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Original Research

Analysis of Environmental Factors Impacting Galvanic Current Appearance within the Oral Cavity; *in vitro* Study

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Abstract

The aim of the present study was to evaluate how chosen factors of diet impact the galvanic currents appearance, when different generations of amalgams and Cr-Ni orthodontic brackets were present.

For the study 12 cells, which can occur in the oral cavity, were set. The experiments were run in 3 arrangements: orthodontic bracket–Stabil B amalgam, orthodontic bracket-Amalcap plus amalgam, orthodontic bracket-Lojic+ amalgam. Four electrolytes (with different pH) were applied: artificial saliva, apple juice, orange juice, and Coca-Cola. The measurements of current intensity were performed in a thermostatic chamber of organic glass, connected to a thermostatic water bath. The temperature was stabilized at 37ºC±0.5ºC. The distance between opposing test surfaces was 60 mm. In this study, the corrosion tendencies of alloys were investigated by measuring the current between electrodes as a function of time. The current density by the surface of the electrodes was expressed in $\mu A/cm^2$.

The influence of low pH drinks on the appearance of galvanic currents was found. The highest initial volume of current density was observed in the orthodontic bracket-Stabil B cell, orange juice electrolyte employed (66.4 $\mu A/cm^2$ by the amalgam's surface and 182.3 $\mu A/cm^2$ by the bracket's surface).

Keywords: corrosion, dental amalgam, orthodontic bracket, *in vitro* test

Introduction

Metal alloys of different physico-chemical properties still find a wide use in all branches of dentistry.

In conservative dentistry, amalgams are still used to restore a tooth's hard tissue.

These fillings, known for many years, are used when aesthetics are a minor issue for restoring the rear teeth cavities of class I and II according to Black [1]. The first amalgam alloy was prepared and introduced in medicine by Black in 1926. It was a so-called conventional amalgam – i.e. of the 1st generation. During the bonding of this filling (amalgamation) the Ag_3Hg_4 phase appeared (i.e. the amalgam matrix) and phase γ_2 Sn_8Hg and not bonded Ag_3Sn molecular – phase γ. The generation I amalgam contained ca 60% of Ag, 29% of Sn, less than 6% of Cu and less than 2% of Zn. It was found that γ_2 phase caused the amalgams' corrosion [1]. In generation II amalgams, after mixing the alloy with mercury, γ_1 and γ_2 phases appear. The content of copper in these amalgams is higher and, in contrast to the conventional amalgams, the reaction carries on – the phase η Cu_6Sn_5 and phase ε Cu_3Sn appear. The released mercury

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reacts with silver and phase γ_1 appears. Modern amalgams of generation III are the physicochemical combinations of mercury with metals like silver (up to 70%), tin (up to 32%), copper (up to 30%), zinc (to 2%) and, to diminish the amalgam's corrosion – indium (up to 5%), and palladium or platinum (up to 1%) [2, 3]. In generation III amalgams the γ_2 ($Sn_{6-8}Hg$) phase does not form because Ag-Cu-Sn molecules and the high content of copper (above 1%) block it [1]. When bonding the phases: γ_1 Ag_3Hg_4, η Cu_6Sn_5 and ε Cu_3Sn appear. The products of corrosion that may be found on the amalgams' surfaces are mostly the compounds of copper and tin: (Cu_2O), $Sn_4(OH)_6Cl_2$, SnO, and SnO_2 [2]. Within one person's oral cavity amalgams of different generations may be found.

In orthodontics, to correct the malocclusions despite movable braces, the steady ones are in wide use now. Children and youngsters as well as older patients are cured with them. Their metal elements like arcs, bands, brackets, and orthodontic band with brackets create a big surface. All these elements may be manufactured with various metal alloys. The orthodontic arcs are made of Cr-Ni, TMA (titanium-molybdenum), CuNiTi (nickel-titanium with copper additive), and NiTi (nickel-titanium alloys of different properties) [4]. The brackets and other orthodontic elements are made of Cr-Ni steel and titanium and its alloys. The metallic nickel and the compounds of it may cause allergies. Nickel allergy is specific and cross allergies for other metals occur accidentally. The histochemical research proves that nickel gathers in the external layer of the epidermis, sweat canals, and hair follicles. The release of ions, especially of Ni from the metal orthodontic elements [5, 6] and their allergy-causing citotoxical, mutagenic and carcinogenic properties has recently been the object of many studies [7-10]. Kerosuo et al. [8] in their research in Norway and Finland found the physicians in both countries noticed the patients using the metal orthodontic elements containing nickel felt discomfort within the oral cavity [8]. Menezes et al. [11] stated the nickel urine concentration appears 2 months after the orthodontic braces were put in place.

