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Protective Effect of Resin Coating on the Microleakage of Class V Restorations Following Treatment with Carbamide Peroxide *In Vitro*

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Clinical Relevance

Carbamide peroxide treatment increased the microleakage of Class V conventional glass-ionomer cement and resin modified glass-ionomer cement restorations. The resin coating is an effective method to avoid bleaching-induced microleakage without affecting the bleaching outcome.

SUMMARY

This *in vitro* study evaluated the effects of a resin coating on the microleakage of Class V restorations due to bleaching. One-hundred and sixty Class V cavities were randomly restored with one of four different restorative materials (n=40): a compomer (Dyract AP), a conventional glass-ionomer cement (Ketac Molar Easymix), a resin modified glass-ionomer cement (Fuji II LC) and a resin composite (Filtek Z350). For each kind of material, 40 restorations were divided into four subgroups: bleached with resin coating (group BC), bleached without resin coating (group B), immersed in artificial saliva with resin coating (group SC), immersed in artificial saliva without resin coating (group S). In groups B and BC, the specimens were bleached with 10% carbamide peroxide gel for eight hours daily, while groups SC and S were stored in artificial saliva instead. After 28-day treatment, all the samples were subjected to a dye penetration test using the multiple-sectioning technique. In addition, one more test was performed to investigate the color difference between the coated and uncoated tooth surface after bleaching. There was a statistically significant increase in cervical microleakage in the

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group B specimens of Fuji II LC and Ketac Molar Easymix compared to their respective control specimen (group S). These effects on microleakage were not found in the bleached specimens with resin coating (group BC). There was also no visually-detectable color difference between the coated and uncoated tooth surface. In conclusion, resin coating is an effective method for avoiding the bleaching-induced microleakage of glass-ionomer cement.

INTRODUCTION

Tooth bleaching is becoming a common and popular treatment in dentistry.[1] Among all the bleaching techniques, nightguard vital bleaching (sometimes also referred to as at-home bleaching), using a moderate concentration of carbamide peroxide (CP), has been considered to be the safest, most cost-effective and patient-pleasing method for improving the smile's appearance.[2] Usually, the application of nightguard vital bleaching involves two hours twice a day or overnight wear of a custom-made tray. The entire treatment takes at least two weeks to complete.[3] Meanwhile, daily clinical practices frequently encounter restorations in teeth planned for bleaching. Long-term bleaching has inevitably led to an increased potential for the broad exposure of restorative materials to bleaching agents.[4] Crim has reported an increase in microleakage at the dentin margins of Class V resin composite restorations following exposure to home bleaching agents.[5] Likewise, in another study, it was found that the microleakage of resin composite restorations occurs in both pre- and postoperative bleaching groups.[6] However, recent studies show that bleaching had no influence on the microleakage of Class V tooth-colored restorations.[7-8] Apart from microleakage, other detrimental effects of bleaching on both restorative materials and tooth-hard tissues (surface and subsurface softening, increased surface roughness and substance loss)[9-12] have been reported. Although the effects of bleaching on tooth-colored restorative materials are still controversial, in some cases, replacement of the restoration after tooth bleaching is advised due to poor post-treatment color match and the degraded properties of the restorative material.[13-14] It should be noted that, during the procedure, the bleaching-induced effects, such as increased microleakage, might lead to a series of clinical problems, including bacterial accumulation, staining and pulp damage.[5-6]

Although some concerns have been raised over bleaching agents inducing deleterious effects on dental materials, the importance of pre-bleaching surface protection seems to be underestimated. In the literature, the protective effects of resin varnish against bleaching agents has been demonstrated by a previous study.[15] Generally speaking, resin coating is considered to be beneficial in reducing marginal staining and enhancing marginal integrity.[16-17] Resin coating could potentially eliminate the effects of bleaching agents on the microleakage of tooth-colored restorative materials. Moreover, it has been documented that resin-based varnishes, which are indicated for the treatment of dental hypersensitivity, did not reduce the bleaching outcome of the underlying enamel.[18] This finding showed that resin is a diffusible barrier towards bleaching agents. However, to date, relatively little information is available. Therefore, this *in vitro* study evaluated the effects of resin coating on the bleaching of dental materials. Three null hypotheses were proposed: 1) bleaching has no effect on the microleakage of restorative materials; 2) resin coating has no influence on bleaching on the microleakage of restorative materials; 3) resin coating of enamel does not affect the outcome of bleaching.

