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Effect of Carbamide Peroxide Treatments on the Metal-ion Release and Microstructure of Different Dental Amalgams

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Clinical Relevance

Carbamide peroxide bleaching releases metal-ions from dental amalgam.

SUMMARY

Objectives: A variety of methods have been used to model the effects of bleaching agents on tooth tissue and dental materials. Although several studies have evaluated the effects of bleaching agents on restorative materials, little attention has been directed to metal ion release from dental amalgam following exposure to bleaching agents. This *in vitro* study investigated the effects of two carbamide-peroxide-based bleaching gels on metal ion release from different dental amalgams.

Methods: Thirteen discs (10x2 mm) prepared from tgloy (non-gamma 2, admix amalgam), Septalloy NG 50 (single composition, non-spherical, non-gamma 2, ternary amalgam), Dispersalloy (dispersed phase, admix amalgam) and Permite C (high-copper, non-gamma 2, admix alloy), according to the manufacturers' instructions and polished after 24 hours, were aged for seven days at 37°C in air. The discs were then immersed in 10 ml of distilled water for 24 hours at 37°C. The amount of metal ion (Hg, Ag, Sn and Cu) release was determined using inductively coupled plasma mass spectrometry. The discs were treated with either 16% or 30% carbamide peroxide gel and ion release analysis was repeated. The specimens were also evaluated for surface changes using scanning electron microscopy (SEM). The data were analyzed using the Mann-Whitney U, Wilcoxon Signed Ranks and Kruskal Wallis tests.

Results: Statistical analysis showed that treatment with either 16% or 30% carbamide peroxide resulted in a significant release of Hg from all tested amalgams ($p<0.05$). There was no signifi-

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DOI: 10.2341/06-136

cant difference between 16% and 30% carbamide peroxide treatments (*p*>0.05). The use of carbamide peroxide gels did not make any difference in Ag levels (*p*>0.05). The release of Sn after treatment with 16% or 30% carbamide peroxide was increased (*p*<0.05). The release of Cu release was decreased with tgloy and Septaloy NG 50, but increased with Dispersalloy. Additionally, Permite C (*p*<0.05) SEM images revealed slight differences after treatment with 30% carbamide peroxide. Changes in the surface levels of ions were also in accordance with the ion release analysis.

Conclusion: The release of metal ions and the microstructure of dental amalgams could be changed by treatment with 16% or 30% carbamide peroxide.

INTRODUCTION

The demand for conservative esthetic dentistry has grown dramatically, with a rapid development in new, non-restorative treatments. Vital bleaching has become one of the most frequently used treatment modalities for improving the esthetic appearance of teeth, primarily because of its relative ease of application.[1-4]

In esthetic dentistry, according to application mode and peroxide concentrations, two methods of whitening procedures are generally used to treat discolored and stained teeth. Bleaching agents for-professional-use-only contain high concentrations of carbamide or hydrogen peroxide (30%-37%) solution, while at-home whiteners contain low concentrations (3%-20%) of both peroxides and are used under the supervision of a dentist or not.[2,5]

A recently published review showed that tooth bleaching is comparatively safe in terms of potential risk for the alteration of dental hard tissues.[6] This corresponds with the fact that, in the literature, to date, little attention has been paid to macroscopically or clinically visible damage due to vital bleaching.[7-8] Despite the fact that vital bleaching is not regarded as creating macroscopically visible defects, there are numerous studies that have exhibited microstructural changes in dental hard tissue induced by bleaching agents, especially when peroxides are applied in high concentrations.[9] These possible effects on dental hard tissues are discussed as being minimal and not relevant, provided that the bleaching agents are applied in a sensible manner according to the manufacturers' instructions.[8,10] Aside from these aspects regarding the influence of bleaching agents on hard tissues, some clinicians have also expressed concern about the effects of these agents on restorative materials.[11-12] Although the influence of various bleaching agents on the physical properties, surface morphology and color of different restorative materials has been investigated in several *in vitro* studies,[13-17] there have been a limited number of studies addressing their effects on dental amalgam.[18-22]

