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LIPID PEROXIDATION AND OXIDATIVE PROTEIN MODIFICATION IN EXPERIMENTAL PERIODONTITIS OF BACTERIAL-IMMUNE ORIGIN UNDER CONDITIONS OF METAL CROWN PLACEMENT (SERUM STUDY)

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Studying changes in oxidative stress accompanying the placement of fixed structures in periodontitis will allow for a deeper understanding of the mechanisms of the pathological process and its prevention.

The aim of the work was to investigate disturbances in oxidative metabolism and the accumulation of peroxidation products in experimental periodontitis of bacterial-immune origin and under conditions of metal crown fixation.

Materials and methods. Experimental periodontitis of bacterial-immune origin was induced in animals by injecting a suspension of microorganisms mixed with egg protein into the periodontal tissues. On the 30th day of inflammation, the levels of diene and triene conjugates, products of oxidative protein modification, thiobarbituric acid-reactive compounds, and nitric oxide metabolites in blood serum were assessed using biochemical methods, while considering the fixation of both stamped and cast crowns.

Results and discussion. The results of the study indicate that after fixation of metal crowns, the level of lipid peroxidation decreases compared to the group without prosthetics. However, cast crowns demonstrate a greater effect in reducing oxidative stress than stamped ones, which may be due to their better adaptation to periodontal tissues and a lower reaction of soft tissues to this alloy. Moreover, even with the application of cast crowns, the level of oxidative stress remains elevated compared to control animals, highlighting the necessity for further studies aimed at optimizing the effects of metal prosthetic structures on periodontal tissue condition.

Conclusion. The development of the inflammatory process in periodontitis is accompanied by an increase in the level of lipid peroxidation in the blood serum, which is a marker of oxidative stress. After fixation of metal crowns, the level of oxidative stress is partially reduced, and cast crowns have a greater effect in reducing the intensity of lipoperoxidation than stamped ones.

Keywords: prosthetics, stamped crowns, cast crowns, periodontitis, lipid peroxidation.

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ПЕРОКСИДНЕ ОКИСНЕННЯ ЛІПІДІВ ТА ОКИСНА МОДИФІКАЦІЯ БІЛКІВ ПРИ ЕКСПЕРИМЕНТАЛЬНОМУ ПАРОДОНТИТІ БАКТЕРІАЛЬНО-ІМУННОГО ГЕНЕЗУ ЗА УМОВ ВИКОРИСТАННЯ МЕТАЛЕВИХ КОРОНОК (ДОСЛІДЖЕННЯ СИРОВАТКИ КРОВІ)

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У роботі досліджено пероксидне окиснення ліпідів та оксидативний статус при експериментальному пародонтиті бактеріально-імунного генезу у білих щурів. Визначали рівні дієнових і трієнових кон'югатів, продуктів окисної модифікації білків, тіобарбітуровокислотно-активних сполук і метаболітів оксиду азоту у сироватці крові на 30-ту добу запалення з урахуванням фіксації штампованих і суцільнолитих коронок. Отримані результати характеризують особливості системної оксидативної відповіді організму при експериментальному пародонтиті бактеріально-імунного генезу та за умов використання металевих коронок. Встановлено, що при суцільнолитих коронках ліпопероксидація менш виражена, однак оксидативний стрес зберігається, що свідчить про триваюче ураження тканин.

Ключові слова: протезування, штамповані коронки, суцільнолиті коронки, пародонтит, пероксидне окиснення ліпідів.

Introduction

One of the priority areas of modern dentistry is the improvement of existing and development of new methods of prevention and treatment of periodontitis [1]. Inflammatory lesions of the periodontal structures occupy a leading place among inflammatory diseases of the maxillofacial region and can negatively affect the effectiveness of orthopedic treatment of patients. The main role in the development of periodontitis is played by pathogenic microflora, in particular associations of *Staphylococcus aureus and Streptococcus hemolyticus*, the activity of which increases under conditions of reduced protective properties of the tissues of the oral cavity [2]. An important pathogenetic factor is the disruption of oxidative metabolism, among which the activation of lipid peroxidation is a key mechanism of cellular stress, which leads to damage to membranes at the cellular and subcellular levels [3].

