Metal alloys in the oral cavity as a cause of oral discomfort in sensitive patients

Jarmila Procházková[1], MD, PhD; **Štěpán Podzimek**[1], PhD; **Milan Tomka**[1], MD; **Hana Kučerová**[1], MD; **Martin Mihaljevič**[2], PhD; **Karel Hána**[3], Ing; **Martin Mikšovský**[1], MD; **Ivan Šterzl**[4], MD, PhD & **Jana Vinšová**[5], PhD

[1] The Institute of Dental Research 1st Medical Faculty, Charles University, and General Faculty Hospital;
[2] The Institute of Geochemistry, Mineralogy, and Mineral Sources, Faculty of Nature Sciences, Charles University;
[3] The Centre of Bio-Medical Engineering, Czech Technical University;
[4] The Institute of Immunology and Microbiology, 1st Medical Faculty, Charles University, and General Faculty Hospital;
[5] Information and Advisory Centre of Charles University; Prague, Czech Republic

Correspondence to: Dr. Jarmila Procházková, The Institute of Dental Research
1st Medical Faculty, Charles University, and General Faculty Hospital
Vinohradská 48, Prague 2, CZECH REPUBLIC
TEL: +420 224 256 718; FAX: +420 224 247 034
EMAIL: prochazkova@vus.cz

Submitted: December 14, 2005 *Accepted: December 28, 2005*

Key words: **galvanism; dental metals; saliva; oral discomfort**

Neuro Endocrinol Lett. 2006; **27**(Suppl 1):53–58 **PMID:** 16804514 NEL270706A03 ©Neuroendocrinology Letters **www.nel.edu**

Abstract

OBJECTIVE OF THE STUDY: The occurrence of galvanism with its heterogeneous symptomatology is often the source of considerable problems. Abrasion and corrosion not only damage dental alloys but also burden the organism by release of metallic particles. The objective of this study is to evaluate the hypothesis that measurement of galvanic currents could be a useful diagnostic method.
PATIENT GROUPS AND METHODOLOGY: Three hundred fifty-seven persons with dental metal restorations were divided into groups according to abnormal values of galvanic currents and by oral discomfort. In all persons a detailed examination of the oral cavity was performed, and galvanic currents were measured. In one hundred fifty-nine patients abnormal galvanic currents were found. Measurement of metallic elements in saliva was performed in these patients and in a group of 21 healthy volunteers without any metals in the oral cavity. Thirty-three patients agreed to treatment which involved removal of the causative alloys and their replacement by non-metallic restorations.
RESULTS: No correlation was found between the values of measured currents and the number of teeth treated by metal restorations. However, patients with metal restorations had significantly higher contents not only of mercury, but also of tin, silver, copper, and gold in the saliva than patients without metallic restorations. After removal of the electro-active restorations, both the contents of metals in saliva and galvanic currents decreased in comparison with the levels before the treatment.
CONCLUSIONS: Galvanic effects as well as metal particles may induce a series of local or systemic pathological phenomena in sensitive individuals. The occurrence of pathologically acting galvanic effects is influenced not only by the composition and combination of different dental alloys, but to a significant degree also by the quality of used materials and processing.

To cite this article: **Neuro Endocrinol Lett** 2006; **27**(Suppl 1):53–58

Abbreviations

dc – direct current
ICP-MS LA – mass spectrometer with inductively coupled plasma in connection with laser probe

Introduction

After dental treatment, dental materials remain in close contact with the tissues in the oral cavity. Due to the functional burden and the specific environment of the oral cavity, all alloys undergo more or less mechanical and electrochemical changes, which may cause oral discomfort [32]. The intensity of the galvanic effect is determined by the difference of electrode potentials between the causal metals [4, 7]. This effect is further influenced by creation and function of passivation layers on the metal-electrolyte interface [28].

The presence of different metal alloys in the oral cavity may influence the induction and the adverse effects of electrochemical corrosion in which the metallic materials act as electrodes and the liquids in the oral cavity, such as saliva as crevicular fluid, as electrolytes [1, 9, 35]. Patient's own mucous membrane often acts as an electrode for the electrochemical dissolution rather than metals [18].

