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UNREMOVABLE PROSTHETICS WITH METAL STRUCTURES OF TEETH, ITS TYPES, CHARACTERISTICS AND POSSIBLE COMPLICATIONS

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Abstract

Introduction. A wide variety of orthopedic structures, including artificial crowns, are used to treat defects in the hard tissues of teeth, but even today there is no material that is completely indifferent to the oral tissues and the body. The purpose of this work was to substantiate, based on a review of literary sources, the use of various types of fixed prosthetic metal structures to increase the effectiveness of orthopedic treatment of patients with defects of dental crowns.
Materials and methods. Literature review was conducted using PubMed, Web of Science, SCOPUS, Google Scholar until April 2024. There were no restrictions on the date of publication or the language of scientific sources. Searches were conducted according to MeSH (Medical Subject Headings) using the following search terms: «unremovable prosthetics», «cast crowns», «stamped crowns», «mucous membrane», «materials science», «metal alloys», «tooth preparation», «galvanization». Used methods: bibliographic and analytical.
Results. The most common unremovable constructions for restoring damaged teeth are artificial crowns. They have different design features and are used for different purposes, classified according to various characteristics, including the material of manufacture. The main materials: metal alloys based on iron, nickel, cobalt, chromium, silver, palladium, gold, plastic, and ceramic materials. The choice of a specific composition of the alloy depends on the requirements for the crown, such as strength, aesthetics, resistance to wear, as well as on the individual needs and financial capabilities of the patient. The most common types of crowns, which are made of metals or their alloys, are cast and stamped crowns. Complications arising from the use of crowns prompt scientists to search for optimal methods of material selection, design features of prostheses, improvement of their manufacturing technologies, development of methods and means to prevent negative consequences and side effects of fixed prosthetics.
Conclusions. Unremovable orthopedic constructions are perceived by the organism as a foreign body and can contribute to the emergence and development of immune-inflammatory processes in the oral cavity. The study of complications arising from the use of non-removable orthopedic structures will allow finding out and clarifying the pathogenetic links in their development, which will provide a basis for the development of preventive measures for this category of dental patients.

Keywords: **unremovable prosthetics, solid-cast crowns, stamped crowns, mucous membrane, materials science, metal alloys, tooth preparation, galvanization, prosthetic dentistry, traumatic occlusion**

INTRODUCTION

The accelerated positive technological and medical-biological vector of the development of dentistry involves the search for new solutions to the problem of effective complex treatment of defects of tooth crowns and tooth rows, which is one of the most prevalent nosological forms, the most frequent cause of which is carious lesions and their complications [1].

The clinical picture of defects in tooth crowns is diverse and often highly complex. It depends not only on the variety and size of defects or their combinations, but also on the cause of the defect, the specifics of the bite, the condition of the hard tissues and periodontium of the supporting tooth, the age of the patient and various accompanying diseases, both local (anomalies, periodontopathy) and general (diabetes, circulatory disorders, etc.) [2-4]. To date, a wide variety of orthopedic structures, including prosthetic crowns, are used for the treatment of defects of hard dental tissues [5], but at the moment there is no information that would be completely

neutral regarding the interaction between materials and tissues of the mucous membrane, supporting teeth and the organism in general [6]. The goal of permanent prosthetics is to restore the dentition and chewing efficiency. The main condition for prosthetics is the adaptation of teeth and periodontal tissues to the selected structure.

In patients with orthopedic pathology, the reaction to metal alloys of dental prostheses depends on the influence of various factors, both local and general [7]. On the one hand, it may be the result of physicochemical processes that occur between metal structures of prostheses in the oral cavity, and which often manifest themselves in the form of electrochemical reactions [8]. On the other hand, the development of this pathological condition largely depends on the individual biological characteristics of the oral cavity and the patient's organism [9]. These features are determined by the activity of biochemical processes occurring in the oral cavity and may be related to both the clinical stages of prosthetic treatment and the material from which the structure of the fixed denture is made [10].

AIM

The purpose of this work was to substantiate, based on a review of literary sources, the use of various types of fixed prosthetic metal structures to increase the effectiveness of orthopedic treatment of patients with defects of tooth crowns.