Fixed orthopedic structures can be perceived by the body as foreign elements, causing the development of immuno-inflammatory reactions in the oral cavity. Studying changes in lipoperoxidation processes and manifestations of oxidative stress that accompany the placement of fixed structures made of different types of metal alloys against the background of periodontitis will allow a deeper understanding of the mechanisms of the pathological process and will become the basis for the development of effective preventive measures in the treatment of this category of dental patients [4].

The aim of the work was to investigate disturbances in oxidative metabolism and the accumulation of peroxidation products in experimental periodontitis of bacterial-immune origin and against the background of the placement of metal crowns.

Materials and methods

The study was conducted on clinically healthy male white rats weighing 150–200 g, which were kept in vivarium conditions in compliance with sanitary and hygienic standards and requirements of good laboratory practice (GLP). The animals were randomly divided into four groups: Group I – intact animals (control, n = 10); Group II – rats with periodontitis on the 30th day of the experiment (n = 8); Group III – rats with periodontitis on the 30th day, in which stamped crowns were placed (n = 8); Group IV – animals with periodontitis on the 30th day of the study, in which cast crowns were placed (n = 8). Within the framework of this experiment, the aim was to study changes in oxidative status precisely under the conditions of a combination of experimental periodontitis and the placement of orthopedic structures. The formation of separate groups without an inflammatory process or in combination with other concomitant pathologies may be the subject of further research.

To manufacture fixed orthopedic structures, impressions were first taken from the central incisors of the lower jaw using the silicone material “Speedex”. Crowns were manufactured using standard clinical and laboratory methods: stamped crowns were formed by stamping from standard sleeves from the manufacturer “Medtekhnika” (Ukraine) [5], and cast crowns were formed by casting using the cobalt-chromium alloy “Argeloy N.P. Supreme” (“ARGEN”, USA) [6]. Orthopedic elements were designed in such a way as to avoid covering the occlusal surfaces of the teeth, with fixation of the structures simultaneously on both central incisors.

In experimental rats, a model of experimental periodontitis of bacterial-immune origin was created by injecting a suspension of *Staphylococcus aureus and Streptococcus hemolyticus*, prepared on the basis of egg white, into the periodontal tissues. Key structural elements of the cell wall of gram-positive bacteria – lipoteichoic acids, peptidoglycan and lipoproteins – activate the inflammatory response through toll-like receptors 2, which are involved in pathogen recognition and activation of the innate immune defense system. To enhance the immune response, animals were additionally administered complete Freund's adjuvant. Repeated administration on the 14th day of the experiment provided stable induction and transition of the process to a chronic form [7]. On the 30th day of the experiment, animals were euthanized under deep anesthesia with sodium thiopental in accordance with ethical standards, after which blood serum was collected for further analysis.

To determine the concentration of thiobarbituric acid-reactive substances (TBARS), the reaction between malondialdehyde and thiobarbituric acid was used, which in an acidic environment led to the formation of a colored complex. The assessment of the level of oxidative modification of proteins (OMP) in blood plasma was based on the ability of oxidized amino acid residues to interact with 2.4-dinitrophenylhydrazine (2,4-DNFH), resulting in the formation of 2.4-dinitrophenylhydrazones. Compounds with neutral aldehyde and ketone groups were recorded at 370 nm (OMP_{370}), and derivatives with basic properties – at 430 nm (OMP_{430}). Measurement of the optical density of the samples was carried out on a SF-46 spectrophotometer at the indicated wavelengths relative to the control sample. The concentration of diene and triene conjugates was determined by a method involving extraction of hydroperoxides with a heptane-isopropyl mixture followed by fixation of the absorption maximum: for diene conjugates (DC) – at 232 nm, and for triene conjugates (TC) – at 275 nm. The determination of the total level of nitric oxide metabolites, in particular nitrite anions (NO_2^-), was carried out by a photometric method at a wavelength of 546 nm using a photoelectrocolorimeter [8].

