The Internet Journal of Dental Science
Volume 6 Number 2

Effect of bleaching on microleakage, surface hardness, surface roughness, and color change of an ormocer and a conventional hybrid resin composite

N Ayad, A Bedewi, S Hanafy, S Saka

Citation

N Ayad, A Bedewi, S Hanafy, S Saka. *Effect of bleaching on microleakage, surface hardness, surface roughness, and color change of an ormocer and a conventional hybrid resin composite*. The Internet Journal of Dental Science. 2008 Volume 6 Number 2.

Abstract

Objectives: the aim of this study was to determine the effects of two bleaching systems on an ormocer and a conventional hybrid resin composite.
Methods and materials: Microleakage, hardness, roughness, and color change of an ormocer (Admira/Voco), and a hybrid composite (Glacier/SDI), were determined before and after bleaching using two bleaching systems (Vivastyle paint-on/ Vivadent)(VSP), and ((Vivastyle/ Vivadent)(VS), for 2 weeks. A total of 120 samples were prepared, thermocycled, and classified into: Group 1: 30 human premolars into which class V cavities were prepared, restored (15 using Admira, & 15 using Glacier), then examined for microleakage using dye-penetration method and stereomicroscope. Groups 2,3, and 4:each consisted of 30 disc-shaped samples, divided into 15 samples of each restorative material, subdivided into: 5 control samples, 5 samples bleached using (VSP) once daily for 20 minutes, and 5 samples bleached using (VS) once daily for 2 hours. Groups 2, was tested for hardness using Vickers tester, group 3, was tested for roughness using talysurf machine, and group 4 was tested for color change using spectrophotometer. Data were analyzed using Mann-Whitney and paired sample t-test.
Results: Both bleaching regimens significantly increased microleakage, decreased hardness, increased roughness, and caused lighter color change, but the effects caused by VSP were higher than those of VS.
Conclusion: Ormocer achieved a light color change on bleaching, and showed greater resistance to adverse microleakage and hardness effects.

INTRODUCTION

The esthetic of an existing restoration is important in affecting clinical success. Although the initial color match of a light-polymerized restoration may be established, long term color changes may occur because of surface staining, microleakage, and wear-dependant surface changes.

Bleaching has become a popular treatment to remove surface stains and restore esthetics. Although bleaching is safe from a procedure stand point, it may not be safe for dental materials that have high degradation characteristics. Peroxide-based agents provide whitening through decomposition of their peroxides into unstable free radicals that breakdown large pigmented molecules either through an oxidation or a reduction reaction. Accordingly, these agents may possibly affect sealing ability or surface quality of the restoration. ([1],[2],[3])

The aim of this study was to evaluate the effect of two carbamide peroxide bleaching systems on microleakage, surface hardness, roughness, and color change of an ormocer and a conventional hybrid resin composite.

MATERIALS AND METHODS

An ormocer-based material, Admira(Voco, Cuxhaven, Germany) and a hybrid composite, Glacier(South Dental Industries, Australia) together with two bleaching systems, Vivastyle paint-on (VSP)and Vivastyle(VS) / Ivoclar-vivadent, Schaan, Liechtenstein, were utilized for this study, All materials were handled according to the manufacturers' instructions.

