest environments to keep restorative materials (10). These conditions lead to change in properties of the composites over time. After polymerization, penetration of water and ions into the composite polymeric matrix and filler, activator elements and non-polymerized monomers are exited that lead to changes in the materials and properties of the composition (11).

Hardness of the material surface is among these properties that plays an essential role in the wear rate and clinical repair durability. For this reason, changed composites during their clinical act may differ from new composites in exposure to bleaching agents. Hardness is defined as resistance of a material against depression or penetration of other materials (8). Results of various studies about composites microhardness after bleaching have reported a decrease in hardness (2, 3, 5, 7, 9, 12-16), increase in hardness (14, 17-19) or no significant change (3, 8, 20-26).

This study was designed to examine the effect of bleaching at the clinic and at home on microhardness of four types of aged composites and zero hypothesis included: 1-Various types of aged composites bleaching treatment do not change their microhardness and 2- Microhardness rate of various types of aged composites are not different from each other after bleaching.

2. Objectives

The aim of this study was to investigate variations of micro hardness in types of composite materials after bleaching treatments and comparison of hardness in types of composites.

3. Methods

3.1. Specimen Fabrication

Four composites were examined in this study, which were produced by the 3M (3M ESPE, USA) company that included: Z250 (microhybrid), Filtek Z350 (nanofield), Filtek P90 (Siloran) and Filtek Z100 (hybrid).

From each composite sample, 36 discs with diameter of up to 8 mm and thickness of up to 3 mm were selected. Shade of all composites was chosen as A3. To prepare the disks, a Mylar band (Maquira dental product - Brazil) was placed on a glass plate and plastic material with dimensions of up to 8 × 3mm was placed on it. The composite was placed inside the generator and its surface was coated with a Mylar tape (2). Before curing, a glass slab was placed on the composite surface in order to remove its excess and to decrease its porosities, and curing was done.

Then, the slab was removed and each surface of the sample was cured for 40 seconds by light cure LED device (Demi / Kerr / USA). Meanwhile, light intensity of light cure device was measured several times by a Demetron radiometer (kerr / Taiwan), which had power of up to 800mw / cm^2. All samples were polished in one direction using silicon carbide polishing discs (Tor - Russia) and low speed hand piece by medium, fine and superfine discs, respectively (2). Then they were washed with water for two minutes to clean the surface debris and they were kept in distilled water at 25°C at room temperature for 24 hours in order to accomplish the polymerization process (2).

3.2. Aging Process

The samples were kept in artificial saliva for 28 days (Hypozalix / France) containing potassium chloride, sodium chloride, magnesium chloride, dipotassium phosphate and phosphate monopotassium to achieve the conditions of the oral cavity (16). After this time, the samples were exposed to a temperature of 5 - 55°C for 30 seconds, and at each temperature (27) thermo-cycling (Vafay - Iran) of up to 5000 cycles was performed in order to simulate the thermal aging process (28). Then, the composite samples of each group were randomly divided to three subgroups with 12 samples (2):

Group A (control group): Samples of this group were kept in artificial saliva for 14 days and bleaching treatment was not implemented for them (2).

Group B (office bleaching): samples were under bleaching treatment during three 30-minute periods with 40% Power Whitening hydrogen peroxide gel YF (White smile / Germany). The interval between two treatment periods was up to one week (2).

Group C (Home bleaching): samples were under bleaching treatment for 14 days and every day for four hours with carbamide peroxide gel, 16% white smile Home Whitening (White smile / Germany) (2).

During this period, the test samples were kept at room temperature and were washed with pure water after each treatment to remove bleaching agents from the surface. The samples were kept in artificial saliva during sample treatment intervals (25).

3.3. Measurement of Hardness (Microhardness Test)

All samples were kept in distilled water for 24 hours before the test to remove debris and the remaining ingredients from the surface and be ready for the test. Then the samples were dried at room temperature and their microhardness rate was assessed by Vikers hardness testing machine (Koopa Pazhohesh / Iran), applying 100 g force for 10 seconds (29). The hardiness rate of each sample was observed and measured with distance of up to 2 mm from disc edge at three different points and Vikers microhardness number of samples was recorded and average of these three samples was considered as Vikers number of the sample (2).

