Original Article

Effect of Home Bleaching on Surface of Zinc Phosphate Cement: A Scanning Electron Microscopic Study

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ABSTRACT

Context: The effect of home bleaching on surfaces of dental cements is controversial. **Aim:** The aim of this study was to microscopically evaluate and compare the effect of different concentrations of carbamide peroxide (CP) home bleaching agents on the surface of zinc phosphate cement. **Materials and Methods:** Forty 10 mm × 2 mm specimens of zinc phosphate cement were prepared following the manufacturer's directions. All specimens were immersed in artificial saliva at 37°C for 24 h. The specimens were equally divided into four groups ($n = 10$). One control group received no CP bleaching. Three experimental groups were exposed to 10%, 16%, and 22% of CP home bleaching agents. The bleaching agents were applied daily for 4 h for 14 days. Specimens were stored in artificial saliva at 37°C for 24 h and then examined under a scanning electron microscope. The surface micromorphology of the specimens was carefully evaluated and compared. **Results:** The zinc oxide particles in the specimens of the control group were tightly packed with well-defined plate-like crystals. When specimens were exposed to 10% CP gels, the particles became flat and irregular with few areas of eroded matrix. When 16% CP gel was used, the crystals became flatter and irregular with rounded edges. Bleaching with 22% CP gel showed little more erosion of the surface of the matrix of the cement. Fewer flat and irregular crystals were observed on the surface of the cement. **Conclusions:** At-home bleaching using 10%, 16%, and 22% CP may be safely used in the presence of zinc phosphate-luted crown restorations without adverse effects.

KEYWORDS: *Carbamide peroxide bleaching, dental cement, home bleaching*

Date of Acceptance:
26-Nov-2017

INTRODUCTION

Bleaching is considered as a conservative treatment of discolored teeth. Different methods of tooth bleaching have been introduced such as in-office and at-home bleaching methods. At-home bleaching is the most popular method. In-office bleaching uses high concentrations of hydrogen peroxide (HP) of 35% to 50% whereas at-home bleaching uses lower concentrations of carbamide peroxide (CP) of 5% to 22%. Haywood[1] stated that CP products can be used in concentrations up to 35%. A 10% solution of CP is roughly 3% HP and 7% urea.[1] The HP is considered as the active ingredient.

The effect of bleaching on dental restorative materials is contradictory.[2] In-office bleaching did not change microhardness and surface roughness of composite resins.[3] However, surface roughness of tooth-colored restorative materials after application of 10% and 15% CP was reported.[4] Turker and Biskin[5] found that surface roughness of tooth-colored restorative materials was slightly changed by 10% and 16% CP concentrations. Color changes of composite restorations treated by 10% CP were also reported.[6] In 2010, Prabhakar *et al*.[7] reported a reduction in hardness but not the bond strength of composite restorative materials when exposed to 10% and 22% CP. However, Mujdeci and Gokay[8] found no

Access this article online

Quick Response Code:

Website: www.njcponline.com

DOI: 10.4103/njcp.njcp_322_17

PMID: *******

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How to cite this article: AlZain SA. Effect of home bleaching on surface of zinc phosphate cement: A scanning electron microscopic study. Niger J Clin Pract 2017;XX:XX-XX.

adverse effect of 10% CP and 14% HP on microhardness of tooth-colored restorative materials. Ulukapi *et al*.[9] reported a negative effect of 10% CP on the marginal adaptation of composite restoration, but not of amalgam restoration. Bektas *et al*.[10] stated that "microleakage of composite resin restorations differs according to the bleaching methods used."

The effect of 10% and 16% CP home bleaching agents significantly decreased the microhardness of porcelain,[11] but no significant changes in surface roughness were reported for feldspathic porcelain.[5]

Cemented crown restorations show a microscopic cement-filled gap at the margin that may not be visible to the naked eye. There is a high chance of exposure of the restorations to bleaching agents. Then, the cement-filled gap may be adversely affected by the bleaching agents.

Cements such as resin, glass ionomer, resin-modified glass ionomer, or zinc phosphate cement may be used to cement crown restorations.

Several investigators studied the effect of at-home and in-office bleaching on dental luting cements. Torabi Ardakani *et al*.[12] reported a significant effect of in-office bleaching on sorption and solubility of resin-luting cements. Bagheri *et al*.[13] reported reduced bond strength of resin-luting cements after they were exposed to 10% CP. Resin-modified glass ionomer cements demonstrated an increase in surface roughness when exposed to 10% CP.[5,14] Therefore, it was not considered a suitable restorative material to be used prior to exposure to 15% CP bleaching because of its susceptibility to increased microleakage.[15]

It was found that both in-office and at-home bleaching significantly increased the depth loss of zinc phosphate-luting cement and increased the resin-modified glass ionomer roughness.[14] However, the changes were considered clinically insignificant.[14] When 37% CP was used, Lima *et al*.[16] reported a higher bond strength of glass ionomer than zinc phosphate cement. The highest bond strength was reported when resin-modified glass ionomer was used.[16]

The objective of this study was to microscopically evaluate and compare the effect of different concentrations of CP home bleaching agents on the surface of zinc phosphate cement.