For more than a century, dental amalgam has played an important role in restorative dentistry. To date, it is still the most widely used restorative material for posterior teeth. Its physical and mechanical properties, stability, ease-of-use and relatively low cost have made amalgam the preferred choice in many clinical situations when compared with other direct restorative materials, such as composites and glass ionomers. However, one of its major components, mercury, is of particular concern due to its potential adverse effects on humans and the environment.[23-25]

As bleaching products containing peroxide come in contact with tooth structures for extended periods of time, the bleaching material may inadvertently make contact with amalgam-restored premolars and molars and enhance their metal-ion release. Therefore, this *in vitro* study investigated the effects of two carbamide-peroxide-based bleaching gels on metal ion release from different dental amalgams.

METHODS AND MATERIALS

Specimen Preparation

Four commercially available dental amalgams were selected for this study. The chemical compositions of these alloys are summarized in Table 1. Thirteen specimens of each of the four dental amalgam brands were

Table 1: *Composition of Amalgam Alloys in Percentage by Weight and Properties*

	Manufacturer	Composition	Properties
tgloy	Technical & General Ltd, London UK	45% Ag, 24% Cu, 31% Sn	Non Gamma II Admix Amalgam, consisting of lathe cut and spherical particles
Septalloy NG 50	Airel Pharma, 300 Rue Marcel Paul; 94500 Champigny-sur-Mame, France	46% Ag, 22.7%Cu, 31.3% Sn	Single Composition, Non Gamma II, non-spherical, ternary alloy
Dispersalloy	Dentsply Caulk, Milford, DE, USA	69.3% Ag, 17.9% Cu, 11.8% Sn	A dispersed phase admix amalgam, containing lathe-cut particles and silver/copper eutectic spheres
Permite C	Southern Dental Industries Limited, Bayswater, Victoria, Australia	56% Ag, 15.4% Cu, 27.9% Sn, 0.5% In, 0.2% Zn	Non-gamma 2, admixed alloy, containing lathe-cut, silver/copper eutectic spheres

prepared in a similar manner for a total of 56 specimens. The amalgam capsules were automatically mixed in a dental amalgamator (SDI, Bayswater, Victoria, Australia) according to the manufacturers' instructions. The freshly prepared mix was condensed into Teflon molds 10 mm in diameter and 2 mm thick using hand condensers. The specimens were left in the molds for 60 minutes, then they were removed and placed in distilled water. Twenty-four hours later, the specimens were polished using standard silicone polishers (Shofu Amalgam Polishing Kit, Shofu Inc, Kyoto, Japan) mounted on a slow-speed contra angle. After rinsing with distilled water, the specimens were randomly divided into two groups of seven and aged for seven days at 37°C in air. They were then immersed in 10 ml of distilled water for 24 hours at 37°C.

Ion Release

After the discs were immersed in distilled water for 24 hours, the water samples were analyzed for ion release using Inductively Coupled Plasma-Mass Spectrometry (Thermo Electron X7, Winsforth, Cheshire, UK).

Scanning Electron Microscopy

One disc from each series was prepared for Scanning Electron Microscopy evaluation. The discs were vacuum desiccated, gold sputter coated and examined for topographical and compositional changes (JSM- 6400 Electron microscope equipped with NORAN System 6 X-Ray micro analysis system, JEOL, Tokyo, Japan).

Bleaching Treatments

The specimens were treated with either 16% or 30% carbamide peroxide as recommended by the manufacturer (Vivastyle, Ivoclar, Vivadent AG, Schaan, Liechtenstein):

1. A one-millimeter thick layer of 16% carbamide peroxide was applied to the disc surface for one-hour daily for 14 days.
2. Thirty percent carbamide peroxide was applied in the same manner for 30 minutes three times a day, with an interval of three days.