METHODS AND MATERIALS

The current study protocol was approved by the WHUSS (School of Stomatology, Wuhan University) Institutional Review Board. Four types of tooth-colored restorative materials were tested: a conventional glass-ionomer cement (CGIC), a resin-modified glass-ionomer cement (RMGIC), a polyacid-modified composite (compomer) and a resin composite. For all the materials, shade A3 was selected. The materials, the product names and the manufacturers are listed in Table 1.

Specimen Preparation

Ninety previously extracted, caries-free human molars were collected for this study. One cavity preparation per buccal and lingual surface (two cavity preparations total per tooth) with a mesiodistal width of 4 mm, an occlusogingival height of 3 mm and a depth of 2 mm, were prepared on the buccal and lingual surfaces of each tooth. The cavities were placed with the occlusal margin located 1.5 mm coronal from the cemento-enamel junction (CEJ) and the gingival margin located 1.5 mm apical from the CEJ. The cavities were prepared using the diamond bur (TF-21 and TF-21F, Mani, Tochigi, Japan) in a high-speed handpiece cooled with an air-water spray. Each diamond bur was discarded following the preparation of five cavities. The dimensions of each cavity were then measured with a periodontal probe to maintain uniformity. All cavosurface angles were kept at 90 degrees.

For each type of restorative material, 40 Class V restorations were prepared. The 40 restorations were further submitted to four subgroups randomly (n=10): bleached with resin coating (group BC); bleached without resin coating (group B); immersed in artificial saliva with resin coating (group SC); immersed in artificial saliva without resin coating (group S). In each tooth, the buccal and lingual cavities were randomly restored with one of the four restorative materials.

Table 1: *Materials Used in This Study*

Material Code Batch Type Main Composition Manufacturer

Material	Code	Batch	Type Main	Composition	Manufacturer
Ketac Molar Easymix	KM	294466	Conventional glass-ionomer cement	Polycarboxylic acid, aluminum-calcium-lanthanum fluorosilicate glass UDMA, TCB resin, Alkanoyl-poly-methacrylate,	3M ESPE AG, Seefeld, Germany
Dyract AP	DY	604010300	Polyacid-modified composite	strontium-fluoro-silicate glass, strontium fluoride, photo initiators, butyl hydroxy toluene, iron oxide pigments	Dentsply DeTrey GmbH, Konstanz, Germany
Fuji Ⅱ LC	FJ	610033	Resin-modified glass-ionomer cement	Powder: fluoroaluminosilicate; Liquid: polyacrylic acid, HEMA	GC Corp, Tokyo, Japan
Filtek Z350	Z350	6088A3	Nano-hybrid resin composite	Combination of aggregated zirconia/silica cluster filler, Bis-GMA, UDMA, TEGDMA and Bis-EMA	3M ESPE, St Paul, MN, USA