MATERIALS AND METHODS

Forty Teflon rings of 10 mm internal diameter and 2 mm thickness were used. Each ring was placed on a celluloid strip that was seated on a glass slab. Zinc phosphate cement (Zinc Phosphate Cement, Henry Schein Inc., Melville, NY 11747, USA) was mixed on a glass slab at room temperature following the manufacturer's directions and loaded into the rings. A celluloid strip was placed on top of the loaded ring and another glass slab was seated onto it. After 15 min, the ring containing the set cement was cleaned of excess cement. All specimens were immersed in 15 ml artificial saliva at 37°C for 24 h. The specimens were then equally divided into four groups ($n = 10$). One group was selected as a control and received no CP bleaching treatment. The other three experimental groups were repeatedly exposed to three different concentrations of CP home bleaching agent (10%, 16%, and 22%) (NiteWhite ACP, Discus Dental®, LLC, CA 90232, USA) following the manufacturer's directions. The bleaching agents were applied daily for 4 h for 14 days as was recommended by the manufacturer. During exposure to CP, specimens were stored at 37°C, and then after 4 h, the CP bleaching gel was thoroughly rinsed with saline. Specimens were stored in artificial saliva at 37°C for 24 h to be ready for the next exposure to CP gel. Specimens were prepared and gold coated to be ready for examination under a scanning electron microscope (SEM) (JOEL, JSM-T330A SEM, JOEL Ltd., 1-2 Musashino 3-Chome Akishima, Tokyo 196-85558, Japan). The surface micromorphology of the specimens was carefully evaluated and compared.

RESULTS

The zinc oxide particles in the specimens of the control group were tightly packed [Figure 1a]. They were well-defined plate-like zinc oxide crystals. The particles were formed on all the surfaces of the cement, masking the matrix.

In specimens that were exposed to 10% CP gels, the plate-like well-defined crystalline particles were not evident [Figure 1b]. However, multiple flat and irregular particles were seen covering a large cement surface area. The particles had rounded edges. Some of them were fused together. The matrix of the cement was slightly eroded at few areas. Small oxide particles were seen embedded within the cement matrix. Several cracks were observed at some areas due to drying of specimens during their preparation for SEM examination. Some pores were evident.

Specimens of the 16% CP gel group showed slight erosion of the matrix [Figure 1c]. The crystals were flatter and more irregular with rounded edges. They were observed on the surface of the cement and some of them were fused together. Small particles were seen embedded within the cement matrix. There were some pores.

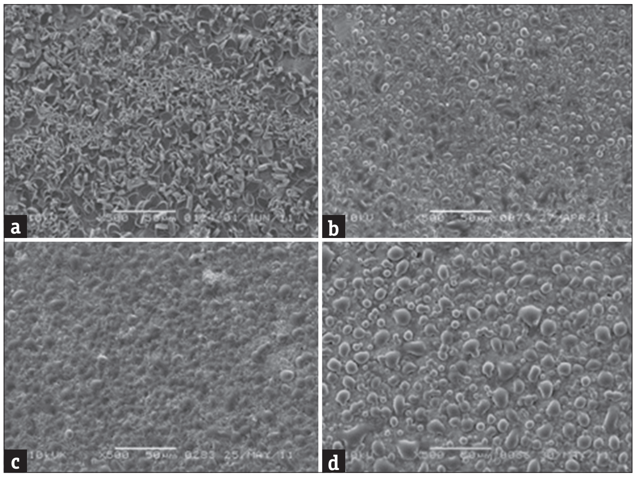

Figure 1: Scanning electron microscope image of zinc phosphate cement (×500). (a) Control group: The well-defined plate-like zinc oxide crystals are tightly packed covering the entire surface of the cement. (b) 10% CP bleaching: Multiple flat, irregular zinc oxide particles. Some are fused together. (c) 16% CP bleaching: Slight erosion of the matrix and flatter and more irregular particles are evident. (d) 22% CP bleaching: More erosion of the matrix is evident. Fewer irregular crystals are observed. The particles are more rounded and some are fused together. Few pores are evident. CP = Carbamide peroxide

Specimens that were exposed to 22% CP gel showed little more erosion of the surface of the matrix of the cement. Fewer flat and irregular crystals were observed on the surface of the cement [Figure 1d]. The particles are more rounded. Some of them fused together. Few pores were evident.

