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Elemental Release from Dental Casting Alloys by Atomic Absorption Spectrophotometer (AAS) in Variable Conditions of Oral Cavity: In-Vitro Study

Dental Science

KEYWORDS: Elemental release, Dental Casting alloys; AAS

Dr. Kalpana Singh	Assistant Professor, Department of Biochemistry KGMU, Lucknow-226003, UP India
Shikha Gupta	(Ph.D. Scholar) Prosthodontics, Crowns & Bridges KGMU, Lucknow-226003, UP India
Dr. Jitendra Rao	Professor, Prosthodontics, Crowns & Bridges King George's. Medical University, Lucknow-226003, UP India
Dr. A.B. Pant	Principal Scientist In-Vitro Toxicology Indian Institute of Toxicology Research (IITR), Lucknow, India
Dr. V.P. Sharma	Senior Principal Scientist Developmental Toxicology Indian Institute of Toxicology Research (IITR), Lucknow, India

ABSTRACT

This study was proposed to investigate the release of element from five brands of commercially available dental casting alloys. Finished and polished specimens of dental casting alloys (five brands Cr, Ni, Cu, Mo and Ag) were washed using sterilized distilled water, then dried and again soaked in alcohol to disinfect them for 20 minutes. Each specimen of casting alloys was accounted for 2 ml of simulating solvent. The sealed vials were kept in shaker water bath at different temperature i.e. 4 ^{0}C, 37 ^{0}C, 60 ^{0}C for a period of 24 hours and 7 days accordingly. Elemental release from five brands of non-precious dental casting alloys was assessed at different variables using the AAS. Continuous variables will be presented as mean and SD. Quantitative variables will be compared using one-way ANOVA test between three groups and paired t test will be used for comparison of pair at day 1 and day 7. At 1-day temperature had a significant association on concentration of Cr, Ni and Mo. At 7-day temperature had a significant association with concentration of Cu, Cr, Ni and Mo. pH had no association with concentration of non-precious alloys. The concentration of Cu, Cr, Ni and Mo on 7 days was significantly higher as compared to that on day 1. No statistically significant difference in concentration of Ag was seen between 1 day and 7 days. Time had a significant effect on concentration of trace elements. An overview of the present study dictates that there is definite release of elements from dental casting alloys.

Introduction

The dental profession is consistently witnessing a constant search for the casting alloys alternatives that are less expensive and readily accessible for various purposes of dental restorations. Metallurgical science has produced variety of dental casting alloy system in the field of dentistry for the dental restorations. Base metal alloys currently account for a sizable portion of fixed prosthesis alloy market (1). The low price of these alloys is their major attraction as compared to gold alloys but their biocompatibility to the oral tissue is still controversial. In the oral cavity, these alloys undergo chemical or electrochemical reaction with the biologic environment resulting dissolution of ionized element that interact with biologic tissue and transported through the body seeking a specific target organ where they accumulate and causes an allergic reaction commonly nickel sensitivity and dermatitis. Women are ten times more sensitive to Ni compared with men (2). In-vitro studies on elemental release have specified that change in pH from food & plaque, tooth brushing condition and alloys type increases their elemental release (3-5). Wear is another key factor which can accelerate corrosive processes in vivo, especially due to a local breakdown of the passive layer (5). It is expected that effect of element release will have bearing on the profession for the selecting different kind of alloys for the purpose of dental restorations. This study, is undertaken for investigation of the release of element from dental casting alloys by atomic absorption spectrophotometer (AAS) and also to evaluate the factors which influence them.

Materials & Methods

Material and Sample preparation: Forty-five specimens were evaluated under each group for each brands of dental casting alloys e.g.- Non-Precious Metal casting alloy (CA)-1 (Orden co. ltd. Japan), two brands of Ni-Cr alloys CA-2 (Ugin Dentaire, France) and CA-3 (Niadur DFS, Germany), Co-Cr Alloy Ca-4 (Durex, PDA, Thermabond alloy LA, USA) and Type III Gold alloys CA-5 (Laboratory made based on formulation recommended in Philips's Science of dental material 11th edition). The fabrication of specimens by investing and casting into definite size of (12x10x1.5 mm) with the surface area of 3.06 cm2 were made by Induction casting (Ni-Cr & Co-Cr), Centrifugal casting (K-metal & type III gold alloy). Each specimen was finished and polished by standard & conventional protocol of laboratory procedure. All the specimens were made as per guide lines of the manufacturer using the pellets, without altering their contents by standard technique and equipment.