For the cavities restored with CGIC (KM), Ketac Conditioner (3M ESPE, Seefeld, Germany) was applied to the cavity for 10 seconds. The cavity was rinsed with water for 20 seconds, then air-dried. Subsequently, KM was mixed and placed into the cavities in one increment. The restoration was then left undisturbed for eight minutes. Finally, the surface of the restoration was coated with a protective varnish (Ketac Glaze, 3M ESPE). Before restoring the cavities with RMGIC (FJ), Fuji Conditioner (GC, Tokyo, Japan) was applied over the enamel and dentin surfaces for 20 seconds. The cavities were then rinsed with water for 20 seconds and air-dried. FJ was mixed and placed into the cavities in one increment, then light-cured for 40 seconds. Subsequently, the surfaces of the restoration were sealed with Fuji Varnish (GC). Before application of the compomer (DY), one layer of Prime & Bond NT (Dentsply DeTrey, Konstanz, Germany) was applied over the cavity surfaces for 20 seconds, gently air-dried from a dental syringe for five seconds and light-cured for 10 seconds. DY was applied in a single increment and light-cured for 40 seconds. For the resin composite restoration (Z350), enamel and dentin was etched with 37% phosphoric acid (Scotchbond Etchant Gel, 3M ESPE, St Paul, MN, USA) for 15 seconds and rinsed for 10 seconds. Excess water was removed using a cotton pellet. Immediately after blotting, one coat of adhesive (Single Bond 2, 3M ESPE) was applied and light-cured for 10 seconds. Z350 was then placed in one increment and light-cured for 40 seconds.

Subsequent to the restoration fabrication, all the teeth were stored in deionized water at 37°C for 24 hours. Following storage in deionized water, the restorations were polished by the same operator, using medium, fine and superfine discs (Sof-Lex, 3M ESPE) rotating in one direction. Finally, all the teeth were placed in 37°C artificial saliva for one month to simulate the aging process of the restoration. The artificial saliva was mixed according to the formulation given by Wataha and others.[19] The artificial saliva was renewed daily.

Immediately after storage in artificial saliva, the restorations in groups BC and SC were lightly air-dried and coated with one layer of Seal & Protect (Dentsply) for 20 seconds. Then, the coating was air-thinned and light-polymerized for 20 seconds. The second layer was applied in the same manner. The coating area covered the restoration and approximately 1 mm beyond the margin of the restoration.

Bleaching Procedure

Before bleaching, the root of each tooth was sealed with epoxy resin. For groups BC and B, the restorations were exposed to 10% CP (Opalescence PF 10%, Ultradent Products, Inc, South Jordan, UT, USA) for eight hours daily in a humid 37°C atmosphere. Applied to the whole crown was a 0.5-mm thick layer of bleaching gel. During this period, the specimens from groups SC and S were stored in artificial saliva. After eight hours of bleaching, the samples were rinsed with deionized water for 30 seconds and stored in artificial saliva for the remainder of the day (16 hours). During the 28-day treatment, toothbrushing was performed twice a day using a customized brushing machine for one minute (60 strokes, brushing force 2 N). During the toothbrushing process, the sample was kept in a 33% paste/water (w/w) slurry of Crest Total dentifrice (Procter & Gamble, Cincinnati, OH, USA)

Microleakage Measurement

After 28-day treatment, all the specimens were subjected to a thermocycling regimen of 1000 cycles maintained at 5°C and 55°C with an immersion time of 30 seconds and a five-second transfer time between baths. Then, the entire tooth, except for 1 mm beyond the margin of the restoration, was coated with two layers of nail varnish (Quick Shine, Zhejiang Cosmetic, Zhejiang, China). The restoration surfaces were examined visually under a stereomicroscope (Stemi SV11 Apo, Carl Zeiss, Inc, Maple Grove, MN, USA) after thermocycling to check whether the surface coatings were intact. The teeth were then soaked in 0.5% basic fuchsin dye (Shanghai MED, Shanghai, China) for 24 hours. After rinsing under deionized water, each tooth was embedded with epoxy resin and sectioned in a buccal-lingual direction along its long axis using a low-speed saw (IsoMet, Buehler, Chicago, IL, USA). Each tooth was cut into five sections (400 µm thickness). Subsequently, the sectioned surfaces of each specimen were polished with wet carborundum papers progressively (1200- and 2400-grit). Both sides of each tooth section were examined visually with a stereomicroscope at 50x magnification. The measurements were performed by two operators who were blind to the specimen preparation. Two evaluators independently scored the coded specimens, and any discrepancies were discussed. If no agreement could be achieved, a third-party opinion was sought.

