sciendo Acta Marisiensis - Seria Medica 2023;69(1):30-36 DOI: 10.2478/amma-2023-0002

RESEARCH ARTICLE

A study of the impact of solid cast removable dentures with silver electroplating on the condition of patients

Andriy Nikonov[1], Valeriia Krynychko[1*], Nataliia Bobrovska[1], Nataliia Breslavets[1], Olha Smirnova[2], Zahar Muhin[3]

1. Department of Dentistry, Faculty of Medicine, V. N. Karazin Kharkiv National University, Kharkiv, Ukraine
2. National Technical University "Kharkiv Polytechnic Institute", Kharkiv, Ukraine
3. Department of Pediatric Dentistry and Orthodontics, Faculty of Surgery, Kharkiv Medical Academy of Postgraduate Education, Kharkiv, Ukraine

Objectives: The aim of our study was to determine the effectiveness and biocompatibility of the use of solid clasp dentures with silver plating in the restoration of partial defects of the dentition. **Methods:** The study involved 23 patients with partial secondary adontia after oral rehabilitation. At the first stage, before the start of treatment and after a month of using a clasp prosthesis, patients underwent studies of blood biochemical parameters, Schiller-Pisarev's test and Papillary-marginal-alveolar index. At the second stage of the research, silver electroplating was applied to the metal parts of the clasp prosthesis and after a month of use, its effect on oral hygiene and blood biochemical parameters was assessed. **Results:** After installation of the removable prosthesis with solid structures, the PMA index after the use of silver-plated clasp prosthesis decreased to medium severity, which is explained by positive impact on the inflammatory process in the gums. We can see the stability of biochemical parameters of blood in patients with solid removable prostheses can serve as a justification for the administration of silver electroplating for prophylactic and therapeutic purposes. **Conclusions**: The effectiveness of the use of silver plating in the treatment of partial defects of the dentition eliminates the clinical manifestations of the pathological condition and prevents possible complications in the oral cavity.

Keywords: treatment of partial dentition defects, clasp dentures, silver electroplating

Received 19 September 2022 / Accepted 8 January 2023

Introduction

The trends in the development of science and medicine in recent decades have been focused on improving the quality of human life. Already now we can see the results in the increase in life expectancy and we can state the increase in the number of the elderly population. Improvement in overall health status, namely dental health, has resulted in a reduction in tooth loss, indicating an increased need for treatment of partial secondary edentulous compared to complete edentulous.

Partial removable dentures are the most common designs of dentures. At the present level, solid clasp dentures are one of the most favorable types of removable structures used to repair dentition defects, due to which the loss of hard and soft tissues are restored, and the integrity of the dental arch is maintained, and chewing efficiency is fully restored.

However, the use of clasp dentures is associated with complications such as: damage to abutment teeth by caries, inflammatory processes in the periodontium, changes in electrochemical potentials (galvanosis) in the oral cavity, abnormal changes in the oral mucosa [1].

Issues of prevention of lesions of abutment teeth, adjacent periodontal tissues and oral mucosa are quite relevant. For the purpose of preventing possible complications, it is advisable to use silver, which is used in medicine as an antibacterial component; silver ions prevent reproduction of pathogenic bacteria, viruses and fungi. Based on the results of bibliometric analysis, global research interest regarding silver in dentistry has rapidly increased in recent years [2].

The first use of silver in dentistry has been documented since 1840 [3]. Silver, the natural biocide, is used in medicine since the time of Hippocrates to treat burn wounds because of its antibiotic and wound healing properties. In Dentistry, Silver amalgam had been in use for centuries owing to its superior physical and mechanical properties [4].

But the present time is the time of nanotechnologies. The nanometric size and large contact area of nanoparticles give silver ions new characteristics, manufacturability, and possibilities. Silver nanoparticles have proved to be highly promising in applications for the development of different areas of dentistry. The use of AgNPs has been investigated in conservative dentistry, orthodontics, restorative dentistry, endodontics, periodontics, implantology, and prosthodontics mainly because of their antimicrobial effects and biocompatibility [5].

