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HYDROGEN PEROXIDE BLEACHING: effect of various concentrations on mercury and other metal ions release from admixed and spherical dental amalgam

Clareamento por peróxido de hidrogênio: efeito de várias concentrações de mercúrio e liberação de outros íons metálicos pelos amálgamas dentais misturado e esférico

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Abstract

OBJECTIVE: The aim of this study was to determine the effect of different hydrogen peroxide concentrations (HP) on mercury and other metal ions release from admixed and spherical dental amalgam. **MATERIALS AND METHODS**: Dental amalgam discs were prepared from GS.80 and Lojic+ alloys (Southern Dental Industries, Australia) according to manufacturer's instructions in stainless steel moulds (10mm diameter and 2mm thickness). The discs (n=25 of each alloy) were divided into five equal groups for each alloy. Each group was immersed in 20 ml of 38%, 24%, 10%, or 3% HP solution for 24 h at 37ºC with 0% (distilled water) as control. Following immersion procedure, solutions were taken for metal ion release determination (Hg, Ag, Sn and Cu) using inductively coupled plasma mass spectrometry (ICP-MS). Statistical analysis was conducted using one and two way ANOVA tests to determine significance of differences between test groups. Bonferroni Post Hoc test was conducted for multiple comparisons. **RESULTS**: Metal ion release for the elements (Hg, Ag, Sn and Cu) increased with exposure to increasing concentrations of HP for both GS.80 and Lojic+ amalgam alloys. The differences in concentration of metal ions released after treatment with 0% (control), 3%, 10%, 24% or 38% HP were statistically significant ($p < 0.05$). **CONCLUSION**: Metal ions (Hg, Ag, Cu and Sn) were released from dental amalgam following treatment with all HP concentrations. Metal ion release increased with increasing HP concentration. Even with exposure of dental amalgam to relatively high HP concentration (38%), released Hg did not exceed the maximum acceptable limit.

Keywords: Mercury. Ions release. Dental amalgam. Hidrogen peroxide bleaching.

Resumo

OBJETIVO: *O objetivo deste trabalho foi determinar os efeitos de diferentes concentrações de peróxido de hidrogênio na liberação de íons de Hg e outros metais de amálgamas misturados e esféricos.* ***MATERIAIS E MÉTODOS***: *Discos de amálgama dental foram preparados com ligas GS.80 e Lojic+, de acordo com instruções dos fabricantes, em moldes de aço inoxidável (10 mm de diâmetro e 2 mm de espessura). Os discos (n=25 de cada liga) foram divididos em cinco grupos iguais para cada liga. Cada grupo foi imerso em 20 ml de solução HP a 38%, 24%, 10% ou 3% a 37ºC, por 24 h a 37ºC, e com água destilada 0% como controle. Após os procedimentos de imersão, soluções foram tomadas para determinação da liberação de íons metálicos (Hg, Ag, Sn and Cu) utilizando-se espectometria da massa de plasma pareadas por indução (ICP-MS). Análise estatística foi conduzida utilizando-se ANOVA testes para determinar significância das diferenças entre os grupos testes. estes Bonferroni Post Hoc foram feitos para comparações múltiplas.* ***RESULTADOS***: *A liberação de íons metálicos para os elementos (Hg, Ag, Sn e Cu) aumentou com a exposição a concentrações aumentadas de peróxido de hidrogênio após o tratamento, tanto para a liga de amálgama GS 80 como para a Lojic +. As diferenças de concentração dos íons liberados após tratamento com concentrações de peróxido de H a 0%, 3%, 10% ou 38 % foram estatisticamente significantes ($p < 0.05$).* ***CONCLUSÕES***: *Íons metálicos (Hg, Ag, Cu e Sn) foram liberados de amálgamas dentais seguindo-se tratamento com todas as concentrações de H^2O^2. A liberação de ions metálicos aumentou com a elevação da concentração do peróxido de hidrogênio. Mesmo com exposição de amálgama dental a concentrações relativamente altas de peróxido de hidrogênio (38%), a liberação de Hg não excedeu o limite máximo aceitável.*

Palavras-chave: *Mercúrio. Liberação de íons. Amálgama dentário. Clareamento com peróxido de hidrogênio.*

INTRODUCTION

Nowadays the increased esthetic demand by most patients has resulted in an increase in the usage of bleaching agents to whiten discolored teeth (1-3). Bleaching of discolored vital and non-vital teeth has a long and successful history including both in-office and at-home techniques (4, 5). Home bleaching has attracted the interest of patients due to its high success rates and ease of use (6, 7). In this procedure, patients apply bleaching agents, most of which contain low concentrations of hydrogen peroxide (3% to 7%) or carbamide peroxide (10% to 22%), to their teeth in custom-fitted trays for a few hours per day (8, 9).