MICROLEAKAGE

Thirty recently extracted sound permanent human upper premolars were cleaned from any calculus deposits or soft tissue debris using an ultrasonic scaler. All teeth were microscopically examined at X20 magnification to assure the absence of cracks or defects. Then, the teeth were stored in distilled water that contained an antibacterial agent (0.2 % sodium azide), until being used. ([4]) A trapezoidal class V cavity with dimensions of 3, 2, 2, 2 mm was prepared on the buccal surface of each tooth 0.5 mm coronal to cemento-enamel junction using No. 56 fissure carbide bur Komet, Germany, in a high speed hand piece with air and water spray. The cavities were adjusted to an approximate depth of 2 mm using periodontal probe. All the prepared cavities were rinsed thoroughly with water, and air-dried. The whole cavity of each tooth was acid etched for 20 seconds, then rinsed with water spray and dried gently with oil-free air stream. The bonding agent was applied to the etched cavity with a brush then air-thinned gently with oil-free air stream and light-cured for 20 seconds using a light-curing device Astralis 5-Vivadent-TUV product service-Austria.Restorative materials were packed in the prepared cavities and covered with transparent matrices (15 using Admira, & 15 using Glacier). Then, they were light-cured for 40 second. Then, the matrices were removed and the excess material was excised with scalpel. All restored teeth were kept in distilled water at 37 ° C for 24 hours in an incubator RUMO incubator, Model 2010, Ehret Gmbh, Emmendigen, and then subjected to thermocycling between 5 ° C to 55 ° C for 500 cycles. ([5]) The samples were subdivided into 3 subgroups: Subgroup T1: consisted of 5 teeth (control) immersed in distilled water in the incubator at 37 ° C for a period of 14 days, subgroup T2: consisted of 5 teeth bleached using (VSP): 6 % carbamide peroxide bleaching agent, applied once daily for 20 minutes over a period of 14 days (once it dries, its concentration becomes about five times higher reaching 30%) as within few seconds, the ethanol evaporates and leaves behind a layer of varnish which is enriched with carbamide peroxide, subgroup T3: consisted of 5 teeth bleached using (VS)10 % carbamide peroxide bleaching agent, applied once daily for 2 hours over a period of 14 days. After each daily bleaching, the teeth were removed from the bleach, washed and cleaned with a toothbrush in running distilled water for 30 seconds and replaced in the incubator. ([6]) The distilled water was changed daily. Prior to assessment of microleakage, each tooth root apex was sealed with sticky wax and all tooth surfaces were coated with nail varnish except for the restoration and 1 mm of tooth surface adjacent to the restoration. Then teeth were then immersed in 0.5% solution of basic Fuschin dye (Hopkin & Williams, Essex, UK) at room temperature (18 ± 2 ° C) for 24 hours. After removing them from the solution, the teeth were rinsed in tap water and the superficial dye was removed with a pumice slurry and brush. Each tooth was sectioned longitudinally in a bucco-lingual direction through the center of the restoration using a diamond disc DICA 72 in a low-speed handpiece. The cavity margins of both sectioned halves of each tooth were examined and photographed under a binocular stereomicroscope (Olympus Zoom Stereo microscope, Sz 40-45, Japan) at X20 to assess the evidence and extent of dye penetration through the tooth-restoration interfaces. The degree of microleakage at both enamel and dentin levels was rated on a scale from 0-4 as follows ([4]) : 0 = no dye penetration (DP = 0 mm),1 = 0.2 mm < DP ≤ 0.25 mm, 2 = 0.25 mm < DP ≤ 0.5 mm, 3 = 0.5 mm < DP ≤ 1 mm, 4 = DP > 1 mm.

SURFACE HARDNESS

Thirty disc-shaped samples were prepared in a split stainless steel mold (6 mm in diameter and 3 mm in thickness). The mold was slightly over-filled with the restorative material under evaluation, placed between two celluloid matrix strips and then sandwiched between two microscopic glass slides to extrude the excess material. The samples were light-cured from the top and the bottom for 40 seconds, then removed from the mold and stored in distilled water at 37 ° C for 24 hours in the incubator. The samples were thermocycled, then fixed in acrylic resin boxes with one of their surfaces exposed. The surface hardness testing was accomplished using Digital Vickers Microhardness tester FM-7 Japan, at room temperature (18 ± 2 ° C), where a standard force of 50 gm was applied for 5 seconds. ([7,8,9])

SURFACE ROUGHNESS

Thirty disc-shaped samples were prepared in a split stainless steel mold (9 mm in diameter and 3 mm in thickness). The samples were prepared and fixed in acrylic resin boxes as mentioned in the preparation of surface hardness samples. Then, they were stored in distilled water at 37 ° C. Surface roughness measurement was carried-out using an electronic surface roughness measuring apparatus Talysurf, Advanced Meteorology System, Leicester, England, at room temperature (18 ± 2 ° C) to measure Ra (average roughness height) in micrometer. For accuracy, Ra for each sample was measured in 3 different sites. ([7,10,11])

