

n View of the Influence of Removable Dentures on the Oral Cavity Tissues and the Organism (Review)

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Abstract

In modern dentistry, impact of dental prostheses on the tissues of the oral cavity is a crucial consideration and actual. The treatment of patients with partial absence of teeth should be comprehensive, taking into account the patient's state of health, the presence of general diseases, the bone tissue structure, the microcirculatory channel, the degree of mobility of supporting teeth, bite, bone tissue atrophy.

In this regard, the direct influence of orthopedic structures made of various materials on the homeostasis of the oral cavity, as well as the importance of changes in the of the oral cavity's homeostasis on adaptation to dental prostheses, is of great interest.

As a result of the use of prostheses, chronic pathological processes of the mucous membrane can occur, acting as an entrance gate for both microorganisms and components of the manufactured orthopedic product. During the analysis of literary sources, the relationships between the properties of the materials from which the prosthesis is made and the mucous membrane of the prosthetic bed were revealed, and a direct dependence of the quality of the construction, the terms of using, and the level of oral hygiene was determined.

This issue remains highly urgent, and despite considerable resources being expended on its resolution, an optimal way to enhance not only the functionality and durability but also the safety of removable prosthetics in orthopedic practice has yet to be found.

Review (J Int Dent Med Res 2024; 17(1): 420-428)

Keywords: Removable prosthetics, dental materials, mucous membrane, absence of teeth, stomatitis, base plastics.

Received date: 23 January 2024

Accept date: 16 February 2024

Introduction

Complications related to the violation of oral hygiene and prostheses include general and local complications. Local complications are bad breath, which is a problem for many patients, as it impairs the quality of life, reduces communication capabilities, and is a signal of the presence of periodontopathogenic microorganisms. The cause of bad breath can be xerostomia, which leads to an increase in the number of microorganisms in the oral cavity^{1,2}.

General disorders caused by poor oral hygiene and prostheses include changes in the body's immunological reactivity and a state of sensitization, and due to the weakening of the protective properties of the mucous membrane, autoinfection may occur³.

The mucous membrane of the oral cavity has its own immune system, which works autonomously from the general immunity. Many immunological reactions take place in the oral cavity aimed at natural protection and preservation of homeostasis^{4,5}. In the epithelial layer of the mucous membrane itself, there are many immunocompetent cells – neutrophils, which migrate from the vessels of the lamina propria and retain up to 90% of their functional activity on the surface of the epithelium^{6,7}.

The use of removable dentures contributes to the development of morphological

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changes in the mucous membrane⁸. The speed of their development, intensity, character depend primarily on the reactive abilities of the patient's body. The state of local immunoreactivity at the stages of treatment with removable orthopedic structures, as well as the reaction and changes of immunoglobulins in mixed saliva during inflammatory processes in the tissues of the oral cavity, are highly significant⁹. The study of cellular factors of innate immunity can be an objective criterion for assessing the quality of adaptation to removable denture structures¹⁰.

The term of patient adaptation to using a removable prosthesis depends on a number of factors: the type of orthopedic construction, clinical conditions of the oral cavity, the method of fixing the prosthesis, as well as individual psychosomatic status^{11,12}. To speed up the processes of adaptation to orthopedic structures, it helps to observe the stages of the technology of its manufacture, as well as its operation¹³.

Effect on the immune system

In general, the mechanisms of protection of the oral cavity are divided into two groups. The first group is represented by non-specific protective factors of innate immunity, which affect all types of foreign microorganisms. The second group includes specific factors of the adaptive branch of immunity, which affect only certain types of microorganisms¹⁴.

Non-specific protection is carried out by two mechanisms: mechanical (washing and cleaning the mucous membrane during meals, washing away microbiota with saliva, adhesion of microorganisms to the epithelium) and biological (action of certain biologically active substances and processes^{15,16}). It has been established that in dental pathology the level of all oral cavity protection factors are reduced¹⁷.

One of the main factors in the development of prosthetic stomatitis is the weakening of the interaction of specific resistance factors of the adaptive immunity of the oral cavity and non-specific ones, such as lysozyme, salivary neutrophils, immunoglobulins, and especially secretory IgA¹⁸. As a result, prosthetic stomatitis is characterized by an increase in the level of lysozyme, β -lysine and secretory IgA and, conversely, by suppression of neutrophil function¹⁹.