Artificial Saliva: The composition of artificial saliva prepared as per Katz et al. (6). The pH of the artificial saliva buffer was adjusted to 4.0, 6.8 and 7.5 by using aqueous solution of phosphoric acid and sodium chloride (0.1mol/L).

Atomic absorption spectrophotometer (Varian 250 Plus): One of the most extensively employed technique for detection of trace element in all kind of environment and biological sample used for the detection of mass loss into the medium i.e. artificial saliva.

Figure 1: Atomic absorption spectrophotometer (Varian 250 Plus)

Methodology

The present in vitro study was designed to investigate the release of element from five brands of dental casting alloys. Finished and

polished specimens of dental casting alloys were washed using sterilized distilled water, then dried and again soaked in alcohol to disinfect them for 20 minutes. Finally, specimens were rinsed twice with sterile distilled water and dried at least for 24 hours. The specimen then immersed in simulating solvent i.e. artificial saliva buffer of different pH 4.0, 6.8 and 7.5. Each specimen of casting alloys was accounted for 2 ml of simulating solvent. The sealed vials were kept in shaker water bath at different temperature i.e. 4 0C, 37 0C, 60 0C for a period of 24 hours and 7 days accordingly.

Statistical Analysis

Continuous variables will be presented as mean and SD. Quantitative variables will be compared using one-way ANOVA test between three groups and paired t test will be used for comparison of pair at day 1 and day 7. A p value of <0.05 will be considered statistically significant. The data will be entered in MS EXCEL spreadsheet and analysis will be done using Statistical Package for Social Sciences (SPSS) version 21.0.

Results

The present study was conducted to investigate the release of elements from the non-precious dental casting alloys at different variables using the Atomic absorption spectrophotometer (AAS). For the convenience of the study a total number of 15 specimens of each brand of dental casting alloys were prepared and immersed in artificial saliva buffer for 24 hours and 7 days under different temperature i.e. 4 0C, 37 0C, 60 0C and pH of 4.0, 6.8 and 7.5 to assess for the release of elements e.g. Cr, Ni, Cu, Mo and Ag.

Table 1: Mean Leaching of elements at different temperature

			Day 1			Day 7		P value	#P value at day 1 vs day 7
Element	temperature	N	Mean	Std. Deviation	P value	Mean	Std. Deviation		
Cu	4	15	.00	.001	0.074	.01	.009	0.032*	
	37	15	.03	.076		.06	.128		
	60	15	.10	.195		.16	.233		
	Total	45	.05	.126		.07	.163		0.008*
Ag	4	15	.00	.000	0.087	.00	.000	0.111	
	37	15	.01	.018		.02	.038		
	60	15	.05	.100		.09	.207		
	Total	45	.02	.061		.04	.125		0.067
Cr	4	15	.01233	.022423	<0.001*	.03320	.031378	<0.001*	
	37	15	.07893	.087335		.20273	.186521		
	60	15	.23507	.212291		.79100	.739290		
	Total	45	.10878	.160743		.34231	.541417		<0.001*
Ni	4	15	.01	.021	0.013*	.01	.021	0.011*	
	37	15	.01	.023		.04	.055		
	60	15	.11	.175		.27	.423		
	Total	45	.05	.111		.11	.268		0.016*
Mo	4	15	.00	.000	0.031*	.00	.000	0.001*	
	37	15	.07	.152		.15	.248		
	60	15	.10	.096		.35	.349		
	Total	45	.06	.110		.17	.282		0.001*

Applied one-way ANOVA for significance. *Significant, #Applied paired t test for significance for comparison between day 1 and day 7.

Leaching of Cu, Cr, Ni and Mo elements were observed with higher mean at 60 C and the lowest mean was found at 4 C on day 1 and same observation was found on day 7, p value was found to be statistically significant on day 1 and day 7 except Cu which was not significant on day 1. The total mean difference of day 7 from day 1 was observed statistically significant than that of Ag element which was not found significant neither on day 1 nor on day 7. Overall the above table shows that on day1 temperature had a significant association on concentration of Cr, Ni and Mo and on day 7 temperature had a significant association with concentration of Cu, Cr, Ni and Mo. Time had a significant effect on concentration of trace elements.

Figure 2: Mean Leaching of elements at different temperature.

