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Biological compatibility of metal structures of dentures made from multiple melted alloys

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Biological compatibility of metal structures of dentures made from multiple melted alloys

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The issue of reuse of metal alloys in dentistry raises debatable questions about their impact on the human body.

The aim of the study was the evaluation of the biocompatibility of metal structures of dentures made from cobalt-chromium and nickel-chromium alloys Remanium GM 700 and Remanium CSe after repeated vacuum remelting.

Materials and methods. Clinical study and treatment with fixed prostheses based on Remanium GM 700 and Remanium CSe were performed among 120 patients aged 25-60 years. The biocompatibility of the above-mentioned denture designs with oral tissues was studied.

Results. Prostheses made from Remanium GM 700 and Remanium CSe alloys are biologically indifferent, which is confirmed by the indicators of alkaline and acid phosphatase activity within the physiological norm. Regardless of the number of remelts, these alloys do not cause dysbacteriosis. The obtained results do not depend on the terms of observation, which indicates the safe use of remolten alloys for dental prosthetics.

Conclusions. The investigated alloys are biocompatible and can be used for the manufacture of solid structures of dentures.

Key words: casting, cobalt-chromium alloy, nickel-chromium alloy, biocompatible alloy

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Zgodność biologiczna konstrukcji metalowych protez wykonanych ze stopów wielokrotnie topionych

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Ponowne wykorzystania stopów metali w stomatologii budzi kontrowersje dotyczące ich wpływu na organizm człowieka.

Celem pracy było zbadanie biogodności konstrukcji metalowych protez wykonanych ze stopów kobaltowo-chromowych i niklowo-chromowych Remanium GM 700 i Remanium CSe po wielokrotnym przetopie próżniowym.

Materiał i metody. Badanie kliniczne i leczenie protezami stałymi opartymi na Remanium GM 700 i Remanium CSe przeprowadzono u 120 chorych w wieku 25-60 lat. Zbadano biogodność wyżej wymienionych konstrukcji protez z tkankami jamy ustnej.

Wyniki. Protezy wykonane ze stopów Remanium GM 700 i Remanium CSe są obojętne biologicznie, co potwierdzają wskaźniki aktywności fosfatazy alkalicznej i kwaśniej w granicach normy fizjologicznej. Niezależnie od liczby przetopów stopy te nie powodują dysbakteriozy. Uzyskane wyniki nie zależą od czasu trwania obserwacji, co wskazuje na bezpieczne stosowanie stopów wielokrotnego użytku do protetyki stomatologicznej.

Wnioski. Badane stopy są biogodne i mogą być wykorzystywane do wykonywania odlewanych konstrukcji protez.

Słowa kluczowe: odlew, stop kobaltowo-chromowy, stop niklowo-chromowy, stop biogodny

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Dental materials science provides a wide range of materials, the properties of which allow their use in certain clinical cases, what dictate the choice of material for the manufacture of orthopedic structures, based on its properties, which is not always possible to achieve using modern materials. One of such constructions are solid prostheses [7,11]. Changes in the main indicators of physical and mechanical properties of metal alloys during their operation can lead to galvanic disorders, toxic effects, allergic reactions, changes in the reactivity of the organism [14]. In the available literature there are a small number of studies of physicochemical and technological characteristics of these alloys by their repeated remelting, which does not fully disclose the biocompatibility of orthopedic structures made on their basis [15]. Thus, this issue is relevant and needs a comprehensive study.

The aim of the study was to evaluate the biocompatibility of metal structures of dentures made from cobalt-chromium and nickel-chromium alloys Remanium GM 700 and Remanium CSe after repeated vacuum remelting.

MATERIALS AND METHODS

Clinical examination and orthopedic treatment with fixed cast structures were performed among 120 patients aged 25 to 60 years, including 79 women (65.9%) and 41 men (34.1%), who were divided into 4 groups of 30 people, with which I, II groups – control, III, IV groups – research [6].