Prior to bleaching, the disc surfaces were dried with cotton pellets. After each bleaching treatment, the carbamide peroxide gel was carefully removed with a soft toothbrush under running tap water. Throughout the experiment, the specimens were stored in distilled water during the hiatus period. At the close of treatment, ion release and SEM analysis were repeated.

Statistical Analysis

Changes in the level of mercury, silver, tin and copper before and after treatment with either 16% or 30% carbamide peroxide gel were recorded, and the difference between the means of the groups was analyzed statistically through the use of the Mann-Whitney U, Wilcoxon Signed Ranks and Kruskal Wallis tests.

RESULTS

Changes in the mean levels of mercury (Hg), silver (Ag), tin (Sn) and copper (Cu) after treatment with 16% or 30% of carbamide peroxide is summarized in Table 2.

The carbamide peroxide treatments resulted in a significant release of Hg in all the tested amalgams ($p<0.05$). There was no significant difference in the release of Hg between the 16% and 30% carbamide peroxide treatments ($p>0.05$). Dispersalloy showed the highest Hg release with 16% carbamide peroxide, whereas Septalloy NG 50 showed the lowest Hg release with 30% CP ($p<0.05$).

The carbamide peroxide treatments did not make any significant difference in Ag levels ($p>0.05$).

With carbamide peroxide treatments, Sn release was increased ($p<0.05$). Septalloy showed the highest Sn release with 30% carbamide peroxide ($p<0.05$). Dispersalloy showed the lowest Sn release with 16% carbamide peroxide ($p<0.05$).

Treatment with either 16% or 30% carbamide peroxide gel resulted in a significant difference in Cu release ($p<0.05$). The release of Cu was decreased with tgloy and Septalloy NG 50 but increased with Dispersalloy and Permite C ($p<0.05$). Septalloy NG 50 showed the greatest decrease in Cu release with 16% carbamide peroxide; whereas, Dispersalloy showed the greatest increase in Cu release with 30% carbamide peroxide ($p<0.05$).

Figures 1 through 4 show typical SEM images and the surface levels of Hg, Ag, Sn and Cu of each of the dental amalgams before and after treatment with 16% or 30% carbamide peroxide bleaching gels.

Slight differences were observed after 30% carbamide peroxide treatment on the surface of the dental amalgams that were tested. Specimen surfaces treated with 30% carbamide peroxide showed less of a regular granular appearance with Septalloy, which seemed to be the most affected amalgam. Surface levels of the metal ions investigated by SEM were in accordance with the ion release analysis. According to SEM investigations and, comparing all the tested amalgams, Hg was the only metal ion that showed a surface increase after treatment with carbamide peroxide.

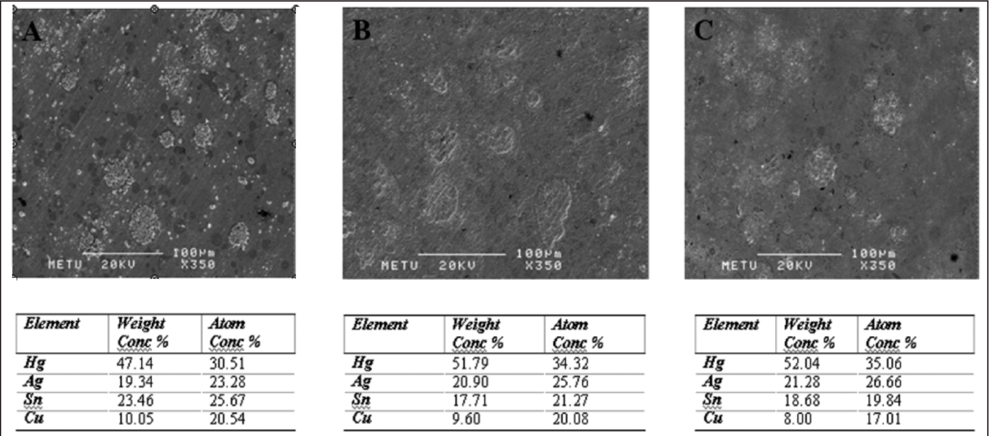
DISCUSSION

In this study, the amalgams tested were all high-copper amalgams. It is difficult to make a direct comparison between the data from this study and published data due to the limitations of either method or the carbamide peroxide concentrations. Based on the results of this study, the standard deviations were often higher than the means. The relatively low number of spec-