DISCUSSION

Zinc phosphate cement has powder and liquid components. The powder is composed of 90% zinc oxide and 10% magnesium oxide and other pigments such as silica oxide and bismuth oxide. The liquid is composed of concentrated orthophosphoric acid, 40% water, 2.5% aluminum phosphate, and 5% zinc phosphate. Both components are mixed together to form a matrix of amorphous glass-like noncrystalline tertiary zinc phosphate which binds unreacted particles of zinc oxide together.[17] The aluminum content is confined only to the matrix of the cement and it aids in moderating the reaction.[17] The amorphous glass-like non-crystalline component is stable under relatively dry conditions (relative humidity less than 30%). However, in the presence of excess moisture or high humidity after complete hardening of the cement, the unstable surface layer of the cement transforms to the crystalline form, hopeite ($Zn_3[PO_4]_2.4H_2O$).[18,19] However, Servais and Cartz[18] stated that the hopeite crystals at the surface grow from zinc oxide particles situated at the surface that act as nuclei. The hopeite crystals are held weakly to the cement surface.[18] After 1 or 2 weeks at 100% relative humidity, large crystals of hopeite can be seen freely at the surface.[18] The rate of growth of the hopeite crystals was found to be dependent on the temperature conditions; at 37°C, the rate of growth was found distinctly greater.[18] This supports the finding of the present study where more free crystals were observed due to exposure of the specimens to moisture (artificial saliva). Furthermore, more hopeite crystals may have formed on the surface of the set cement because all specimens were stored at all times in artificial saliva at 37°C. Boston and Jefferies[20] stated that exposure of zinc phosphate cement to 36% HP bleaching gel could reduce the water content near the cement surface through osmotic effect. This explains the reduced formation of the hopeite crystals due to the osmotic effect of the CP bleaching gels on the surface of the cement in this study. In the present study, the plate-like zinc oxide particles were evident on the surface of specimens of the control group. But, they were not similarly evident when specimens were treated with 10%, 16%, and 22% CP bleaching agents. They appeared as multiple flat and irregular crystals with rounded edges. They covered most of the surfaces of the cement. Similar findings were reported by Jefferson *et al*.[17] after using 10% CP bleaching.

It was found that the mean roughness, hardness, and modulus of zinc phosphate exposed to 36% HP agents were not statistically different from the unexposed control samples.[20] In the present study, CP agents were used at much lower concentrations. Therefore, it was clear that the effect of CP on zinc phosphate cement was minimal.

The solubility of zinc phosphate cement increases when the pH of the medium is lowered.[17] This may result in an increase in the solubility of zinc oxide particles of the cement. Londono *et al*.[14] stated that solubility of zinc phosphate cement as a result of the bleaching process might be due to the low pH and oxidizing effect of home bleaching agents. In their study, they used 38% HP in-office and 20% CP at-home bleaching. However, they concluded that the observed changes were clinically insignificant. Haywood[1] stated that a 10% CP did not etch like phosphoric acid did. In the present study, as the concentration of CP was increased, the number of the zinc oxide particles was slightly decreased, but no major changes of zinc phosphate cement were observed.

In this study, the matrix of the cement was slightly eroded. This finding is supported by Jefferson *et al*.[17] who used energy-dispersive X-ray microanalysis of the zinc phosphate cement and reported a decrease in aluminum content of zinc phosphate cement when treated with 10% CP. Since aluminum is confined to the matrix, the matrix was eroded by the 10% CP bleaching gel.[17] Occasional loss of matrix surrounding the zinc oxide particles was reported when using 36% HP.[20] However, they found no decrease in hardness or increase in roughness as might be expected. They concluded that their findings did not indicate the need for caution when using a high concentration of (36%) of HP bleaching agent in the presence of restorations luted with zinc phosphate cement. In this study, the matrix was not extensively lost because of the low concentrations of CP agents used. Therefore, there was no major problem of using 10%, 16%, and 22% CP home bleaching agents in the presence of cast restorations luted with zinc phosphate cement.

In this study, the porosity of the set cement was evident at few areas. This porosity was due to the excess water which resulted into globules because it is unable to diffuse out of the cement before it hardened. Subsequently, this excess water diffuses out of the cement, leaving pores.

Intraoral conditions such as load cycling due to mastication and parafunctional activities, toothbrushing and food abrasion, thermal cycling, exposure to a wide range of dietary liquids, smoking, and oral hygiene products in addition to saliva may have additional effects on the surface of the zinc phosphate cement that is exposed to CP agents. Therefore, further studies are needed to evaluate the effect of those factors on the integrity of the zinc phosphate cement after exposure to bleaching agents.

CONCLUSIONS

Within the limitations of this study, the following conclusions were drawn:

1. The plate-like crystals were evident on the surface of specimens of the control group and appeared as multiple flat and irregular crystals with rounded edges when specimens were treated with 10%, 16%, and 22% CP home bleaching agents
2. As the concentration of CP bleaching agent is increased, the number of the zinc oxide particles was decreased and a little more erosion of matrix was observed, resulting in minor morphological changes of the surface of the cement
3. Bleaching with the use of 10%, 16%, and 22% CP may be safely used in the presence of zinc phosphate-luted crown restorations
4. Further studies are needed to evaluate the effect of other multiple intraoral factors on the integrity of the zinc phosphate cement after exposure to CP bleaching agents.

Acknowledgment

The author would like to acknowledge the College of Dentistry Research Center (CDRC) at King Saud University for technical support of the research.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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