All experimental manipulations were performed in accordance with the provisions of the “European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes” (Strasbourg, 1986) and the “General Ethical Principles for the Conduct of Experiments on Animals” (Kyiv, 2001). The study was approved by the Bioethics Commission of Horbachevsky Ternopil National Medical University of the Ministry of Health of Ukraine (protocol No. 80 dated January 10, 2025).

The results were processed using nonparametric statistical methods in the STATISTICA 10.0 software environment (StatSoft, USA). Statistical analysis included the estimation of variation series by determining the arithmetic mean (M) and the standard error of the mean (m). For non-normally distributed data, the Mann-Whitney U test was used. Nonparametric indicators were also

taken into account, in particular the median (Me) and the interquartile range (25%; 75%), corresponding to the 25th and 75th percentiles. The level of statistical significance for all types of analysis was set at $p<0.05$.

Research results and their discussion

In the course of the conducted studies, it was found that during the development of the inflammatory process in the periodontal structures, recorded on the 30th day of the experiment, excessive accumulation of lipoperoxidation products was observed in the blood serum. This was confirmed by an increase in the concentration of diene conjugates (4.33-fold; $p<0.001$) and triene conjugates (3.79-fold; $p<0.001$) compared to the control group of experimental animals (Table 1, Fig. 1). In rats fitted with stamped crowns, on the 30th day of the pathological process, a decrease in the level of DC (1.11-fold; $p<0.001$) and TC (1.15-fold; $p<0.001$) in the blood serum was noted compared to the group of animals with periodontitis without fixation of metal structures. At the same time, these indicators remained significantly higher compared to the intact group of animals (3.91-fold; $p<0.001$ and 3.30-fold; $p<0.001$, respectively).

During further observation, on the 30th day of the development of the inflammatory process in periodontal tissues and after fixation of cast crowns, the concentration of diene conjugates in the blood serum exceeded the corresponding indicators of the control group 2.91-fold ($p<0.001$). At the same time, this indicator was 1.49-fold lower ($p<0.001$) compared to the level recorded in the same period in animals without prosthetics. When compared with rats fitted with stamped crowns, the level of this metabolite in the blood serum also turned out to be significantly lower – 1.34-fold ($p<0.001$).

The level of triene conjugates in animals with cast crowns changed in a similar way, but the decrease in their concentration in the blood serum was less pronounced –1.15-fold ($p<0.001$) compared to the indicators on the 30th day without crowns. At the same time, an increase in this indicator was observed 2.54-fold ($p<0.001$) compared to the control group. When compared with the data of the group of animals with experimental periodontitis, which

Table 1

Indicators of lipid peroxidation products in the blood serum of white rats with experimental periodontitis and under the condition of using crowns (M±m)