MATERIALS AND METHODS

A review of the literature was conducted in order to research and analyze publications on the types, characteristics and influence of fixed orthopedic structures made of various metal alloys on the homeostasis of the oral cavity, as well as possible complications during their use. A literature review was conducted from September 20, 2023 to April 20, 2024 to analyze the most recent evidence. MeSH (Medical Subject Headings) searches were conducted using synonyms and combinations of the following search terms: «fixed prosthodontics», «solid-cast crowns», «stamped crowns», «mucous membrane», «materials science», «metal alloys», «preparation teeth», «galvanosis». In addition to the electronic search, a similar search was performed in the bibliographic references of the selected articles. Used methods: bibliographic and analytical.

RESULTS AND DISCUSSION

After analyzing literary sources, it can be stated that patients initially perceive dental prostheses as a foreign object, which can cause discomfort due to unusual sensations on the mucous membrane of the oral cavity [11]. This is explained by the fact that the use of prostheses leads to a decrease in the volume of the oral cavity, which simultaneously disrupts the contact of articulation points, which are necessary for the correct formation of various sounds. New occlusal contacts created by fixed crowns can change the nature of the movement of the lower jaw during chewing. The change in bite height creates new conditions for the functioning of the masticatory muscles and the temporomandibular joint [12].

A significant role is played by various factors affecting the adaptation process in fixed prosthetics, such as the size, shape and duration of use of the structure, eating process, material and type of prosthesis, feeling of pain after fixation of the prosthesis, presence of premature occlusal contacts, quality of fixation and stabilization, personal hygiene and individual characteristics of the patient's nervous system.

At different phases of adaptation to crowns, patients may experience certain complications or side effects. The reaction of tissues to prosthetics can be manifested by an impairment of the sensitivity of the mucous membrane of the oral cavity in its outwardly satisfactory condition, focal/diffuse acute and chronic inflammations [13]. This reaction is determined by the quality of the prosthesis design, material properties, characteristics of fixation devices, transmission of masticatory pressure, occlusal relationships, condition of the mucous membrane of the oral cavity, features of the bone structure of the alveolar processes, and the psychological setting of the patient.

Direct influence of fixed structures on periodontal tissues and mucous membrane of the oral cavity [14]:

- pain and (or) discomfort in the oral cavity;
- irritation of the mucous membrane;
- temporomandibular joint dysfunction;
- galvanic syndrome;
- decementation and destabilization of fixed prosthetic structures;
- damage and chipping of the facing material from the crowns, if they are present;
- intolerance to materials of fixed (non-removable) prostheses.

The impact of orthopedic structures on the periodontal tissues and mucous membrane can be manifested in the form of both local and systemic disorders: point hyperemia/large hyperemia spots, diffuse inflammation, erosions, ulcers, hyperplastic growth, galvanic syndrome, allergic reactions.

In 8-12% of patients who use fixed prosthetic structures, gingivitis and stomatitis caused by contact with metal ions are observed [15]. In particular, alloys containing Ni^{2+}, Co^{2+} and Cr^{3+} are key components of dental prostheses and implants, they can cause unwanted reactions in the oral cavity and body, which can lead to intolerance of these materials. The allergic reactions induced by the metal ion Ni^{2+} have been studied in

detail at the molecular level. Molecular immunological mechanisms responsible for recognition of metal ions by T-lymphocytes have been established experimentally. This process can lead to the development of allergic reactions and intolerance to the material of the fixed prosthetic structure [16]. Despite extensive research revealing the molecular mechanisms of contact hypersensitivity, and confirming the high sensitizing effect of metal ions of fixed structures on the human organism, the issue of further study of the impact of the relevant materials remains relevant [17].

Metal components of fixed structures, which are fixed in the oral cavity, become the subject of biological destruction, which can affect the factors that regulate both specific and non-specific resistance of tissues. This can lead to suppression of local immunity. One of the main factors in pathogenesis is the weakening of the effectiveness of the interaction between the components of specific and non-specific resistance of the local immunity of the oral cavity, such as lysozyme activity, the presence of neutrophils in saliva and the level of immunoglobulins, primarily secretory immunoglobulin A [18].

