CHANGES IN THE MICROELEMENT COMPOSITION AND PH OF THE ORAL LIQUID AFTER PROSTHESIS WITH SOLID-CAST BRIDGE DENTURES

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Summary

Introduction. The environment of the oral cavity is a complex electrolyte environment with variable pH values, in which metal restorations release metal ions. These ions can induce cell apoptosis through intrinsic and extrinsic pathways. Dental alloys require excellent wear resistance and biocompatibility, which can extend the service life of removable prostheses.

Aim. To study the composition of microelements and pH in the oral fluid in the presence of fixed cast prostheses made of cobalt-chromium and nickel-chromium alloys Remanium GM 700 and Remanium CSe of certified delivery and after multiple remelting.

Materials and methods. 120 patients aged 25 to 60 took part in our study, including 79 women (65.9 %) and 41 men (34.1 %), who were divided into 4 groups of 30 people each. In the presented research studied the composition of microelements and pH in the oral fluid in the presence of fixed cast prostheses made of cobalt-chromium and nickel-chromium alloys Remanium GM 700 and Remanium CSe of certified supply and after multiple remelting. Depending on the type and topography of the defect in the dental row, patients were made permanent cast dentures.

Results. After 7 days, the pH value shifted to the acidic side in people who were made solid-cast constructions with the specified alloys, and after 3 months it reached a neutral value. The dynamics and degree of expression of the change in pH depend on the timing of the study, the quality of the alloy, and the technological process of manufacturing solid-cast structures of dental prostheses.

Conclusions. We determined that the composition of microelements of oral fluid in the presence of solid-cast prostheses changes under the influence of random factors. The studied alloys do not harm the patient’s organism and therefore can be used for the production of solid-cast constructions of dental prostheses.

Keywords: prosthesis, dental materials, metal alloys, stomatitis, oral fluid

INTRODUCTION

Success with cast partial denture frameworks requires close attention to both clinical and laboratory procedures. Over the years, the philosophy of developing cast partial prostheses has undergone minor changes. However, there have been drastic changes in the manufacturing procedure in relation to smelting materials, casting techniques and, especially, foundry alloys. A few years ago, gold alloys remained the main material for the production of cast frameworks of partial prostheses, but the unstoppable increase in the cost of gold shifted the focus to relatively cheaper alloys of low-value metals [1]. Metal alloys, which are used for the manufacture of solid-cast bridge prostheses, form substances with the properties of haptens. Among them, nickel, chromium, cobalt, which, combining with whey protein, acquire the properties of full-fledged antigens. The latter can cause various diseases and allergies [2-4].

The environment of the oral cavity is a complex electrolyte environment with variable pH values, in which metal restorations release metal ions [5]. These ions can induce cell apoptosis through intrinsic and extrinsic pathways. Dental alloys require excellent wear resistance and biocompatibility, which can extend the service life of restorations [6-8]. Co-Cr alloys are widely used in the manufacture of frameworks for removable partial prostheses, PFM and metal crowns [9, 10].
Cobalt–chromium (Co–Cr) alloys were first used to make cast frameworks for partial dentures in 1933. Initially, there were many technical difficulties and the use of Co–Cr in dentistry was limited until improvements in alloy production and processing techniques led to a wider use of these alloys. Co–Cr alloys exhibit good strength and stiffness, are light and corrosion resistant, and have a low cost, making them ideal for use in cast partial dentures. In the current economic conditions, dentists and technicians must be aware of the costs involved in the production of cast frameworks [11, 12-14].

AIM

To study the composition of microelements and pH in the oral fluid in the presence of fixed cast prostheses made of cobalt–chromium and nickel–chromium alloys Remanium GM 700 and Remanium CSe of certified delivery and after multiple remelting.

MATERIALS AND METHODS

In total, 120 patients aged from 25 to 60 years, 79 women (65.9 %) and 41 men (34.1 %) participated in the study, who were divided into 4 groups, 30 people in each. In the I control group, prostheses were made of Remanium GM 700 alloy (cobalt chrome alloy) of certified supply; in the II control group – from the Remanium CSe certified alloy (nickel chrome alloy); in the III group – from repeatedly remelted (1-6 times) Remanium GM 700 alloy; in the IV group – from repeatedly remelted (1-6 times) Remanium CSe alloy. Depending on the type and topography of the defect in the dental row, patients were made permanent cast dentures. A total of 65 solid-cast bridge prostheses were manufactured, including 130 supporting solid-cast crowns and 69 individual crowns made of certified and recirculating alloys.

The study of the effect on the pH of solid-cast dental prostheses made of cobalt–chromium and nickel–chromium alloys in the state of recirculation was carried out on 40 patients, 10 people from each study group. The study of this indicator was carried out before prosthetics, 7 days and 3 months after prosthetics using a universal ionometer EB-74.