Initial data and study design	Control. Intact animals	White rats with experimental periodontitis of bacterial-immune origin		
		Without prosthetics	Stamped crowns	Cast crowns
Experiment duration (days)	–	30	30	30
Number of animals	10	8	8	8
DC, cond. units/ml	1.42 ± 0.05	6.15 ± 0.12 $p_1<0.001$	5.55 ± 0.04 $p_1<0.001$; $p_2<0.001$	4.13 ± 0.04 $p_1<0.001$; $p_2<0.001$; $p_3<0.001$
TC, cond. units/ml	1.67 ± 0.06	6.33 ± 0.11 $p_1<0.001$	5.51 ± 0.06 $p_1<0.001$; $p_2<0.001$	4.24 ± 0.05 $p_1<0.001$; $p_2<0.001$; $p_3<0.001$
DC / TC	0.85 ± 0.02	0.97 ± 0.01 $p_1<0.001$	1.01 ± 0.01 $p_1<0.001$; $p_2<0.05$	0.98 ± 0.01 $p_1<0.001$; $p_2>0.05$; $p_3>0.05$
Thiobarbituric acid-reactive substances, μmol/l	0.58 ± 0.04	2.86 ± 0.12 $p_1<0.001$	2.14 ± 0.14 $p_1<0.001$; $p_2<0.01$	1.19 ± 0.05 $p_1<0.001$; $p_2<0.001$; $p_3<0.001$
$NO_2^-+NO_3^-$, μmol/l	0.553 ± 0.008	0.778 ± 0.007 $p_1<0.001$	0.700 ± 0.005 $p_1<0.001$; $p_2<0.01$	0.668 ± 0.006 $p_1<0.001$; $p_2<0.001$; $p_3<0.01$
OMP_{370}, mmol/ml	0.231 ± 0.006	0.445 ± 0.008 $p_1<0.001$	0.260 ± 0.002 $p_1<0.01$; $p_2<0.001$	0.292 ± 0.006 $p_1<0.001$; $p_2<0.001$; $p_3<0.01$
OMP_{430}, mmol/ml	0.270 ± 0.006	0.463 ± 0.004 $p_1<0.001$	0.311 ± 0.004 $p_1<0.001$; $p_2<0.01$	0.298 ± 0.002 $p_1<0.001$; $p_2<0.001$; $p_3<0.05$
OMP_{370} / OMP_{430}	0.86 ± 0.02	0.96 ± 0.02 $p_1<0.01$	0.84 ± 0.02 $p_1>0.05$; $p_2<0.01$	0.98 ± 0.02 $p_1<0.01$; $p_2>0.05$; $p_3<0.01$

Note: p_1 – significance of differences relative to control animals; p_2 – significance of differences relative to animals with experimental periodontitis on the 30th day without the placement of crowns; p_3 – significance of differences relative to animals with experimental periodontitis on the 30th day with stamped crowns.

stamped crowns were placed, the level of triene conjugates was 1.30-fold lower ($p<0.001$).

Analysis of the ratio of DC/TC content in blood serum showed that this indicator significantly increased on the 30th day of the periodontitis study both in the group without prosthetics and in animals with metal stamped and cast crowns –1.14-fold ($p<0.001$), 1.19-fold ($p<0.001$) and 1.15-fold ($p<0.001$), respectively, compared with the control group. In addition, on the 30th day of the inflammatory process in animals with stamped structures this indicator exceeded the level of the group without prosthetics 1.04-fold ($p<0.05$).

When analyzing this ratio in rats with cast crowns compared to the indicators of animals without prosthetics and with stamped structures, no statistically significant differences were found ($p<0.05$).

When studying the main indicator of the level of lipid peroxidation – the content of TBARS – significant changes were found (see Table 1). In particular, it was found that on the 30th day of the development of experimental periodontitis, this indicator in the blood serum exceeded the value of the control group 4.93-fold ($p<0.001$).

On the 30th day of the development of periodontal inflammation of bacterial-immune origin against the background of prosthetics with stamped crowns, a decrease in the level of TBARS (1.34-fold; $p<0.01$) in the blood serum was observed compared to the group of animals without prosthetics. However, this indicator remained elevated relative to the intact group (3.69-fold; $p<0.001$), which indicates a significant activation of free radical processes of lipid oxidation during the formation of inflammation.

Studies conducted on animals with cast crowns revealed that the level of TBARS in the blood serum decreased (1.34-fold; $p<0.001$ and 1.80-fold; $p<0.001$) compared to the groups with experimental periodontitis without prosthetics and with stamped structures, respectively. However, the concentration of these products in the group with cast crowns was higher (2.05-fold; $p<0.001$) compared to intact white rats (Fig. 2).