COLOR CHANGE

Thirty disc-shaped samples were prepared in a split stainless steel mold (13 mm in diameter and 1 mm in thickness) as mentioned in the preparation of surface hardness samples. Due to the larger surface area of the sample relative to the exit window of the light source, each sample was cured at the center for 30 seconds and then selecting a north, south, east, and west corners of the disc sample and curing each location for 30 seconds. Then, they were stored in the incubator. The color shifts of the samples were determined using the Datacolor 3881 spectrophotometer UV-Shimadzu 3101 PC-Spectrophotometer, Japan. L*, a* and b* values of the samples were determined and the general color shift ΔE was calculated according to the following formula, ([12])

$$\Delta E = [(\Delta L)^2 + (\Delta a)^2 + (\Delta b)^2]^{1/2}$$

STATISTICAL ANALYSIS

The data obtained were tabulated for statistical analysis using SPSS version 10. The Mann-Whitney test and the paired sample t-test were used to detect the significant differences among the variables tested in this study.

RESULTS

MICROLEAKAGE

Table I displays that microleakage score values of both Admira and Glacier increased significantly after carbamide peroxide bleaching but Admira values were lower and the difference was highly significant regarding all test groups ($p \leq 0.01$). Also, there was a highly significant difference between the score values of the different test conditions for each tested material separately, ($p \leq 0.01$), as apparent in table II.

SURFACE HARDNESS

Table III displays that the mean values of Vickers Hardness Number (VHN) for both

Admira and Glacier decreased significantly after bleaching but Admira was less affected and the difference was of extremely high significance ($p \leq 0.001$). Also, there was an extremely high significant difference between the mean (VHN) values of all test groups for each tested material separately, ($p \leq 0.001$), table IV.

SURFACE ROUGHNESS

Surface roughness values of both Admira and Glacier increased after carbamide peroxide bleaching but Admira values were higher and the difference was highly significant in case of using VSP system ($p \leq 0.01$), and of extremely high significance in case of VS system ($p \leq 0.001$) as apparent in table V. Also, there was an extremely high significant difference between the mean roughness values of all test groups for each tested material separately, ($p \leq 0.001$) as obvious from table VI.

COLOR CHANGE

Table VII reveals the color difference (ΔE) of Admira and Glacier after bleaching. The color change values for both tested materials were nearly similar in each test condition showing no significant difference (p?0.05). On the other hand, table VIII shows an extremely high significant difference between (ΔE) of all test groups for each restorative material separately, ($p \leq 0.001$).

Figure 1

Table 1: Median score values, Z-values & P-values of microleakage test

	Admira	*Glacier*	Mann-Whitney test	
	Median	Median	Z-value	P-value
Control	1	2	3	0.003**
VSP	3	4	3	0.003**
VS	2	3	3	0.003**

**Highly significant difference at $P \leq 0.01$

Figure 2

Table 2: Correlations, Z-values & P-values of microleakage between different test-conditions for both Admira & Glacier

	Admira		Glacier	
	Z-value	P-value	Z-value	P-value
Control vs. VSP	3	0.003**	3	0.003**
Control vs. VS	3	0.003**	3	0.003**
VSP vs. VS	3	0.003**	3	0.003**

** Highly significant difference at $P \leq 0.01$.

Figure 3

Table 3: Mean VHN values, SD, t-values & P-values of hardness test

	Admira		Glacier		Significant t-test	
	Mean	SD	Mean	SD	t-value	P-value
Control	62.56	± 0.39	50.94	± 0.16	27.450	0.000***
VSP	54.72	± 0.32	41.82	± 0.23	32.682	0.000***
VS	57.88	± 0.19	44.66	± 0.18	49.614	0.000***

*** Extremely High significant difference at $P \leq 0.001$

Figure 4

Table 4: Correlations, t-values & P-values of surface hardness between different test conditions for both Admira & Glacier

	Admira		Glacier	
	t-value	P-value	t-value	P-value
Control vs. VSP	15.465	0.000***	32.655	0.000***
Control vs. VS	10.653	0.000***	26.258	0.000***
VSP vs. VS	8.421	0.000***	9.684	0.000***

