Assessment of surface roughness and compressive strength of resin-based composite using different types of bleaching protocols

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Background and objective: This study aimed to evaluate the effect of three types of bleaching protocols on the surface roughness and compressive strength of composite resin.

Methods: Eighty composite resin samples were prepared using metal molds; forty samples (2 mm in height and 8 mm in diameter) for surface roughness evaluation and the other forty samples (6 mm in height and 4 mm in diameter) for compressive strength. Every forty samples were divided into four groups; Group 1 (n = 10) The samples were stored in deionized water at 37°C for two weeks as control, group 2 (n =10) The samples were subjected to bleaching with 22% Carbamide Peroxide (CP) Home bleaching, group 3 (n =10) The samples were subjected to bleaching with 14% Hydrogen Peroxide (HP) Home bleaching and group 4 (n =10) The samples were subjected to bleaching with 25% Hydrogen Peroxide (HP in-Office) in a dental clinic. After bleaching, groups 2, 3, and 4 were evaluated for surface roughness and compressive strength.

Results: The enamel surface roughness of all specimens were increased after bleaching protocols to a very similar extent with no statistically significant difference between the means of enamel roughness of the control group and the other three groups and the highest value was recorded in the Carbamide Peroxide group (CP), while compressive strength of the composite was decreased after using bleaching protocols in all groups in comparision with the control group and the least compressive strength was recorded in (HP) group followed by (HP in-Office) group and (CP) group respectively.

Keywords: Bleaching protocol, Hydrogen peroxide, Carbamide peroxide.

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INTRODUCTION

The accomplishment of maximum esthetic restorations is the most stressful procedure that is concerned by dentists. Although esthetics can be enhanced using different types of techniques, bleaching is considered a safe, conservative, low cost and effective esthetic procedure for treating of discolored teeth. Numerous bleaching agents have been marketed, but the commonly used active ingredient is carbamide peroxide (CP).[1]

Vital and nonvital tooth bleaching has a long and successful history.[2] Bleaching treatment presents in the forms of at-home or in-office bleaching with the use of carbamide peroxide (CP) and hydrogen peroxide (HP), respectively. About 15% CP is the most commonly used bleaching agent for at-home bleaching, while HP is the most effective bleaching agent for the removal of internal stains in the office setting.[3]

It has been noted that tooth bleaching is relatively safe in a matter of potential alteration in tooth structure. However, some concerns still exist regarding the adverse effects of bleaching agents on restorative materials and their adhesion to dental tissues.[4,5]

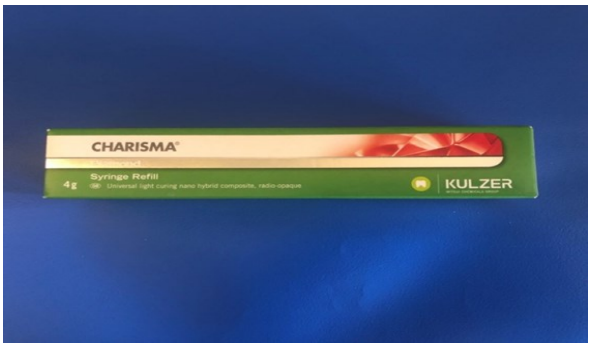
Restorative filling materials used in dentistry require long-term durability in the oral cavity. To find out the effectiveness of restorative materials against masticatory forces, it is required to determine the compressive strength values of the restorative materials.[6] Several investigators have studied the effects of home bleaching on

oral tissues and restorative materials.[7]
Types of bleaching methods include nonvital bleaching, in-office professional bleaching, and home bleaching. Nightguard home bleaching uses a relatively low level of whitening agent and is applied to the teeth by a custom-fabricated mouthguard and is worn at night for a duration of at least two weeks. It was reported that the bleaching agent, regardless of the whitening products used, will reduce the microhardness of the enamel and promote an increase in surface roughness.[8]
This study sought to assess the effect of different tooth bleaching protocols using 22% CP, 14% HP at-Home bleaching and 25% HP in-Office bleaching activated by light on the surface roughness and compressive strength on the composite resin.