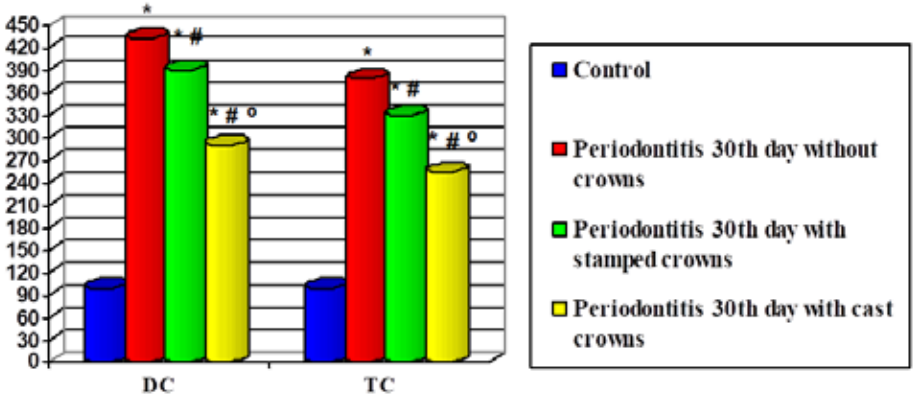

Fig. 1. Changes in the content of lipid peroxidation products in blood serum under conditions of experimental periodontitis development and placement of crowns (in % of control)

Notes: * – significance of differences relative to intact animals ($p<0.001$); # – significance of differences relative to animals with periodontitis on the 30th day without prosthetics ($p<0.001$); º – significance of differences relative to animals with periodontitis on the 30th day with stamped crowns ($p<0.001$)

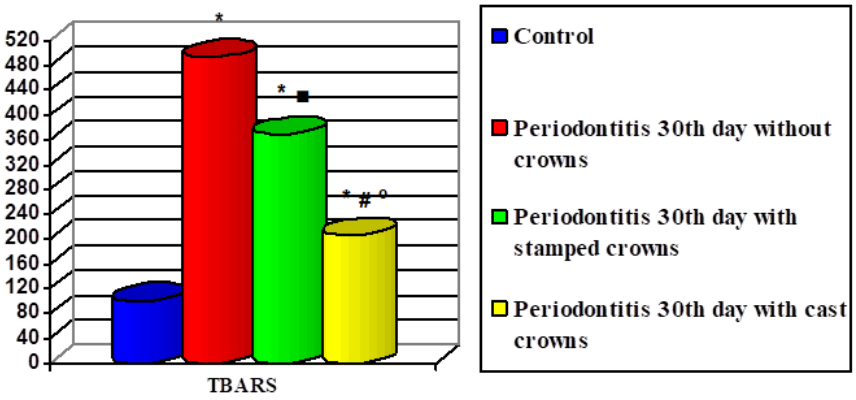

Fig. 2. Changes in the content of thiobarbituric acid-reactive substances in blood serum under conditions of experimental periodontitis development and placement of crowns (in % of control)

Notes: * – significance of differences relative to intact animals ($p<0.001$); # – significance of differences relative to animals with periodontitis on the 30th day without prosthetics ($p<0.001$); ■ – significance of differences relative to animals with periodontitis on the 30th day without prosthetics ($p<0.01$); º – significance of differences relative to animals with periodontitis on the 30th day with stamped crowns ($p<0.001$).

In this study, on the 30th day of the development of the inflammatory process in the periodontal structures, an increase in the concentration of nitric oxide (NO) metabolites (NO_2^- + NO_3^-) in the blood serum was recorded. These compounds belong to unstable products of free radical oxidation, and their level exceeded the indicators of the intact group 1.41-fold (p<0.001) (table).