Currently, silver is used in the form of a gel, in the composition of ointments, for impregnation of polymers of therapeutic agents [6, 7].

Oral cavity is a gateway to the entire body and protection of this gateway is a major goal in dentistry. Plaque biofilm is a major cause of majority of dental diseases and although various biomaterials have been applied for their cure, limitations pertaining to the material properties pre-

* Correspondence to: Valeriia Krynychko
E-mail: liza.pysarieva@gmail.com

vent achievement of desired outcomes [8, 9]. Ineffective treatment leads to 60% of cases of loosening of intraosseous dental implants with their subsequent rejection, especially if there is a deterioration in the quality of the jaw bone due to osteopenia or osteoporosis, in combination with atrophy of the alveolar processes of the jaws.[10]

The aim of our study was to determine the effectiveness and biocompatibility of the use of solid clasp dentures with silver plating in the restoration of partial defects of the dentition.

Methods

The study involved 23 patients (9 females and 14 males, aged 52 to 72) with partial secondary adontia after oral rehabilitation, made of solid clasp dentures with NEY system staples. At the first stage, before the start of treatment and after a month of using a clasp prosthesis, patients underwent studies of blood biochemical parameters, Schiller-Pisarev's test and PMA index [11].

To determine the level of the inflammatory process in the periodontium, the Schiller-Pysarev test (glycogen test) was performed - the method of setting the test includes treating the gums with Schiller-Pysarev solution, which changes their color with a reaction to glycogen.

With an intact periodontium, the mucous membrane of the alveolar process has a straw-yellow color. With chronic inflammation of the gums, their color changes from light brown to dark brown, which is due to the activity of the inflammatory process.

Sample evaluation:
– Negative - straw-yellow color;
– Weakly positive - light brown color;
– Positive - brown color;
– Sharply positive - dark brown color;

Quantitative expression of the Schiller-Pysarev test:
– 0 points - straw-yellow color;
– 2 points - brown color of the gingival papilla;
– 4 points - brown color of the gingival margin;
– 8 points – brown color of the alveolar part.

The papillary-marginal-alveolar (PMA) index in the Parma (1960) modification - the gingivitis index - allows you to assess the inflammatory process in the gums, while the assessment of the condition of the gums is carried out for each tooth:
– 1 point - inflammation of the gingival papilla - R
– 2 points - inflammation of the gingival (marginal) edge - M
– 3 points - inflammation of the entire mucous membrane of the alveolar process -*A*

The formula for calculating the RMA index:

$$PMA = \frac{\text{The sum of the indicators of each tooth}}{3*n} 100\%,$$

where
n = 24 (6-11 years old)
n = 28 (12-14 years old)
n = 30 (from 15 years)
3 – the maximum number of points

Evaluation criteria of the PMA index:
– up to 25% - gingivitis is mild
– 25-50% - gingivitis of moderate severity
– more than 51% – gingivitis is severe

At the second stage of research, silver electroplating was applied to the metal parts of the brace prosthesis according to the original technology developed at the Department of Technical Electrochemistry of the National Technical University «Kharkiv Polytechnic Institute» [12,13,14,15].

The nonparametric Friedman test was used to compare the averages in more than two dependent groups (1, 2, 3). It shows the difference between the averages in the groups. The nonparametric Wilcoxon test was used to compare the averages in the two dependent groups [11].

The principles of electrochemical surface treatment and electroplating, modified for orthopedic dentistry, were taken as a basis for the silvering technique. The technology of silver plating of dentures from cobalt-chromium alloy (CCA) was performed as follows. Making of a solid clasp prosthesis and careful fitting in the mouth of the patient were followed by sequential processing of the prosthesis by such technological operations as:

1. Installation of the product on the suspension in the galvanic bath.
2. Electrochemical degreasing (cathodic) in a standard alkaline electrolyte based on sodium carbonate, trisodium phosphate and liquid sodium glass. The temperature of the solution was 70-90°C, j_k = 2-5 A/dm^2, processing time – 3-5 minutes
3. Rinsing in hot running water.
4. Rinsing in cold running water.
5. Anodic processing in the electrolyte, which included sulfuric and hydrochloric acids [12]. The temperature of the solution was 18-25°C, j_a = 0.5-1.0 A/dm^2 or ε_a = 0.0 ± 0.05 V, processing time – 20-40 minutes, titanium cathodes.
6. Rinsing in cold running water.
7. Activation, carried out immediately before coating in a solution containing nitric and hydrofluoric acid [16]. The temperature of the solution – 18-25°C, processing time – 0.25-0.5 minutes
8. Rinsing in cold running water.
9. Copper plating in the electrolyte, which included copper salt (citrate or copper (II) nitrate), thiourea, citric acid and sodium selenium [17, 18]. Temperature – 18-50°C, j_k = 0.3-1.0 A/dm^2, processing time – 15 minutes, anodes – copper.
10. Catching in cold stagnant water.
11. Rinsing in cold running water.
12. Silvering in the electrolyte, the main components of which were silver salt (citrate or silver nitrate (I)), thiourea, citric acid and sodium selenium [12]. Temperature – 18-35°C, j_k = 0.5-1.0 A/dm^2, processing

time – 40 minutes, anodes – silver.
13. Catching in cold stagnant water.
14. Rinsing in cold running water.
15. Drying and dismantling of products.

After applying the silver coating, its effect on the state of oral hygiene and biochemical blood parameters was observed.

To compare the averages in more than two dependent groups (1,2,3), the Friedman ANOVA test (Friedman) test was used, which is a non-parametric analog of univariate analysis of variance with repeated measurements. The significance of the Friedman test at the level of less than 0.05 means that in the comparison groups there is at least one significant ($p<0.05$) difference between the average values of the indicator in the groups. The Wilcoxon test was used to compare average indicators in two dependent groups, which is a non-parametric alternative to the t-test for comparing averages in two dependent samples. The Wilcoxon test is based on the ranking of the values of the indicator under consideration. And the calculation of the sum of the ranks of the values of the second sample in the general variation series of the two samples [16].

The advantages of the proposed technology include: good quality and reliability of dentures; high biocompatibility, active antimicrobial action of silver; the use of modern electrolytes of copper and silver, which are non-toxic because they do not contain cyanides, which can significantly improve the working conditions of employees and reduce the negative effects of wastewater generated during processing [19].

Biochemical blood tests were performed to determine the biocompatibility of clasp dentures with patients. Aspartate aminotransferase (AST) and alanine aminotransferase (ALT) in serum were determined to characterize the hepatobiliary system. Studies of bilirubin content were performed according to generally accepted clinical methods [19, 20].

The state of tissue hypoxia and liver dysfunction are characterized by indicators of ceruloplasmin (CP) and transferrin (TF), which were studied by methods [21,22].

The content of the final product of malonic dialdehyde (MDA) lipid peroxidation (LPO) was determined by the method based on the reaction with thiobarbituric acid [23].

The content of sulfhydryl SH-groups of whole blood was determined by V.F. Folomeev's method [24] based on the equivalent interaction of molecular iodine with the SH group and reduced in the SH group disulfides of proteins and low molecular weight compounds.

Results

At the beginning of prosthesis installation, after preparatory activities, the index of the Schiller-Pisarev's test in dental patients was 1.8 ± 0.02 points. After installation of prosthesis with solid removable structures, this figure was 2.71 ± 0.03 points throughout the observation period, indicating a deterioration in the condition of the oral mucosa. At the second stage of the research, there was no significant difference between the indicators before prosthetics and after the use of a silver-plated brace prosthesis, which proves the normalization of the hygienic condition in the oral cavity ($p23<0.0000$). The deterioration of the oral hygiene condition of our patients coincides with the studies of other authors [25], who also noted a high prevalence of