Scientists have established that the secretory activity of the salivary glands changes under the influence of dentures²⁰. Dental

prostheses are able to significantly change the ratio of factors that regulate the acid-alkaline balance of the oral cavity. At the first stage of dental prosthetics, the activity of lysozyme decreases sharply, which gradually recovers over time²¹. Immunological indicators of oral fluid largely reflect adaptation processes occurring in patients after prosthetics using various structures²².

A prolonged inflammatory process indicates the failure of an adequate reaction of a specific immune response caused by structural and/or functional defects of the immune system. From these positions, along with the influence on the inflammatory process itself, the identification of structural and/or functional disorders of the immune system and their correction should be of significant, if not primary, importance in the treatment program²³.

Depending on the basic material for prosthetics, changes in the content of immunoglobulins can have different directions and magnitudes, which are caused, first of all, by microbial colonization. The more microorganisms develop on the surface of the prostheses, the stronger the antigenic stimulation and the higher the content of immunoglobulins, mainly secretory ones, which are determined in the oral fluid²⁴.

Of the 6 classes of immunoglobulins, only three are present in the oral cavity – IgA, IgG, IgM. Under the influence of dentures, not only non-specific (lysozyme), but also specific (sIgA, IgG and IgM) reactivity decreases²⁵. Immunoglobulins of the body's external secretions are attracting more and more attention of researchers, as they participate in the formation of local immunity of the mouth. The biological role of secretory immunoglobulins is related to protective properties directed against the action of viruses, bacteria and other harmful agents²⁴.

Cytokines play an important role in the mechanisms of oral immune response. Cytokines act as biochemical messengers and regulate the stimulation and inhibition of inflammatory reactions that trigger the immune response. The sources of cytokines in saliva are serum transudate and salivary glands²⁶. Cytokines are also produced when mucosal epithelial cells themselves come into contact with microorganisms. In the case of intolerance to prostheses, IFN- γ and IL-8 in the oral fluid are significantly increased and contribute to the

maintenance of the inflammatory process and the development of destructive changes in the mucous membrane of the oral cavity²⁶.

Thus, tooth loss and subsequent orthopedic dental treatment can affect the functions of oral fluid, salivary glands, and immune factors, which contributes to the disruption of the balance of microflora in the oral cavity²⁷.

It was noticed that the use of dental prostheses can affect not only the cellular part of the innate immunity of the oral cavity, but also the general one²⁸. For example, the phagocytic activity of neutrophils in patients with removable prostheses decreased to 55% compared to the normal range of (55-95%) in healthy individuals²⁹. A significant decrease in IgA and IgG was found among indicators of the humoral link of adaptive immunity²⁵.

When using lamellar prostheses, adaptation disorders are caused by two categories of complications: inflammation of the mucous membrane of the base of the prosthesis and neuropathological syndromes characteristic of visceral-reflex lesions of the nervous system. Both adaptation disorders are associated with hypersensitivity, hyperpathy, most often continuous hyperesthesia, as well as hyposalivation^{30,31}.

Adaptation (keratinization) of the epithelium of the mucous membrane to the artificial base occurs on average within a year, but inflammatory processes prolong the period of adaptation of the epithelium of the prosthetic bed³². Moreover, as the authors established, the degree of keratinization is closely related to the hygiene of the inner surface of the base of the palatine prosthesis: the greater the contamination, the lower the index of epithelial keratinization³³.

One of the most frequent complications in the clinic of orthopedic dentistry is allergic stomatitis that occurs under the base of prostheses³⁴. At the same time, contact allergic reactions can increase with the help of various endogenous and exogenous factors, including individual increased sensitivity to plastics³³.

Pathological conditions associated with the use of removable prostheses made of basic plastics are indicated in the literature³⁵. According to various authors, the inflammatory reaction of the mucous membrane is observed in 40 to 70% of cases³⁶. The causes of its

occurrence are determined mainly by local factors caused directly by the removable prosthesis and the base material (mechanical, thermal, allergic and toxic irritation)³⁷. The reaction of the mucous membrane to removable prostheses also depends on individual reactivity³⁸.

In most cases, the bases of removable prostheses are made of various acrylic and methacrylic plastics³⁹. A number of studies have shown a direct correlation between changes in the mucous membrane of the oral cavity and the type of plastic used in the base of the prosthesis⁴⁰.