Table 2: *Mercury (Hg), Silver (Ag), Tin (Sn) and Copper (Cu) Levels Before and After Carbamide Peroxide (CP) Treatments (ppd) (mean±SD)*

		16% CP		**30% CP**	
n=6		**Before**	**After**	**Before**	**After**
tgloy	**Hg**	21.67±13.65	121.74±136.63*	13.18±1.85	107.89±75.40*
	Ag	0.46±0.44	2.46±5.43	0.34±0.25	1.65±1.45
	Sn	3.02±1.32	23.24±5.56*‡	5.21±2.33	78.50±13.02*‡
	Cu	37.40±25.08†	20.25±14.00*	88.35±41.35†	19.75±14.66*
Septalloy NG 50	**Hg**	9.46±4.49	121.40±228.13*	11.07±3.46	61.87±44.19*
	Ag	0.59±0.33	0.37±0.41	0.38±0.15	0.46±0.36
	Sn	4.56±2.20	36.63±10.01*‡	5.89±1.46	74.70±13.90*‡
	Cu	133.10±17.38	32.35±7.02*	133.10±17.38	32.35±7.02*
Dispersalloy	**Hg**	14.52±8.06	243.28±273.45*‡	7.08±3.30	108.66±7.24*‡
	Ag	1.04±1.14	0.26±0.13	0.53±0.43	0.26±0.19
	Sn	1.20±0.83	11.06±5.69*‡	0.97±0.69	37.70±8.84*‡
	Cu	21.16±4.13	46.10±25.86*	20.94±7.08	40.41±5.42*
Permite C	**Hg**	13.53±2.80	182.87±126.46*	5.33±2.75	94.91±137.91*
	Ag	0.10±0.06	0.27±0.14‡	0.36±0.30	2.26±4.22‡
	Sn	1.49±0.51	25.39±6.02*‡	1.11±0.27	39.50±13.93*‡
	Cu	21.61±2.82†	36.94±5.92*	28.06±2.00†	33.29±14.19*

**statistical significance before and after CP treatments (p<0.05)*
†statistical significance between 16% and 30% CP treatment (p<0.05) (before)
‡statistical significance between 16% and 30% CP treatment (p<0.05) (after)



Element	*Weight Conc %*	*Atom Conc %*
Hg	47.14	30.51
Ag	19.34	23.28
Sn	23.46	25.67
Cu	10.05	20.54

Element	*Weight Conc %*	*Atom Conc %*
Hg	51.79	34.32
Ag	20.90	25.76
Sn	17.71	21.27
Cu	9.60	20.08

Element	*Weight Conc %*	*Atom Conc %*
Hg	52.04	35.06
Ag	21.28	26.66
Sn	18.68	19.84
Cu	8.00	17.01

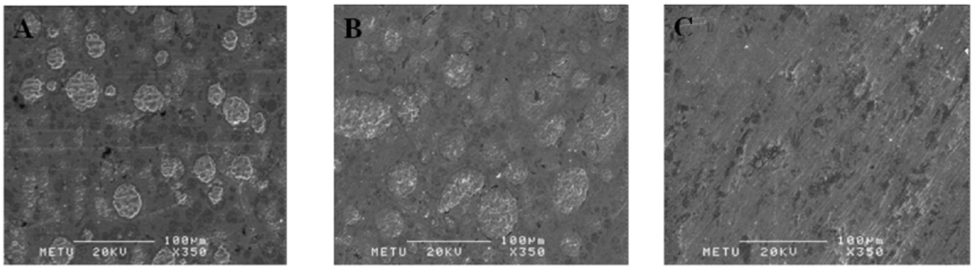
Figure 1: *Scanning electron photograph (350x) and surface levels of Hg, Ag, Sn and Cu of tgloy. A: before treatment; B: after treatment with 16% CP; C: after treatment with 30% CP.*

imens could be responsible for the high standard deviations obtained within the experimental conditions of this study.