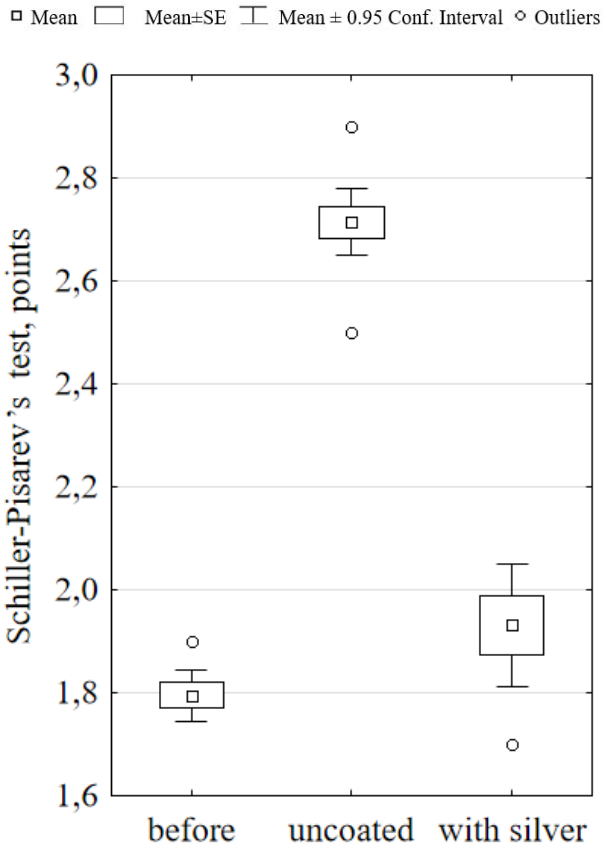

Fig. 1. Box Plots of Schiller-Pisarev's test.

Table I. Periodontal indices

Clinical tests	Before prosthesis n_1=23	After using an uncoated clasp prosthesis n_2=23	After using a clasp prosthesis with silver electroplating n_3=23	Wilcoxon's criterion (Z; p)
	1	2	3	
Schiller-Pisarev's test, points	1.8±0.02	2.71±0.03	1.9±0.06	Z_{12}=4.106 p_{12} <0.000 Z_{13}=2.023 p_{13} = 0.043 Z_{23}=3.98 p_{23}<0.0000
PMA index,%	24	63	47	

Table II. Biochemical blood parameters in patients with partial defects of dentitions at treatment by clasp prostheses

Indices	Patients before prosthesis installation n_1=23	Patients with clasp prostheses		Wilcoxon's criterion (Z; p)
		Patients after 1 month of using an uncoated clasp prosthesis n_2=23	Patients after 1 month of using a clasp prosthesis with silver electroplating n_3=23	
	1	2	3	
AST, mmol / (l · h)	0.39±0.008	0.63±0.014	0.56±0.023	Z_{12}=4.197 Z_{13}=3.92 $p_{12.13}$ <0.000 Z_{23}=2.01 p_{23} = 0.045
ALT, mmol / (l · h)	0.51 ±0.006	0.76±0.016	0.46 ±0.016	$Z_{12.23}$=4.197 $p_{12.23}$ <0.000 Z_{13}=2.01 p_{13} = 0.045
Total bilirubin, μmol / l	19.07 ±0.015	18.81 ±0.04	18.95 ±0.07	Z_{12}=3.88 p_{12} <0.000 Z_{13}=2.43 p_{13} = 0.015 Z_{23}=0.547 p_{23} = 0.584
Direct bilirubin, μmol / l	6.94 ±0.008	6.8 ±0.04	6.77±0.07	-
Indirect bilirubin. μmol / l	12.13±0.013	11.83 ±0.032	12.13±0.07	Z_{12}=4.106 p_{12} <0.000 Z_{13}=0.076 p_{13} = 0.939 Z_{23}=2.829 p_{23} = 0.0047
Ceruloplasmin (CP), units ext.	29.47 ±0.025	32.04 ± 0.081	28.96 ±0.07	$Z_{12.23}$=4.197 Z_{13}=4.01 $p_{12.13.23}$ < 0.000
Transferrin (TF), rel.units	0.19 ±0.004	0.17±0.002	0.17 ± 0.003	Z_{12}=3.136 p_{12} = 0.0017 Z_{13}=2.0 p_{13} = 0.046 Z_{23}=1.269 p_{23}= 0.204
CP/TF	155.11 ±0.045	188.89 ±1.10	162.8 ±0.66	$Z_{12.13.23}$=4.197 $p_{12.13.23}$ < 0.000
Malone dialdehyde (MDA), mmol / l	74.61±0.023	73.51 ±0.042	72.95±0.5	-
Sulfhydryl groups (-CH-), mmol / l	1.47 ± 0.013	1.43±0.023	1.49±0.016	-

periodontal diseases and caries in teeth supporting removable prostheses.

