KAPITEL 2 / *CHAPTER 2* [2]
DIAGNOSTIC FEATURES OF PATHOLOGICAL PROCESSES CAUSED BY DENTAL PROSTHESES WITH METAL INCLUSIONS

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Introduction

The prevalence of major dental diseases among the population reaches 95-100%. The dentures used in prosthetic dentistry are made of different construction materials [1, 2]. Various metal alloys are used for prosthetic dentistry and orthodontic treatment: stainless steel, cobalt-chromium, silver-palladium, gold, and titanium alloys. [2, 3, 5]. They most often include such metals as iron, chromium, nickel, titanium, manganese, silicon, molybdenum, cobalt, zinc, silver, and gold [4, 5, 6]. Solder, which includes silver, copper, manganese, magnesium, cadmium, and other metals, is used to connect individual parts of dentures and, in orthodontics, orthodontic crowns and braces with brackets. These materials are foreign to humans and can contribute to the development of a number of disorders [6, 7, 8].

In some cases, after orthopedic treatment, a symptom complex of denture intolerance develops, which includes a number of diseases and various pathological conditions of organs and tissues of the oral cavity: traumatic, allergic, toxic effects of dentures, development of oral candidiasis, galvanism and galvanosis, “prosthetic periodontitis”, intolerance to dental materials, idiosyncrasy, dry mouth, contact allergic stomatitis, etc. [2, 3, 9].

The following forms of intolerance are distinguished: galvanic, reflex, toxic, allergic, and combined. Each form occurs as a result of one of the negative effects of metal inclusions [9, 10, 11].

Objective manifestations can include swelling and hyperemia of the tongue and lips, hemorrhagic elements on the oral mucosa (petechial hemorrhages - Figure 1), as well as non-hemorrhagic elements of the rash (erosions, papules).

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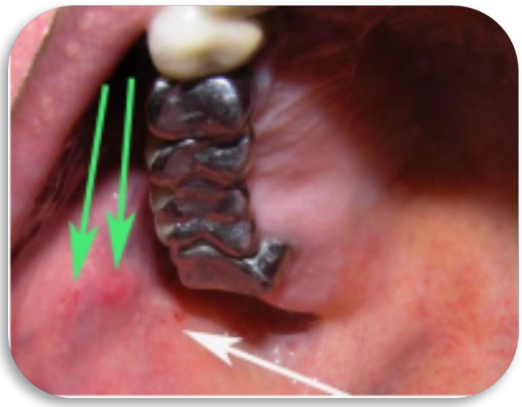

Figure 1 - Petechial hemorrhages on the mucous membrane

In addition, materials of orthopedic structures that are in contact with the organs and tissues of the oral cavity for a long time can have a pathological effect not only at the local level, but also on the body as a whole, aggravating the course of existing chronic diseases and initiating the development of new pathological conditions [4, 5, 6, 12].

The development of general complications to metal alloys is known in patients with diseases of the gastrointestinal tract, liver, and kidneys, as well as nervous system disorders [6, 7, 12].

The first references to complications associated with the use of metals in dental practice date back to the second half of the nineteenth century.

Metal inclusions in the oral cavity can adversely affect the human body in the form of chemical toxicity, electrogalvanic and allergic effects.

As a result of this exposure, the composition of saliva, hard dental tissue, bone tissue, periodontal tissue, oral mucosa and the human body as a whole change [3, 6, 8].

It has been proven that in 4-11% of cases, patients with metal inclusions in the oral cavity complain of discomfort, which sometimes progresses to intolerance of dentures and most often manifests itself in the form of subjective symptoms, such as galvanosis, toxic stomatitis, allergic reactions to metal inclusions and exacerbation of general somatic diseases [4, 6, 8, 12].

As mentioned above, there are 3 main types of effects of metal inclusions in the oral cavity on the surrounding tissues and the body as a whole.

So, let's consider pathological conditions in sequence, starting with the characteristics of galvanosis.