3.4. Data Analysis Method

After data collection, they were decoded and entered in the computer. The SPSS18 software package and bilateral analysis of variance (ANOVA) statistical tests and Tukey post hoc test was used for data analysis. Moreover, significant limit was up to 0.05.

4. Results

The results related to the microhrdness tests are presented in Table 1 and Figure 1.

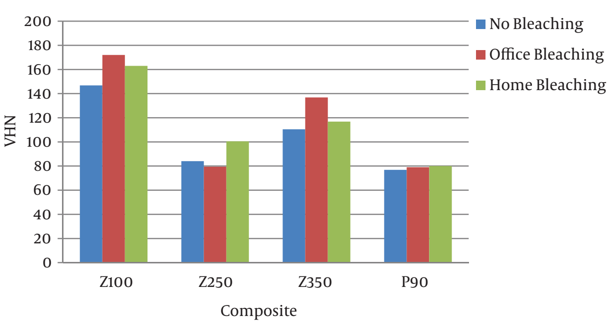

Figure 1. Mean Vickers Microhardness Value of the Studied Groups

The data were analyzed via SPSS software by ANOVA statistical tests. The ANOVA indicated that the behavior of various composites is different regarding exposure to bleaching agents, thus they were compared and studied in the samples via Tukey's test.

Composite variable was studied and the microhardness results of each composite were obtained. The obtained data were analyzed via Tukey honest significant difference (HSD) test in order to study the significance of group difference. The results of this analysis are shown in Table 2.

In comparison to the composite groups, it was clear that Z100 had the highest hardiness and after that Z350 had the highest hardiness. The least hardiness belonged to Z250 and P90, with no significant difference in microhardness between them.

Bleaching treatment variables were studied to investigate the mean Vickers microhardness value of bleaching treatment of each group regardless of the type of composite. Tukey HSD test was used to study the results of the Vickers microhardness value before and after bleaching treatments. The results of this test are shown in Table 3.

The results revealed that microhardness of the samples was significantly higher than untreated samples after bleaching treatment yet significant difference was not observed between the microhardness of samples subjected to office bleaching and home bleaching treatments.

Bleaching treatments were compared individually to the control group for each composite, with the results presented in Table 4.

It was observed that office bleaching treatment of the Z100 and Z350 composites is the only treatment that increases micro hardness significantly and there was no significant different when other groups were compared with the control group.

Finally, both office and home treatments were studied individually regarding each composite and they were analyzed with significance level of up to 0.05 (Table 5).

It was clear that in Z250, home bleaching had greater effect than office bleaching, with this difference being significant. While, in Z350 the effectiveness of office bleaching treatment was significantly higher than home bleaching treatment.

5. Discussion

Hardness is defined as material resistance to deformation and penetration of other material to the surface and it is assessed as mean hardness or micro-hardness. Also there is a direct relationship between surface hardness and ductility, elasticity, stiffness, plasticity, toughness, viscosity and viscoelasticity of the material. Material abrasive ability and the rate of material wearing with the front teeth, brush or other materials in the mouth are effective in determining the durability of clinical restoration (2).

Compared to the composite microhardness groups in this study, it was found that Z100 has the most microhardness followed by Z350. The least microhardness was related to two groups of Z250 and P90, with no significant difference between these groups. During a separate study about the effect of home bleaching with 16% carbamide peroxide, it was found that compared with the control group, it did not lead to significant change in microhardness in any one of the composite groups. However, a small increase was seen in the composite hardness of all composite groups. The cause of this phenomenon can be stated as resin matrix degradation exposing to oxidizers (1). In 2011, Yu reported that by increase in composites environment temperature, composite microhardness rate is decreased, because it leads to hydrolysis of composite polymeric section

Table 1. Mean Vickers Microhardness Value of the Studied Groups

Composite	Bleaching Method	Mean	Standard Deviation
Z100	No bleaching	146.814	6.17
	Office bleaching	172.056	21.62
	Home bleaching	163.006	21.66
Z250	No bleaching	84.086	20.55
	Office bleaching	79.444	18.22
	Home bleaching	100.467	22.05
Z350	No bleaching	110.481	13.02
	Office bleaching	136.881	12.70
	Home bleaching	116.792	13.45
P90	No bleaching	76.839	3.85
	Office bleaching	79.031	8.48
	Home bleaching	80.069	15.82