Table 1 shows findings of clinical Schiller-Pisarev's test and the PMA index.

Papillary-marginal-alveolar index (PMA) showed the following indicators:

– 24% before prosthesis installation
– 63% after installation of prosthesis with solid cast removable structures
– 47% after application of silver electroplating

The results of the PMA index showed a mild degree of gingivitis before prosthesis installation. After installation of prosthesis with solid removable structures, the PMA index increased significantly due to difficulties in oral care due to the presence of a clasp prosthesis as a foreign body, but after the use of silver plated clasp prosthesis, the PMA index decreased to medium severity, which is explained by positive impact on the inflammatory process in the gums.

Our studies of the effect of silver applied by the galvanic method on the metal surface of the brace prosthesis coincide with the data of A.V. Podopryhor. in co-authorship [26], who proposed to use the method of chemical silvering of the inner surface of the base of a removable prosthesis.

Table 2 shows the results of the study of biochemical blood parameters in patients with partial secondary adontia at the stages of application of clasp prostheses before prosthesis installation (n_1), after a month of use of clasp prosthesis without silvering (n_2) and after a month of use of clasp prosthesis with silver plating (n_3), and indices data (average sample and error of averages).

Patients who used cobalt-chromium alloy clasps without silver electroplating after one month of use, were found to have an initial increase in AST 1.6 times compared to previous studies. This may indicate a violation of metabolic processes in the liver associated with a stressful situation after installation of a removable structure or due to changes associated with metallo toxic effects [27].

A 1.5-fold increase in ALT, which correlated with an increase in AST, may also indicate a toxic impact on liver, heart and skeletal muscle cells, and a stressful situation during the adaptation of the prosthesis as a foreign body in the mouth.

However, a study of these indices after a month of using silver-plated clasp prostheses showed a weakening of the activity of the cytolytic syndrome, which was manifested in the restoration of AST and ALT concentration almost to normal.

Secondary to an increase in ALT and AST concentrations, the indices of total, direct and indirect bilirubin did not change significantly.