The body perceives fixed dental orthopedic structures as a foreign body in the oral cavity, which can contribute to the emergence of infectious processes. The degree of adhesion of these structures for microbiota depends on the material and quality of their manufacture. Metal-ceramic prostheses have a low level of adhesion. The highest level of adhesion is observed in unpolished prostheses made of nickel chrome steel. Studies have shown that a significant number of microorganisms accumulate on unpolished surfaces of metal alloys [19]. The microbial biofilm that forms on the surface of fixed orthopedic structures includes streptococci, staphylococci, peptostreptococci, fusobacteria, veillonella, neisseria, and Candida fungi [20, 21]. According to the analysis of scientific literature, the composition of this microflora changes under the influence of prosthetic fixed structures, which can contribute to the development of inflammatory diseases [22].

The most common permanent structures for the restoration of teeth are full-coverage artificial crowns. These designs have different design features and are used for different purposes. They are classified according to various characteristics, including the material of manufacture:

– metal (alloys of stainless steel, gold, cobalt-chromium, titanium, silver-palladium alloys, etc.);

– non-metallic (plastic, all-ceramic, zirconium);

– combined (lined with plastic (metal-plastic), ceramics (metal-ceramic), etc.).

In modern orthopedic dentistry, the success of treatment is determined not only by the knowledge and skills of the doctor and dental technician, but also to a large extent by the correct, optimal choice and use of dental materials.

The oral cavity is an aggressive environment that actively interacts with orthopedic structures, exposing them to various physical, chemical and biological factors [23]. Fixed structures also withstand significant dynamic and mechanical loads during chewing food. Materials and alloys for making crowns have a great influence on the tissues of the abutment tooth and the surrounding tissues of the oral cavity. In connection with the negative impact of many structural materials, the requirements for their use have increased recently [24].

Materials used for fixed prostheses must meet the following requirements: safety for oral cavity tissues, biological indifference, resistance to chemical influences, resistance to pressure that occurs when teeth are clamped, durability during chewing, preservation of shape and it, convenience in processing and absence of unpleasant taste or smell [22]. Biological compatibility depends on the composition of materials and their safety both in the free state and in the composition of prostheses [25].

Constant impact of forces in the oral cavity causes wear of materials used in prosthetics. Tooth enamel is considered the hardest substance in the human body, and the hardness of materials is often compared with it.

Metal alloys based on iron, nickel, cobalt, chromium, silver, palladium, gold, acrylate-based plastics, and ceramic materials are the main materials from which fixed dental orthopedic structures are made [26]. The most common types of fixed orthopedic crowns, which are made of metals or their alloys, are cast and stamped crowns.

A stamped crown is a stable dental prosthetic structure that is made by stamping metal. It covers the tooth and restores its anatomical form and function [27]. Stamped crowns are used in the case of a defect in the crown part of a tooth, when it is impossible to seal it or make an insert, it is necessary to protect a healthy tooth, which will become a support for a removable structure, as a support for bridge prostheses, for the restoration of destroyed temporary teeth.

It should be noted that there are also contraindications to the use of stamped crowns, namely: bruxism – excessive clenching of the teeth due to the tension of the chewing muscles, which is especially manifested in sleep; pathological abrasion of teeth; complete destruction of the supporting tooth crown [28].

The advantage of this type of non-removable orthopedic construction is that when preparing a tooth under a stamped crown, a smaller amount of hard tissue is removed compared to other types of crowns [29]. This is ensured by the thin walls of the crown. In addition, the advantage is that the tooth remains viable, that is, it does not need to be depulped and endodontic treatment performed before prosthetics.

If we analyze in detail the manufacturing stages of this design, we can conclude that these crowns are difficult to manufacture. In this regard, they have a number of disadvantages:

• the anatomical shape of the tooth is not completely reproduced (bumps and fissures are practically not expressed), and therefore, the function of the tooth is also not completely restored [30];

• no aesthetic qualities. While giving teeth aesthetics is one of the main tasks of modern dentistry;

• insufficiently accurate fit to the abutment tooth, only at the level of the neck, as a result of which food falls under the edge of the crown. This leads to the fact that an unpleasant smell appears in the mouth and secondary caries is formed;

• the cement that fixes the stamped crowns can dissolve after some time, and this leads to the fact that microorganisms begin to multiply in the empty space, and as a result, carious destruction of the tooth occurs directly under the crown [31];

• small thickness of steel, which is the main material of this design. As a result, there is rapid wear of the crowns up to their thinning and the appearance of perforations;

• the presence of bare metal, which can later lead to the development of galvanosis (current generation in the presence of dissimilar types of alloys or metals in the oral cavity) and electrochemical corrosion of crowns [7, 32].