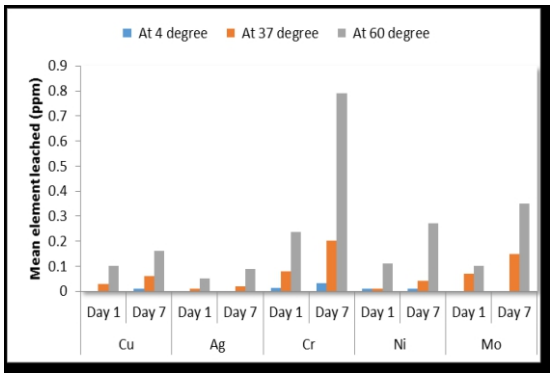

Table 2: Mean Leaching of elements on different PH

Element	pH	Day 1		P value	Day 7		P value
		Mean	Std. Deviation		Mean	Std. Deviation	
Cu	4	.02	.043	0.183	.06	.136	0.293
	6.8	.03	.047		.04	.080	
	7.5	.05	.204		.13	.232	
Ag	4	.02	.052	0.929	.04	.135	0.851
	6.8	.03	.046		.03	.057	
	7.5	.02	.082		.05	.165	
Cr	4	.11847	.157304	0.503	.32447	.510497	0.621
	6.8	.07017	.117822		.24927	.386716	
	7.5	.14800	.199906		.44520	.700324	
Ni	4	.04	.099	0.576	.08	.141	0.538
	6.8	.03	.058		.09	.200	
	7.5	.08	.157		.18	.400	
Mo	4	.08	.160	0.506	.18	.293	0.567
	6.8	.04	.047		.12	.219	
	7.5	.06	.095		.22	.332	

Applied one-way ANOVA for significance.

Irrespective of temperature, pH had limited or no association with concentration of elements.

Discussion

Non-precious casting alloys are routinely used in dentistry from past decade in various restorations in oral cavity. It has been outlined that these non-precious casting alloys were vulnerable to oral environment due to release of elements and passes potential to various health hazards (7-8). Type III Gold casting alloys have successfully been employed for dental restorations in order to prevent tarnish and corrosion. Numerous studies have been outlined about the release of metallic elements from dental alloys. The release of elements from dental casting alloys has been investigated with many different material and methods (15-17).

Cr, Ni, Cu, Mo and Ag metals were used in this study as non-precious dental casting alloys. These alloys basically used for laboratory procedure in dentistry but these alloys also being used by dental quacks for the patients of low socio-economic strata. To determine the release of element from dental casting alloys, casting alloys pellets as procured from the market were cast, finished and polished to simulate the clinically relevant conditions. For detection of the

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release of elements, artificial saliva of the different pH was used as medium. The composition of artificial saliva prepared as per Katz et al. (6). The pH of the artificial saliva buffer was adjusted to 4.0, 6.8 and 7.5 by using aqueous solution of phosphoric acid and sodium chloride (0.1mol/L).

In this study, Atomic AAS was used to determine the elemental release in the artificial saliva at different variables like pH, temperature and immersion time. AAS was used as opposed to inductively coupled plasma mass spectroscopy (ICP-MS) because of the simplicity, speed and economy of AAS technique.

As observed, elemental release had no association with the pH. The elemental release from casting alloys has also been studied extensively in vitro in short and long term experiments in various other studies (18-20). A reduction in pH will increase elemental release from dental alloys. This effect is especially pronounced for nickel–based alloys. Wataha et al. found that transient exposure of casting alloys to an acidic oral environment is likely to significantly increase elemental release from Ni-based alloys, but not from high-noble or noble alloys (12). Wataha et al. (10) observed transient exposure of casting alloys to an acidic oral environment is probably to significantly increase elemental release from Ni-based alloys, but not from high-noble or noble alloys. Once the pH returned to pH 7, effect of elemental release was increased with the exposure time. Similarly, in other studies a reduction in pH increases elemental release from dental alloys. This effect is especially pronounced for Ni-based alloys (11-13). Wataha measured the release of elements from dental alloys at monthly intervals for 10 months (14). They hypothesized that element release should decrease as a function of time of exposure to the medium. Also, they stated that the initial release rates were the highest (12).

Time had a significant effect on concentration of trace elements. Leaching of Cu, Cr, Ni and Mo elements were observed with higher mean at 60 C and the lowest mean was found at 4 C on day 1 and same observation was found on day 7, p value was found to be statistically significant on day 1 and day 7 except Cu which was not significant on day 1. Results shows that on day1 temperature had a significant association on concentration of Cr, Ni and Mo and on day 7 temperature had a significant association with concentration of Cu, Cr, Ni and Mo. The total mean difference of day 7 from day 1 was observed statistically significant than that of Ag element which was not found significant neither on day 1 nor on day 7. Wataha et al. measured elemental release from different alloys with compositions ranging from 0 to 94 % noble elements after exposure for 1 week to different biological media. More elemental release occurred into the saline-bovine serum albumin (BSA) solution compared to saline alone for all released elements (Ag, Cu, Pd, and Zn) except for nickel. Elemental release was less in the cell-culture medium than in the saline-BSA solution for most elements (21).