Electrodes with different potentials have the tendency to change the potential difference. This occurs by an electric current passing from one electrode to the other in the conducting environment of the oral cavity [27].

These processes may affect the development of inflammation of the oral mucosa and the tongue (Fig.1 and 2), paresthesia, glossodynia, stomatodynia, hyperaemia of the pulp, neuralgy, etc. An electric current may also manifest its effects in mucosal changes.

Release of metal ions from the dental alloys depends not only on their composition but also very significantly on the quality of their processing [3, 10, 17, 29, 31, 32].

The protecting passivation layers are continuously damaged by abrasion [34]. Neither abrasion nor corrosion can be completely eliminated but can be minimized by the choice of suitable materials and strict observance of the optimal technology [33].

An objective characterization of the galvanic effects may be attained by detection of metal elements in saliva and/or by measurement of galvanic potentials and currents [16, 18, 19, 27, 33].

Both of these approaches have their proponents and opponents [6, 14, 33]. Therefore, an intensive interdisciplinary investigation with precisely-defined conditions of measurements and parameters of the apparatus as well as unified interpretation is highly desirable.

Patients and Methods

Patients

In this study we examined a set of 357 patients, 81 men and 276 women, of average age 51 years. Three hundred thirty-six patients were referred to this investigation because of suspicion of "galvanic problems". These symptoms were either local, such as pain of tongue, painful, peeling lips and oral mucosa, taste sensations, metallic taste, coloring of prosthetic structures, metallic pigmentations, inflammatory signs of mucosa, or systemic, such as chronic fatigue, drowsiness, skin eruptions, digestive disorders, headaches, painful joints, breathing difficulties, and heart arrhythmia. The common description, as used by referring dentists, general practitioners, dermatologists, or psychiatrists, was "oral discomfort of unspecified origin". All patients had amalgam fillings and a variety of other dental alloys in the mouth.

Pathological values of the measured galvanic current were the guide for the choice of patients for treatment. Galvanic currents between 5–50 μA were found in 159 patients, 34 men and 125 women (average age 53.5 years) forming Group 1. Thirty-tree patients agreed to therapy consisting of removal of the electro-active dental restorations and their replacement.

Figure 1: Inflammatory lesion on the oral mucosa due to the galvanic features of the electro-active amalgam filling on the left lower first molar.

Figure 2: Inflammatory lesion on the tongue due to the galvanic features of the electro-active amalgam fillings on the lower molars.

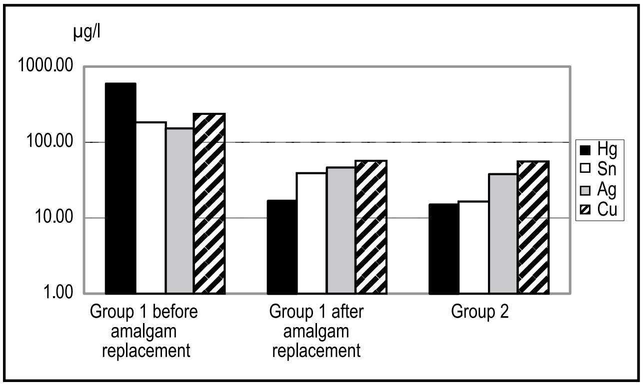

Figure 3: Mean values of Hg, Sn, Ag, and Cu in saliva in Group 1 before and after amalgam replacement compared to control Group 2.

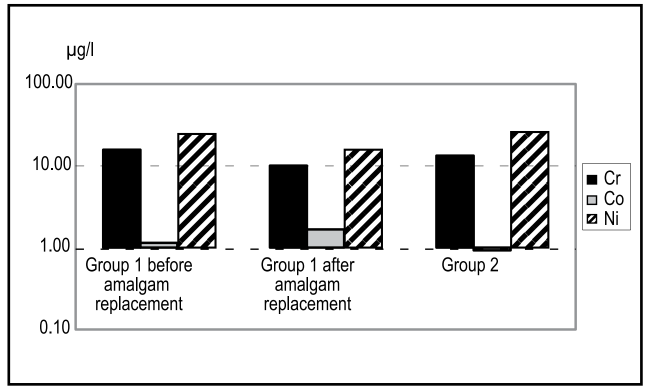

Figure 4: Mean values of Cr, Co and Ni in saliva in Group 1 before and after amalgam replacement compared to control Group 2.