Al-Salehi and others[26] examined the release of mercury, silver, tin and copper from dental amalgam (high copper, unicompositional spherical alloy/Sybraloy-Kerr) after treatment with 10% carbamide peroxide and stated that carbamide peroxide did not significantly enhance subsequent metal ion release from dental amalgam. The data presented in this study revealed higher levels of mercury and tin with either 16% or 30% carbamide peroxide gels. No significant release was observed in silver levels; whereas, an increase or decrease was observed in copper levels.

Rotstein, Mor and Arwaz[24] investigated the effects of 10% carbamide peroxide on the surface levels of mercury, silver, tin and copper of zinc free, palladium enriched, high copper dental amalgam (Valiant/Caulk). They reported a significant increase in mercury and silver levels after 14 days of treatment with 10% carbamide peroxide, but a significant reduction in tin levels after 28 days and in copper levels after 14 days of treatment. These authors stated that prolonged treatment with bleaching agents may cause microstructural changes in amalgam surfaces, possibly resulting in increased exposure of patients to toxic byproducts. The surface levels of mercury and silver were also found to increase in this study.

Various studies investigated mercury release from amalgam exposed to commonly used bleaching agents and reported that its release was augmented under bleaching conditions.[19-22,27-29] Factors found to enhance mercury release were the duration of treatment, age of amalgam, surface conditions and the composition and pH of the bleaching agent.

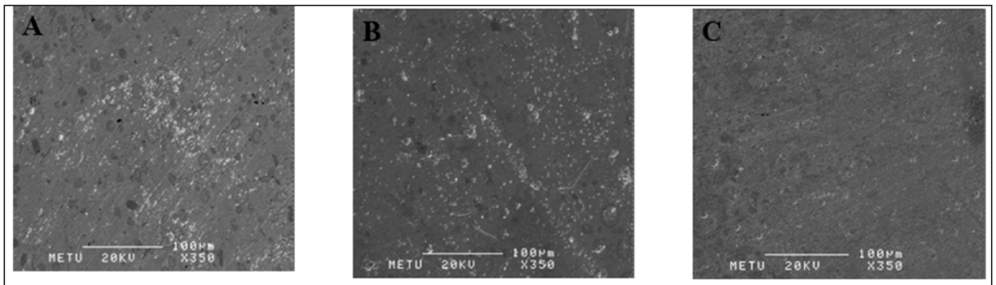


Element	Weight Conc %	Atom Conc %
Hg	58.41	41.61
Ag	21.59	28.77
Sn	12.99	15.64
Cu	5.86	13.16

Element	Weight Conc %	Atom Conc %
Hg	58.56	41.63
Ag	20.47	27.06
Sn	13.20	15.99
Cu	5.51	12.47

Element	Weight Conc %	Atom Conc %
Hg	59.69	42.77
Ag	23.34	30.93
Sn	15.11	18.16
Cu	5.26	11.82

Figure 2: *Scanning electron photograph (350x) and surface levels of Hg, Ag, Sn and Cu of Septalloy NG 50. A: before treatment; B: after treatment with 16% CP; C: after treatment with 30% CP.*