Materials and Methods

In this *in vitro*, experimental study, a nanohybrid filler A2 shade of Diamond (CHARISMA, Kulzer, GmbH, Germany) (Figure 1) was used to fabricate 80 samples for both surface roughness (2 mm in height and 8 mm in diameter) and compressive strength (6 mm in height and 4 mm in diameter).[9]

Figure 1 : Diamond, Charisma composite resin used in the study.



After fabrication and polishing, the samples were immersed in the deionizing solution to ultrasonically remove the residues and were then randomly divided into four groups ($n = 10$) as follows:

- Group 1: The samples were stored in deionized water at 37°C for two weeks as the control.
- Group 2: The samples were subjected to bleaching with 22% Carbamide Peroxide (CP) (Flash, Take Home Whitening System, WHITEsmile, Germany) for 1-4 hs a day for a total of 10 days according to manufacturer instructions. (Figure 2).
- Group 3: The samples were subjected to bleaching with 14% Hydrogen Peroxide (HP) (Philips Zoom Day White, Discus Dental, USA) recommended by the manufacturer every 3 –5 days for 30 min for a total of 2 weeks. (Figure 3).
- Group 4: The samples were subjected to bleaching with 25% Hydrogen Peroxide (HP in-Office) in the dental clinic (Philips Zoom, Chair Side Light-Activated Whitening Gel, Discus Dental, Ontario, CA, USA) activated by light using PHILIPS ADVANCED ZOOM LED Curing and Whitening System (Discus Dental, USA) for 40 min according to the manufacturer's instructions. (Figure 4).

Figure 2 : 22% Carbamide peroxide, Flash, Take Home Whitening System, WHITEsmile Home Bleaching.

Figure 3 : 14% Hydrogen Peroxide Philips Zoom Day White, Discus Dental Home Bleaching.

Figure 4 : 25% HP Philips Zoom Day White, Discus Dental in-Office Professional Bleaching.

The chemical composition of the bleaching used in this study was illustrated in Table (1).

Table 1: The chemical composition of the bleaching materials.

Bleaching material	Composition
Take Home Whitening System (CP)	Glycerin, Hydrogen carbamide 22%, Carbomer, Tromethamine, Disodium pyrophosphate, Aroma
Philips Zoom Day White (HP)	Water, Glycerin, Hydrogen peroxide 14%, Propylene, Potassium nitrate, Eugenol, Phosphoric acid
Philips Zoom, Chair Side Light Activated Whitening Gel (HP in-Office)	Water, Poloxomer 407, Glycerin, Hydrogen peroxide 25%, Propylene Glycol, Potassium Hydroxide, Eugenol, Ferrous Gluconate.

Samples were cleaned with a soft toothbrush and deionized water for 1 min to eliminate the tooth surfaces' bleaching agents. This was done daily after bleaching in Group 2, after each bleaching cycle in Group 3, and after the completion of bleaching in Group 4.

Surface roughness:- Ten samples for each group were prepared by filling the cylinder cavities (with an inner diameter of 8mm and a height of 2mm) with composite resin.[10] The cylindrical cavities were made at the center of the self-cured acrylic resin block, which was poured in plastic tube 2cm in diameter and 2.5cm in height.[11] Figure (5).