Over the past few years, in-office bleaching products employing the use of strong oxidizing agent up to 38% hydrogen peroxide have been used (10). The advantages are that treatment is totally under the dentist's control, the soft tissues are generally protected from the process and it has the potential for quick bleaching (3, 11). Very often in the daily clinical practice, restorations exist beside or even inside the teeth that are planned to be bleached. Some clinicians express concern about the effect of these agents on teeth and dental restorative materials (12, 13).

The influence of various bleaching agents on physical properties, surface morphology and color of different restorative materials, has been investigated in several in vitro-studies simulating the clinical situation as closely as possible. In those studies, home-bleaching products (10–16% carbamide peroxide) were generally used within a 2–6 weeks bleaching simulation with application intervals of 4–8 h per day. Bleaching products for in-office-application (30–38% hydrogen or carbamide peroxide) were applied at treatment intervals of 15–60 min (as recommended by the manufacturers) (14). The results of these studies were controversial. Some reports in the dental literature have suggested that bleaching agents may have adverse effects on the physical properties of dental restorative materials (15-20).

Other investigations revealed no significant change in enamel or existing restoration physical properties due to bleaching agents.(12, 20-24) Moreover, some studies reported increase in enamel or composite resin surface hardness following bleaching. (25, 26) Regarding dental amalgam, some in vitro studies have reported a significant increase in mercury release as a result of treatment with peroxides compared to control treatments (27-29). While there was also a relatively recent report that found carbamide peroxide bleaching to have no significant effect on dental amalgam (30).

This obvious and still lasting controversy means that the effect of oxidizing bleaching agents on dental amalgam still remains a source of concern. Therefore, the aim of this study was to investigate the effect of hydrogen peroxide bleaching agent in different concentrations including recently-used high concentrations on metal ion release from dental amalgam.

MATERIALS AND METHODS

Materials

Two high copper dental amalgam alloys were selected for this study, an admixed one (GS.80, Southern Dental Industries, Australia). The composition of this alloy is 40 Ag, 31.3 Sn, and 28.7 Cu (% w/w). It is mixed at an alloy to mercury ratio of 1– 0.92 (w/w). The other was a unicompositional spherical alloy (Lojic+, Southern Dental Industries, Australia). The composition of this alloy is 60.1 Ag, 28.05 Sn, 11.8 Cu, and 0.05 Pt (% w/w). It is mixed at an alloy to mercury ratio of 1– 0.67 (w/w). Both alloys were supplied as capsules that were activated according to manufacturer's instructions for 5 s using a mechanical amalgamator, (De Trey, Hallam Dental Ltd, England). Amalgam Discs (n=25) for each alloy type were prepared in split stainless steel moulds (10mm diameter x 2mm thickness), and allowed to fully set for 24 h. The discs were then polished using silicone carbide paper (Grit number 800). A 40% HP solution, (Sigma Chemical Co. St. Louis, MO, USA) was diluted to obtain 3%, 10%, 24% as well as 38% HP solutions with 0% (distilled water) as the control. The 50 amalgam discs were divided into 10 equal groups, (5 discs each). Each of the 5 discs in a group was individually immersed in 0%, 3%, 10%, 24% or 38% HP solution (20ml) for 24 h at 37^o C creating 5 samples of each solution. Each disc was placed in a tapered centrifuge tube, with all surfaces exposed to the particular HP concentration in that tube. All the 50 solutions samples were analyzed by inductively coupled plasma-mass spectrometry (ICP-MS, Agilent 4500).

Ion release measurement

All ion release samples were acidified with 200 µl of nitric acid (for Ag determination) and hydrochloric acid (for all other ions). (30) For each analysis, the instrument performed five measurements and the mean values were calculated for each element.

Statistical analysis

A two-way ANOVA was conducted, followed by a one-way ANOVA and Bonferroni Post Hoc test for multiple comparisons between solutions of different concentrations for each element.

RESULTS

The relationships between metal ion release from both GS.80 and Lojic+ amalgam alloys and HP concentration are shown in Figures 1 and 2 respectively. Values for the mean and standard deviation of metal ion release data for mercury, silver, copper and tin from both GS.80 and Lojic+ are shown in Table 1, at 0%, 3%, 10%, 24% and 38% HP concentrations. Metal ion release increased with increasing hydrogen peroxide concentration for all elements for both amalgam alloys.