2.1. Galvanosis

This is a disease caused by the action of galvanic currents that arise as a result of electrochemical processes in the oral cavity between metal inclusions [13, 15, 16].

The main mechanism is the formation of a galvanic element due to: the difference in the electrical potential of different metals in the alloy; different composition of metal alloys; different structural state of metal alloys of the same composition (Figure 2).

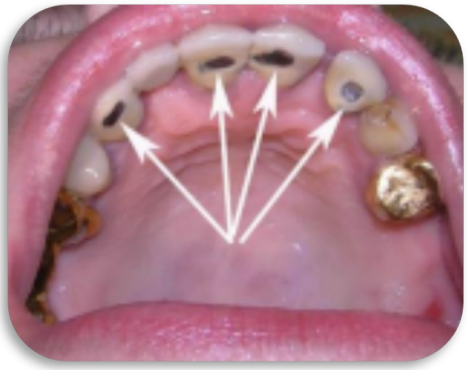

Figure 2 - Chipped veneer from the palatal surface of crowns [14]

The formation of a galvanic cell is based on redox reactions.

Metal prostheses give off positive ions to the electrolyte (saliva), becoming negatively charged. Their number depends on the metal and its chemical activity. Therefore, corrosion of metal products reduces the strength and ductility of the alloy, changes its surface, and deteriorates its electrical and optical properties [13, 16]. The occurrence of microcurrents in the oral cavity and related complications is explained by the presence of two or more alloys with a heterogeneous crystal lattice. Also, clinical observations have established the occurrence of pathological changes in the oral cavity when using prostheses made of homogeneous alloys [13, 14, 15, 16].

Due to the potential difference between metal alloys in the oral cavity, the formation of galvanic microcurrents can lead to the development of 2 forms of negative

effects: galvanic and reflex [9, 11].

The galvanic form is characterized by a low threshold of individual electrical sensitivity of oral tissues - up to 9 μA and the current strength of galvanic elements, which is more than 2-3 times higher than the threshold of individual sensitivity, i.e. more than 10-15 μA [9]. As for the mechanism of development of the pathological process, it is defined as the body's response to the direct effect of galvanic current on the tissues of the oral cavity. This clinical form manifests itself 1-7 days after fixation of dentures in the form of a reaction of intolerance to metal alloys due to irritation of the receptor apparatus of the oral cavity by galvanic currents of different magnitudes [10].

In this case, the reflex form is characterized by the value of individual electrosensitivity in the range of 9-25 μA and the current strength of galvanic elements in the oral cavity of 8-12 μA. The mechanism of development of the pathological process is the body's response to prolonged (5-11 months) irritation of the receptor field and oral tissues with a small galvanic current. An important role in the mechanism of development of the pathological process is played by the pH of the oral fluid, which is constantly changing during the day. Thus, with a change in pH by 1 unit, the value of prosthetic potentials changes by 40-55 mV, which is the most important point, since the body cannot adapt to the effects of constantly changing current values [11].

The analysis of the study of local and general nonspecific resistance of the body showed a sharp decrease in all indicators in patients with galvanosis. Normalization of the electrical conductivity of the oral fluid directly depends on both the magnitude of the potential difference and the severity of clinical symptoms of galvanosis [17, 18]. Instead, corrosion processes initiate an increase in current and potential difference. In users of metal orthopedic structures in the oral cavity, the potential difference exceeds 150 mV, and there is a clinical manifestation of intolerance to orthopedic materials, which indicates the development of galvanosis [19, 21].

At the same time, most patients who use metal dentures for a long time do not develop galvanosis, which should be explained by the body's good adaptation to pathological factors (induced galvanic currents, increased concentration of metal ions,

decreased saliva pH, etc.) [15, 17, 20].

Many oral bacteria are known to degrade metal dental materials, which leads to potentially prolonged metal release and surface degradation [15].

Although there is much debate about the biological significance of such metal release from dental implants and connected prostheses, there is increasing evidence linking it to chronic inflammatory processes in the surrounding "peri-implant" structures [15, 19, 21].