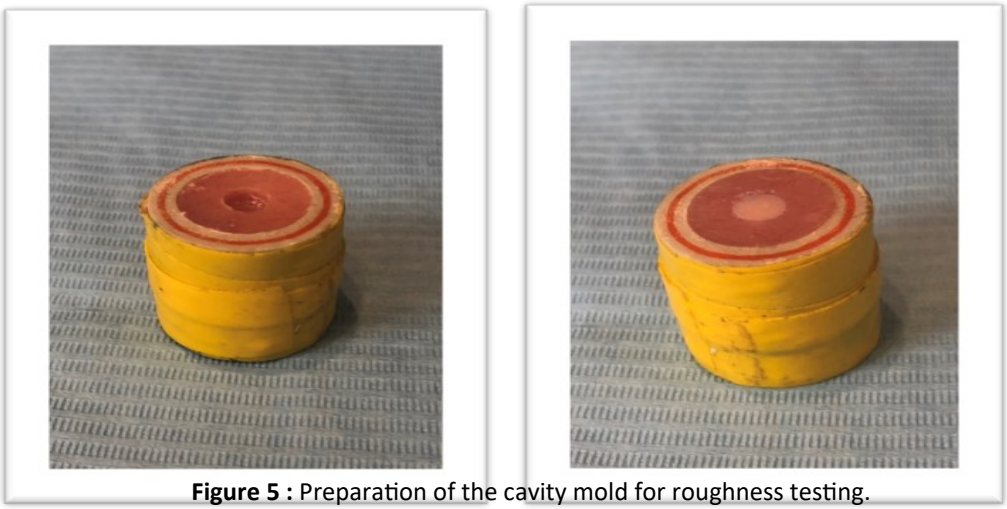


Figure 5 : Preparation of the cavity mold for roughness testing.

The composite resin was packed directly against the cavity with an Ash plastic instrument in 2mm thickness, which is the thickness of the cavity then the surface was covered with polyester matrix strip and microscopic glass slide to make sure that there was a uniform distribution of the materials and avoid air entrapment and flush out any excess material.[12] Polymerization of each material was performed by a blue phase C8 light cure.

The specimens were thoroughly rinsed with water spray for 15 seconds and dried with oil-free air spray for 15seconds. Specimen were finally ultrasonically cleaned in deionized water for ten minutes to remove debris and incubated in deionized water at 37°C for 24 hours.[13]

The specimens were dried with white filter paper, labeled according to the material categories, encoded, and prepared for surface roughness. A surface profilometer was used to measure and record surface roughness. The most commonly used instrument was a diamond stylus, which travels on a straight line along the surface. The average surface roughness for the composite surface sample was expressed as Ra (µm) value, Figure (6).

Figure 6 : Taylor Hobson Roughness Profilometer device and Ra reader.

The cut-off value (distance transverse by the stylus over which the data were collected) for surface roughness was set at 0.25mm, and the needle was moved at the constant speed of 0.5mm/s, and measuring the length of 1.5mm, the radius of the tracing diamond tip was 2µm, three readings were recorded for each specimen, Figure (7). The average of these three traces was used as the score for each specimen.[14]To ensure reliable readings, the machine was calibrated after every three specimens by calibration block with an exact value of the surface roughness 1.64µm, Figure (8).

Figure 7 : Surface roughness testing by using Taylor Hobson profilometer head.

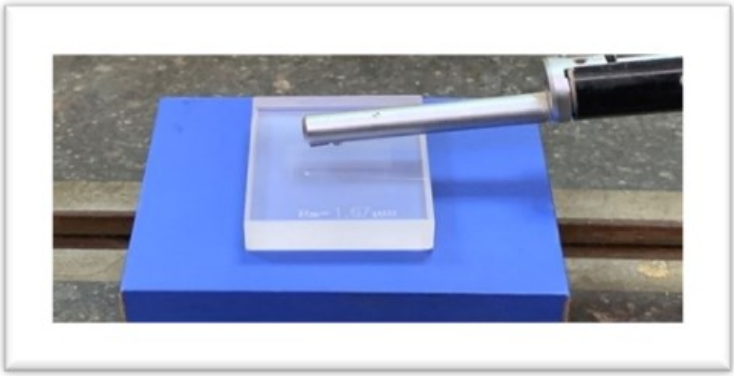


Figure 8 : Calibration of the profilometer by using 1.64 µm block.