Patients in all experimental groups were divided by age into three age categories: 25-35 years, 36-45 years, 46-60 years; 30 people in each group. Prosthetics began with the rehabilitation of the oral cavity. When choosing the design of dentures, the age of patients, the topography of dentition defects, the condition of abutment teeth and periodontal tissues were taken into account. A total of 65 solid bridge prostheses were manufactured. Observation and clinical examination of patients was performed after fixation of prostheses in the oral cavity with „Meron” (Voco) cement, after 7 days and after 3 months. The prostheses had a high quality cast, which was determined by the exact fit on the models and on the abutment teeth in the oral cavity.

In clinical examination used tests for determination: saliva pH, potential values of metal inclusions, potential strengths between individual metal structures and elements. The biocompatibility of the dentures with oral tissues was studied by cytological examination of the mucous membrane in the area where the dentures fit. The effect of metal alloys on marginal periodontal tissues was studied using the test by Schiller-Pisarev, and the factors of local immunity and nonspecific protection of the oral mucosa were studied by studying the activity of lysozyme, alkaline and acid phosphatase in oral fluid and microflora [5].

For an objective assessment of the results and determine the probability of all study data were statistically processed according to the methods adopted in clinical medicine. The obtained data were processed using the licensed program „Statistica” of the company „StatSoft” [1,10].

The general ethical rules of humane treatment of patients were observed in accordance with the requirements of the Tokyo Declaration of the World Medical Association, the International Recommendations of the Helsinki Declaration of Human Rights, the Council of Europe Convention on Human Rights and Biomedicine.

RESULTS

The study of the effect of solid dentures made of cobalt-chromium and nickel-chromium alloys in the state of recirculation on the pH of oral fluid was performed on 40 patients. The studies were performed before prosthetics, 7 days and 3 months after prosthetics using a universal ionometer EV-74 (tab. 1).

Table 1. Average indicators of measurements of pH of oral fluid in different terms of research

Tabela 1. Średnie pomiary pH śliny ustnej w różnych momentach badania

Group	Number of studies	Terms of observations		
		Before prosthetics	7 days after prosthetics	3 months after prosthetics
I	10	7.3±0.005	6.2±0.05	7.4±0.05
II	10	6.7±0.008	6.2±0.05	7.3±0.05
III	10	6.8±0.007	6.5±0.008	7.3±0.07
IV	10	6.9±0.007	6.3±0.05	7.2±0.05

After 7 days, the pH value shifted to the acidic side, and after 3 months reached a neutral value and there were no significant differences compared with the control ($p>0.05$). The

dynamics and severity of pH changes after remelting Remanium GM 700 and Remanium CSe depend on the timing of the study, the quality of the alloy, the technological process of manufacturing solid structures of dentures. However, the average pH does not lead to pathological changes in local tissues and the body as a whole ($p>0.05$).

For study the lysozyme activity, acidic and alkaline phosphatase of oral fluid in patients of the experimental groups, the level of lysozyme in the saliva of 40 patients was studied (tab. 2).

Prosthetics with non-removable structures made from Remanium GM 700 and Remanium CSe alloys slightly reduces the lysozyme activity of oral fluid, affecting the local immunity in the first days after prosthetics compared with the data before prosthetics. In the future, this indicator is growing. This dependence is observed in groups where prostheses were made of the same remolten alloys.

Studies of alkaline and acid phosphatase activity were evaluated by the amount of isolated inorganic phosphorus selectively in all experimental and control groups (total 40 patients) before prosthetics, after 7 days and after 3 months (tab. 3).

The results of the study of alkaline and acid phosphatase of the oral fluid show that they respond to the presence of metal inclusions in the oral cavity. In all control and experimental groups, the activity of acid phosphatase was higher than the activity of alkaline phosphatase ($p<0.05$). Alkaline phosphatase activity was within normal limits, and acid phosphatase activity was slightly higher than normal in some patients, due to the adaptive-compensatory period.