Currently, there is evidence of corrosion and metal release from dental implants. For example, tissue biopsy of titanium dental implants with peri-implantitis revealed a high concentration of dissolved titanium and metal particles, which is associated with the structure/diversity of the subgingival plaque microbiome (Figure 3) [19].

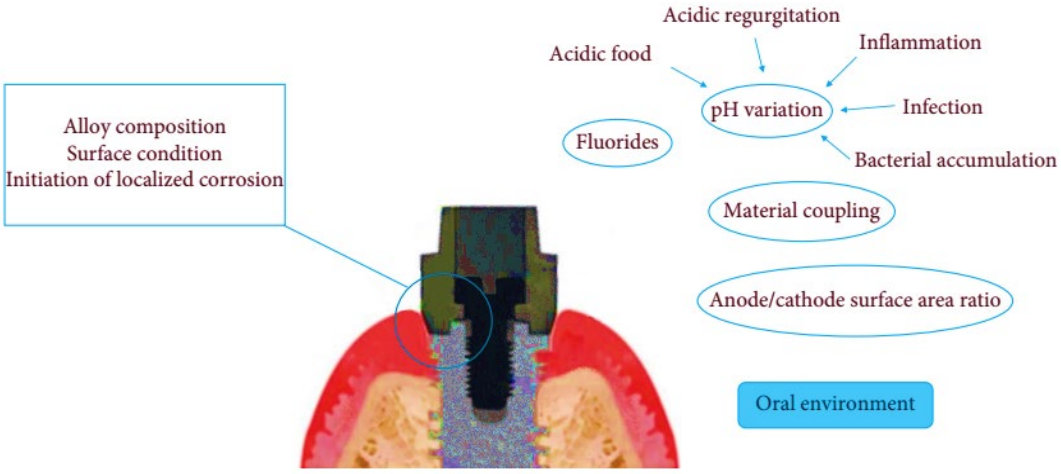

Figure 3 - Internal and external factors affecting corrosion [19]

However, dental implant corrosion and infections caused by microbial biofilms remain serious clinical problems leading to implant rejection, and individual variability makes prediction and follow-up extremely difficult [19, 20, 30, 31, 32, 33].

The process of generating electric potentials is called galvanism. It is observed when any metal is immersed in saliva solution. During the operation of dental prostheses, the phenomena of galvanism are enhanced in the presence of internal stress defects in metal structures.

In the presence of coating defects, deflections of intermediate parts of bridges, electrochemical processes are activated and lead to the development of galvanosis,

which is already a disease [13, 15, 19, 21].

The clinic of galvanosis

Thus, up to 40% of patients who use metal dentures complain of a metallic taste, heartburn, tingling of the tip or lateral surfaces of the tongue, distortion of taste sensitivity (bitterness acidity), increased salivation or dry mouth, sore throat, teeth crunching, redness and swelling of the soft tissues of the face (eyelids, nose, lips, cheeks) [13, 14, 15, 17].

When metal prostheses are installed and fillings are placed on antagonistic teeth, a feeling of "electric shock" occurs when the jaws close [13]. These sensations are more pronounced in the morning and gradually decrease after eating. These symptoms appear 1-2 months after primary prosthetics or re-prosthetics with the addition of metal inclusions.

Other symptoms include headache, dizziness, weakness, fatigue, vomiting, eating disorders, sleep disturbances, and pain in the heart area [15, 16, 17, 18, 19].

The diagnosis is made on the basis of clinical and paraclinical methods.

Clinical methods include: interviewing (finding out characteristic complaints and taking anamnesis); examination of the mucous membrane and organs of the oral cavity; assessment of the quality of dentures; and exposure test [13, 15, 17].

Paraclinical research methods include: chemical spectral analysis of oral fluid, blood, gastric juice, urine; determination of saliva pH; determination of potential difference (in the presence of metal inclusions); hygienic assessment of dentures and oral cavity; epimucosal tests; blood counts; immunological studies [14, 16, 18].