Compressive strength:- Split metal mold; coated with an appropriate separating medium, was fabricated for the preparation of a cylindrical specimen of 4.0±0.1mm diameter 6.0±0.1mm height was used. Ten specimens from each material were used for the compressive strength experiment. The metallic mold was isolated with vaseline before the application of materials; a myler matrix strip was first secure on a glass slide to form the base of the mold, then filled with composite used in this study added incrementally of 2mm thickness- then the materials light cured with Bluephase C8 LED lamp (Ivoclar Vivadent) curing light 800mW/cm^2 intensity for 20 seconds, the intensity of the light cured checked by radiometer (Ivoclar Vivadent) before curing of each specimen. The materials were covered with another strip and glass microscopic slide; then pressure was applied to expel excess material from the mold. Each specimen was light cured through the top of the glass slide for 40 seconds. Immediately after completion of irra-

diation, the specimen had been removed and cleaned of excess materials with plastic spatula (to avoid contamination with metallic particles). The specimens were visually inspected, for detection of voids, irregularities and measurements, in which if it was detected the specimen was discarded and replaced by another one. Each specimen was transferred to plastic test tubes containing 3ml of deionized water for 24 hours. All specimens were incubated at 37°C for 24 hours before they were subjected to compressive load, the specimens were dried after incubation with a sheet of white filter paper. The compressive strength value was determined by using the universal testing machine with a cross head speed of 1mm/min.[9] Figure (9).

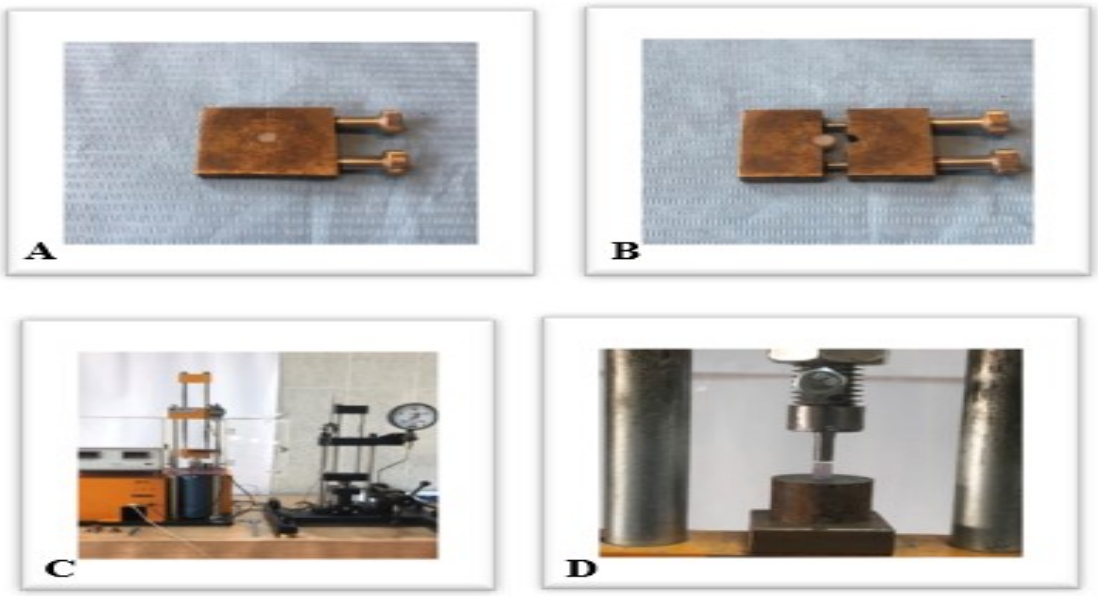


Figure 9 : Compressive strength test procedure: (A) Cylindrical metal mold filled with tested materials, (B) Specimen of 4.0mm diameter and 6.0mm height, (C) Universal testing machine, (D) Specimen before load

The analysis of compressive strength has been done by recording the maximum failure load for each specimen and divided by the net cross-sectional area to determine the compressive stress (K) in MPa by this equation:[15,16]

$K = 4F/\pi d^2$

where:

F= Maximum applied load in Newton

d = The mean diameter of the specimen in mm.

Statistical analysis: Data collected were analyzed using SPSS version 16.0. All statistical analysis was conducted at a significance level of $P < 0.05$ Post Hoc (Least Statistical Difference LSD) test.