The following scale was used to assess the extent of dye penetration at the tooth-restoration interface.[20]

Microleakage at the enamel walls was rated on a scale from 0 to 3, where 0 = no microleakage; 1 = dye penetration within the enamel of the occlusal wall; 2 = dye penetration reaching the dentin of the occlusal wall up to the axial wall and 3 = dye penetration spreading along the axial wall. Microleakage at the dentin walls was rated on a scale from 0 to 3, where 0 = no microleakage; 1 = dye penetration up to halfway along the gingival wall; 2 = dye penetration within the gingival wall up to the axial wall without reaching the axial wall and 3 = dye penetration spreading along the axial wall. The medians of the dye penetration measurements were then calculated for both the cervical and occlusal margins of the materials tested.

Additional Color Measurement

In order to investigate the possible effects of resin coating on tooth color changes due to bleaching, an experiment was performed on 20 additional Class V restorations (for each material n=5). The samples were prepared and treated (coated and bleached) in the same manner as described above. After 28-day treatment, the resin coatings of the 20 samples were carefully removed with fine and superfine Sof-Lex discs. As shown in Figure 1, the color differences of the coated tooth surface (the tooth surface surrounding the restoration) and the uncoated tooth surface (2 mm beyond the occlusal margin of the restoration) were evaluated using a spectrophotometer (PR-650 Spectra Scan, Photo Research, Inc, Chatsworth, CA, USA) before (measured before coating) and after bleaching. This procedure has been described in detail elsewhere.[14] Briefly, the spectrophotometer and optic light cable (positioned at a 45° angle right and left to the vertical plane) provided an optical configuration of 0° observation and 45° illumination to the object. The spectrophotometer was standardized to 91.4 mm from the measured objects with a measurement aperture of 1.5 mm. The standardized illumination source D65 and 2° observer configuration were used. For all color measurements, spectral reflectance was obtained from 380 to 780 nm, with 2 nm interval, and subsequently converted to Commission International de I'Echairage (CIE) L*, a* and b* values. Prior to measuring, the spectrophotometer was calibrated with a white reflectance standard tile supplied by the manufacturer. The CIE L*, a* and b* values were then used to calculate the color differences using the following formula[21]: $\Delta E = (\Delta L^2 + \Delta a^2 + \Delta b^2)^{1/2}$

Furthermore, three senior prosthodontists conducted the visual evaluation on the tooth surfaces, with the restoration covered by a neutral grey plate. The evaluators were then asked to evaluate whether the color of the tooth surface was uniform.

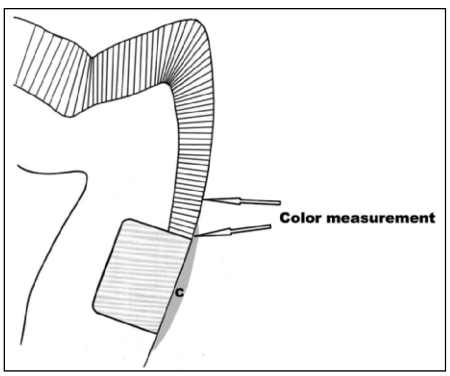

Figure 1. *Diagram of color measurement on the coated enamel and uncoated enamel surfaces (C: coating). Note that the color measurement was made before placement of the resin coating and after removal of the resin coating.*

Statistical Analysis

The data was analyzed using the SPSS statistical software package (SPSS 13.0 for Windows, SPSS, Chicago, IL, USA). The scores of the microleakage tests were analyzed with the Kruskal-Wallis test to identify statistical differences in marginal microleakage among the four groups. The sealing quality at the occlusal and cervical margins in each group was compared with the Mann-Whitney test and the *p*-values were adjusted with the Bonferroni method. All statistical analyses were carried out at a significance level of 0.05.

RESULTS

For all specimens with a surface coating, the resin coating remained intact after bleaching and thermocycling.