For quantitative and qualitative characterization of microorganisms in oral fluid, 379 cultures were isolated, of which 205 (54.0%) were *Streptococci*, 114 (30.0%) were *Staphylococci* and 60 (16.0%) were *Candida* fungi. Prior to prosthetics, *Streptococcal* cultures were isolated from 74 patients (92.5%) out of 80, *Staphylococci* from 39 patients (48.7%), and *Candida* fungi from 20 patients (25.0%). 1 day after prosthesis, *Streptococci* were detected in 29 patients (36.3%), *Staphylococci* – in 15 patients (18.7%), yeast-like fungi – in 9 patients (11.2%). 3 months after prosthesis, respectively, in 79 patients (98.7%), in 45 patients (56.2%), in 24 patients (30.0%).

Studies of the dynamics changes of the total number of oral microorganisms show that in all experimental groups a day after prosthetics decreased by 3 times the frequency of cultures of *Streptococci*, *Staphylococci*, *Candida* fungi. There was no statistically significant difference between the total amount of microflora when using prostheses made of Remanium GM 700 and Remanium CSe in the state of certified delivery and after repeated remelting ($p>0.05$). Alloys Remanium GM 700 and Remanium CSe, regardless of the number of

Table 2. Lysozyme activity of saliva in patients with prostheses based on Remanium GM 700 and Remanium CSe

Tabela 2. Aktywność lizozymu śliny u pacjentów z protezami opartymi na Remanium GM 700 i Remanium CSe

Experimental groups	Number of patients	Mean square value		
		Before prosthetics	After prosthetics	
			7 days	3 months
I group – certified alloy Remanium GM 700	10	41.6%	40.1%	41.5%
II group – certified alloy Remanium CSe	10	36.8%	32.6%	36.5%
III group – remolten alloy Remanium GM 700	10	38.0%	36.0%	38.2%
IV group – remolten alloy Remanium CSe	10	32.0%	30.0%	32.0%

Table 3. Average indicators of enzyme activity in patients (n=10) of control and experimental groups (mmol / g*1)

Tabela 3. Średnie wskaźniki aktywności enzymatycznej u pacjentów (n=10) z grupy kontrolnej i eksperymentalnej (mmol / g*1)

Groups of patients	Oral fluid enzymes	
	Alkaline phosphatase	Acid phosphatase
Group I – control	0.41±0.03	0.52±0.06
Group II – control	0.46±0.02	0.81±0.02
Group III – 6 x remolten Remanium GM 700	0.44±0.02	0.67±0.11
Group IV – 6 x remolten Remanium CSe	0.28±0.03	0.91±0.04

remelts in the clinic do not have antimicrobial activity against naturally occurring microorganisms in the oral cavity, therefore, when used will not cause dysbacteriosis, which is important for homeostasis of the oral cavity.

The magnitude of electropotentials between the support crowns and the oral mucosa and between the body of the prosthesis and the mucous membrane was measured for study the electrochemical processes in the oral cavity during prosthetics with structures made of remolten alloys Remanium GM 700 and Remanium Cse. All measurements were made immediately after fixation of the prosthesis, after 7 days and 3 months (tab. 4).

Compared the indicators of groups II with IV, where Remanium CSe was used – constructions show better indicators. The statistical difference between them is significant and highly reliable ($p < 0.01$). In groups III and IV of patients, the indicators of electropotentials in similar leads differed significantly from those in groups I and II ($p < 0.01$). This is due to the chemical purity of alloys devoid of various inclusions. These differences do not depend on the timing of observation, which is an indicator of the homogeneity of the structure and indifference in the oral cavity and indicates the possibility of using reusable alloys for dental prosthetics.

thorough examination, a qualitative cytological analysis was performed, which found that 7 days after fixation of prostheses, the process of leukocyte migration and exfoliation of mucosal epithelial cells in patients who made prostheses from remolten alloys, was more active than control. The same pattern of leukocyte migration, but less pronounced, was observed after 3 months, and the exfoliation of epithelial cells decreased. The ratio of „epithelial cells-granulocytes” in smears-imprints of the oral mucosa is 1:2. In patients, the cellular composition of smears-imprints from the surface of the oral mucosa was approaching normal ($p > 0.01$). Thus, our research is a strong argument that indicates that solid prostheses made of remolten alloys are characterized as biocompatible.