Group 2 consisted of 21 volunteers with intact teeth, without subjective oral problems. These 12 men and 9 women (of average age 32.5 years) formed the standard control group. The content of metallic elements in saliva as well as galvanic currents were determined in both groups at the beginning of the study and in follow-up examination.

Detailed clinical examination of the oral cavity

We performed detailed examination of the hard and soft tissues in the oral cavity, which included acquisition and evaluation of panoramic x-ray images and detailed determination of the number of teeth treated by metal alloy restorations.

Measurement of galvanic currents

The currents flowing between dental alloys and gingiva, tongue, lips or cheek mucosa or between alloys were measured using the specialized voltmeter / amperemeter "Odontologik 2000" (Embitron). It determines the peak values of direct current (dc) and voltage in the oral cavity. The currents flowing were consecutively measured

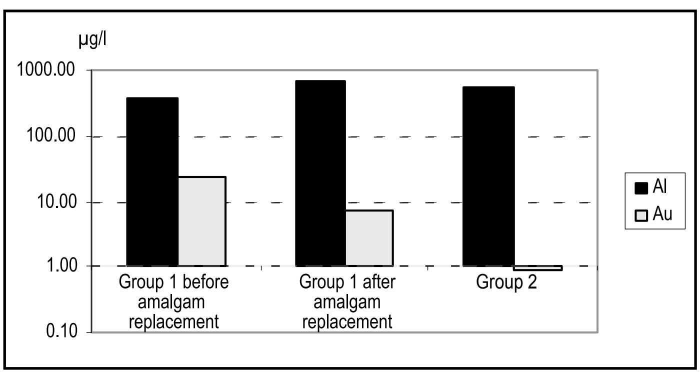

Figure 5: Mean values of Al and Au in saliva in Group 1 before and after amalgam replacement compared to control Group 2. The Au amount was significantly higher in Group 1 than 2 (p = 0.02).

Figure 6: Electro-active amalgam filling on the right lower second molar with no polished surface.

Figure 7a: Defect of the metal-ceramic crown on the right upper middle incisor – the cause of galvanic currents.

Figure 7b: Same patient after replacement of the unsuitable metal-ceramic crowns with other metal-ceramic ones made by the correct technology – no galvanic currents were detected.

between all affected locations as follows: metal-gum, metal-metal, metal-tongue or other soft tissue in the oral cavity.

A galvanic current of 5 μA was considered as the limit of pathological values [2, 8, 13, 16, 20, 22].

Material sampling

To determine metallic elements in saliva, samples of 1 ccm of non-stimulated saliva were taken into polyethylene test tubes and immediately frozen to −18ºC. The frozen samples were transported to the laboratory of the Institute of Geochemistry and Faculty of Natural Science, Charles University and examined by ultra-trace element analysis using the mass spectrometer ICP-MS LA (mass spectrometer with inductively coupled plasma in connection with laser probe). The content of individual elements is presented in μg per liter of saliva (parts per billion). The metals tested were silver (Ag), aluminum (Al), gold (Au), cadmium (Cd), cobalt (Co), chromium (Cr), cupper (Cu), mercury (Hg), nickel (Ni), lead (Pb), palladium (Pd), platinum (Pt), tin (Sn), and zinc (Zn)..

Therapy

The treatment consisted mostly of removal of amalgam fillings and their replacement by glass-ionomer cements, composite plastics, or composite or ceramic inlays. In one case, the problematic amalgam fillings were replaced, in accordance with the wish of the patient, by new amalgam restorations.