As a result of the shortcomings listed above, the supporting tooth may be subject to further destruction during the period of use of this crown, is not subject to restoration, which subsequently leads to its irreversible extraction [33].

The alloys used to make stamped crowns often include precious metals such as gold or platinum, or their alloys with other metals such as palladium, rhodium, or other biometallic alloys, which have high strength, corrosion resistance, and good adhesion to tissues. These alloys may also contain some non-metallic components, such as ceramics or composites, which improve the aesthetic properties of the crowns. The choice of a specific composition of the alloy depends on the requirements for the crown, such as strength, aesthetics, resistance to abrasion and other factors, as well as on the individual needs and financial capabilities of the patient [29].

Standard sleeves used for the production of stamped crowns are manufactured from 20Cr18Ni9T stainless steel in a factory way [9]. It is an alloy of iron and carbon, which, as a result of primary crystallization under equilibrium conditions, acquires a single-phase structure. 20Cr18Ni9T consists of 0.20% carbon (provides hardness, brittleness, increases corrosion resistance); 9% nickel (increases plasticity, malleability, viscosity, strength, improves anti-corrosion properties, reduces the coefficient of linear expansion of the alloy); 18% chromium (provides resistance against oxidation and corrosion, increases alloy hardness, elasticity, reduces its plasticity, viscosity and brittleness, is a nitrogen solvent and ensures its necessary concentration in steel); 2.0% manganese (increases the strength and hardness of steel, reduces plastic properties, improves fluid flow rates, is a good absorber, lowers the melting point and helps remove harmful sulfur compounds in the alloy, ensures the required concentration of nitrogen in steel); 1.0% titanium (gives the steel a fine-grained structure, reduces brittleness, eliminates steel's susceptibility to intergranular corrosion); 1.0% silicon (gives the alloy a liquid, more uniform structure, improves its casting properties, increases the viscosity and elastic properties of steel); the rest is made up of iron. Nitrogen in the composition of this alloy helps to increase corrosion resistance and hardness, provides a high potential for strain hardening and improves elasticity characteristics. This contributes to the stable preservation of shape in thin openwork structures. The melting point of stainless steel usually varies between 1460-1500 °C [34].

In connection with the development of materials science and the newest methods of prosthetics in orthopedic somatology, the expediency of using stamped crowns raises a number of debatable issues among practicing dentists. In the modern world, almost all developed countries of the world have abandoned this type of crowns. This is due to the fact that these crowns have many disadvantages and at the same time have practically no advantages over other designs. Modern dentistry is aimed at preserving the abutment tooth, but with the use of stamped crowns, its destruction often occurs. Despite this, they are still used as an alternative to other types of prosthetics in our country, so the question of using stamped crowns continues to be relevant. Stamped crowns have been the primary type of fixed structure in a significant number of older people who have received prosthetics in the past, and therefore their prevalence in patients over 50 years of age is quite high. A significant number of dentists-clinicians express the opinion that stamped crowns are a relic of the past, but not everyone agrees with this. There are also dentists who believe that these crowns should be used in modern dentistry, because this type of orthopedic structures, given their low cost, can be an alternative for patients who cannot afford prosthetics with other types of expensive work [35].

A solid-cast crown is a non-removable orthopedic structure, which is made of a metal alloy by the casting method [27].

Solid-cast fixed consrtructions are the most modern metal structures of dental prostheses. They more accurately restore the anatomical shape of the teeth, occlusal contacts and contact points, ensure a tight fit

of the inner surface of the supporting crowns to the prepared teeth, and have a relatively simple manufacturing technology [36].

The absence of additional impurities and inclusions in the alloy makes it possible to achieve minimal oxidization of the material [37]. This circumstance has a positive effect on the condition of the mucous membrane of the oral cavity; soft tissue diseases occur much less often [38-39].

One should distinguish solid-cast crowns, made only of metal, and combined crowns, made by combining plastic or porcelain with a metal alloy. Crowns are made of gold, titanium, chrome-cobalt alloys, as well as on the basis of bimetallic alloys [40].

Gold crowns usually contain gold in various proportions, as well as other metals such as platinum, palladium or silver. These alloys are very strong, elastic and resistant to corrosion. Titanium crowns are light, strong and biocompatible with tissues, so they can be an ideal choice for patients with allergic reactions to other metals. Biometallic alloys can contain various metals, such as titanium, cobalt, chromium, as well as non-metallic components, such as ceramics. They combine the strength of metal and the aesthetics of non-metallic materials [41].