None of the groups tested in the current study completely eliminated microleakage (Figure 2). In most cases, the group SC samples showed relatively lower microleakage scores compared with the group S samples. For all the materials tested, among the four

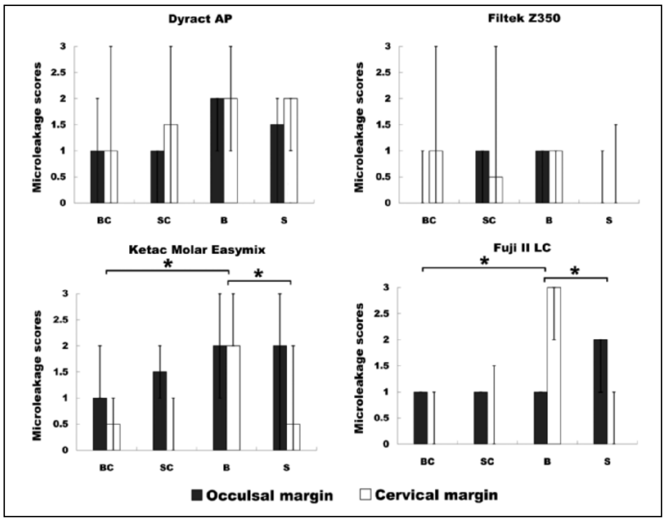

Figure 2. *Medians of the microleakage scores of all the materials tested at the occulsal and cervical margins. The error bar represents the 25%-75% percentiles. Significant differences were marked with *. Note that the 25% and 75% percentiles of group BC, SC and B from Fuji II LC are the same as their medians.*

groups, there were no statistically significant differences in microleakage scores at the occlusal margins. With regard to the cervical margins, no significant differences were observed in microleakage scores among the four groups of compomer and resin composite. However, for CGIC and RMGIC, the group B specimens showed the worst marginal sealing. The group B specimens exhibited significantly greater cervical microleakage, as compared with the group S samples (bleaching effect). Moreover, the groups BC and SC specimens demonstrated the same microleakage scores. Statistically significant differences were found at the cervical margins between the groups BC and B (coating effect against bleaching).

With regard to visual assessment, 100% of the specimen surfaces were considered uniform in color. In addition, the color differences (ΔE) after bleaching between the coated and uncoated tooth surfaces measured by the spectrophotometer were all under 1.8, suggesting that the color differences were not visually perceptible (Table 2).

Based on the above results, the two null hypotheses, that bleaching has no effect on the microleakage of dental materials and resin coating has no influence on the microleakage of bleached dental materials, were rejected. The third null hypothesis, that the resin coating does not affect bleaching outcome, was accepted.

DISCUSSION

A restoration is usually not bleached immediately after preparation, therefore, in contrast to previous studies,[5,8,22] the specimens were kept in 37°C artificial saliva for one month before bleaching. To some extent, this was done to simulate the clinical situation. The most common method in microleakage testing is to use a single, midline section of the tooth. However, this may not be representative of the total microleakage distribution.[23] Thus, the multiple-sectioning method was applied in the current study in order to overcome the shortcomings of the single-section method.

In the literature, microleakage has been defined as the "clinically undetectable" passage of bacteria, fluids, molecules or ions between a cavity wall and the restorative material applied to it. This can occur due to deterioration of the tooth-restoration interface, differences between thermal expansion coefficients of material-tooth tissue or polymerization shrinkage, causing staining, possible recurrent caries and restoration replacement.[24] Thus, it would be advantageous to find a way to protect the restoration during bleaching.