In animals that had stamped and cast structures against the background of periodontitis of bacterial-immune origin, compared with the group without prosthetics, this indicator acquired the opposite direction of changes, i.e. began to decrease – 1.11-fold (p<0.001) and 1.17-fold (p<0.001), respectively. However, the results obtained in rats with metal crowns were increased relative to the control indicators. With stamped ones – 1.27-fold (p<0.001), with cast ones – 1.21-fold (p<0.001) (Fig. 3).

Analyzing the dynamics of the content of nitric oxide (NO) metabolism products in the blood serum of experimental animals with periodontitis and various types of metal crowns, it should be noted that its level in animals with cast crowns was significantly, but slightly lower (1.05-fold; p<0.01).

The results obtained indicate that the level of products of oxidative modification of neutral proteins (OMP_{370}) on the 30th day of periodontitis development increased 1.93-fold (p<0.001) in the group of animals without prosthetics, 1.13-fold (p<0.01) when using stamped crowns and 1.26-fold (p<0.001) when fixing cast crowns, compared to intact animals (table). It is worth noting that in animals that underwent prosthetics, the level of OMP_{370} in the blood serum was lower compared to the group without prosthetics: when using stamped crowns – 1.71-fold (p<0.001), and when cementing cast crowns – 1.52-fold (p<0.001), which may indicate a certain influence of metal structures on the course of oxidative stress (Fig. 4).

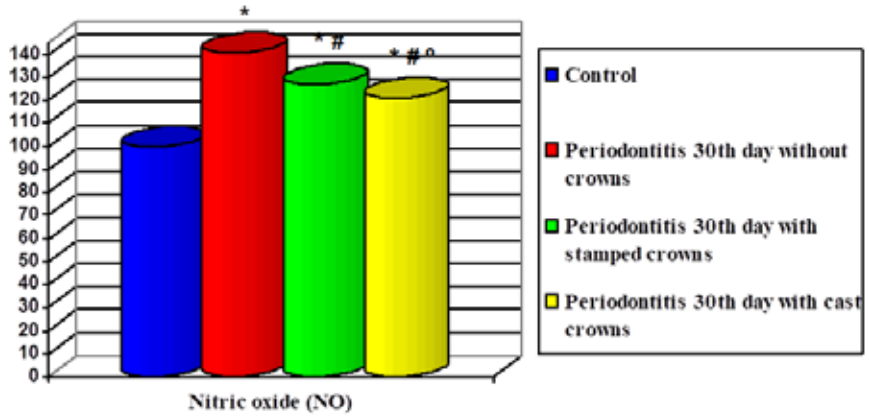

Fig. 3. Changes in the content of nitric oxide (NO) in blood serum under the conditions of experimental periodontitis development and the placement of crowns (in % of control)

Notes: * – significance of differences relative to intact animals (p<0.001); # – significance of differences relative to animals with periodontitis on the 30th day without prosthetics (p<0.001); º – significance of differences relative to animals with periodontitis on the 30th day with stamped crowns (p<0.01)

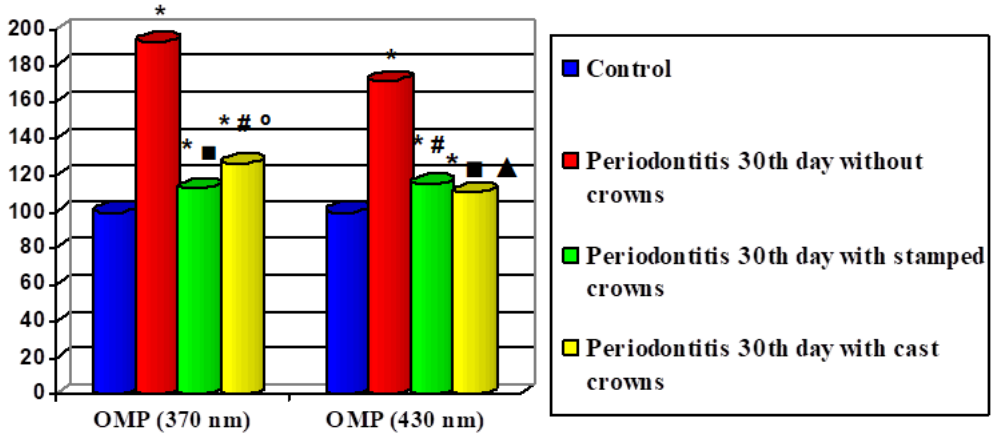

Fig. 4. Changes in the content of OMP in blood serum under the conditions of experimental periodontitis and the placement of crowns (in % of control)