Both amalgams and the elements of orthodontic apparatus may stay together in the oral cavity for some years, especially older patients. They constitute the galvanic cell within the oral cavity environment. Galvanic cell consists of two hemicells (electrodes) of different electrochemical potential connected directly by a solution of electrolytes. Each metal and alloy employed in dentistry may be subject to corrosion in the oral cavity environment, the ions are released, the galvanic currents appear [12-16]. These phenomena may influence the durability and endurance of the metal, and the chemical combinations that appear during corrosion may act as toxins both generally and locally, causing various diseases and disturbing physiological processes [17-19]. The oral cavity environment, whose basic ingredients are saliva and tissue fluids, is conductive to it. This environment may be modified with different drinks and mouth-washing liquids, which can also create the electrolyte for the metals and alloys placed in the oral cavity. Temperature, quality and quantity of saliva, dental plaque, pH rate, food and liquids consumed, and medicines taken, and the general state of health impact corrosion [13, 18].

Despite the importance and universality of the problem, there is no analysis available regarding the different external factors impact (for example: liquids provided to oral cavity with food) on the oral cavity environment and on the appearance and volume of electrochemical phenomena taking place in this environment. Until now the authors studied the scope of corrosion and the release of ions of the alloys employed in dentistry using artificial saliva and different pH buffers in experimental conditions [9, 20-23].

The aim of this study was the estimation of different factors connected with diet impact on the oral cavity environment with regard to the galvanic currents appearance with the presence of different generations to amalgams and the orthodontic brace of Cr-Ni alloy.

Experimental Procedures

For the experiment a galvanic cell was constructed – the electrodes were: low-copper amalgam of generation I with γ_2 phase (Stabil B-SB) (Mifam Poland), consisting of: Ag=65%, Sn=29%, Cu=6%, Hg=50% (fillings and Hg 1:1); high-copper amalgam of generation II with reduced γ_2 phase (Amalcap plus-Ap) (Vivadent) consisting of: Ag=70%, Sn=18%, Cu=12%, Hg=50%; high-copper amalgam of generation III without γ_2 phase (Lojic+-Lj) (SDI Australia) consisting of: Ag=60.1%, Sn=28.05%, Cu =11.8%, Pl=0.05%, 42.2% Hg and orthodontic bracket (OB) (Dentaurum, alloy stainless-steel) were used for the experiments. The amalgam alloy were triturated in accordance with the instructions of manufacturers. The specimens of each alloy were then condensed as a form of drop. After 24 h the one sample surface was polished by using grey and green polishing cups and polishing paste (Vivadent) at slow speed. Then, it was washed in distilled water and alcohol. For this study 3 couples were prepared, in which the orthodontic bracket was the fixed electrode, and the amalgam was altered: couple No. 1 orthodontic bracket-Stabil B, couple No. 2 orthodontic bracket-Amalcap plus and couple No. 3 orthodontic bracket-Lojic+. Four electrolytes with different pH (artificial saliva, apple juice, Coca-Cola, and orange juice) were used for examinations. Apple juice of 3.4 pH and 4.0 mS conductance, Coca-Cola of 2.5 pH and 1.25 mS conductance and orange juice of 3.8 pH and 5.5 mS conductance were made by Coca-Cola Poland Industries. The pH ratio values were measured using PW 9409 pH-meter with integrated glass electrode. The artificial saliva, imitating the natural conditions in oral cavity was prepared ex tempore according to Ardvidson dispensing [24]. Artificial saliva of 6.7 pH and 5.8 mS conductance, and consisting of 100 ml 25 mM KH_2PO_4, 100 ml 24 mM Na_2HPO_4, 100 ml 150 mM $KHCO_3$, 100 ml 100 mM NaCl, 100 ml 1.5 mM $MgCl_2$, 6 ml 25 mM citric acid, and 100 ml 15 mM $CaCl_2$. The electrolyte employed was not oxygenized nor deoxygenized.