In the current study, the treatment of Class V restorations with bleaching gels had no effect on enamel microleakage regardless of whether or not their surfaces were coated. This finding is in accordance with previous studies.[5,7] Moreover, bleaching effects on cervical (dentin) microleakage depended on the materials tested and the surface being coated with Seal & Protect. For compomer and resin composite, no bleach-

Table 2: *Means and Standard Deviations (SD) of the Coated Enamel Surface and Uncoated Enamel Surface Before and After Bleaching*

		Coated Enamel Surface			Uncoated Enamel Surface			
Materials		**L***	**a***	**b***	**L***	**a***	**b***	**ΔE**
Filtek Z350	Baseline	73.47(1.11)	0.50(0.09)	15.83(2.36)	73.52(0.50)	0.44(0.06)	15.32(1.81)	1.32(0.16)
	Bleached	78.05(2.08)	1.13(0.17)	10.05(0.74)	79.18(2.33)	0.93(0.10)	9.40(0.65)	1.55(0.21)
Dyract AP	Baseline	73.24(1.41)	0.53(0.08)	15.44(0.93)	74.03(0.55)	0.43(0.10)	15.31(0.93)	1.36(0.49)
	Bleached	77.98(2.54)	1.09(0.16)	10.16(0.55)	78.93(2.61)	0.89(0.12)	9.29(0.54)	1.43(0.40)
Ketac Molar Easymix	Baseline	73.80(1.48)	0.48(0.10)	15.65(1.68)	73.84(0.29)	0.45(0.05)	15.42(1.44)	1.06(0.55)
	Bleached	76.75(1.71)	1.08(0.14)	10.60(0.52)	77.93(1.43)	0.91(0.14)	9.42(0.51)	1.76(0.66)
Fuji II LC	Baseline	73.01(1.72)	0.51(0.11)	15.13(1.31)	73.80(0.92)	0.43(0.07)	15.18(1.09)	1.52(0.36)
	Bleached	78.75(3.10)	0.97(0.12)	9.85(0.79)	79.58(2.84)	0.85(0.10)	9.55(0.62)	1.27(0.52)

ΔE: color difference between the coated enamel surface and uncoated enamel surface ing effects on the cervical microleakage were detected. In contrast, an increase in cervical microleakage of RMGIC and CGIC was found in group B, compared to group S, indicating detrimental effects of CP treatment. It has been shown that microleakage occurs as a result of the presence of marginal gaps between the restoration and cavity wall.[25] Thus, the fact that microleakage occurred at the cervical margin suggests discontinuity between the restoration and dentin following bleaching. This may be due to the bleaching effects on either the restoration, the tooth structure or both. In support of this hypothesis, several studies have determined that bleaching results in significantly greater effects on the surface and subsurface structure of both tooth and restoration, compared to their respective controls.[10,26] However, such deleterious potential of CP was not found at the enamel margins of RMGIC and CGIC. The reason could be the difference in composition of enamel and dentin. Dentin contains less mineral and more organic matrix, which might easily be affected by bleaching agents.[27] It has been shown that hydrogen peroxide could affect the organic and inorganic components of dentin, causing the denaturation of proteins. These morphological changes could also reduce the performance of resin bonded restorations.[28]

With regard to RMGIC and CGIC, no bleaching effects on cervical microleakage were found in specimens with resin coating, suggesting that the resin coating eliminated any bleaching effects on the cervical microleakage of RMGIC and CGIC. This might be due to its ability to create a uniform layer, which prevented contact between CP and the restoration surfaces. However, this hypothesis needs to be clarified in further studies.

In accordance with a previous study,[29] the resin coating of the materials remained intact during the 28-day treatment procedure. In order to investigate the influence of resin coating on tooth color changes due to bleaching in the additional test, the coating was removed by Sof-Lex discs after bleaching and complete removal of the resin coating was confirmed by observation under stereomicroscope. After bleaching, there was a slight increase in the a* values, indicating that there was more red in the tooth color. Further studies are needed to clarify this phenomenon. Moreover, minor loss of enamel might happen and it can influence the results. However, given the fact that the color change of bleached teeth might highly relate to color change of the subsurface dentin,[30] a slight loss in enamel thickness seems to not be a critical issue. In the current study, no clinically relevant color difference between the coated and uncoated part of the tooth after removal of the surface coating was detected. Interestingly, the color differences between these two parts after bleaching were similar to the data before bleaching. This phenomenon could be mainly due to the strong penetration ability of CP.[18,31]

Based on the findings of the current study, both dentists and patients should be aware of the potential effects of bleaching on existing tooth-colored restorations. Bleaching agents should not be used indiscriminately when tooth-colored restorations are present. The authors recommend applying a resin coating as surface protection to avoid possible microleakage when bleaching teeth with glass-ionomer cements. After bleaching, the coating can be easily removed by polishing.