Subjective evaluation of the therapy by the patients was obtained by means of a questionnaire filled in by the patients after 1 month. The patients were asked to grade the results of the therapy treatment as follows: 1) Small effect (don't know, not much, maybe), 2) Good effect (yes, it helped, certainly, it is better), or 3) Very good effect (it helped a lot, it is much better, big improvement).

Objective evaluation of the therapy involved measurement of galvanic features as well as of metallic elements in the saliva before and after removal of the metal restorations from the oral cavity.

Statistics

The qualitative data were statistically analyzed using paired and unpaired Student's t test and the quantitative data using the Pearson's χ^2 test and Fisher's exact test. Values of probability $p < 0.05$ are considered as significant.

Results

Pathological values of the current from 7–25 μA were detected in 150 patients. Nine additional patients had the critical value 5 μA. These 159 patients subsequently formed the basis for Group 1. The patients had values of galvanic currents in the range 7 to 25 μA. The persons in Group 2 (controls) showed no galvanic phenomena in their mouth.

Mercury constituted the largest part of metallic elements in saliva in Group 1 (594.6 μg/l, Fig. 3). Comparison with the control Group 2 showed that Group 1 had significantly higher amounts not only of Hg ($p = 0.05$) but also of Sn ($p = 0.01$), Ag ($p = 0.01$), and Cu ($p = 0.01$). The amounts of Cr, Co, and Ni in saliva were markedly lower (0.98 to 16.4 μg/l), and not significantly different from Group 2 (Fig. 4). On the contrary, the amount of Al; (220.3 to 560.9 μg/l)(Fig. 5) was high in both examined groups (220.3 to 560.9 μg/l). The content of Au was higher in saliva of patients in Group 1 (87.5 μg/l; $p = 0.02$; Fig. 5). The values of other measured metals were low and showed no significant differences between the groups.

After removal of the electro-active restorations, pathological values of galvanic currents normalized in all patients. Due to their chemical composition and according to our experience, these materials always exhibit high values of voltage. Therefore we did not take into account the voltage values in patients treated in this way.

Further, we detected a decreased amount of some metallic elements, present in amalgam, in saliva of patients in Group 1, as compared to values before the treatment. A significant decrease was found for Sn ($p = 0.03$), Au ($p = 0.05$) and Cu ($p = 0.01$) but not for Hg ($p = 0.07$). The comparison of Group 1 after treatment with the control Group 2 shows no statistically significant differences in the contents of the examined metals (Figs 3, 4, 5).

The results of the questionnaire survey in Group 1 showed that 91% of treated patients reported a good or very good effect of the treatment, such as disappearance or a marked reduction of the feeling of oral discomfort. Only 9% of the treated patients reported only a mild or no improvement. None of the treated patients observed deterioration of health.

The occurrence of pathologically acting galvanic effects was influenced not only by the composition and combination of the employed dental alloys, but also by the quality of processing of used materials (Fig. 6). When correctly processed restoration replaced a bad restoration, the pathologic galvanic currents were not present any more (Fig. 7a and 7b).

Discussion

The findings of higher amounts of Hg, Sn, Ag, Cu and Au in Group 1 were expected due to the difference in dental status between the examined groups. The high amount of Al detected in both groups could be caused by common environmental exposure e.g. by alimentation etc. These findings are in agreement with published studies [6, 14].

The removal of amalgam fillings in patients of Group 1 resulted in a significant decrease of the amount of Sn, Ag, and Cu, but the decrease of Hg in saliva was not significant. This could be due to larger dispersion of values in the samples. On the other hand, the decrease of metal concentrations in saliva after amalgam removal to the levels found in Group 2 points to the influence of galvanic phenomena on the corrosion of metallic restorations.

Dental alloys in the oral cavity may induce adverse side effects in sensitive individuals [8, 15, 21, 29, 30]. Our results indicate that galvanic effects can play an important role in this phenomenon.

Oral discomfort, such as burning and itching, may often occur in individuals with various systemic disorders along with usually non-characteristic objective diagnosis. These conditions occur in patients who often have other health problems such as climacterium changes, senium, viroses, stress, neuroses) [8, 11]. The removal of electroactive dental restorations could be one of the treatment tools for these patients.