Notes: * – significance of differences relative to intact animals (p<0.001); # – significance of differences relative to animals with periodontitis on the 30th day without prosthetics (p<0.001); ■ – significance of differences relative to animals with periodontitis on the 30th day without prosthetics (p<0.01); º – significance of differences relative to animals with periodontitis on the 30th day with stamped crowns (p<0.01); ▲ – significance of differences relative to animals with periodontitis on the 30th day with stamped crowns (p<0.05).

When analyzing the level of aldehyde and ketone derivatives on the 30th day of the development of experimental periodontitis and after prosthetics, their increase was found to be 1.12-fold ($p<0.01$) in animals with cast crowns, which may indicate the activation of oxidative processes in these conditions.

On the 30th day of periodontitis, an increase in the serum of products of oxidative modification of proteins of a basic nature (OMP_{430}) was also observed (1.72-fold; $p<0.001$) compared to the intact group. When studying the effect of stamped structures, this indicator changed in the opposite direction, that is, it began to decrease (1.49-fold; $p<0.001$), compared to the indicators of rats without crowns, but remained higher compared to the intact group of animals (1.15-fold; $p<0.001$) (Fig. 4).

When assessing the impact of cast prosthetics, a similar decrease in this indicator was observed – 1.55-fold ($p<0.001$) compared to animals without prostheses. At the same time, its level remained elevated relative to the intact group (1.10-fold; $p<0.01$).

A comparative analysis of two types of metal crowns showed that in animals with cast structures this indicator was 1.04-fold lower ($p<0.05$) compared to the group with stamped crowns. This may indicate a certain advantage of cast prosthetics in reducing the intensity of oxidative stress in conditions of periodontitis.

When determining the ratio of aldehyde and ketone derivatives of neutral and basic nature in blood serum, it was found that on the 30th day of the course of experimental periodontitis, an increase in its content was observed relative to the control in the groups without prosthetics and with cast crowns (1.12-fold ($p<0.01$) and 1.14-fold ($p<0.01$), respectively). Compared with the results obtained after fixation of stamped structures, this ratio decreased, but these changes were not statistically significant ($p>0.05$).

However, comparing OMP_{370} / OMP_{430} in animals with periodontitis without crowns and with stamped structures, it turned out that the indicator decreased (1.14-fold; $p<0.01$). At the same time, when comparing the ratio between the groups of animals without prosthetics and with cast crowns, the changes were statistically insignificant ($p>0.05$).

When comparing this ratio of OMP_{370} / OMP_{430} in animals of the third and fourth experimental groups with each other, an increase 1.14-fold ($p<0.01$) of the indicators obtained in periodontitis of bacterial-immune origin was established, provided that cast structures were fixed.

The chronic course of periodontitis is associated with persistent immunological changes, in particular, an imbalance in the system of pro-inflammatory and anti-inflammatory cytokines, activation of neutrophils and macrophages [9; 10], which, in turn, causes excessive formation of reactive oxygen species, stimulates lipoperoxidation processes and leads to the development of systemic oxidative stress, which is one of the key pathogenetic mechanisms of periodontal tissue damage [11].