Results

As apparent from the results that are shown in table (2), there was no significant difference between all the bleaching groups with the control group, although there was an increase in the surface roughness values after using different bleaching protocols, and the highest value was recorded in Carbamide Peroxide group (0.68 μm) as shown in figure (10).

The compressive strength of the composite was decreased after using bleaching protocols in all groups in comparision with a control group (200.48 MPa), and the least compressive strength was recorded in the HP group followed by the Prof group and CP group respectively (171.8MPa, 181.6 MPa and 185 Mpa) as seen in figure (11) .

Although the bleaching groups recorded less compressive strength values than the control group, but there was no statistical

Table 2. Post Hoc Test (LSD) of enamel roughness (µm) after bleaching protocols

Groups	N	Mean	(±SD)	SE	p
Control group	10	0.53	0.216	0.068	0.067
CP group	10	0.68	0.165	0.052	0.17
HP group	10	0.58	0.104	0.032	0.229
HP in-Office group	10	0.58	0.181	0.057	0.20
Total	40	0.59	0.173	0.027	

*Statistically significant P< 0.05

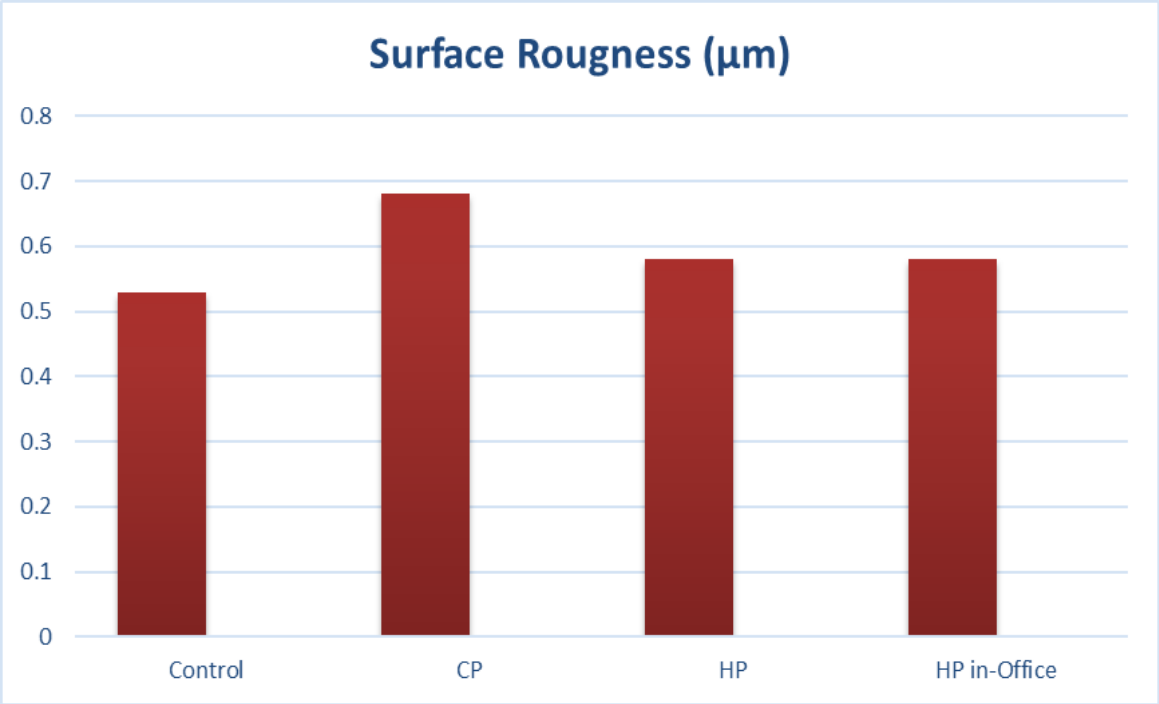


Figure 10 : Bar Chart of surface roughness of all groups.

The compressive strength of the composite was decreased after using bleaching protocols in all groups in comparision with a control group (200.48 MPa), and the least compressive strength was recorded in the HP group followed by the Prof group and CP group respectively (171.8MPa, 181.6 MPa and 185 Mpa) as seen in figure (11) .

