Comparative Study on Nickel and Chromium Salivary Concentration in Patients with Prosthetic Restorations on Metallic Frame

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The present study aims to analyze the compozition of saliva in wearers of metallic prosthetic restorations by determining the concentration of Cr, Ni, Co in the saliva of the studied subjects. The saliva composition was analyzed in subjects at 6 months after they received prosthetic restorations in the oral cavity compared with the salivary composition of the same subjects before receiving these restorations.

Keywords: salivary concentration, microelements, corrosion

The problem of cytotoxicity elements in the dental alloys has been the subject of numerous studies being a controversed topic.

One of the main aspects with projection in the clinical domain specifically refers to the corrosion products which through the action at the oral cavity level have both local and general manifestations[6,7, 19-21]. The composition of the Ni-Cr alloys in accordance with ISO standard is: Ni: basic constituent, Cr: not less than 20%, Mo: not less than 4%, Be: not more than 2%. Ni + Co + Cr not less than 85%. A typical alloy contains 70-80% Ni, 10-25 Cr, and small amounts of Mo, tungsten, Be. As in the case of Co-Cr alloys, the concentration of minor constituents has an effect upon the properties of the alloy. Alloys based on Ni-Cr and Co-Cr have a good corrosion resistance due to the passivation effect, the oxides layer on the surface of the alloy, being immediately rebuilt in the event of scratching the surface. Accordingly, the amount of released metal ions is relatively low, which entails that their biocompatibility is good. The relative low ductility represents a major disadvantage of these alloys. Analyzing the characteristics of the two non-nobile alloys types indicates the use of Co-Cr mainly for the metallic frame of partial movable framed dentures, where the increased value of elasticity module is very important. Non-nobile alloys contain components with toxic or allergic potential. For the patient, the greatest risk is represented by Ni, causing allergic contact reactions, even in low concentrations. Chromium is known for its carcinogenic potential and it represents an increased risk for staff, who inhales dust during processing and polishing.

Permanent deformation under the action of mechanical forces, according to Co-Cr alloys properties should not be allowed. In addition, the low density of Co-Cr alloys makes them lighter. The metal frames of restorations should also bear high levels of mechanical forces without deformation, and a lower elasticity module would allow them engage with ease at the retentive areas. The alloy from which the frames are manufactured must be ductile, so that they can be adjusted without being fractured.

Ni-Cr alloys are used increasingly for the metallic frame of the movable partial framed prostheses due to an easier finishing and polishing.

Experimental part

Material and methods

Sample preparation

Sample preparation is done according to ISO 11464 - Pretreatment of samples for physico-chemical analyzes.

The saliva specimens were collected from a group of 20 patients of which in 10 there were inserted prosthetic restorations on Ni-Cr frame and in 10 there were inserted prosthetic restorations on Co-Cr frame. There were used control samples obtained before inserting restorations in the oral cavity. The collected samples for testing were obtained at 6 months after the patients received prosthetic restorations in the oral cavity.

Control sample

The control sample is preserved until getting the samples for testing through cryogenics. For testing it is prepared at the same time with the sample to be analyzed, following the same procedure and using for determination the same quantities of all reagents.

For Chrome. In case of measurement in flame/acetylene, 10 mL of lanthanum chloride solution is added in the control container and in each container with standards and samples. The efficiency of chromium extraction from the analyzed samples depends on the nature of the present compounds with chromium; the analytical serum is strongly affected by elements of matrix from the extract.

In case of Nickel. For the wavelength $\Lambda = 232.0$ nm, it is selected a spectral band width of 0.2 nm to seperate the analytical line from the adjacent non-absorbent lines.

Calibration

The atomic absorption spectrometer is turned on according to the instructions at the right wavelength in compliance with the recommended conditions and corresponding background correction system in operation. A calibration solution is sucked up and the suction conditions are optimized, as well as the height of the burner and the flame conditions. The instrument response is adjusted at zero absorbance while the water is sucked up. The set of calibration solutions is sucked up in ascending order and as the zero deadline the control solution of calibration is sucked up (drawn in). After about 10 min the

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Element	Wave length (nm)	Flame type	Lanthanum chloride	Main interference	Background correction
Chromium	357.9	Air/acetylene or acetylene/ reducing N2O	Yes	Fe, Al	Halogen
Cobalt	240.7	Aer/acetilenă oxidantă	No		Deuterium
Nickel	232.0	Aer/acetilenă oxidantă	No	Fe	Deuterium

Table 1
METAL CONTENT OF THE EXTRACT WAS DETERMINED USING Ni, Co AND Cr:

		Ni µg/L	Cr µg/L	Co µg/L
Ni-Cr alloys	1	18.7	3.46	0.56
	2	19.2	3.72	0.45
	3	18.5	3.03	0.49
	4	18.8	3.54	0.65
	5	19.1	3.58	0.58
	6	23.3	3.64	0.44
	7	18.7	3.41	0.51
	8	18.9	3.51	0.54
	9	19.2	3.58	0.62
	10	19.6	3.32	0.67

Table 2
MEDIUM VALUES OF DETERMINATION FOR THE PATIENTS WITH Ni-Cr ALLOYS

		Ni µg/L	Cr µg/L	Co µg/L
Co-Cr alloys	1	12.8	3.23	0.39
	2	13.4	3.21	0.36
	3	14.1	3.08	0.37
	4	12.3	3.04	0.34
	5	12.5	2.89	0.27
	6	12.9	2.75	0.32
	7	14.6	3.01	0.31
	8	13.8	2.89	0.35
	9	14.0	2.91	0.29
	10	12.9	2.97	0.31

Table 3
MEDIUM VALUES OF DETERMINATION FOR THE PATIENTS WITH Co-Cr ALLOYS

absorbance of each solution is checked at least twice. If the values fall within an acceptable range, thier average is performed. When higher concentration standards are used, the absorbance should be > 1, preferably <7.

Results and discussions

From the obtained calibration curve it is determined the content of element corresponding to the absorbance of the analyzed sample and of the control sample. It is calculated the content (W) of element M in the sample using the equation:

$$W(M)=(\Lambda_1 - \Lambda_0)/f x V$$

where:

$W_{(M)}$ – the amount of element M in the sample, mg/kg;

Λ_1 – the content of element corresponding to the absorbance of the analyzed sample mg/L;

Λ_0 – the content of element corresponding to the absorbance from control sample solution, mg/L;

f – dilution factor, if the sample for testing was diluted,

V – the volume of the sample taken for analysis, in liters; 0.1l in accordance with ISO 11466;

m – the mass (weight) of sample in kg corrected toward the water content according to ISO11465 and treated according to ISO 11466. The measurement uncertainty reported for results should reflect the results from quality control measurements and include the deviation between the individual readings for the sample in question. In general, the values should not be expressed with a degree of accuracy greater than two significant digits. Rounding of the values depends on the statistics of quality control procedures aforementioned and of the analysis requirements.

Element	Mg/Day	Toxicity	Citotoxicity	Alergies
Cr	0.1	Low for the metal and Cr (III) High for Cr (VI)	Low for Cr (III) High for Cr (VI)	High for Cr (IV)
Co	0.02	Low	High	3% of population
Ni	0.5	Fine granules-carcinogenic effect Low for others	Low	High frequency

Table 4
BIOLOGICAL EFFECTS OF SOME CHEMICAL ELEMENTS[4]

The microelements analysis was done on three parallel samples for each patient. For the series of samples obtained, the results of the analysis are presented in table 2 and 3.

The largest amount of Ni has been identified in patients with restorations on Ni-Cr frame. However, the amount is comparable to the one measured at the others, what implies that the analyzed Co-Cr alloy contains Ni. Regarding the saliva analysis, the results can be correlated with the literature [8, 10-13] that incriminate the ions of Ni, Cr, Co as ions with cytotoxic potential [2,3, 5,9].

If we transform the results from μg/L to μg/cm^2/week and if we consider de EU standards(0.5 μg/cm^2/week) then we can affirm that the two alloys may be used in dentistry without problems.

The obtained values do not exceed the limits imposed by the European directives of Nickel. As for Cr and Co we do not have information about a limit at level of European legislation [12,14,15], therefore, we refer to the Nickel limits, this meaning that the values we obtained are relatively small.

The alloys used for RPF have to be tough, rigid and durable, both Ni-Cr and Co-Cr due to their suitable properties. High rigidity of Ni-Cr indicates it for bridges, especially the long ones. As for the ductility, alloys based on Co-Cr has a distinct advantage, they also having a shrinkage less than Ni-Cr. In case of performing the occlusal surfaces of metal, the occlusal adaptation is done more difficult for Co-Cr alloys due to the alloy hardness.

Conclusions

All the samples studied have a low metal content, situated within the limits of the actual reglementations, which allow and actually recommend them for the ISO standard[13,16-18]. The oligoelement, Ni is found in concentrations of over 0.5 μg/cm^2/week in whole samples, and the microelements Cr, Co determined are under 0.5 μg/cm^2/week[1].

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