The results obtained indicate that the placement of metal crowns in periodontitis partially reduces the intensity of oxidative stress, which is manifested by a less pronounced accumulation of lipoperoxidation products, in particular diene and triene conjugates. A decrease in the level of these metabolites in the blood serum of animals with prosthetic teeth indicates the potential impact of metal structures on the course of the inflammatory process and the balance of the oxidant-antioxidant system [12]. At the same time, although the fixation of crowns contributes to a decrease in the intensity of lipoperoxidation compared to the group without prosthetics, the level of oxidative stress remains elevated relative to intact animals, which indicates an ongoing pathological process [13].

The DC/TC ratio reflects the degree of lipid peroxidation intensity and the balance between primary and final products of lipoperoxidation, which is a marker of oxidative stress [14]. An increase in this indicator in the conditions of periodontitis indicates an increased accumulation of early oxidation products, which may indicate insufficient activity of the antioxidant system and progression of the inflammatory process [15]. An increase in the level of TBARS in the blood serum on the 30th day of periodontitis indicates an activation of lipid peroxidation, which is a marker of oxidative stress that accompanies the inflammatory process [16]. Inflammation in periodontal tissues can cause the formation of free radicals that activate lipoperoxidation processes [17].

The results of the study indicate that the presence of any type of metal crowns reduces the level of lipid peroxidation compared to the group without prosthetics. However, cast crowns demonstrate a greater effect in reducing oxidative stress than stamped ones, which may be due to their better adaptation to periodontal tissues and a reduced risk of mechanical irritation. At the same time, even when using cast crowns, the level of TBARS remains higher than in control animals, which indicates the need for further research on optimizing the impact of prosthetic structures on the condition of periodontal tissues.

The increased level of nitric oxide (NO) metabolites ($NO_2^- + NO_3^-$) in the blood serum indicates an increase in free radical oxidation processes, which is a typical reaction of the body to inflammation. Nitric oxide (NO) performs a dual role: on the one hand, it has a vasodilating and regulatory effect; on the other hand, in excessive concentrations it promotes the formation of peroxynitrite, which damages cellular structures and enhances the course of the inflammatory process [18].

One of the key indicators of the balance of free radical processes is the formation of oxidative modification of proteins, which causes the activation of proteolysis in proteasomes and promotes the development of alternative changes in the inflammation zone [19]. Oxidation of amino acid residues in protein molecules leads to structural transformations, manifested by fragmentation, aggregation and increased sensitivity to proteolytic cleavage. Unlike lipid peroxides, OMP products are characterized by greater stability and are rapidly metabolized under the influence of low-molecular antioxidants and peroxidases, which plays an important role in the regulation of oxidative stress in the body [20].

The results obtained indicate that in periodontitis without prosthetics and with the fixation of cast

crowns, an increase in the level of aldehyde and ketone-derived products of oxidative modification of proteins is observed. This may indicate the activation of oxidation processes in the body, which are indicators of inflammatory changes. The decrease in the ratio between aldehyde and ketone derivatives when using stamped structures, on the contrary, is not statistically significant, which may indicate a less pronounced oxidative activity compared to cast crowns.

It should be noted that the study focused on assessing the systemic oxidative response of the body, particularly in blood serum. The study of lipid peroxidation and antioxidant defense indicators directly in periodontal tissues may be a promising direction for further research.

Conclusions

1. The development of the inflammatory process in periodontitis of bacterial-immune origin is accompanied by an increase in the level of lipid peroxidation in the blood serum, which is a marker of oxidative stress. Lipid oxidation indicators, in particular diene and triene conjugates, significantly increase compared to control groups. This process is characteristic of inflammatory changes in periodontal tissues and indicates increased oxidative stress.

2. After fixation of metal crowns, the level of oxidative stress is partially reduced, in particular, the number of lipoperoxidation products is reduced compared to the group without prosthetics. The results obtained indicate less pronounced manifestations of lipoperoxidation when using full-cast crowns compared to stamped ones, however, the preservation of signs of oxidative stress indicates a possible additional influence of orthopedic structures on the course of the inflammatory process.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Ethical statement

All authors declare that ethical approval was obtained for this experimental study.

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