*** Extremely high significant difference at $P \leq 0.001$.

Figure 5

Table 5: Mean (Ra) values, SD, t-values & P-values of roughness test

	Admira		Glacier		Significant t-test	
	Mean	SD	Mean	SD	t-value	P-value
Control	0.37	± 0.02	0.27	± 0.02	3.503	0.008**
VSP	1.46	± 0.05	1.21	± 0.03	4.599	0.002**
VS	0.85	± 0.03	0.54	± 0.03	6.747	0.000***

*** Extremely High significant difference at $P \leq 0.001$

Figure 6

Table 6: Correlations, t-values & P-values of surface roughness between different test conditions for both Admira & Glacier

	Admira		Glacier	
	t-value	P-value	t-value	P-value
Control vs. VSP	22.211	0.000***	27.658	0.000***
Control vs. VS	13.688	0.000***	6.777	0.000***
VSP vs. VS	11.185	0.000***	15.240	0.000***

*** Extremely high significant difference at $P \leq 0.001$.

Figure 7

Table 7: Mean (ΔE) values, SD, t-values & P-values of color change test

	Admira		Glacier		Significant t-test	
	Mean	SD	Mean	SD	t-value	P-value
Control	3.19	± 0.01	3.28	± 0.07	1.277	0.237n.s
VSP	5.45	± 0.08	5.45	± 0.14	0.012	0.990n.s
VS	4.57	± 0.12	4.54	± 0.07	0.211	0.838n.s

n.s: no significant difference at $P > 0.05$

Figure 8

Table 8: Correlations, t-values & P-values of color change between different test conditions for both Admira & Glacier

	Ormocer		Hybrid composite	
	t-value	P-value	t-value	P-value
Control vs. VSP	28.902	0.000***	13.646	0.000***
Control vs. VS	11.401	0.000***	12.261	0.000***
VSP vs. VS	6.126	0.000***	5.629	0.000***

*** Extremely high significant difference at $P \leq 0.001$.

DISCUSSION

Bleaching has become a popular treatment to remove surface stains and restore esthetics. Numerous bleaching agents have been used, including carbamide peroxide which is considered as one of the best bleaching agents. Restorative materials with different monomer systems, such as composites or organically modified ceramics (ormocer), may react in different ways to the application of bleaching agents. Accordingly, this study has got the concern of evaluating the effects of two bleaching systems (Vivastyle paint-on/ Vivadent), and (Vivastyle/ Vivadent) on microleakage, surface hardness, roughness, and color change of an ormocer (Admira/Voco), and a hybrid composite (Glacier/SDI). (2,6,13,14)

MICROLEAKAGE

The results of this study revealed that carbamide peroxide bleaching had a significant adverse effect on the sealing ability at the tooth-restoration interface and that the higher the concentration of the bleach, the stronger are its deleterious effects. Some studies revealed the adverse effects of carbamide peroxide on the bond strength of resin composite to enamel and dentin and on marginal seal at the tooth-restoration interface, together with the directional proportionality between the bleach concentration and the severity of its effects on the restoration. (2,14,15,16,17,18)

Residual peroxides from the bleaching agent could explain the increase in microleakage as they would interfere with resin attachment to the tooth, hence, increasing the gap between the restoration and the tooth. This explanation coincide with that of Titley et al., 1992, who explained the reduction in adhesiveness of carbamide peroxide bleached enamel on the basis of the interaction between the restorative resin and residual peroxides that remained at the resin-enamel interface. (19)

On the other hand, Crim et al., 1992, found no significant difference in microleakage between teeth that have been exposed to carbamide peroxide and the non-bleached controls. Most probably, these results are attributed to the fact that cavity preparations were carried-out following the completion of bleaching, thus, the bleached enamel surfaces that would adversely affect the sealing ability of resin composite restoration were not found. Also, Cvitko et al., 1991 suggested that removing superficial enamel after bleaching could restore the bond strengths to normal levels. ([20,21])

The results of this study also showed that, the score of microleakage values was lower for Admira than for Glacier in all test groups, and the difference was highly significant, this could be attributed to the difference in composition between the restorative materials used. Ormocer-based composite possesses a modified organic matrix, formed by monomers with a single polymerizable end. The other end is formed by an alkoxy group, resulting in an inorganic area, bonded to other monomers by a condensation reaction, converting the monomer precursors, creating a complex structure with the formation of the Si-O-Si chain in the inorganic area of the polymer. The combination of this inorganic-organic matrix and filler particles in high concentration would result in lower polymerization shrinkage and superior sealing ability to that of hybrid composites, whose matrix is composed of the traditionally-known resins that undergo a relatively higher degree of polymerization shrinkage. ([11,22,23])