For the measurement of galvanic current intensity the following measuring system was applied:

1. DC ammeter 1 μA range, 4.5 digit resolution, 0.05% error, 100 Ω resistance
2. Thermostatic chamber of organic glass, 30 ml volume, 6 cm diameter connected with high temperature – proof (hose, wire) line to thermostatic water bath
3. U1 thermostatic water bath – employed to enforce water flow and stabilize the temperature at 37ºC and precision better than 0.5ºC
4. PW 9409 pH-meter with integrated glass electrode.

The connection of metal elements to the measuring system was done with teflon-insulated wire and soft soldering. To avoid the creation of undesirable additional galvanic cells between soldering and metals, the soldered place was insulated with a special varnish resistant to the pH 1-13 range fluctuations. The measurements of current intensity in the examined cell was performed with natural air access and the temperature of the liquid, in which the assays were taken, was set for +37ºC. The experiment was started after the stable temperature of the system was achieved. The measurements of current intensity (μA) were made in terms of short-circuit, i.e. when the resistance of metal-electrolyte-metal set was significantly higher than the resistance of the measuring system. The effective surface of electrodes was calculated based on the measuring method prepared in the Department of Physics and Biophysics of the Medical University in Gdańsk and described in [16]. The current density of the galvanic cell is determined according to the equation:

$$j = \frac{I}{S}$$

...where: j – current density [μA/cm^2],
I – galvanic current [μA],
S – surface of electrode [cm^2].

The current density (GP) by the surface of the electrodes was expressed in μA/cm^2.

Just before examination tested electrodes were brushed using a medium hardness toothbrush (Jordan) to imitate rubbing teeth while eating and then washed with distillated water and placed in the test cell, which was open to air, at a constant temperature of 37ºC±0.5°C. The distance between opposing test surfaces was 60 mm. In this study, the corrosion tendencies of alloys were investigated by measuring the current between electrodes as a function of time. The galvanic current was measured every 10 seconds during the first minute, then every minute during the next 9 minutes. The experiment was repeated for every galvanic cell, after 2 days. Before experiment I and II the electrodes were kept in special containers with no air access. The obtained results were analyzed with t-Student test employed.

Results

The current density (GP) measurements in 12 cells composed of orthodontic bracket– amalgam Lojic+ (high-copper generation III) (OB/Lj), orthodontic bracket-Amalcap plus (generation amalgam II) (OB/Ap) and orthodontic bracket-Stabil B (generation I amalgam) (OB/SB) in 4 different electrolytes showed the full recurrence of the results in experiments I and II (Tables 1 and 2). Regardless, the set and electrolyte applied the highest GP volume in each measurement was observed at the moment of dipping the electrodes in electrolyte (initial GP value) which decreased rapidly in the first 10 seconds of examination (Tables 1 and 2).

The initial GP values, regardless of the electrode couples applied, were always the highest when orange juice was the electrolyte, lower with Coca-Cola, much lower with apple juice, and the lowest with artificial saliva (Tables 1 and 2).

When the artificial saliva and apple juice were the electrolyte, the initial GP values were similar in all amalgam-orthodontic bracket sets. Regardless, the amalgam was of Ist, IInd or IIIrd generation, but significantly higher when apple juice was used. But when the apple juice and Coca-Cola were used the significant difference in initial GP values was apparent depending on the amalgams' generation. For the OB/SB (generation I amalgam) this value was twice higher compared to OB/Ap (generation II amalgam) or OB/Lj (generation III amalgam) sets (Tables 1 and 2).