Although the bleaching groups recorded less compressive strength values than the control group, but there was no statistical difference between all groups in comparision with the control group as illustrated in table (3).

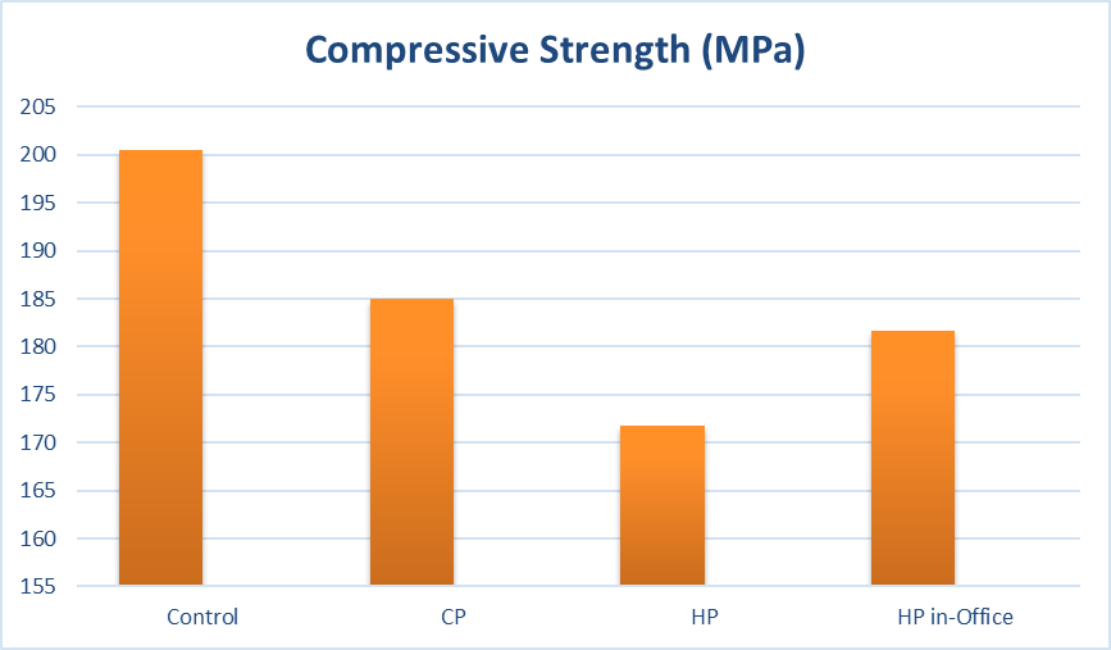


Figure 11 : Bar Chart of compressive strength of all groups.

Table 3: Post Hoc Test (LSD) of compressive strength (MPa) after bleaching protocols

	Compressive Strength (MPa)				
Groups	**N**	**Mean**	**(±SD)**	**SE**	**p**
Control group	10	200.48	37.65	11.9	0.264
CP group	10	185	45.72	14.46	0.387
HP group	10	171.8	38.85	12.28	0.113
HP in-Office group	10	181.6	34.78	10.99	0.294
Total	40	184.7	39.32	12.40	

*Statistically significant P< 0.05

Discussion

Surface roughness (Ra) refers to the finer irregularities of the surface texture and is measured in micrometer. Ra is a property resulting from the interaction of many factors. Some of these factors are intrinsic to the material and are related to its composition, such as filler type, shape, size, and distribution, the type of resin matrix, the degree of final cure achieved, and the bond efficiency at the filler/matrix interface. Extrinsic factors are associated with the type of polishing system used, such as the flexibility of the material in which the abrasives are incorporated, the hardness of

the abrasives, the instruments' geometry, and the way they are used.[17,18]

The resistance to fracture within a restorative material is specified by fracture stress, which is often referred to as the materials' strength. Compressive strength is an important property in restorative materials, particularly in the process of mastication. It is well known that the mechanical characteristics of the fissure sealant, are strongly associated with the filler content, filler distribution, particle size, and particle type. As well as coupling between particles and matrix are also factors that influence mechanical properties such as strength and modulus of elasticity.[19,20]

Considering the different composition and structure of bleaching materials, the current study assessed the effect of different bleaching protocols on the surface roughness and compressive strength on resin-based composite.