Metallic elements may be deposited in soft as well as in hard tissues of the oral cavity and this may cause discoloration of other structures made of dental alloys [12, 25, 30].

Saliva may play a protective role against the induction of galvanic currents, particularly if its molecules have a high molecular weight [10]. This could explain why some patients with various alloys in the oral cavity have galvanic phenomena while the other have not. Our results may suggest that the amount of metal particles in saliva is influenced more by environmental factors than by the primary saliva composition.

In ionised form, certain metals such as Hg and Ni easily bind to body proteins, and then as haptens they may activate the immune system [23]. The Hg^{+} ions enhance the sensitivity to other metals [26].

Intolerance to metals may be demonstrated by skin tests, which are subjective and may carry a risk of sensibilization [5], or by a less distressing objective *in vitro* immunological test, MELISA® [24, 25]. On the basis of such examinations, further therapeutic options could be designed.

Prevention of galvanism is based on strict adherence to optimal technology in dental alloy processing [33], during production as well as in the final application, and on minimization of their amounts and combinations.

Acknowledgement

This study was supported by grant no. NR 8324-3 from the Internal Grant Agency of the Czech Ministry of Health.

REFERENCES

1 Arvidson K, Johansson EG: Galvanic currents between dental alloys in vitro; Scand J Dent Res. 1985; **93**: 467–73.
2 Axell T, Nilner K, Nilsson B: Clinical evaluation of patients referred with symptoms related to oral galvanism; Swed Dent J. 1983; **7**: 169–78.
3 Bergman M, Ginstrup O, Nilner K: Potential and polarization measurements in vivo of oral galvanism; Scand J Dent Res. 1978; **86**: 135–45.
4 Bergman M, Ginstrup O, Nilsson B: Potentials of and currents between dental metallic restorations; Scand J Dent Res. 1982; **90**: 404–8.
5 Bieger WP: Immunotoxikologie der Metalle. Labordiagnostik der Quecksilber- und Dentalmetall-Sensibilisierung; Clin Labor. 1996; **42**: 243–55.
6 Ganss C, Gottwald B, Traenckner I, Kupfer J: Relation between mercury concentrations in saliva, blood, and urine in subjects with amalgam restorations; Clin Oral Invest. 2000; **4**: 206–11.
7 Gjerdet NR: Galvanic cells including cobalt-chromium alloys; Acta Odontol Scand. 1980; **38**: 273–8.
8 Hampf G, Ekholm A, Salo T, Ylipaavalniemi P, Aalberg V, Tuominen S, Alfthan G: Pain in oral galvanism; Pain. 1987; **29**: 301–11.
9 Holland RI: Galvanic currents between gold and amalgam; Scand J Dent. Res. 1980; **88**: 269–72.
10 Johansson BI: An in vitro study of galvanic currents between amalgam and gold alloy electrodes in saliva and in saline solutions; Scand. J Dent Res. 1986; **94**: 562–8.
11 Johansson B, Stenman E, Bergman M: Clinical study of patients referred for investigation regarding so-called oral galvanism; Scand J Dent Res. 1984; **92**: 469–75.
12 Joska L, Venclíková Z, Bystrianský J, Novák P: Corrosion processes leading to the development of metallic pigmentation of the gingiva; Cs Stomat. 2002; **102**: 197–203.
13 Kucerova H, Dostalova T, Prochazkova J, Himmlova L: Influence of galvanic phenomena on the occurence of algic symptoms in the mouth; Gen Dent. 2002; **50**: 62–5.
14 Lygre GB, Hol PJ, Eide R, Isrenn R: Mercury and silver in saliva from subject with symptoms self-related to amalgam fillings; Clin Oral Invest. 1999; **3**: 216–8.
15 Muris J, Feilzer AJ. Micro analysis of metals in dental restorations as part of a diagnostic approach in metal allergies. Neuro Endocrinol Lett. 2006; **27** (Suppl1): 49-52.
16 Nilner K: Studies of electrochemical action in the oral cavity; Swed Dent J. 1981; **5(**Suppl.): 1–42.
17 Nilner K, Glantz PO, Ryge G, Sundberg H: Oral galvanic action after treatment with extensive metallic restorations; Acta Odontol Scand. 1982; **40**: 381–8.
18 Nilner K, Glantz PO, Zoger B. On intraoral potential- and polarization-measurements of metallic restorations. A methodological and time dependent clinical study; Acta Odontol Scand. 1982; **40**: 275–81.
19 Nogi N: Electric current around dental metals as a factor producing allergenic metal ions in the oral cavity. Nippon Náfuka Gakkai Zasshi, 1989; **99**: 1243–54.
20 Podzimek S, Prochazkova J, Hana K, Kucerova H, Bartova J: The influence of galvanic currents and voltage on the proliferation activity of lymphocytes; Clin Invest Med. 2004; 27: 62D.
21 Prochazkova J, Sterzl I, Kucerova H, Bartova J, Stejskal VDM: The beneficial effect of amalgam replacement on health in patients with autoimmunity; Neuro Endocrinology Lett. 2004; **25**: 211–8.
22 Rutten WLC: The influence of galvanic current on the neuron cell; Presentation on 2nd European Medical and Biological Engineering Conference, Wien, 4– 8.12.2002.
23 Stejskal VDM: Human hapten-specific lymphocytes: Biomarkers of allergy in man; Drug Information J. 1997; **31**: 472–5.
24 Stejskal VDM, Cederbrandt K, Lindvall A, Forsbeck M: MELISA – an in vitro tool for the study of metal allergy; Toxicol In vitro 1994; **5**: 991–1000.
25 Stejskal VD, Hudecek R, Stejskal J, Sterzl I. Diagnosis and treatment of metal-induced side-effects. Neuro Endocrinol Lett. 2006; **27**(Suppl1): 7-16.
26 Sterzl I, Prochazkova J, Hrda P, Bartova J, Matucha P, Stejskal VDM: Mercury and nickel allergy: risk factors in fatigue and autoimmunity; Neuro Endocrinol Lett. 1999; **20**: 221–8.
27 Sutow EJ, Maillet WA, Taylor JC, Hall GC: In vivo galvanic currents of intermittently contacting dental amalgam and other metallic restorations; Dent Mater. 2004; **20**: 823–31.
28 Syrjanen S, Piironen P, Yli-Urpo A: Salivary content of patients with subjective symptoms resembling galvanic pain; Oral Surg Oral Med Oral Pathol. 1984; **58**: 387–93.