(1). Cathelan (30), Schmidt (28) and Bauer (27) stated in different researches that aging process decreases composite microhardness due to the softening of the polymeric matrix in the aging process. Also, organic and inorganic composite structure was affected with exposure to bleaching agents and leads to chemical changes (8). Bleaching agents with their high oxidation ability in contact with organic molecules are able to harm the composite matrix network and make this material susceptible to degradation. Also, changes created in inorganic phase content will change the surface and physical properties of a material (9). In some studies, aging or bleaching has led to an increase in microhardness with increase in the time or intensity being the reason for the partial removal of the hydrolyzed resin matrix part by abrasion (31). It can be suggested that in this study, where three processes of aging, thermocycling and bleaching have been studied, the resin softening was affected synergistically and led to the removal of resin at a higher rate. This process resulted in an increase in filler ratio toward matrix in the composite surface layer.

On the other hand, hardness test used in this study was Vickers, which investigated microhardness and recorded this hardness in contact with filler or resin. Ceramic filler hardness is generally higher than polymers. Therefore, with increase in fillers ratio, the possibility of indentor insertion on a filler will be increased in each measurement of hardness, as a result, the final rate of microhardness will be increased, which is the average of three hardness measurements.

The results of home bleaching effect on the composites in this study is consistent with the results reported in studies by YU (8), Costa (25), Mujdesi (23), Compos (20), Kamangar (29) and Shafiei (3), which have stated that carbamide peroxide at home bleaching concentrations is ineffective on the composites microhardness.

The findings of our research are different from the results from researches by Alaghehmand (17) and Turker (19), who have observed an increase in microhardness. This difference could be due to a higher concentration of carbamide peroxide used in these studies or further exposure (28 days) that has led to the elimination of most of the matrixes and creation of significant changes in the results.

The effect of office bleaching with hydrogen peroxide (40%) was also studied, and it was found that compared with the control group, Z100 and Z350 hydrogen peroxide leads to a significant increase in microhardness. In all groups except the Z250, increase was observed in composite hardness. Degradation of resin matrix with exposure to oxidizers can be stated as the cause of this phenomenon (1). As it was mentioned, by removing the resin matrix, filler ratio to the matrix on the surface and possibility for indentor contact to quarts and silica fillers in composite was increased. Due to more hardness of the fillers, compared with matrix, composite surface hardness is also increased with increase in filler ratio. In Z250 composite, fillers have less percentage volume in the composite (2), Also pre-polymerized composite fillers are used in microhybrid composites, that have rate of wear and separation from surface different from silica mineral fillers (26), thus, it is likely that with degradation of the surrounding matrix, the fillers are also separated easier from surface and less change occurs in the matrix filler ratio. Therefore, the effect of increase in surface hardness will not be seen.

Comparing home bleaching and office bleaching treat-

Table 2. Tukey's Honest Significant Difference (HSD) Analysis Relevant to Vickers Microhardness in Various Composites (α = 0.05)

First Composite	Mean VHN	Second Composite	Mean Difference	P Value
Z100	160.625	Z250	72.626	0.000
		Z350	39.241	0.000
		P90	81.979	0.000
Z250	87.999	Z100	-72.626	0.000
		Z350	-33.385	0.000
		P90	9.353	0.083
Z350	121.384	Z100	-39.241	0.000
		Z250	33.385	0.000
		P90	42.738	0.000
P90	78.646	Z100	-81.979	0.000
		Z250	-9.353	0.083
		Z350	-42.738	0.000

Table 3. Tukey Honest Significant Difference Analysis of Vickers Microhardness With Various Bleaching Methods (α = 0.05)

First Bleaching Method	Mean VHN	Second Bleaching Method	Mean difference	P Value
No bleaching	104.555	Office B.	- 12.298	0.001
		Home B.	- 10.528	0.006
Office bleaching	116.853	No bleach	12.298	0.001
		Home B.	1.769	0.860
Home bleaching	115.083	No bleach	10.528	0.006
		Office B.	- 1.769	0.860

ments, it was found that home bleaching in Z250 increases the microhardness, while office bleaching decreases the hardness, with this difference being significant. However, increase in hardness by office bleaching in Z350 was significantly higher than home bleaching.