Acrylic plastics contain many components (eg, dyes, plasticizers, inhibitors) that act as hapten allergens⁴¹. If they enter the body through the mucous membrane of the oral cavity, they can cause inflammatory changes. However, we cannot talk about only chemotoxic or allergic lesions of the mucous membrane of the prosthetic bed. Chemical components released from the acrylic base into the oral cavity can also be both chemical toxins and allergens, so it is difficult to determine when the toxic exposure has ended and the allergic reaction has begun. A major role in the occurrence of such changes belongs to hydroquinone⁴².

Acrylic plastics series are subject to biological destruction in the oral cavity, as a result of which the products formed affect the factors of specific and non-specific resistance, which are manifested by suppression of the state of local immunity⁴³.

Violation of oxidative processes

A removable prosthesis should be counted among strong irritants of a combined nature⁴⁴. The prosthesis and the base material negatively affect various elements of the homeostasis of the oral cavity, the state of which is normally strictly balanced. The impact can be increased in the event of a violation of the technology of manufacturing prostheses, especially in the case of pathologies of the protective system of the oral cavity⁴⁵.

Dozens of volatile catabolism products of lipids and other compounds (volatile short-chain organic compounds) released from acrylic plastics have been identified, some of which are pathogenic, cause inflammation, and disrupt immunity²³.

It has been shown that prosthetic stomatitis is accompanied by a decrease in the

secretory activity of the salivary glands, a shift in the pH of saliva to the acidic side⁴⁶. At the same time, changes in the intensity of saliva secretion, the correlation coefficient of secretion with saliva, and the concentration in it of potassium, sodium, total protein, biogenic amines reflect with sufficient objectivity the processes of adaptation to lamellar prostheses and the possibility of the development of reactive inflammation of the mucous membrane of the prosthetic bed^{47,48}.

At the same time, the intensity of salivation and changes in the concentration of potassium, sodium, total proteins, and biogenic amines in saliva fairly objectively reflect the process of adaptation to orthopedic structures and the possible development of reactive inflammation in the mucous membrane of the prosthetic bed⁴⁹.

A major role in the development of stomatitis, as indicated by numerous studies, is played by increased lipid peroxidation and a decrease in antioxidant protection factors^{50,51}. During prosthetics with removable acrylic prostheses, the processes of oxidative modification of oral fluid proteins and, as a result, a decrease in the antioxidant activity of saliva and an increase in lipid peroxidation processes are observed^{52,53}. In patients, the level of free radical oxidation of lipids in the blood and oral fluid increases, and the activity of antioxidant defense enzymes changes⁵⁴. This phenomenon is regarded as a reaction to the insertion of a prosthesis and the development of a stress reaction⁵⁵.

Violation of the general reactivity of the body can also cause an inflammatory reaction of the mucous membrane⁵⁶. Autonomic and central nervous systems can play a certain role in the formation of pathological processes in the area of the prosthetic bed^{11,33}. On the other hand, the monomer of acrylic plastics, being a protoplasmic poison, causes not only local irritation, but can also have a toxic effect on the whole body¹⁹.

Influence of residual monomer

From the analysis of literary sources, it can be concluded that the release of residual monomer into the patient's oral cavity is observed in 100% of cases, but allergic manifestations and the phenomenon of so-called "intolerance" do not occur in all patients.¹⁹ They depend on the individual characteristics of the patient, on the reactive abilities of the body⁵⁷.

According to scientists, the negative impact of acrylic removable prostheses is enhanced due to the presence of chemically active components, such as plasticizers, catalysts, and dyes in the powder formulation of the base polymer. These components, being placed between the polymer molecules, disrupt the monocrystalline structure of the prosthesis, contribute to the biodegradation of the base material and enter the oral cavity as a result of abrasion of the plastic during eating. The cytotoxicity of monomers is explained by the fact that they dissolve in lipids, form chemical compounds with them and suppress the vital activity of tissues⁵⁷. A monomer, as a low-molecular compound, is a hapten, which, connecting with the proteins of body tissues, turns into an antigen²⁶. Its presence in the oral cavity leads to the release of histamine from basophils and mast cells, which leads to the development of allergic stomatitis⁵⁸. Residual monomers help reduce the content of lysozyme in saliva and affect the functional state of neutrophils, reducing their activity²⁶.