During an oral examination, changes in the mucous membrane are often not detected, with the exception of the tongue. It is swollen, its lateral surfaces and tip are hyperemic (Figure 4).

There are damages or signs of abrasion on crowns, inlays, fillings made of dissimilar metals, metals with a decorative coating of titanium nitride. There are large oxide films in the soldering areas of the intermediate part (Figure 5).

In case of galvanosis, the current strength increases (normally 1-3 μA), the difference in electrical potentials between metal inclusions is more than 50 mV,

sometimes it can reach 150 mV (normally 10 mV), and the pH of saliva shifts to the acidic side (pH 6.5-6.0).

Figure 4 - Characteristic changes of the tongue in galvanosis [13, 14].

Figure 5 - Changes in galvanosis in the area of previously manufactured fixed dentures [13]

According to the results of spectral analysis, electrochemical processes show a direct link between changes in the quantitative and qualitative composition of saliva of elements such as iron, copper, manganese, chromium, nickel, etc. Skin tests for metals are negative, and clinical blood tests are also unchanged [15, 16, 17].

Thus, the diagnosis is based on patient complaints, objective examination, galvanometry, and direct potentiometry.

Removing the structure and replacing it with a structure made of a homogeneous alloy eliminates these symptoms.

The pathogenesis of the combined form is almost equally involved in the generated currents and the products of electrolysis, metal prostheses and orthodontic appliances that are released during this process [12, 13].

The next pathological manifestation with a more pronounced clinical picture is toxic stomatitis.

2.2. Toxic stomatitis

This is a disease caused by the action of "heavy" metals, as well as trace elements (Cu, Cd, Cr, Sn, etc.) that enter the oral cavity as a result of electrochemical processes that occur in metal inclusions of the patient's structures [22, 23, 24].

When metal dentures containing such elements come into contact, the permeability of capillaries is impaired, and due to the redistribution of metals, they enter the cytoplasm [24, 25, 26, 27].

When interacting with enzymes and other organic molecules, metals (mercury, lead, cadmium, arsenic, etc.) block or bind sulfhydryl SH, carboxyl COOH and NH2 amino groups, which determines the selectivity of their biological action:

- transaminases are inhibited, acid and alkaline phosphatases are activated, regulation of glycolysis and tissue respiration is disturbed;
- the activity of proteolytic enzymes and their inhibitors - non-metals - is disrupted, which leads to the development of inflammatory reactions, tissue destruction and circulatory disorders;
- energy metabolism and blood lipid peroxidation are impaired [25, 28].

Patients with pathological galvanic currents have low levels of secretory IgA, lysozyme, and elevated levels of cytokines in the oral cavity [26].

In vitro studies have shown that exposure to non-toxic doses of metals (titanium, cobalt, chromium, etc.) on lymphocytes, macrophages, keratinocytes, and fibroblasts

leads to an increase in cytokine production by these cells [12]. Most of these cytokines are anti-inflammatory. An increase in their level indicates the development of an inflammatory reaction [25, 26, 27].

Thus, the presence of metals in the oral cavity and their corrosion leads to the formation of a large number of ions or particles of these metals, which react with organic components of body tissues and fluids, come into contact with cells and microflora of the body. The course of these processes depends on the acidity of the environment, which is reflected in the pH value. Accumulating in the body, heavy metal ions can have a toxic effect on its cells [25, 29].

Induced electric currents, regardless of their strength, affect both the oral cavity and the entire body. They cause and intensify corrosion processes associated with corrosion of orthopedic materials [30, 31, 34]. This results in both the destruction of prosthetic materials and the accumulation of metal ions with their intensive transfer to tissues.

Also, characteristic is the effect of metals directly on the parasympathetic fibers innervating the salivary glands, a decrease in the content of pepsinogen in gastric juice [28].

Subjective signs: burning sensation in the tongue (by the type of causalgia), severe "burning" pain), hypersalivation (ptyalism), 1-7 days after fixation of metal prostheses in the oral cavity, sometimes dryness in the oral cavity with a sufficient amount of saliva, sour taste, paresthesia of the tongue and mucous membranes, disturbance of nervous status (emotional lability, irritability, carcinophobia) [22, 23, 25].