This issue can be explained by the type of filler material. Among the methacrylates composites, Z100 and Z350 had greater office bleaching effect on increase in hardness and composite matrix hydrolysis. The reason for this is that carbamide peroxide is used in home bleaching method that is turned to urea, ammonia, carbon dioxide and almost 30% hydrogen peroxide during the reaction, while in office bleaching, 100% of the effective ingredient is hydrogen peroxide (32). Therefore, the effect of office bleaching agents is more in matrix hydrolysis and subsequently the indentor contact to fillers is greater. While in the Z250 composite the opposite action is observed. This composite is not able to attract a volume percent suitable for the filler due to the size of filler microhybrid and high surface to volume ratio, so the manufacturer uses pre-polymerized fillers to increase strength and wear resistance of the composite (33). These pre-polymerized fillers have lower hardness than the silica and zirconia mineral fillers and contain organic portion, which can be affected by bleaching agents.

It is likely that these fillers are changed or removed from the surface when exposed to bleaching agents, and the organic matrix portion remains in the underlay that indicates less hardness exposure to indentor. This effect in office bleaching agents becomes more aggregated with high concentration of hydrogen peroxide, therefore decrease in microhardness following the fillers dislodge is reported.

An opposite situation is seen in Z350. The mineral fillers with volume percentage of up to 63% and nano-sized are used in this c composite that have the ability to become a cluster (32). Thus, bleaching agents are not able to penetrate into filler line matrix and do not lead to their removal from the surface, but the materials hydrolyze the free matrix part and increase the filler present ratio on the surface and thus filer exposure to the indentor is increased.

Table 4. Comparison of Bleaching Treatments in the Aged Composites ($\alpha = 0.05$)

Composite	Mean Difference Home Bleachingand Control Group	P Value	Mean Difference Office Bleaching and Control Group	P Value
Z100	16.19	0.167	25.24	0.012
Z250	16.38	0.171	4.64	1.000
Z350	6.3	0.735	26.40	0.000
P90	3.23	1.000	2.19	1.000

Table 5. Comparison of Home and Office Treatment Effect in Aged Composites ($\alpha = 0.05$)

Composite	Mean Difference Home B. ,Office B.	P Value
Z100	9.05	0.826
Z250	21.02	0.049
Z350	20.08	0.002
P90	1.03	1.000

Although this effect is likely to occur in both bleaching methods, but higher increase in hardness is observed in office bleaching due to its higher concentration. The surface hardness of P90 composite was similar in three groups including control, carbamide peroxide and hydrogen peroxide, and it seems that bleaching agents are not able to hydrolyze the silorane polymers and oxiran used in matrix of this composite.

The results of composite microhardness are consistent with results of Hatanaka's study, who suggested the highest hardness is for Z100, followed by Z350 a (34). The difference between composite groups can also be justified based on the amount of their filler. The higher the volume fraction of filler in composite, the possibility of indentor contact with filler on the surface will also be higher.

According to information provided by the factory, Z100 contains 66% filler, Z350 in type of Dentin contains 63.3% filler with the becoming cluster possibility, and subsequently Z250 with 60% filler, and P90 with 55% filler. The result of this study also confirms this subject. The greatest hardness of composites is related to Z350, followed by Z250, Z100 and P90, respectively. Of course, the type and distribution of composite fillers and the degree of matrix polymerization can also be effective (34).

To interpret the results, microhardness of samples with electron microscopes after exposure to bleaching agents is suggested in order to determine the effect of these materials on various phases of composite materials and types of fillers. In addition, bleaching agents in the composition, PH and different concentrations are available that may affect their reactions. A more extensive study on these substances regarding exposure to wide dental composite restorations will provide the required information for dentists.

5.1. Conclusion

Considering the limitations of this study, the following results were obtained:

1- Aged composite bleaching in all groups except the Z250 in exposure to hydrogen peroxide leads to increase in microhardness compared to the control group.

2- Increase in microhardness only in Z100 and Z350 composite is significant in exposure to hydrogen peroxide.

3- Office bleaching damages the composites surface matrix more than home bleaching.

4- After bleaching, the highest microhardness is related to composite Z100 and Z350, followed by Z250 and lowest microhardness is related to Z250 and P90.

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Footnote

Authors' Contribution: Najmeh Johar developed the original idea and the protocol, abstracted and analyzed the data, wrote the manuscript, and was the guarantor; Alireza Danesh Kazemi contributed to the development of the protocol, abstracted data, and prepared the manuscript.

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