Cobalt-chromium alloys have high strength and durability, not high cost, so they are most often used for the manufacture of these crowns. These alloys have good mechanical properties [42]. Cobalt-chromium alloy contains: cobalt – 67%, chromium – 26%, nickel – 6%, molybdenum and manganese – 0.5% each. Cobalt contributes to hardness, improving the mechanical properties of the alloy; chromium is introduced to ensure hardness and anti-corrosion resistance by forming a protective layer on the surface of the alloy; nickel is used to increase the plasticity, viscosity and malleability of the material; molybdenum helps to increase the strength of the alloy due to the formation of a fine-grained structure; manganese improves fluidity and lowers the melting point, helps to remove toxic granular inclusions from the alloy. An iron admixture is allowed in a concentration of no more than 0.5%, since its presence leads to an increase in shrinkage during casting and negatively affects the physical and mechanical characteristics of the alloy [43]. In addition to cobalt-chromium alloys, such as cobalt-chromium alloy, other cobalt alloys for dentistry are known, such as ShotAlloy (USA) and Remanium-2000 (Germany).

Cobalt-chromium alloy has high physical and mechanical properties, relatively low density and excellent fluidity, which allows casting very strong and complex dental products [9]. The melting point is 1458 °C, the mechanical viscosity is 2 times higher than that of gold, and the tensile strength is at least 6300 kgf/cm^2. High elasticity index and lower density (8 g/cm^3) make it possible to manufacture lighter and stronger prostheses. They are also more resistant to abrasion and retain a glossy surface longer after polishing [44].

The choice of alloy for a solid-cast crown depends on the requirements for strength, aesthetics, resistance to corrosion and other factors, as well as on the individual needs and financial capabilities of the patient.

Solid-cast metal crowns are used as a preventive and therapeutic design that meets certain requirements of toxicology, technology, hygiene and function. The requirements of toxicology consist in the use of alloys that, possessing anti-corrosion properties, are non-toxic at the same time, do not cause allergies, do not irritate the mucous membrane, do not react with saliva and do not change its properties [45]. There is one technical requirement for a solid-cast prosthesis, namely, high strength and resistance to abrasion of the structure [41]. Hygienic requirements for these artificial crowns include preventing the development of pathological processes in the oral cavity, by reducing the adhesion of microorganisms to them and their ideal marginal fit and tightness at the tooth neck area [46].

Solid-cast metal crowns most accurately restore the defect of the hard tissues of the tooth, as they tightly cover the neck of the tooth and do not damage the gum tissue. Production by the casting method helps to increase the service life, prevents electrochemical processes in the mouth, and does not involve the use of acids and alkalis. These structures are also used as a frame for more aesthetic prostheses, that is, for the manufacture of combined crowns (metal-ceramic, metal-plastic).

Currently, an increasing number of patients do not want to have prostheses with a visible metal part. To provide aesthetic qualities, solid-cast structures with ceramic or plastic cladding are used. It has been established that integral crowns contribute to the elimination of symptoms of intolerance to the materials of fixed dentures and the normalization of saliva parameters (pH, viscosity), as well as taste perception of the tongue [23, 47].

The positive qualities of a solid-cast structure do not provide absolute guarantees of solving the problem, because numerous studies show that for some groups of patients, prostheses that are made according to all the requirements are ineffective, because they are contraindicated for patients with foci of chronic inflammation in the area of the marginal or apical periodontium of the abutment teeth [48, 49]. It should be noted that this type of construction requires high-precision casting and significant preparation of a relatively large thickness of hard tooth tissues in the manufacturing process, compared to stamped crowns. Therefore, endodontic treatment of abutment teeth is sometimes required before prosthetics with solid-cast crowns [50].

So, the complications that arise when using fixed orthopedic crowns prompt scientists to search for optimal

methods of choosing materials, structural features of prostheses, improving their manufacturing technologies, developing methods and means to prevent negative consequences and side effects in fixed prosthetics. However, the mechanisms that cause complications when using fixed prostheses, in particular against the background of inflammatory processes in the periodontal complex, the relationship of important links of homeostasis, such as lipid peroxidation, cytokine status, the general state of nonspecific resistance and humoral immunity of the oral cavity, remain insufficiently studied.