Objectively: increased pain sensitivity of the tongue, secretion of thick, viscous or foamy saliva (Figure 6), changes on the tongue (atrophy of the filiform papillae), hyperemia of the lips, slight swelling of the tongue, lips and oral mucosa, inflammation in places of contact with metal inclusions (Figure 7).

Studies have shown that when studying clinical symptoms, it is worth considering their similarity to similar symptoms in other diseases. For example, a common complaint is burning tongue, which is also found in gastrointestinal diseases, oral candidiasis, diabetes, menopause, cervical degenerative disc disease, Costen's

syndrome, etc. Metal flavor may be present in liver diseases. Impaired salivation is observed in chronic gastrointestinal diseases, Sjogren's syndrome, osteochondrosis, endocrine disorders, etc. [3,5]

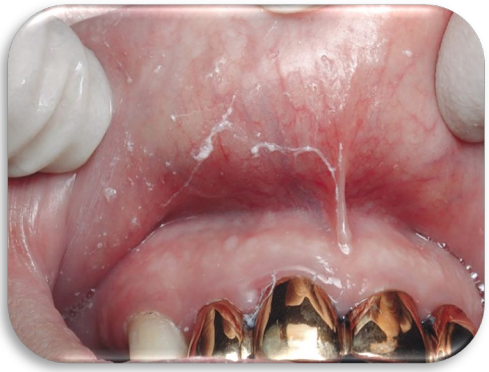

Figure 6 - A characteristic clinical picture of toxic stomatitis (discharge of viscous, thick saliva) [23]

Figure 7 - Inflammation in places of contact with metal inclusions [25]

Oxide films are formed on stainless steel metal prostheses in the areas of soldering, pores and roughness. Structures made of 750 gold and cobalt-chromium alloys can change color [23, 24].

The same methods are used for diagnosis as for galvanosis, adding the following: determination of salivary enzyme activity, determination of energy metabolism in the blood (lactic and uric acid), determination of lipid peroxidation in the blood and saliva, selection of structural materials according to R. Fail [23, 25, 26].

The spectral analysis method can be used to determine the amount of metals and their effects [23].

For example, with an increase in the copper content in saliva, the color of gold alloy dentures may change and a toxic reaction may occur in the form of tongue

burning, an unpleasant metallic taste, acid, vomiting, and dyspeptic symptoms [23, 26, 28].

As a result of chromium exposure, patients may experience ulcers and bleeding gums, increased salivation, and enlarged lymph nodes on palpation [24, 25, 26].

According to the results of laboratory tests: in the blood (leukocytosis; erythropenia; increase in ESR), sharp changes in the mineral composition of saliva (increase in the dose of "heavy" metals); changes in the activity of salivary enzymes (phosphatases, transaminases, proteinases); in gastric juice, blood, a significant increase in the content of Mn, Cu, Pb, Ni, in urine - Fe, Cu [24, 25].

Patients with metal inclusions may develop cheilitis, glossitis, leukoplakia, and lichen planus [32, 45, 46, 47] (Figure 8).

Figure 8 - Manifestations in the oral cavity of chronic diseases of the mucous membrane under the toxic effects of fixed metal prostheses [44]

A diagnosis of toxic stomatitis to metal dentures can be made based on the clinical picture, an increase in the content of "heavy" metals in the oral cavity, changes in saliva enzymes, and blood tests.

The next pathological condition that requires a separate characterization is an allergic reaction to metal components of dentures.

2.3. Allergic reactions to metal inclusions

Prolonged sensitization to chromium and nickel when using stainless steel

dentures can cause allergic reactions [34, 35].

Symptoms of an allergic reaction may include skin rashes, sudden headache, nasopharyngeal swelling, and shortness of breath that occur after the introduction of metal dentures made of stainless steel and gold alloys into the oral cavity [34, 37, 38].