29 Valentine-Thon E, Muller KE, Guzzi G, Kreisel S, Ohnsorge P, Sandkamp M. LTT-MELISA® is clinically relevant for detecting and monitoring metal sensitivity. Neuro Endocrinol Lett. 2006; **27**(Suppl1): 17-24.
30 Venclikova Z, Benada O, Bartova J, Joska L, Mrklas L, Prochazkova J, Stejskal VD, Podzimek S. *In vivo* effects of dental casting alloys. Neuro Endocrinol Lett. 2006; **27**(Suppl1): 61-68.
31 Walker RS, Wade AG, Iazzetti G, Sarkar NK: Galvanic interaction between gold and amalgam: effect of zinc, time and surface treatments; J Am Dent Assoc. 2003; **134**: 1463–7.
32 Wataha JC: Biocompatibility of dental casting alloys: A review; J. Prosthet Dent. 2000; **83**: 223–34.
33 Wataha JC: Alloys for prosthodontic restorations; J Prosthet Dent. 2002; **87**: 351–63.
34 Watson JF, Wolcott RB: A method for the control of galvanism; J Prosthet Dent. 1976; **35**: 279–82.
35 Yontchev E, Sandstrom B, Carlsson GE: Dietary pattern, energy and nutrient intake in patients with oro-facial discomfort complaints; J Oral Rehabil. 1989; **16**: 345–51.