From all the cells examined the highest initial GP value was found in the cell: orthodontic bracket-Stabil B, orange juice as electrolyte (66.4 μA/cm^2 by the amalgam surface and 182.3 μA/cm^2 by the surface of bracket) and the lowest in the cell: OB/SB, artificial saliva as electrolyte (6.5 μA/cm^2 by the amalgam surface and 17.8 μA/cm^2 by the surface of bracket) (Tables 1 and 2).

The GP values for all the time of the experiment (10 minutes) were on the higher level when the alimentary liquids were the electrolyte, then when the artificial saliva was used (Tables 1 and 2).

Discussion

Orthodontic braces, because of the diversity of metal elements and alloys produced, may compose the galvanic cells in the oral cavity environment. The change of the oral cavity environment, because of the introduced alimentary liquids of low pH rate, can intensify already existing electrochemical phenomena. Many scientists researched the release of ions, both *in vitro* and *in vivo*, from the metallic orthodontic elements [5-7, 10, 21, 23, 25].

Hwang et al. [5] prepared the experimental models consisting of bands, brackets, and various orthodontic arcs (Stainless steel from two manufacturers – Ormco and Dentaurum, Ni-Ti, and Bioforce sentalloy) in artificial saliva of pH 6.75±15[25] and temperature 37°C. The examination was done after 1, 3, and 7 days and after 2, 3, 4, 8, and 12 weeks. They found an increase of Ni ion concentrations in artificial saliva during 3 weeks for the Bioforce arc set model. For the other experimental models the increase of Ni ions concentration remained for 2 weeks maximum [5].

Table 1. Galvanic current density in galvanic cells during specific times in different electrolytes - Experiment I.

A.			Current density (μA/cm²) on the electrode surface in time [s]															
	Couple No.	Electrode	*0	10	20	30	40	50	60	120	180	240	300	360	420	480	540	600
Electrolite – artificial saliva	1	Stabil B	6.5	1.5	1	0.9	0.8	0.7	0.7	0.7	0.6	0.07	0.07	0.07	0.1	0.07	0.07	0.07
		orthodontic bracket	17.8	4.1	2.9	2.5	2.3	2.1	2.1	1.9	1.7	0.1	0.1	0.1	0.3	0.1	0.1	0.1
	2	Amalcap plus	4.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
		orthodontic bracket	11.5	0.9	0.7	0.9	0.7	0.7	0.7	0.9	0.9	0.7	0.7	0.7	0.7	0.7	0.9	0.9
	3	Lojic+	7.4	0.4	0.6	0.5	0.3	0.3	0.2	0.1	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
		orthodontic bracket	23.3	1.3	1.9	1.5	0.9	0.9	0.7	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
B.			Current density (μA/cm²) on the electrode surface in time [s]															
Electrolite – apple juice	Couple No.	Electrode	*0	10	20	30	40	50	60	120	180	240	300	360	420	480	540	600
	1	Stabil B	16.7	3.5	3	2.7	2.7	2.6	2.5	2.4	2.2	2.1	2	2	2	2	2	1.9
		orthodontic bracket	46	9.8	8.2	7.6	7.4	7.2	7	6.6	6.2	5.8	5.6	5.6	5.4	5.4	5.4	5.2
	2	Amalcap plus	15	1.3	1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
		orthodontic bracket	38.2	3.3	2.7	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	3	Lojic+	12.1	1.9	1.5	1.4	1.3	1.3	1.3	1.3	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1
		orthodontic bracket	38.2	6	4.9	4.5	4.3	4.3	4.1	4.1	3.9	3.9	3.7	3.7	3.5	3.5	3.5	3.5
C.			Current density (μA/cm²) on the electrode surface in time [s]															
Electrolite – Coca-Cola	Couple No.	Electrode	*0	10	20	30	40	50	60	120	180	240	300	360	420	480	540	600
	1	Stabil B	34	5.1	4.2	3.7	3.5	3.2	3.1	2.9	2.6	2.5	2.3	2.3	2.2	2.2	2.2	2.2
		orthodontic bracket	95.4	14.1	11.7	10.3	9.6	9	8.6	8	7.2	6.8	6.4	6.4	6.2	6	6	6
	2	Amalcap plus	16	2.5	1.5	1.2	1.2	0.8	0.7	0.4	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1
		orthodontic bracket	40.9	6.4	3.9	3.1	3.	2.1	1.9	1.1	0.7	0.5	0.5	0.5	0.3	0.3	0.3	0.3
	3	Lojic+	11	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.1
		orthodontic bracket	34.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.7	0.7	0.7	0.7	0.7	0.5	0.5
D.			Current density (μA/cm²) on the electrode surface in time [s]															
Electrolite – orange juice	Couple No.	Electrode	*0	10	20	30	40	50	60	120	180	240	300	360	420	480	540	600
	1	Stabil B	66.4	4.4	3.1	2.6	2.4	2.2	2.2	2	1.9	1.8	1.8	1.7	1.7	1.7	1.7	1.7
		orthodontic bracket	182.3	12.1	8.6	7.2	6.6	6.2	6	5.4	5.2	5	5	4.9	4.9	4.7	4.9	4.9
	2	Amalcap plus	30	5.7	5.5	4.7	4	3.4	3	2	1.4	1.3	1.2	1	1	1	1	1
		orthodontic bracket	76.6	14.7	14.1	12.1	10.1	8.8	7.8	5	3.7	3.3	3.1	2.7	2.5	2.5	2.5	2.5
	3	Lojic+	27	1.87	1.4	1.3	1.1	1.1	1	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6
		orthodontic bracket	84.9	5.8	4.5	4.1	3.7	3.5	3.3	2.7	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.1