The hydrogen index (pH) of unstimulated saliva in the oral fluid in the presence of fixed cast prostheses made of certified and recirculating alloys Remanium GM 700 and Remanium CSe of certified delivery and after multiple remelting.

RESULTS

The reaction of saliva to the manufactured non-removable solid-cast constructions of prostheses was studied before orthopedic treatment, on the day of delivery of the prosthesis, after 7 days, after 3 months of using the prostheses, which made it possible to detect the patient’s tendency to the occurrence of electrochemical phenomena.

The study of the pH of the oral fluid showed that the extreme measurements in the control group were in the range of 6.2-7.4. In people who were made of solid-cast constructions made of repeatedly remelted cobalt-chromium and nickel-chromium alloys, pH fluctuations were in the range of 6.3-7.3 (fig. 1).

After analyzing the pH indicators of the oral fluid in the study groups, we obtained the following results. After the production of solid-cast constructions from cobalt-chromium alloys, the pH in the subjects was within the parameters of the control group: 6.2-7.4 (for the I group), and in the group where this alloy was subjected to multiple remelting (III group), the pH was equal to 6.5-7.3. In people who were made solid-cast constructions from nickel-chromium alloys (II group), the pH values were 6.2-7.3, and after repeated remelting of this alloy – 6.3-7.2 (IV group).

The obtained results indicate that most often a neutral and slightly alkaline reaction occurs in patients. After 7 days, the pH value shifted to the acidic side in people who were made solid-cast constructions with the specified alloys, and after 3 months it reached a neutral value, and at the same time there were no significant differences compared to the control (p>0.05).

The analysis of clinical studies showed that neutral and slightly alkaline reactions were most often determined. However, the average value of pH is such that it does not lead to a pathological state of local tissues and the organism as a whole (p>0.05).

According to the results of the spectral analysis, in all saliva samples of patients of the control and experimental groups 3 months after prosthetics, Co and Ni were not found, with the exception of 1 patient of group IV, who had an alloy prosthesis made: after 5 remelting — on the 7th day traces of nickel were found. Chromium was found in all patients of all research groups, amounting to 1·10⁻⁴ wt.%. In addition to these elements, Mo, Fe, Al, Si, Mn, Cu, Ca, Na, K were found (tab.1).
Therefore, the content of trace elements in the oral fluid does not have a significant anodic dissolution. Conditions for dissolution of alloys and release of components of dental prostheses into oral fluid do not differ significantly either between groups or within each group.

**DISCUSSION**

In the open-access literature sources, we did not find data on how the physicochemical and technological characteristics of non-noble alloys change after repeated remelting, and whether prostheses made of these alloys are biocompatible for patients. This has become a subject of study. One of the objectives of the study was to evaluate the impact of prostheses made of repeatedly remelted cobalt-chromium and nickel-chromium alloys on the quantitative indicators of oral fluid. An increase in the concentration of cobalt, chromium, nickel, and molybdenum in the oral fluid indicates that the appearance of these elements is a consequence of the interaction of the surface of the samples with the environment. As a result of such interaction, the formation of oxides, carbides, nitrides, etc., as well as more complex compounds involving water and carbon [1, 13, 14].

The formation of surface compounds is regulated by the laws of thermodynamics, an important one of which is the reduction of free surface energy. In parallel with the processes of formation of surface chemical compounds, the effects of selective dissolution of the alloy components by keeping them in an active chemical solution, which can be considered saliva, are possible.

According to some authors, there is no completely inert dental metal alloy, which is confirmed by the results of special studies. The analysis of literature data on this issue showed that in connection with different opinions there is a need to further search for the perfect quality of dental alloys [15-18].

Aspects of this problem can be considered as the corrosion behavior of materials in an electrolyte environment, which is saliva (oral fluid) of people, on the one hand, and the phenomenon of galvanism — on the other [13, 19]. The basis of these phenomena is the release of metal ions from the surface of the alloys through the oxide film into the solution. Minor changes in the chemical composition of the alloy can lead to the release of its elements into the solution. The phase composition of the alloy microstructure has a strong effect on the release of alloying elements into the solution. In the case of long-
term metal-electrolyte contact, partial destruction of the dental alloy may occur. Elements isolated from denture alloys can have a harmful effect on the whole organism [20, 21]. Qualitative and quantitative evaluation of the saliva spectrogram is carried out to detect the toxic effects of heavy metals. Evaluation of the quality of dental prostheses structures in the oral cavity together with a spectrogram helps to differentiate mechanical irritation, toxic and allergic stomatitis [22].

In the case of an increase in the content of haptens in saliva – nickel, chromium, cobalt, manganese (more than 1x10^{-6} %) – there is a need to rework the solid-cast construction. An increase in the content of trace elements that create a toxic effect (copper, cadmium, lead, bismuth) is also a reason for removing the prosthesis [1, 11, 23].