The results of the current *in vitro* study highlight the need to protect the restoration during the bleaching process. However, it must be noted that the results of this study must be interpreted with caution, because the bleaching process might be influenced by the presence of pellicle and saliva in the oral cavity. Thus, controlled clinical studies would be particularly valuable for enhancing the understanding of these effects.

CONCLUSIONS

Under the limitations of this *in vitro* study, the following conclusions can be drawn:

1) Significant cervical microleakage of RMGIC and CGIC was found after bleaching with 10% CP gel.
2) Resin coating can decrease the detrimental effects of bleaching gel on the cervical microleakage of RMGIC and CGIC.
3) After bleaching, no difference in color occurred with use of the resin coating.

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References

1. Matis BA, Cochran MA & Eckert G (2009) Review of the effectiveness of various tooth whitening systems *Operative Dentistry* **34(2)** 230-235.
2. Haywood VB (2000) Current status of nightguard vital bleaching *Compendium of Continuing Education in Dentistry* **21(Supplement 28)** S10-S17; quiz S48.
3. Kugel G & Ferreira S (2005) The art and science of tooth whitening *Journal of the Massachusetts Dental Society* **53(4)** 34-37.
4. Attin T, Hannig C, Wiegand A & Attin R (2004) Effect of bleaching on restorative materials and restorations—a systematic review *Dental Materials* **20(9)** 852-861.
5. Crim GA (1992) Post-operative bleaching: Effect on microleakage *American Journal of Dentistry* **5(2)** 109-112.

6. Ulukapi H, Benderli Y & Ulukapi I (2003) Effect of pre- and postoperative bleaching on marginal leakage of amalgam and composite restorations *Quintessence International* **34(7)** 505-508.

7. Khoroushi M & Fardashtaki SR (2009) Effect of light-activated bleaching on the microleakage of Class V tooth-colored restorations *Operative Dentistry* **34(5)** 565-570.

8. Klukowska MA, White DJ, Gibb RD, García-Godoy F, García-Godoy C & Duschner H (2008) The effects of high concentration tooth whitening bleaches on microleakage of Class V composite restorations *The Journal of Clinical Dentistry* **19(1)** 14-17.

9. Moraes RR, Marimon JL, Schneider LF, Correr Sobrinho L, Camacho GB & Bueno M (2006) Carbamide peroxide bleaching agents: Effects on surface roughness of enamel, composite and porcelain *Clinical Oral Investigations* **10(1)** 23-28.

10. Cehreli ZC, Yazici R & García-Godoy F (2003) Effect of home-use bleaching gels on fluoride releasing restorative materials *Operative Dentistry* **28(5)** 605-609.

11. Sasaki RT, Barbosa MC, Florio FM & Basting RT (2007) Enamel microhardness and shear bond strength after treatment with an 18% carbamide peroxide bleaching varnish *American Journal of Dentistry* **20(5)** 324-328.

12. Santini A, Pulham CR, Rajab A & Ibbetson R (2008) The effect of a 10% carbamide peroxide bleaching agent on the phosphate concentration of tooth enamel assessed by Raman spectroscopy *Dental Traumatology* **24(2)** 220-223.

13. Bailey SJ & Swift EJ Jr (1992) Effects of home bleaching products on composite resins *Quintessence International* **23(7)** 489-494.

14. Yu H, Pan X, Lin Y, Li Q, Hussain M & Wang Y (2009) Effects of carbamide peroxide on the staining susceptibility of tooth-colored restorative materials *Operative Dentistry* **34(1)** 72-82.