CONCLUSIONS

Fixed orthopedic structures are perceived by the body as a foreign body and can contribute to the emergence and development of immune-inflammatory processes in the oral cavity. The study of complications arising from the use of fixed orthopedic structures against the background of accompanying pathologies will allow finding out and clarifying the pathogenetic links in their development, which will provide a basis for the development of preventive measures for this category of dental patients.

Prospects for future research. Since recent scientific works have demonstrated the multifaceted impact of fixed orthopedic structures made of metals and their alloys, further clinical and experimental studies are needed, focused on identifying the impact of artificial crowns on the state of the tissues of the oral cavity and the body as a whole with various accompanying pathologies to understand and ultimately minimize negative consequences of this type of prosthetics.

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COMPLIANCE WITH ETHICAL REQUIREMENTS

The article complies with ethical norms: the study was conducted in accordance with the principles of bioethics set out in the Helsinki Declaration «Ethical Principles for Medical Research Involving Human Subjects» and the «Universal Declaration of Bioethics and Human Rights (UNESCO)».

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All authors substantively contributed to the drafting of the initial and revised versions of this paper. They take full responsibility for the integrity of all aspects of the work.

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Резюме

НЕЗНІМНЕ ПРОТЕЗУВАННЯ МЕТАЛЕВИМИ КОНСТРУКЦІЯМИ ЗУБІВ, ЙОГО ВИДИ, ХАРАКТЕРИСТИКА ТА МОЖЛИВІ УСКЛАДНЕННЯ

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Вступ. На сьогоднішній день застосовують велику різноманітність ортопедичних конструкцій, у тому числі штучні коронки, для лікування дефектів твердих тканин зубів, але на даний момент немає інформації, яка була б повністю нейтральною відносно взаємодії між матеріалами та тканинами слизової оболонки, опорних зубів та організмом в цілому. Метою даної роботи було обґрунтувати на основі огляду літературних джерел застосування різних видів незнімних протезних металевих конструкцій для підвищення ефективності ортопедичного лікування пацієнтів з дефектами коронок зубів.

Матеріали та методи. Огляд літератури проводився за допомогою PubMed, Web of Science, SCOPUS, Google Scholar до квітня 2024 року. Не було обмежень щодо дати публікації чи мови наукових джерел. Пошуки проводилися за термінами MeSH (Medical Subject Headings) з використанням таких пошукових термінів: «незнімне протезування», «цільнолиті коронки», «штамповані коронки», «слизова оболонка», «матеріалознавство», «сплави металів», «препарування зубів», «гальваноз». Використані методи: бібліографічний та аналітичний.

Результати та обговорення. Найпоширенішими незнімними конструкціями є штучні коронки, які мають певні конструктивні особливості та застосовуються для різних цілей. Класифікують їх за різними ознаками, включаючи матеріал виготовлення. До основних матеріалів відносять сплави металів на основі заліза, нікелю, кобальту, хрому, срібла, паладію, золота, пластмаси, керамічні матеріали. Вибір конкретного складу сплаву залежить від вимог до коронки, таких як міцність, стійкість до зношування, а також від індивідуальних потреб та фінансових можливостей пацієнта. Найбільш поширеними видами коронок, які виготовляються з металів або їх сплавів є суцільнолиті та штамповані. Ускладнення, що виникають при використанні незнімних коронок, спонукають науковців до пошуку оптимальних методів вибору матеріалів, конструкційних особливостей протезів, вдосконалення технологій їх виготовлення, розробки методів і засобів для запобігання негативних наслідків та побічних ефектів при незнімному протезуванні.

Висновки. Незнімні ортопедичні конструкції сприймаються організмом як чужорідне тіло і можуть сприяти виникненню та розвитку імунно-запальних процесів у ротовій порожнині. Дослідження ускладнень, що виникають при використанні незнімних ортопедичних конструкцій дозволять з'ясувати та уточнити патогенетичні ланки в їх розвитку, що надасть підставу для розробки профілактичних заходів для даної категорії стоматологічних пацієнтів.

Ключові слова: **незнімне протезування, цільнолиті коронки, штамповані коронки, слизова оболонка, матеріалознавство, сплави металів, препарування зубів, гальваноз, ортопедична стоматологія, травматична оклюзія**

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