SURFACE HARDNESS

The results of this study demonstrated that carbamide peroxide bleaching lowered the surface hardness values of Admira and Glacier restorative materials, but Admira was less affected than Glacier and the difference was of extremely high significance in all groups. This could be attributed to the difference in composition as mentioned earlier. It has also been shown that higher concentrations of carbamide peroxide resulted in lower values of VHN. This can be explained by the fact that the quantity of released hydrogen peroxide is directly proportional to the bleach concentration. The oxidizing agent H_2O_2 releases free radicals that have a great oxidative power to break up larger macromolecular stains into smaller ones and by diffusion expel them to the surface. The free radicals eventually combine to form molecular oxygen and water. Some aspects of this chemical process might accelerate the hydrolytic degradation of composite leading to surface dissolution and lowering surface hardness. This explanation is in agreement with Solderholm and others, 1984, Fasanaro et al., 1992 and Cavalli et al., 2004. This also coincide with Campos et al., 2003 who observed a decrease in microhardness of the tested restorative materials after treatment with 10 & 15 % carbamide peroxide. ([24,25,26,27,28])

On the other hand, the results of another study were in disagreement with ours, where, it was shown that restorative resins exposed to home-use carbamide peroxide gels exhibited an increase in surface hardness values. Those results may be attributed to the composition of the materials under investigation where, they consisted of an organic matrix with considerably low surface hardness value into which were dispersed inorganic filler particles with higher surface hardness value. Bleaching abraded the softer matrix phase leaving the filler particles protruding. Accordingly, the Vickers' diamond indenter hit the filler particles rather than the organic matrix resulting in higher VHN records. ([29])

SURFACE ROUGHNESS

The surface roughness of composite restorative materials is the result of the interaction of multiple factors among which are the filler type, size and distribution of particles, type of resinous matrix of the material, and the bond of filler and matrix at the interface. High surface roughness is responsible for undesirable deterioration of the esthetic of the restoration, due to the loss of surface gloss, dental plaque accumulation and increasing the risk of caries. ([2,22,30])

In agreement with Martin et al., 2005, and Uctasali et al., 2004, the results of this study revealed that the base Ra values were significantly higher for Admira than for Glacier. This finding could be attributed to the modified inorganic-organic matrix of ormocer together with the high concentration of its filler particles that would result in higher surface roughness when compared to conventional hybrid composite materials. ([2,9])

The results of this study also demonstrated that bleaching had an adverse effect on the surface roughness of the tested materials which could be explained by selective softening of the resin matrix and dislodgement of filler particles by bleaching. Also, higher concentrations of carbamide peroxide were found to cause more increase in surface roughness values. There was an extremely high significant difference between different test groups where bleaching is supposed to abrade the softer phases of the surface, thus reducing its smoothness. This explanation is in agreement with those of Martin et al., 2005, Colley et al., 1991, Kawai et el., 1998 and Yap et al., 2002. (2,29,30,31)

On the other hand, Robert et al., 2002, found that higher concentrations of carbamide peroxide, pose no significant risk to the surfaces of resin restorations. They explained their findings on the basis that the used bleach had a pH close to neutral and contained a variety of aqueous solvents, any of which could contribute alone or in combination with other components to a decrease in solubility of the resin matrix. (2,13)

COLOR CHANGE

Before application of the bleaching agent, there was no significant difference between the recorded basic color values of the tested materials. This could be attributed to the use of the same color shade with the same filler size (0.7µm). This explanation is in agreement with Martin et al., 2005 who found no differences in the basic color between Admira and Glacier. (2)

After application of the bleaching agent, both Admira and Glacier have shown a tendency to become lighter and the difference between the test groups of each material separately was of extremely high significance. In agreement with, Martin et al., 2005, Senay et al., 2003, Filiz et al., 2005 and Turker et al., 2003, this may be related to the effect of bleaching agents on resin matrix, fillers, or both. However, fillers are basically glass or ceramic, and therefore the influence of the active bleaching ingredient on fillers would be very small. Instead, the resin matrix may be easily degraded by the application of carbamide peroxide. (2,31,32,33,34)