* moment of dipping the electrode in electrolyte.

Table 2. Galvanic current density in galvanic cells during specific times in different electrolytes - Experiment II.

A.			Current density (μA/cm²) on the electrode surface in time [s]															
Electrolite – artificial saliva	Couple No.	Electrode	*0	10	20	30	40	50	60	120	180	240	300	360	420	480	540	600
	1	Stabil B	6.5	1.5	1	0.9	0.8	0.7	0.7	0.7	0.6	0.07	0.07	0.07	0.1	0.07	0.07	0.07
		orthodontic bracket	17.8	4.1	2.9	2.5	2.3	2.1	2.1	1.9	1.7	0.1	0.1	0.1	0.3	0.1	0.1	0.1
	2	Amalcap plus	4.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
		orthodontic bracket	11.5	0.9	0.7	0.9	0.7	0.7	0.7	0.9	0.9	0.7	0.7	0.7	0.7	0.7	0.9	0.9
	3	Lojic+	7.4	0.4	0.6	0.5	0.3	0.3	0.2	0.1	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
		orthodontic bracket	23.3	1.3	1.9	1.5	0.9	0.9	0.7	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
B.			Current density (μA/cm²) on the electrode surface in time [s]															
Electrolite – apple juice	Couple No.	Electrode	*0	10	20	30	40	50	60	120	180	240	300	360	420	480	540	600
	1	Stabil B	16.7	3.5	3	2.7	2.7	2.6	2.5	2.4	2.2	2.1	2	2	2	2	2	1.9
		orthodontic bracket	46	9.8	8.2	7.6	7.4	7.2	7	6.6	6.2	5.8	5.6	5.6	5.4	5.4	5.4	5.2
	2	Amalcap plus	15	1.3	1	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
		orthodontic bracket	38.2	3.3	2.7	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.3
	3	Lojic+	12.1	1.9	1.5	1.4	1.3	1.3	1.3	1.3	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.1
		orthodontic bracket	38.2	6	4.9	4.5	4.3	4.3	4.1	4.1	3.9	3.9	3.7	3.7	3.5	3.5	3.5	3.5
C.			Current density (μA/cm²) on the electrode surface in time [s]															
Electrolite – Coca-Cola	Couple No.	Electrode	*0	10	20	30	40	50	60	120	180	240	300	360	420	480	540	600
	1	Stabil B	34	5.1	4.2	3.7	3.5	3.2	3.1	2.9	2.6	2.5	2.3	2.3	2.2	2.2	2.2	2.2
		orthodontic bracket	95.4	14.1	11.7	10.3	9.6	9	8.6	8	7.2	6.8	6.4	6.4	6.2	6	6	6
	2	Amalcap plus	16	2.5	1.5	1.2	1.2	0.8	0.7	0.4	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1
		orthodontic bracket	40.9	6.4	3.9	3.1	3.	2.1	1.9	1.1	0.7	0.5	0.5	0.5	0.3	0.3	0.3	0.3
	3	Lojic+	11	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.1	0.1
		orthodontic bracket	34.5	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.7	0.7	0.7	0.7	0.7	0.5	0.5
D.			Current density (μA/cm²) on the electrode surface in time [s]															
Electrolite – orange juice	Couple No.	Electrode	*0	10	20	30	40	50	60	120	180	240	300	360	420	480	540	600
	1	Stabil B	66.4	4.4	3.1	2.6	2.4	2.2	2.2	2	1.9	1.8	1.8	1.7	1.7	1.7	1.7	1.7
		orthodontic bracket	182.3	12.1	8.6	7.2	6.6	6.2	6	5.4	5.2	5	5	4.9	4.9	4.7	4.9	4.9
	2	Amalcap plus	30	5.7	5.5	4.7	4	3.4	3	2	1.4	1.3	1.2	1	1	1	1	1
		orthodontic bracket	76.6	14.7	14.1	12.1	10.1	8.8	7.8	5	3.7	3.3	3.1	2.7	2.5	2.5	2.5	2.5
	3	Lojic+	27	1.87	1.4	1.3	1.1	1.1	1	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.6
		orthodontic bracket	84.9	5.8	4.5	4.1	3.7	3.5	3.3	2.7	2.3	2.3	2.3	2.3	2.3	2.3	2.3	2.1