TABLE 1 - Means and standard deviations for metal ion release

	0% HP Mean(SD)		3% HP Mean (SD)		10% HP Mean (SD)		24% HP Mean (SD)		38% HP Mean (SD)	
	GS.80	**Lojic+**	**GS.80**	**Lojic+**	**GS.80**	**Lojic+**	**GS.80**	**Lojic+**	**GS.80**	**Lojic+**
Hg (µg/l)	3.3(0.57)	2.9(0.33)	272(17.8)	286(10.8)	762(26.8)	785.1(9.9)	1210(35.3)	1043(12.2)	1484.4(30.3)	1396(11.9)
Ag (µg/l)	0.09(0.02)	0.05(0.02)	77.6(7.1)	125.3(5.0)	93.5(6.5)	562(7.3)	179.2(15.9)	824.5(7.1)	198.8(19.4)	1193(7.5)
Sn (µg/l)	2.6(0.18)	1.03(0.04)	180.2(9.7)	43.8(6.2)	532(39.3)	198.2(10.0)	896.4(41.3)	487(9.0)	1312(31.8)	630(7.0)
Cu (µg/l)	6.23(0.37)	8.77(0.06)	85(12.1)	49(4.5)	125(14.9)	76.2(2.5)	212.2(13.5)	174(6.6)	368(34.9)	213.2(6.5)

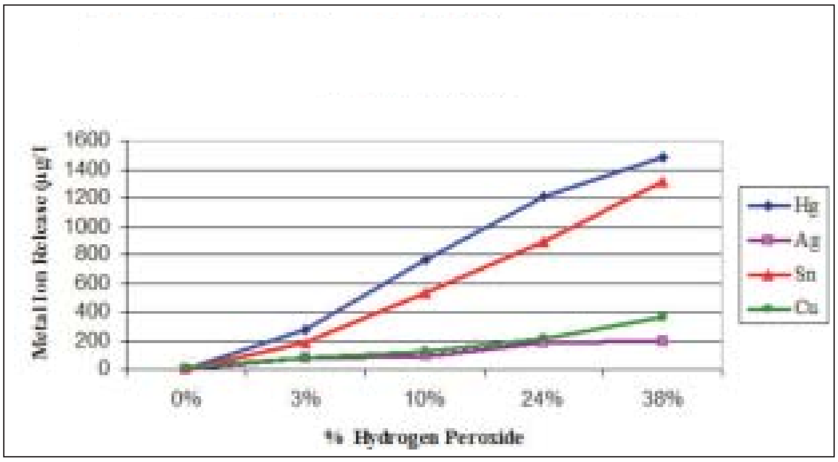

FIGURE 1 - Metal ion release from GS.80 as a result of various HP concentrations

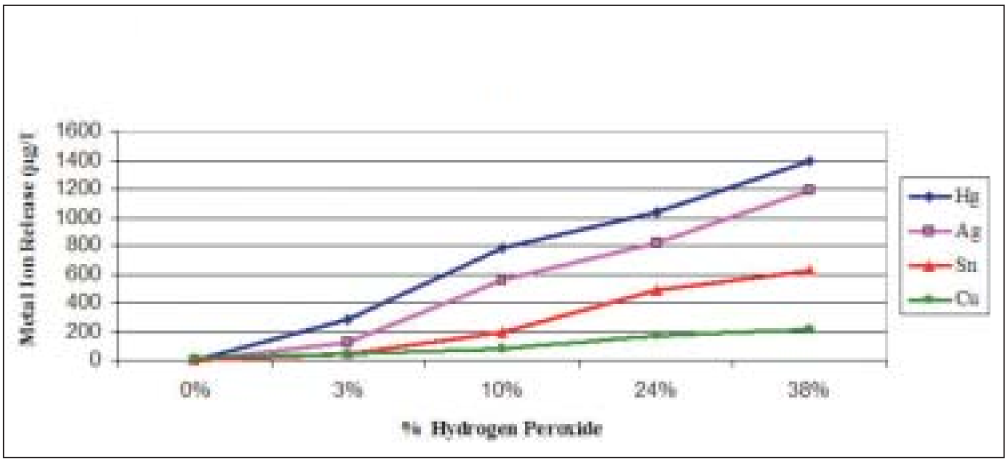

FIGURE 2 - Metal ion release from Lojic + as a result of various HP concentrations

Figure 1 reveals that for GS.80, the highest ion releases were those for mercury followed closely by tin then copper and finally silver. For Lojic+, the highest ion releases were those for mercury followed closely by silver then tin and finally copper as shown in Figure 2. Table 2 demonstrates the p-values for the one-way ANOVA between test groups for each element.