Gold-based alloys for dental prosthetics are susceptible to corrosion, the intensity of which depends on the composition of the alloy and the presence of other metal prostheses in the oral cavity [38].

Electrochemical processes can cause allergic manifestations. In this case, metal oxides, especially copper, act as allergens [34, 35, 37, 41, 42].

Some researchers explain the effect of increased galvanic currents on the development of allergic reactions by the proximity of mast cells and nerves of the oral mucosa, which ensures their interaction. When nerve cells are irritated by electric current, an increase in neuropeptides occurs, which stimulate their degranulation and release of cytokines that affect mast cells. Autocrine and paracrine effects are based on cytokines that support the allergic reaction by accelerating mast cell degranulation [39, 40, 41, 43].

In a study of the effect of metals on cell viability in cell culture (fibroblasts, keratinocytes), it was found that cell viability was significantly reduced after incubation with copper samples, a significant decrease in viability was also observed after incubation with nickel, chromium, cobalt and zinc, and iron, palladium, gold, indium had the least effect on cell viability [42, 44].

Corrosion products can enter into various biochemical reactions with molecules contained in the oral cavity and tissue fluids, resulting in the formation of new chemicals. When they bind to proteins, they can serve as a hapten, forming an antigen molecule to which an immune response can develop [36, 39].

Diagnosis.

The most common manifestations of allergic stomatitis can be mild hyperemia of the mucous membrane of the cheeks, gums, and tongue in areas in contact with metal prostheses. Sometimes there is mucosal edema and erosion [34, 42, 43].

Subjectively: complaints of metallic taste, acid sensation, burning tongue, dry

mouth, swelling of the mucous membranes [34, 41, 42, 43].

Objectively: severe hyperemia of the mucous membranes, which often have erosions, swelling of the mucous membranes of the cheeks, lips and tongue, petechial hemorrhages on the mucous membrane of the soft palate, viscous or foamy saliva, discoloration of bridges, the presence of oxidative films, pores, surface roughness [34, 41, 43].

General reactions are objectively manifested on the skin, in the gastrointestinal tract, with swelling on the face, eyes, eyelids, lips, and pharynx. Glossitis and the development of bronchial asthma are possible [37, 38, 39, 40].

Subjectively, the general symptoms are characterized by burning mucous membranes, itching, a feeling of suffocation and "tightness" in the throat, vomiting, thirst, and fatigue [34, 35, 39, 42].

Allergic stomatitis can also be accompanied by functional disorders of the nervous system: irritability, insomnia, emotional lability, carcinophobia, prosopalgia, as well as exacerbation of chronic cholecystitis, gastritis, and colitis [40, 42, 47].

The manufacture of fixed structures from silver-palladium alloys is a therapeutic tool due to their pronounced oligodynamic, bacteriostatic and bactericidal effects.

Results and conclusions

The paper analyzes the bibliographic sources of PubMed, Google Scholar and Scopus databases for the period from 2011 to the present. According to the data of scientific and practical studies conducted by both domestic and foreign authors, complications during orthopedic treatment of patients with fixed dentures are an important problem.

The analysis of the available literature indicates the lack of a single comprehensive approach to the diagnosis and prevention of intolerance to fixed dentures with metal inclusions and the need to further study the effect of this disease on the local immunity of the oral cavity of dental patients.

Thus, each patient reacts differently to the electrochemical processes that occur in the oral cavity as a result of prosthetics with metal dentures or the use of metal structures of orthodontic appliances, and clinical manifestations are also different.

Therefore, it is necessary to adhere to a certain scheme of diagnostic procedures when providing care to each patient. Failure to comply with all diagnostic procedures can lead to an incorrect final diagnosis, which leads to incorrect treatment tactics.

When eliminating the etiologic factor in patients with a galvanic form of metal alloy intolerance, it is necessary to remove those metal inclusions whose electrochemical activity exceeds the threshold of individual electro-sensitivity of the oral mucosa determined by the patient.