* moment of dipping the electrode in electrolyte.

Costa et al. [9] examined the Ni ion release from the two types of orthodontic brackets (0.022 slot AISI 304 SS (Roth Light) and 0.022 slot manganese SS (Nickel-free Monobloc) in the artificial saliva of pH 6.75±15 at 37°C after 21, 42, and 63 days. They noticed the lower level of ion release from the manganese SS alloy, and the higher Ni ion concentration at AISI 304 SS alloy in the 42nd day of examination. When examining the AISI 304 SS brackets in scanning microscope they found small irregular cavities on their surfaces, which were not found at manganese SS brackets [9].

The experiments performed in the artificial saliva of 6.75 pH rate by Hwang et al. [5] showed that from the Cr-Ni steel arcs (regardless of manufacturer: Ormco or Dentaurum) and Cr-Ni alloy brackets sets the rate of both Ni and Cr ion release is higher compared to the set with CuNiTi alloy arc [5]. Huang et al. [23] in their research run in 3 buffers of pH 4, 7, and 10 and artificial saliva into 480 brackets (new and re-used ones) found the re-used brackets release more Ni ions then new ones. They also noted the bigger Ni disengagement in the artificial saliva, then in buffer of pH 4, 7, and 10. They explained it by the high content of chlorides in the artificial saliva. These authors confirmed the bigger Ni release at pH 4, then at pH 7, or 10 [23]. Costa et al. [9] examined the cytotoxical impact of orthodontic brackets on the cell L 929 colonies. They found the fibroblast colony diminished by 3% in the case of Cr-Ni brackets and fibroblast colony diminished by 2.7% in the case of low-Nickel brackets [9].

Issa et al. [25] studied the influence of different metal ions (Hg, Cu, Ni and other) on human oligodendrocytes (MO3.13) and gingival fibroblasts. They noted the bigger toxical influence of metals on MO3.13 then on gingival fibroblasts [25]. It is necessary to note that the concentration of ions in the experiments was higher compared to those found *in vivo* conditions. Mockers et al. [7] estimating the cytotoxicity of orthodontic elements onto the cells of mice fibroblasts L929, examined 22 new ones and 4 used (from 15 to 25 months) orthodontic brackets made of Cr-Ni and Ti and ceramic and polycarbonate brackets. They found non-toxical influence of the ceramic and metal orthodontic elements on the fibroblast cells *in vitro* conditions [7].