Similarly, dental alloys are subjected to a variety of variable environment from foods and disease states, plaque, occlusal forces and tooth brushing. Due to change in oral environment casting alloys experience mechanical and physical disruption in the oral cavity (4). An overview of the present study dictates that there is definite release of elements from dental casting alloys which is effecting systemically to the dental patients. In-Vivo study is needed to for better approach

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References

1. Kotian R, Mariam SP, Naik S, Prashanthi M. Effect of heat treatment on the microstructure and hardness of Ni-Cr base metal alloys. The Journal of Indian Prosthodontic Society. 2008 Jan 1;8(1):17.
2. Torres F, Das Graças M, Melo M, Tosti A. Management of contact dermatitis due to nickel allergy: an update. Clinical, cosmetic and investigational dermatology: CCID. 2009; 2:39.
3. Denizo lu S, Duymu ZY, Akyalçin . Evaluation of ion release from two base-metal alloys at various pH levels. Journal of international medical research. 2004 Feb;32(1):33-8.
4. Elshahawy W, Watanabe I. Biocompatibility of dental alloys used in dental fixed prosthodontics. Tanta Dental Journal. 2014 Aug 31;11(2):150-9.
5. Geurtsen W. Biocompatibility of dental casting alloys. Critical Reviews in Oral Biology & Medicine. 2002 Jan;13(1):71-84.
6. Katz MP, Nagaraja TG, Fina LR. Ruminal changes in monensin-and lasalocid-fed cattle grazing bloat-provocative alfalfa pasture. Journal of animal science. 1986;63(4):1246-57.
7. Preetha A, Banerjee R. Comparison of artificial saliva substitutes. Trends Biomater Artif Organs. 2005 Jan;18(2):178-86.
8. Mareci D, Nemtoi GH, Aelenei N, Bocanu C. The electrochemical behavior of various non-precious Ni and Co based alloys in artificial saliva. Eur Cell Mater. 2005 Jul 8;10(8):1-7.
9. Hedberg YS, Odnevall Wallinder I. Metal release from stainless steel in biological environments: A review. Biointerphases. 2016 Mar;11(1):018901.
10. Wataha, John C., R. G. Craig, and C. T. Hanks. "The release of elements of dental casting alloys into cell-culture medium." Journal of dental research 70.6 (1991): 1014-1018.
11. Covington JS, Me Bridge MA, Slagle WF, Disney AL. Quantifications of nickel and beryllium leakage from base metal casting alloys. J Prosthet Dent. 1985; 54:127–136.
12. Wataha JC, Lockwood PE, Khajotia SS, Turner R. Effect of pH on element release from dental casting alloys. J Prosthet Dent. 1998; 8:691–698.
13. Wataha JC, Lockwood PE, Nelson SK. Initial versus subsequent release of elements from dental casting alloys. J Oral Rehabil. 1999; 26:798–803.
14. Wataha JC, Lockwood PE. Release of elements from dental casting alloys into cell-culture medium over 10 months. Dent Mater. 1998; 14:158–163.
15. Wataha JC, Malcolm CT, Hanks CT. Correlation between cytotoxicity and the element release by dental casting alloys. Int J Prosthodont. 1995; 8:9–14.
16. Wataha JC. Biocompatibility of dental casting alloy: a review. J Prosthet Dent. 2000; 83:223–234.
17. Brune D. Metal release from dental biomaterials. Biomaterials. 1986; 7:163–175.
18. Bumgardner JD, Lucas LC. Surface analysis of nickelchromium dental alloys. Dent Mater. 1993;9:252–259.
19. Geis-Gerstorfer JG, Sauer KH, Passler K. Ion release for Ni-Cr-Mo and Co-Cr-Mo casting alloys. Int J Prosthodont. 1991;4:152–158.
20. Tai Y, De Long R, Goodkind RJ, Douglas WH. Leaching of nickel, chromium and beryllium ions from base metal alloy in an artificial oral environment. J Prosthet Dent. 1992;68:692–697.
21. J.C. Wataha, S.K. Nelson, P.E. Lockwood. Elemental release from dental casting alloys into biological media with and without protein. Dent Mater, 17 (2001), pp. 409–414.