TABLE 2 - F & p-values for the one-way ANOVA between groups (0%, 3%, 10%, 24%, 38 %)

	GS.80		Lojic+	
	F-value	**p-value**	**F-value**	**p-value**
Hg	3000.2	0.000	15688.0	0.000
Ag	225.5	0.000	32769.8	0.000
Sn	1623.4	0.000	7111.4	0.000
Cu	269.8	0.000	1656.9	0.000

Bonferroni multiple comparison revealed that the difference in metal ion release between 0% HP (control) and all other concentrations (3%, 10%, 24% and 38%) was statistically significant ($p < 0.05$) for all elements.

DISCUSSION

The experimental design in the current study was decided to cover a relatively wide range of HP concentrations that are available in the dental market including both at home and in-office products (3%-38%). Using two kinds of dental amalgam alloys was suggested so that the study includes both spherical and admixed types of dental amalgam so conclusions can, to some extent, be generalized. Comparing between the amounts of mercury or other metal ions released from the tested alloys after exposure to HP bleaching was not in the scope of this study.

Exposure to metal ions, particularly mercury, is considered to be a potential hazard and could cause adverse effects on health. Although this study provides data about the amounts released of Hg, Ag, Sn and Cu from dental amalgam after exposure to HP bleaching, during discussing the results the focus will be on mercury as it is known to be the most hazardous to health.

The World Health Organization (WHO) guideline for maximum intake of mercury is 40 mg/ day (31). From the literature, it has been reported that the release of metal ions from restorations is time dependent and proportional to the surface area of the restoration (32). The quantity of mercury released from dental amalgam as reported in scientific journals varied considerably. Hummert et al. (28) found mercury release values from dental amalgam exposed to bleaching agents to be in the range of 0.014 - 0.020 µg/mm^2 and 0.001 for dental amalgam exposed to saline (control).

Mackert and Berglund (33) found that the rate of mercury release from amalgam to be in the average of 0.014 -0.016 µg/mm^2 calculated from six different in vivo studies. Rotstein et al. (29) reported a concentration of 0.6 – 4.24 µg/mm^2 of mercury released from amalgam samples after 48 h of 10% CP bleaching. This data suggests high metal ion release, mainly due to the use of aggressive test procedures along with the use of unpolished samples. This is in contrast to the in vivo situation where the amalgam restoration is ideally polished and it is known that peroxide levels within bleaching products are depleted during use (34).

In a further study by Rotstein et al. (35) the amount of mercury released from amalgams treated with 10% CP was very similar to that released by 10% HP. In the present study, application of hydrogen peroxide bleaching agent in different concentrations has resulted in metal ion release (Hg, Ag, Cu and Sn) from all samples of both GS.80 and Lojic+ alloys. For all the elements, ion release increased with increasing HP concentrations, with mercury release consistently being the highest (Figures 1 and 2), (Table 1).

The p-values for the one-way ANOVA and Bonferroni Post Hoc revealed that the difference in metal ion release between 0% HP (control) and all other concentrations (3%, 10%, 24% and 38%) was statistically significant ($p < 0.05$) for all elements.

As regards to GS.80, of the four elements reported, mercury and tin were more responsive to changes in HP concentration exhibiting a fairly linear relationship between ion release and HP concentration (Figure 1). The ion release data for copper and silver follow to a great extent a similar trend especially at low HP concentrations. For Lojic+, mercury and silver were more responsive to changes in HP concentration, followed by tin while copper showed the least affection by changes in HP concentration.

The calculated amounts of mercury release from a GS.80 sample were 29.69, 24.2, 15.24 and 5.44 µg/ day and from a Lojic+ sample were 27.92, 20.86, 15.7 and 5.72 µg/ day for 38%, 24%, 10% and 3% HP concentrations, respectively.

Clearly, to exceed WHO's maximum acceptable intake of 40 mg/day would require mercury release from 11, 14, 23 and 66 GS.80 restorations and 12, 16, 22 and 61 Lojic+ restorations when treated with 38%, 24%, 10% and 3% HP concentrations, respectively. It is therefore unlikely that mercury release from amalgam following contact with tooth bleaching agents containing up to 38 % HP constitutes a hazard to health.

CONCLUSION

Metal ions (Hg, Ag, Cu and Sn) were released from dental amalgam following treatment with all HP concentrations. The rate of ion release increased with increasing HP concentration and was statistically significant compared to control treatment ($p < 0.05$).

Although mercury release from amalgam exposed to bleaching agents did not exceed the maximum acceptable limit internationally, highly concentrated bleaching agents should only be available to dental professionals and they should be closely monitored to ensure that no new hazards present themselves in the future.

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