DISCUSSION

The quality of prosthetics and properties of alloys after casting were tested by studying the pH of oral fluid, studying the factors of local immunity and nonspecific protection of the oral mucosa (lysozyme, acidic and alkaline phosphatase), the microbiological state of the oral cavity. The influence of experimental alloys on the marginal periodontium was studied using

Table 4. Values of electropotentials of dentures (in mV) ($p > 0.01$)
Tabela 4. Wartość potencjałów elektrycznych protez (w mV) ($p > 0.01$)

Groups	Number of patients	Placement of electrodes and the difference of electric potentials in different terms of research (M±m)					
		Crown-mucous membrane			The body of the prosthesis-mucous membrane		
		On the day of fixation	After 7 days	After 3 months	On the day of fixation	After 7 days	After 3 months
I	10	52.0±4	54.0±4	52.0±4	53.0±3	76.0±4	53.0±3
II	10	54.0±4	80.0±4	55.0±3	56.0±5	79.0±5	55.0±4
III	10	56.0±3	79.0±4	60.0±3	62.0±3	74.0±5	61.0±4
IV	10	57.0±3	80.0±2	70.0±2	70.0±2	80.0±2	70.0±2

To study the inflammatory processes of the mucous membrane of the marginal periodontium when using fixed solid dentures made from remolten alloys, the intensity of staining of the gingival margin was determined using the test by Schiller-Pisarev (tab. 5).

the test by Schiller-Pisarev and on the condition of the oral mucosa by cytological examination of smears-imprints from the surface of the oral mucosa [2]. The analysis of clinical studies showed that the most commonly determined neutral and slightly alkaline reaction and that the dynamics and degree of

Table 5. Indicators of the test by Schiller-Pisarev in the observation groups
Tabela 5. Wskaźniki testu Schillera-Pisarewa w grupach obserwacyjnych

Patient groups	Number of subjects		Sample parameters								
			Before prosthetics			After 1 day			After 3 months		
			+	++	+++	+	++	+++	+	++	+++
I	Total	30	2	2	1	2	1	-	1	-	-
II	Total	30	3	2	1	2	1	-	1	-	-
III	Total	30	2	2	1	1	1	-	1	-	-
IV	Total	30	4	2	1	2	1	-	1	-	-

The inflammatory reaction of the mucous membrane of the marginal periodontium is determined and persists for 3 months after prosthetics, but it is weakly positive, which indicates adaptation and biocompatibility. The best results of this study were in patients who made prostheses from Remanium GM 700 alloy.

In order to study the biological response of the oral mucosa to solid prostheses made from remolten alloys Remanium GM 700 and Remanium CSe, investigated the cellular composition of smears-imprints of the mucous membrane of the inner surface of the cheek. To assess the nature of the reaction of the oral mucosa on solid prostheses, we took into account the results of qualitative cytological analysis in the dynamics of clinical observations – before prosthetics, 7 days after prosthesis fixation and 3 months after prosthetics. A total made of 60 studies of impression depending on the type of alloy. For a

expression of pH changes depend on the timing of the study and the quality of the alloy. The average pH value does not cause pathogenic effects. Analysis of the obtained results of acid phosphatase activity was higher than the activity of alkaline phosphatase. Alkaline phosphatase activity was within the standardized norm, and acid phosphatase was by 1.6 times higher than normal, which in our opinion is a compensatory effect [3,9,13]. There is no significant difference between the total amount of microflora when using prostheses with Remanium GM 700 and Remanium CSe, in the state of certified delivery and after six remelting, therefore, their use does not cause dysbacteriosis, which is important for oral homeostasis [8]. Cytological examination showed that in patients of the experimental groups the cellular composition of smears-imprints from the surface of the mucous membrane is approaching normal.

This is also a strong argument in favor of the fact that prostheses made from remolten alloys Remanium GM 700 and Remanium CSe are characterized as biocompatible [4,12].

CONCLUSIONS

The examination of Remanium GM 700 and Remanium CSe alloys in a recirculating state showed that the pH of saliva, lysozyme, acid and alkaline phosphatase did not exceed the permissible norms and had no antimicrobial activity against naturally microorganisms growing. According to cytological examination of the cellular response of the oral mucosa and the response of the periodontium, do not cause pathological changes at the cellular level.

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