Our studies have shown that the trace element composition of the oral fluid in the presence of solid-cast prostheses changes under the influence of the above-mentioned factors. According to the obtained data, we have established the absence of cobalt and nickel in the saliva of patients in the experimental and control groups. The chromium content did not exceed 1x10^{-4}. Changes in the inorganic composition of the oral fluid when using prostheses made of repeatedly remelted Remanium GM 700 and Remanium CSe alloys, both quantitatively and qualitatively, are not characteristic of «microelement diseases» — deficiency, excess or imbalance of microelements in the body, which makes it possible to recommend repeatedly remelted alloys for the manufacture of dental prostheses.

**CONCLUSIONS**

Qualitative and quantitative evaluation of the oral fluid spectrogram is carried out to detect the toxic effects of heavy metals. Evaluation of the quality of dental prostheses structures in the oral cavity together with a spectrogram helps to differentiate mechanical irritation, toxic and allergic stomatitis.

Multiple remelting of cobalt-chromium and nickel-chromium alloys affects the concentration of hydrogen ions in the oral fluid. The dynamics and degree of expression of the change in pH depend on the timing of the study, the quality of the alloy, and the technological process of manufacturing solid-cast constructions of dental prostheses. We determined that the composition of microelements of oral fluid in the presence of solid-cast prostheses changes under the influence of random factors.

Our clinical data confirm the opinion that the studied Remanium GM 700 and Remanium CSe alloys after repeated remelting do not harm the organism according to the obtained parameters and therefore can be used for the manufacture of solid-cast constructions of dental prostheses.

**Prospects for future research.** Considering the significant prevalence of dental and dentition defects among the population of Ukraine that require restoration with orthopedic structures, it is advisable to continue the study of the microbiological composition of oral fluid, and also study the electrochemical effect of fixed solid-cast denture to better understand the biocompatibility of fixed solid-cast dentures made from repeatedly remelted alloys.

**COMPLIANCE WITH ETHICAL REQUIREMENTS**

The study was carried out in compliance with the main provisions of the Declaration of Helsinki of 1975, revised in 2000, the Council of Europe Convention on Human Rights and Biomedicine (2007) and the recommendations of the Bioethics Committee of the Presidium of the National Academy of Medical Sciences of Ukraine (2002). The manipulations were approved by the bioethics commission of the I. Horbachevsky Ternopil National Medical University. The clinical dental examination took place after the patients signed the appropriate informed consent for dental procedures.

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**REFERENCES**


Резюме

ЗМІНИ МІКРОЕЛЕМЕНТНОГО СКЛАДУ ТА РН РОТОВОЇ РІДИНІ ПІСЛЯ ПРОТЕЗУВАННЯ СУЦІЛЬНОЛИТИМИ МОСТОПОДІБНИМИ ПРОТЕЗАМИ

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Вступ. Ротова порожнина є складним електролітним середовищем зі змінними значеннями рН, у якому металеві конструкції виділяють іони металів. Ці іони можуть індукувати апоптоз клітин через внутрішні та зовнішні шляхи. Стоматологічні сплави вимагають відмінної зносостійкості та біосумісності, що може подолати термін служби незнімних конструкцій.

Мета. Вивчити склад мікроелементів та рН у ротовій рідині за наявності незнімних суцільнолитих протезів, виготовлених із кобальтохромових та нікелехромових сплавів Remanium GM 700 і Remanium CSe сертифікатної поставки та після багаторазової переплавки.

Матеріали та методи. У нашому дослідженні взяли участь 120 пацієнтів віком від 25 до 60 років, із них 79 жінок (65,9 %) і 41 чоловік (34,1 %), які були розділені на 4 групи, по 30 осіб у кожній. У представленим дослідженні вивчали склад мікроелементів та рН у ротовій рідині за наявності незнімних суцільнолитих протезів, виготовлених із кобальтохромових та нікелехромових сплавів Remanium GM 700 і Remanium CSe сертифікатної поставки та після багаторазової переплавки. Залежно від виду та топографії дефекту зубного ряду пацієнта виготовляли незнімні суцільнолиті протези.

Результати. Через 7 діб в осіб, яким виготовляли суцільнолиті конструкції вказаними сплавами, значення рН змінювалося у кислий бік, а через 3 місяці досягало нейтрального значення. Динаміка і ступінь вираженості зміни рН залежать від термінів проведення дослідження, якості сплаву, технологічного процесу виготовлення суцільнолитих конструкцій зубних протезів.

Висновки. Нами визначено, що склад мікроелементів ротової рідини під впливом випадкових факторів змінюється під впливом випискових факторів. Досліджувані сплави не шкодять організму пацієнтів і тому можуть бути використані для виготовлення суцільнолитих конструкцій зубних протезів.

Ключові слова: протезування, стоматологічні матеріали, металеві сплави, стоматит, ротова рідина