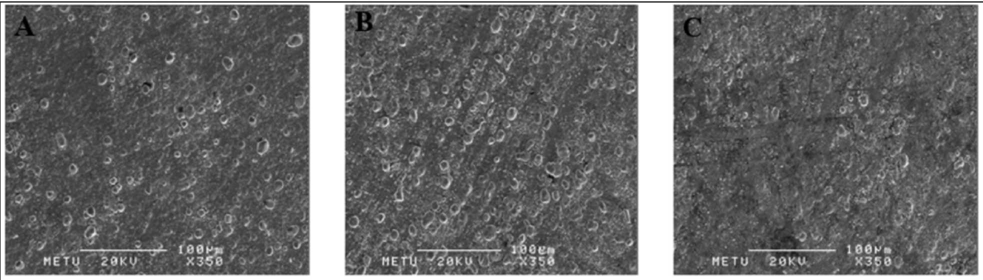


Element	Weight Conc %	Atom Conc %
Hg	49.01	31.81
Ag	30.11	38.97
Sn	8.36	9.83
Cu	4.86	10.73

Element	Weight Conc %	Atom Conc %
Hg	55.94	38.93
Ag	28.19	36.66
Sn	9.46	11.18
Cu	5.58	12.27

Element	Weight Conc %	Atom Conc %
Hg	56.64	39.61
Ag	22.07	26.63
Sn	18.42	20.20
Cu	7.49	15.34

Figure 3: *Scanning electron photograph (350x) and surface levels of Hg, Ag, Sn and Cu of Disperalloy. A: before treatment; B: after treatment with 16% CP; C: after treatment with 30% CP.*



Element	Weight Conc %	Atom Conc %
Hg	51.78	35.10
Ag	24.95	32.82
Sn	13.59	16.24
Cu	4.90	10.93

Element	Weight Conc %	Atom Conc %
Hg	53.20	36.65
Ag	25.29	31.88
Sn	14.68	17.09
Cu	5.74	12.48

Element	Weight Conc %	Atom Conc %
Hg	56.56	40.00
Ag	26.38	33.79
Sn	16.15	18.50
Cu	6.78	14.52

Figure 4: *Scanning electron photograph (350x) and surface levels of Hg, Ag, Sn and Cu of Permite C. A: before treatment; B: after treatment with 16% CP; C: after treatment with 30% CP.*

Rotstein and others[18] and Ferracane and others[19] reported higher concentrations of mercury of unpolished amalgam specimens in solution as compared to polished specimens. In the current study, the specimens were polished after 24 hours and the ion release was measured after 24 hours. Carbamide peroxide treatments were done according to the manufacturer's instructions; whereas, in the other studies, the amalgam specimens were immersed in carbamide peroxide solution for an extended time, such as 24 hours.

Certosimo and others[20] showed that mercury release from spherical alloy (Tytin) exceeded that of admix alloy (Valiant). It can be speculated that carbamide peroxide bleaching agents in different concentrations may enhance the release of mercury from amalgam brands with different alloy types in different ways. In this study, Dispersalloy (admix alloy) showed higher levels of mercury.

SEM photographs showed the typical structure of set amalgams and the nature of alloys, but slight surface differences were observed after treatment with 30% carbamide peroxide. Thirty percent carbamide peroxide produced less of a regular surface than untreated surfaces. Rotstein and others[24] also pointed out changes in the surface appearance of amalgams treated with 10% carbamide peroxide, but Al-Salehi and others[26] reported no differences after treatment with 10% carbamide peroxide.

It is important that this is an *in vitro* study, and the release of ions with carbamide peroxide treatments do not indicate their presence in saliva or their absorption by oral tissues. However, the bleaching agents and dental amalgam relationship still requires further *in vivo* studies, as dental amalgam is still an alternative in the restoration of posterior teeth.

CONCLUSIONS

1. Amalgam brands differed in the amount of Hg release.
2. All the tested dental amalgams exhibited significant release of Hg.
3. Either 16% or 30% carbamide peroxide bleaching gels had the potential to release metal ions that were not related to concentration.
4. The release of metal ions and the microstructure of dental amalgams can be changed by treatment with 16% or 30% carbamide peroxide.

(Received 14 October 2006)

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