CONCLUSIONS

Within the limitation of this study, the following conclusions were obtained:

- Carbamide peroxide bleaching of Admira and Glacier could achieve lighter color change but this was associated with an increase in microleakage, surface roughness and a decrease in surface hardness.
- The higher the concentration of the carbamide peroxide used, the greater the formerly- mentioned affections.
- Admira exhibited greater resistance than Glacier to adverse effects of bleaching except for surface roughness.

ACKNOWLEDGEMENTS

The authors would like to thank Prof. Dr. Abdalla Shahin, Dr. Mahrous Abu El Ein, faculty of Science, and Dr. Osama Badie, faculty of Engineering, Mansoura university, Mansoura, Egypt, for their valuable assistance in the applied part of this work.

CORRESPONDENCE TO

Dr Neveen Mokhtar Ayad, Department of Dental Biomaterials, Faculty of Dentistry, Mansoura University, Mansoura, Egypt. Phone number Home: 020502294041 Mobile: 0123914018 e-mail address neveenmokhtar@yahoo.com Mailing address P.O. box 2 Mansoura University, Mansoura, Egypt.

References

1. Martin R, Reinold L, and Gerhard H: Discoloration of restorative materials after bleaching application. Quintessence International Journal 2005; 36, 33-39.
2. Elias E, and Sajjan G: Effect of bleaching on microleakage of resin composite restorations in non-vital teeth: An in-vitro study. Journal of Endodontics 2002; 14, 9-13.
3. Turkun M, and Turkun LS: Effect of nonvital bleaching with 10% carbamide peroxide on sealing ability of resin composite restorations. International Journal of Endodontics 2004; 37, 52-60.
4. Helvatjoglu M, Kalinderis K, Pedulu L, and Papadoglannis Y: The effect of pulse activation on microleakage of a Packable composite resin and two Ormocers. Journal of Oral Rehabilitation 2004; 31, 1068-74.
5. Huang MS, Huang FM, and Ding SJ: The effect of thermocycling and dentin pre-treatment on the durability of the bond between composite resin and dentin. Journal of Oral Rehabilitation 2004; 31, 492-99.
6. Turker SB, and Biskin T: The effect of bleaching agents on the microhardness of dental esthetic restorative materials. Journal of Oral Rehabilitation 2002 ; 29, 627-31.
7. Yap AU, Lye KW, and Sau CW: Surface characteristics of tooth-colored restoratives polished utilizing different polishing systems. Journal of Operative Dentistry 1997; 22, 260-65.
8. Garcia-Godoy F, and Garcia-Godoy A: Effect of bleaching gels on the surface roughness, hardness, and micromorphology of composites. Journal of General Dentistry 2002; 50, 247-50.
9. Uctasali MB, Bala O, and Gullu A: Surface roughness of flowable and packable composite resin materials after finishing with abrasive discs. Journal of Oral Rehabilitation 2004; 31, 1197-1202.
10. Meserret, and Baseren: Surface roughness of nanofill and nanohybrid composite resin and Ormocer-based tooth-colored restorative materials after several finishing and polishing procedures. Journal of Biomaterials Applications 2004; 19, 121-34.
11. Leonardo GC, Roberta CB, and Mario AC: Comparative study of the surface roughness of Ormocer-based and conventional composites. Journal of Applied Oral Science 2003; 11(4), 348-53.
12. Gurdal P, Akdenziz BG, and Sen BH: The effects of