15. Rotstein I, Dogan H, Avron Y, Shemesh H, Mor C & Steinberg D (2000) Protective effect of Copalite surface coating on mercury release from dental amalgam following treatment with carbamide peroxide *Endodontics & Dental Traumatology* **16(3)** 107-110.

16. Dickinson GL & Leinfelder KF (1993) Assessing the long-term effect of a surface penetrating sealant *Journal of the American Dental Association* **124(7)** 68-72.

17. dos Santos PH, Pavan S, Assunção WG, Consani S, Correr-Sobrinho L & Sinhoreti MA (2008) Influence of surface sealants on microleakage of composite resin restorations *Journal of Dentistry for Children* **75(1)** 24-28.

18. Betke H, Revas P, Werner C & Attin T (2005) Influence of desensitizing agents on tooth color changes after tooth bleaching therapy *Quintessenz* **56(6)** 589-597.

19. Wataha JC, Rueggeberg FA, Lapp CA, Lewis JB, Lockwood PE, Ergle JW & Mettenburg DJ (1999) *In vitro* cytotoxicity of resin-containing restorative materials after aging in artificial saliva *Clinical Oral Investigations* **3(3)** 144-149.

20. Giachetti L, Scaminaci Russo D, Bertini F, Pierleoni F & Nieri M (2007) Effect of operator skill in relation to microleakage of total-etch and self-etch bonding systems *Journal of Dentistry* **35(4)** 289-293.

21. Li Q, Yu H & Wang YN (2009) *In vivo* spectroradiometric evaluation of colour matching errors among five shade guides *Journal of Oral Rehabilitation* **36(1)** 65-70.

22. Yu H, Li Q, Hussain M & Wang Y (2008) Effects of bleaching gels on the surface microhardness of tooth-colored restorative materials *in situ Journal of Dentistry* **36(4)** 261-267.

23. Federlin M, Krifka S, Herpich M, Hiller KA & Schmalz G (2007) Partial ceramic crowns: Influence of ceramic thickness, preparation design and luting material on fracture resistance and marginal integrity *in vitro Operative Dentistry* **32(3)** 251-260.

24. Owens BM & Johnson WW (2007) Effect of single step adhesives on the marginal permeability of Class V resin composites *Operative Dentistry* **32(1)** 67-72.

25. Hakimeh S, Vaidyanathan J, Houpt ML, Vaidyanathan TK & Von Hagen S (2000) Microleakage of compomer Class V restorations: Effect of load cycling, thermal cycling, and cavity shape differences *The Journal of Prosthetic Dentistry* **83(2)** 194-203.

26. Attin T, Vollmer D, Wiegand A, Attin R & Betke H (2005) Subsurface microhardness of enamel and dentin after different external bleaching procedures *American Journal of Dentistry* **18(1)** 8-12.

27. Carrasco-Guerisoli LD, Schiavoni RJ, Barroso JM, Guerisoli DM, Pecora JD & Froner IC (2009) Effect of different bleaching systems on the ultrastructure of bovine dentin *Dental Traumatology* **25(2)** 176-180.

28. Teixeira EC, Hara AT, Turssi CP & Serra MC (2003) Effect of non-vital tooth bleaching on microleakage of coronal access restorations *Journal of Oral Rehabilitation* **30(11)** 1123-1127.

29. Chuang SF, Jin YT, Tsai PF & Wong TY (2001) Effect of various surface protections on the margin microleakage of resin-modified glass ionomer cements *The Journal of Prosthetic Dentistry* **86(3)** 309-314.

30. Wiegand A, Vollmer D, Foitzik M, Attin R & Attin T (2005) Efficacy of different whitening modalities on bovine enamel and dentin *Clinical Oral Investigations* **9(2)** 91-97.

31. Joiner A (2007) Review of the effects of peroxide on enamel and dentine properties *Journal of Dentistry* **35(12)** 889-896.