Petoumenou et al. [10] examined 18 generally healthy and non-smoking patients (8 boys and 10 girls) 12 to 18 years of age. They did not have dental fillings and had not used orthodontic braces at least 6 months before the experiment. They put 2 Ni-Ti arcs, 4 Cr-Ni bands, and 16 to 20 Cr-Ni brackets on everybody. After 2 months the authors found increases of Ni levels in the saliva of these children [10]. Menezes et al. [11] observed the Ni level increase in urine. Based on meta-analysis, Kolokitha et al. [26] ascertained that many orthodontical patients have hypersensivity to Nickel. Kerosuo et al. [8] stated, based on results of many examinations of physicians in Norway and Finland, that many patients using metal orthodontic elements containing Nickel felt discomfort in the oral cavity.

Ilikli et al. [2] making experiments with high-copper amalgams containing indium (Permite C) or platinum (Lojic+), found the least ion release at pH 3.5 for amalgam with indium. The least ions released in pH 6.5 and distilled water amalgam with platinum (Lojic+) [2]. In our study however, in which artificial saliva of pH 6.7 and the same Lojic+ amalgam was used, in OB/Lj set we found the initial GP values for this couple of electrodes were the highest compared to the set of bracket and amalgams Stabil B or Amalcap Plus of generations I or II, respectively (Tables 1 and 2). In our study when Coca-Cola and orange juice were employed, the highest GP low-copper amalgam (Stabil B) showed (Tables 1 and 2). Initial GP values were 10 times higher when orange juice was used compared to artificial saliva (Tables 1 and 2). For generation II and III amalgam sets the initial GP in the apple juice was ca 3.5 times higher for OB/Lj and ca 6.5 times higher for OB/Ap in comparison to artificial saliva. The sets with generation II and III amalgams did not show any variations in the initial GP values, regardless of the electrolyte employed (Tables 1 and 2).

Many authors dealing with the electrogalvanic phenomena emphasized how the acidic pH (pH=1-5) increased the corrosion of metal elements placed in the oral cavity [1, 22, 23, 27]. Not many, however, examined the corrosion and the galvanic currents occuring in cells composed of amalgams and orthodontic elements [27], with the use of low pH artificial saliva as the electrolyte [14-16, 20, 22, 23]. Karov and Hinberg [27] measured the initial values of galvanic currents in the pH 5 artificial saliva, occuring between the generation III amalgams (containing zinc or palladium) and orthodontic bracket of Cr-Ni alloy. The values received were not big and ranged from 0.3 to 1.0 μA [27].

Our study proved that in the cell composed of orthodontic bracket (Cr-Ni alloy) and generation III amalgam (but with the addition of platinum) and artificial saliva of pH 6,7 the GP initial values were 25 times higher and equalled 7.4 $\mu A/cm^2$ by the amalgam surface and 23.3 $\mu A/cm^2$ by the bracket surface (Tables 1 and 2). Ciszewski et al. [20] examined the corrosion of Cr-Ni alloys (Remanium CS and Remanium GM380) and generation II amalgam (Amalcap Plus) in the artificial saliva of pH 5.6. They found the biggest corrosion of the amalgam (potential=-87 mV), and the smallest on Remanium GM380 (potential=5 mV). The literature quotes the artificial saliva of different pH rate as the most often used electrolyte; the specific buffers (pH rates 4, 7, 10) also. The other potential electrolytes were not taken under consideration – like alimentary beverages, mouth washing liquids etc. They have various pH rate, often acidic ones and can modify the environment of the oral cavity, increasing the possibility of galvanic currents occurence by the potential electrodes, which may create different generations of amalgams, orthodontic braces, and more.

The importance of the problem shown by our previous experiments with the different electrolytes employed (including alimentary beverages) and various alloys used in dentistry [14-16], proves that in these conditions the galvanic interactions between the orthodontic band with bracket and orthodontic bracket [14] as well as between amalgams and titanium implant [15] are of the scale to effect the occurence of some symptoms described in literature as oral galvanism [17, 28, 29].

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