mouthrinses on microhardness and color stability of esthetic restorative materials. Journal of Oral Rehabilitation 2002; 29, 895-901.
13. Robert EL, Dunn WJ, Hartup GR, and Murchison DF: Higher-concentration carbamide peroxide effects on surface roughness of composites. Journal of Esthetic Restorative Dentistry 2002; 14, 92-96.
14. Robert JB, Jouse AR, Monica CS, and Luiz AFP: Shear bond strength of enamel treated with seven carbamide peroxide bleaching agents. Journal of Esthetic Restorative Dentistry 2004; 16, 250-60.
15. Mortazavi VN, Fathi M, and Soltani F: Effect of postoperative bleaching on microleakage of composite restorations. Journal of Adhesion 2005; 3, 9-12.
16. Sung EC, Chan M, Mito R, and Caputo AA: Effect of carbamide peroxide bleaching on the shear bond strength of composite of dental bleaching agent enhanced enamel. Prosthetic Dentistry Journal 1999; 82, 595-8.
17. Spyrides GM, Perdiago J, Pagani C, Araujo MAM, and Spyrides SMM: Effect of whitening agents on dentin bonding. Journal of Esthetic Restorative Dentistry 2000; 12, 264-70.
18. Cavalli V, Reis AF, Giannini M, and Ambrosano GM: The effect of elapsed time following bleaching on enamel bond strength of resin composite. Journal of Operative Dentistry 2001; 6, 597-602.
19. Titley KC, Torneck CD, and Ruse ND: The effect of carbamide peroxide gel on the shear bond strength of a microfill resin to bovine enamel. Journal of Dental Research 1992; 71, 20-24.
20. Crim GA: Prerestorative bleaching effect on microleakage of class V cavities. Quintessence International Journal 1992 ; 23, 823-25.
21. Cvitko E, Denehy GE, Swift EJ, and Pires JA: Bond strength of composite resin to enamel bleached with carbamide peroxide. Journal of Esthetic Restorative Dentistry 1991; 3, 100-102.
22. Dilek AT, Funda CY, Funda OB, Burku K, and Hyadar S: Selected characteristics of an Ormocer and a conventional hybrid resin composite. Dental Materials Journal 2004; 20, 487-97.
23. Moszner N, and Salz U: New development of polymeric dental composites. Journal of Progressive Polymeric Science 2001; 26, 535-76.
24. Yap AUJ: Effects of In-office tooth whiteners on hardness of tooth-colored restoratives. Journal of Operative Dentistry 2002; 27, 137-141.
25. Soderholm KJ, Zigan M, Ragan M, Fischlschweiger W, and Bergman N: Hydrolytic degradation of dental composites. Journal of Dental Research 1984; 10, 1248-54.
26. Fasanaro T: Bleaching Teeth : history, chemicals, and materials used for common tooth discoloration. Journal of Esthetic Restorative Dentistry 1992; 4, 71-78.
27. Cavalli V, Giannini M, and Carvalho RM: Effect of carbamide peroxide bleaching agents on tensile strength of human enamel. Dental Materials Journal 2004; 20, 733-39.
28. Campos I, Luiz AB, Andre LF, and Ambrosano G: Effect of bleaching with carbamide peroxide gels on microhardness of restorative materials. Journal of Esthetic Restorative Dentistry 2003; 15, 175-183.
29. Cooley RL, and Burger KM: Effect of carbamide peroxide on composite resins. Quintessence International Journal 1991; 10, 817-21.
30. Kawai K, Iwami Y, and Ebisu S: Effect of resin monomer composition on toothbrush wear resistance. Journal of Oral Rehabilitation 1998; 4, 264-68.
31. Yap AUJ, and Wattanpayungkul P: Effects of In-office bleaching products on surface finish of tooth-colored restoratives. Journal of Operative Dentistry 2002; 28, 15-19.
32. Senay C, Murat C, and Cehreli: The effect of current bleaching agents on the color of light-polymerized composite in vitro. Prosthetic Dentistry Journal 2003; 89, 474-8.
33. Filiz Y, and Sevil G: Bleaching-induced color change in plastic filling materials. Journal of Biomaterials Applications 2005; 3, 187-195.
34. Turker SB, and Biskin T: Effect of three bleaching agents on the surface properties of three different esthetic restorative materials. Prosthetic Dentistry Journal 2003; 89, 466-73.

Author Information

N.M. Ayad
Dental Biomaterials department, faculty of Dentistry, Mansoura university

A.E. Bedewi
Physics department, faculty of Science, Mansoura university

S.A. Hanafy
Dental Biomaterials department, faculty of Dentistry, Alexandria university

S.E. Saka
Dental Biomaterials department, faculty of Dentistry, Mansoura university