The most common complaint of patients who have allergic reactions to the acrylic resin in the base of the prosthesis is soreness and a burning sensation in the oral cavity. Areas where the burning sensation is most pronounced include the palate, tongue, oral mucosa, and oropharynx⁵⁸.

Changes in the microflora when using removable dentures

In the occurrence of prosthetic stomatitis, the microbiota that develops in the area of the prosthetic bed undoubtedly plays a large role. In general, the microflora plays a leading role in the pathogenesis of any stomatitis^{59,60}. Removable prostheses also create a favorable environment for the reproduction of various microorganisms, including pathogenic ones. The fact that microbiological indicators deteriorate under the influence of a lamellar prosthesis is evidenced by the results of numerous studies³⁷. According to research, more than half of plaque covering the surfaces of dentures consists of microflora. All these bacteria, under favorable conditions, can develop inflammatory processes in the area of the prosthetic bed and secondarily contribute to the occurrence of stomatitis⁶¹. At the same time, the microbial balance in the oral cavity is disturbed and the pathogenic flora displaces the non-pathogenic flora. These changes in the

microbial balance activate the processes of lipid peroxidation, which leads to changes in nonspecific resistance, the development of inflammatory processes in the tissues of the prosthetic bed, and subsequent atrophy²⁷.

In patients with fixed dentures, representatives of periodontopathogenic microflora, such as *Porphyromonas gingivalis*, *Prevotella intermedia*, *Actinobacillus actinomycetemcomitans*, are most often found, which is the cause of the development of periodontal tissue inflammation after orthopedic dental treatment⁶². Microorganisms such as *Escherichia coli*, fungi of the genus *Candida*, *Staphylococcus aureus*, bacteria of the genus *Enterococcus* are more often isolated in persons who use removable dental prostheses⁴³.

The change in the microphora of the oral cavity after orthopedic dental treatment depends not only on the design of the prosthesis, but also on the term of its use⁶³. Bacterial insemination of prostheses with an acrylic base is observed already on the second day of the prosthesis being in the oral cavity, by the end of the first week the composition of the microflora changes, and there are already at least two dozen species, including pathogenic ones⁶⁴. In the first 2 weeks, a high number of bacteria of the genus *Streptococcus* and a decrease in bacteria of the genus *Lactobacillus* and fungi of the genus *Candida* were detected. However, after 3-4 weeks, the prevalence of *Lactobacillus* and *Candida albicans* increases, and the level of *Streptococcus* decreases to the initial level. When using a removable dental prosthesis for more than 5 years, the total number of microorganisms significantly increases, as well as the number of pathogenic *Staphylococcus aureus* and *Candida albicans*⁶⁵.

Colonization of the inner surface of removable orthopedic prostheses by *Candida albicans* occurs when the immune defense of the body is weakened, and the fungi then spread to the entire mucous membrane of the oral cavity, contributing to the development of the inflammatory process in the form of "fungal stomatitis"⁶⁴.

In addition to the microbial factor, retention points and irregularities on the surface of the prosthesis, where microorganisms accumulate, play a major role in the formation of dental plaque⁶⁶. On partial removable dentures, areas of the base adjacent to the teeth, various

depressions and irregularities on the base are considered retention points. In addition, it was noticed that the speed of appearance of plaque is directly dependent on the quality of polishing of the prosthesis⁶⁷. The physicochemical properties of its structural materials play an important role in the adhesion of microorganisms to the surface of the dental prosthesis⁶⁸.

It is known that the formation of dental plaque occurs less often in smooth, polished surfaces of prostheses^{66,69}. Under the influence of the products of the vital activity of the microflora of the oral cavity, the smooth inner and outer surfaces of prostheses turn into rough ones, which contributes to the attachment of microorganisms and the formation of dental plaque, which is difficult to remove⁶². Some authors note that with uncontrolled reproduction of pathogenic microflora in the oral cavity, changes in the structure of the plastic base of the prosthesis are registered, which contributes to the release of the monomer into the patient's oral cavity⁷⁰.

In the event of an increase in the period of use of prostheses, their hygienic condition noticeably deteriorates due to the aging of the plastic. Prostheses with long-term unsatisfactory oral hygiene are highly contaminated with microbiota, covered with intense dental plaque and stone pigmented with food dyes, sometimes with smoker's plaque⁶⁴.