Degradation of the surface of composite resins might lead to abrasion, surface roughness and discoloration of restorations. An increase in the surface roughness may lead to gingivitis and periodontal problems through an increase in plaque accumulation.[21]

In the present study, the effect of bleaching was evaluated on the surface roughness of three different types of bleaching protocols (22% CP and 14% HP) as at-Home bleaching technique and 25% in-Office professional HP bleaching. Although there was no statistical difference between all the groups in a matter of surface roughness, it has been noted that the surface roughness was increased after bleaching when compared with the control group.

The reason for the increase in surface roughness after bleaching can be explained by previous studies, which revealed that peroxide bleaching gels might lead to slight roughness of resin-based composites, although it may have no clinical significance. It has been found that bleaching agents impair the surface integrity, affecting the bleaching agents' penetration depth. Chemical softening from bleaching may affect the clinical longevity of the composite restoration.[22]

The present study revealed that composite tested underwent surface alterations of their superficial surface after bleaching. Interestingly, some studies have reported an increase,[23] decrease[24] or unchanged[25] composite surfaces after applying carbamide peroxide gels for varying time periods. The authors suggested that the complex interactions within multi-component bleaching products could have caused the surface changes. Roughening was suggested to result from the loss of matrix, rather than filler particles. Some aspects of this chemical process might accelerate resin composites' hydrolytic degradation as described by Söderholm.[26] Another aspect may be that hydrogen peroxide and free radicals have an effect on the resin-filler interface and cause a filler-matrix debonding, this may cause microscopic cracks, leading to an increase in surface roughness.[27]

Free radicals produced by the peroxides may affect the resin–filler interface and cause filler–matrix detachment. In other words, free radicals eventually form water and accelerate the hydrolytic degradation of composite resins. The latter can also cause bond failure between the resin matrix and filler particles and lead to separation and debonding of filler particles, which further increases the surface roughness of composite resin.[28]

Schemehorn *et al.* reported that 6% HP had no significant effect on the surface morphology of composite resins.[26] Wattanapayungkul *et al.* only found insignificant differences in surface roughness between the control and bleached groups.[28] However, some studies showed that 10% and 16% CP caused a small but significant increase in surface roughness and porosity of microfilled and hybrid composite resins.[29]

Carbamide peroxide (at-Home bleaching) breaks into urea and hydrogen peroxide. Hydrogen peroxide in turn breaks down into free radicals, which eventually combine to form molecular oxygen and water. Some aspect of this chemical process may accelerate the hydrolytic degradation of tooth-colored restorative materials.[25]

The compressive strength was decreased after using bleaching protocols, although there was no statistical difference between all groups seen in the present study. The

possible explanation for the reduction in the compressive strength might be due to the presence of Bis-GMA monomer. Resin composites are reported to be highly susceptible to chemical softening due to the presence of Bis-GMA monomer if the chemicals have a solubility parameter ranging from 1.82 × 104 to 2.97 × 104 (J/m3). Another possible explanation is the degree to which the filler is bonded to the resin matrix.[30]

The negative effect of oxidative bleaching agents on the resin matrix through water sorption of the restorative material and relative or complete debonding of the fillers is still a matter of controversy; this factor might decrease the surface integrity and hardness of the material.[31]

One of the limitations of this study is that different concentrations of bleaching were used. Furthermore, only one type of composite was tested.

Conclusion

Within the limitation of this study, the following conclusions can be withdrawn:

1. There was a decrease in surface roughness using different types of bleaching protocols (22% CP and 14% HP) at-Home bleaching technique and (25%) in-Office HP bleaching. Although there was no significant difference between them.
2. The compressive strength of the composite resin was reduced after bleaching with no significant difference.

Conflicts of interst

The authors reported no conflicts of intersts

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