Microorganisms are activated, releasing waste products – toxins that cause inflammation and other pathological reactions. Under the influence of toxins, the resistance of tissue structures of the prosthetic bed to mechanical loads decreases. It should be noted that the constant presence of microorganisms on the bases of prostheses can lead to a state of sensitization and changes in immunological reactivity. Bacterial antigens form antigen-antibody complexes, activating the complement system and releasing various biologically active mediators⁴. At the same time, there is an increase in phagocytosis, immunoadhesion, chemotaxis of neutrophils, an increase in the permeability of blood vessels – all this leads to a sharp weakening of the function of the mucous membrane of the oral cavity⁷¹.

Thus, M.M. Rozhko and I.V. Paliichuk³⁵ based on clinical examinations, concluded that prostheses cause complications in 1/3 of cases. At the same time, there is sensitization of the

organism to the changed microflora of the oral cavity and the chemical components of the prosthesis, as evidenced by characteristic changes in the quantitative content different classes of immunoglobulins in blood serum⁷².

The presence of prostheses in the oral cavity not only mechanically affects the tissues and organs of the prosthetic bed, but also prevents the cleaning of the mucous membrane, creating a greenhouse effect and a vacuum under the base of the orthopedic structure. As a result, the removable prosthesis is the cause of the inflammatory reaction of the tissues of the prosthetic bed⁵⁶.

Removable prostheses are irritants that have a combined effect on the mucous membrane and the neuroreceptor apparatus. Side effects of removable prostheses include heat-insulating and mechanical, chemical, toxic, and sensitizing effects³⁴. Each of the named factors consists of several components, different in strength and nature of influence depending on parameters of chemical, physical and mechanical properties of prosthetic materials⁷³. The mechanical impact of a removable denture consists in the increased pressure of the prosthesis on the tissues of the prosthetic bed. The epithelial layer of the mucous membrane is damaged during sliding movements of the base. Its traumatic effect significantly increases and is mutually intensified in the presence of roughness on the inner surface of the prosthesis, in the case of weak and poor fixation, as well as uneven loading of the prosthesis during chewing. Chewing pressure, which transmits the base of the prosthesis to the mucous membrane, even with its correct design, leads to a change in the tissues of the prosthetic bed⁷⁴⁻⁷⁶.

Pathomorphological disorders

Microscopic examination of the mucous membrane of the hard palate and alveolar ridge in individuals who used removable prostheses reveals pronounced and significant changes covering all layers without exception⁷⁷. The researchers state significant cytological disorders, manifested in the form of intercellular and intracellular edema, swelling of cells, destruction of their nuclear substances, i.e. characteristic signs of an acute inflammatory reaction of the oral mucosa develop, accompanied by all signs of inflammation and hyperemia of the damaged area⁷⁸. At the heart of these changes are blood circulation disorders in the vessels of the

microcirculatory channel of the mucous membrane of patients, during the period of adaptation to partial removable prostheses, venous stasis occurs. The more often the patient uses a dental prosthesis, the more significant the severity of pathological processes^{19,79}. In addition, as the period of use of the removable prosthesis increases, the severity of pathological changes in the microcirculatory channel increases. This leads to a decrease in the vertical compliance of the prosthetic bed. As a result, zones of increased pressure of the base on the mucous membrane appear, where inflammatory phenomena develop from catarrhal inflammation to decubitus ulcers, which are called "traumatic prosthetic stomatitis" or stomatitis of a traumatic nature⁷¹. Thermoplastic polymers are more flexible and integrated and have a greater cushioning capacity to transmit masticatory loads⁷⁴. Clinical results obtained when using removable thermoplastic polymers prostheses showed that patients adapt to them faster than to prostheses made of acrylic polymers⁸⁰. The results of the study showed that the use of nylon prostheses gives better results in tissues hemodynamics of the prosthetic bed, atrophy of bone tissue occurs much more slowly⁸¹.

Conclusions

Removable prostheses are essentially combined irritants that have a whole complex of negative effects on the mucous membrane, and the longer they are used, the severity of pathological processes increases, in particular in the microcirculatory channel; their hygienic condition worsens, and the contamination by microbiota increases, which subsequently leads to the occurrence of chronic inflammation, which leads to destructive changes in the tissues of the prosthetic bed and can have an adverse effect on the entire organism.

Declaration of Interest

The authors report no conflict of interest.

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