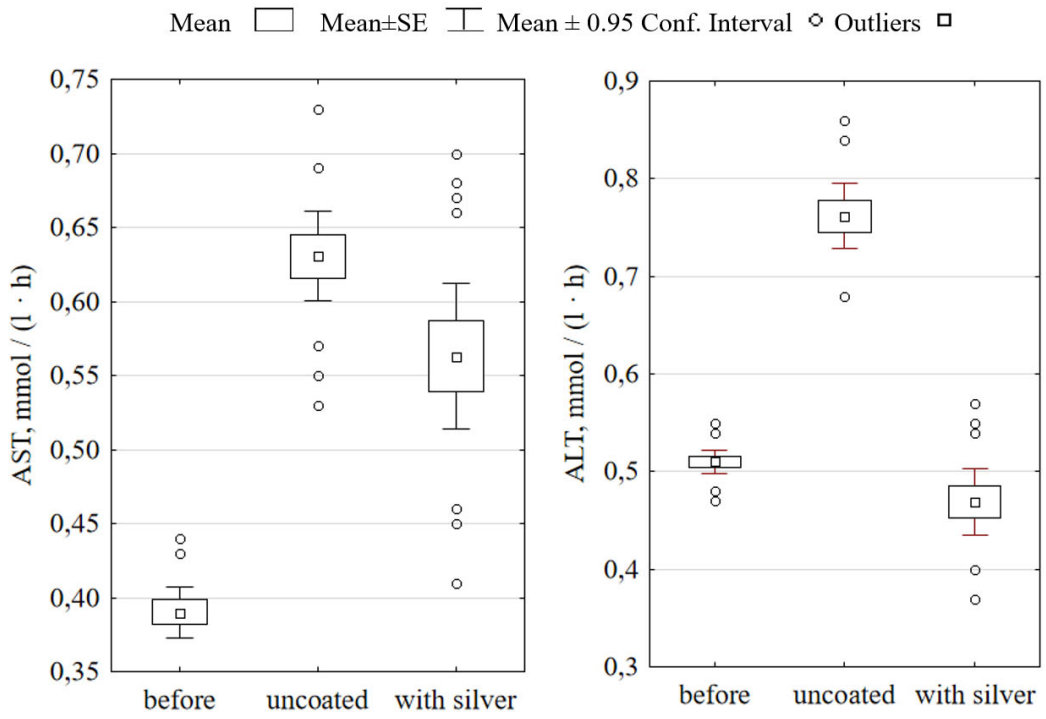

Fig. 2. Box Plots of AST and ALT.

Transferrin, a blood plasma protein which transports iron ions, is one of the indicators of the liver state. In our studies, TF levels were within normal limits, which reflected the good condition of hepatocytes.

After a month of using clasp prostheses, we observed a significant increase in ceruloplasmin and its reduction after a month of using clasp prosthesis with silver electroplating.

Ceruloplasmin has a pronounced oxidative activity, in plasma this protein not only plays a significant role in the metabolism of copper and iron, but also activates the oxidation of norepinephrine, serotonin and sulfhydryl groups. In our opinion, an increase in CP after a month of using clasp dentures indicates a stressful increase in ceruloplasmin levels in the blood.

The stress etiology of the increase in CP, ALT and AST is evidenced by LPO markers, namely MDA, the increase of which indicates an increase in the activity of lipoperoxidation processes. MDA appears at the stage of free radical formation and its excess may indicate the accumulation of

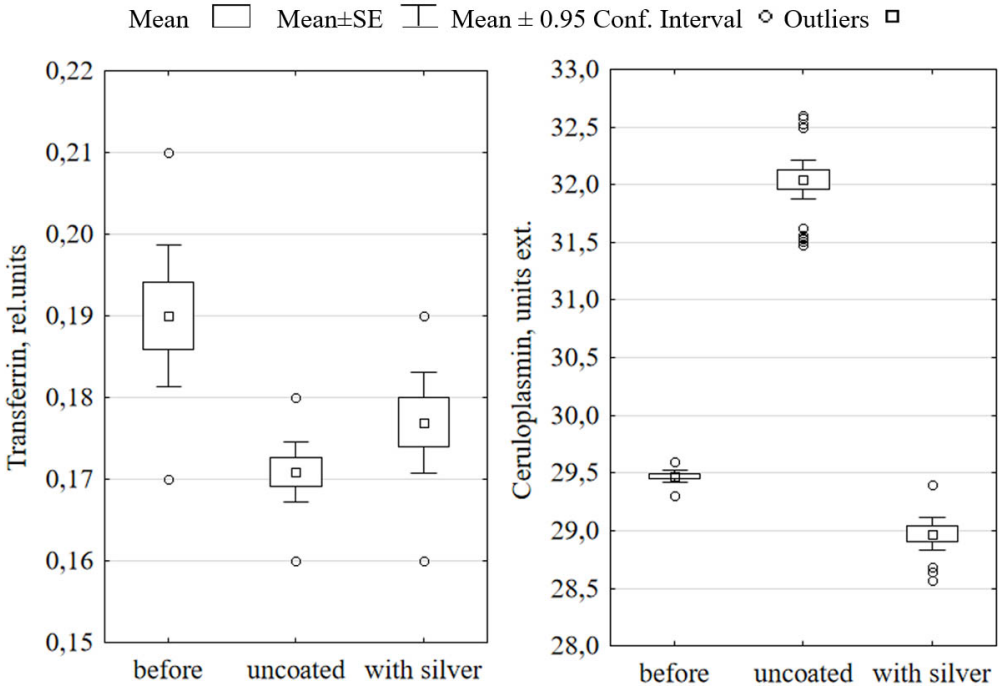

Fig. 3. Box Plots of Transferrin and Ceruloplasmin.

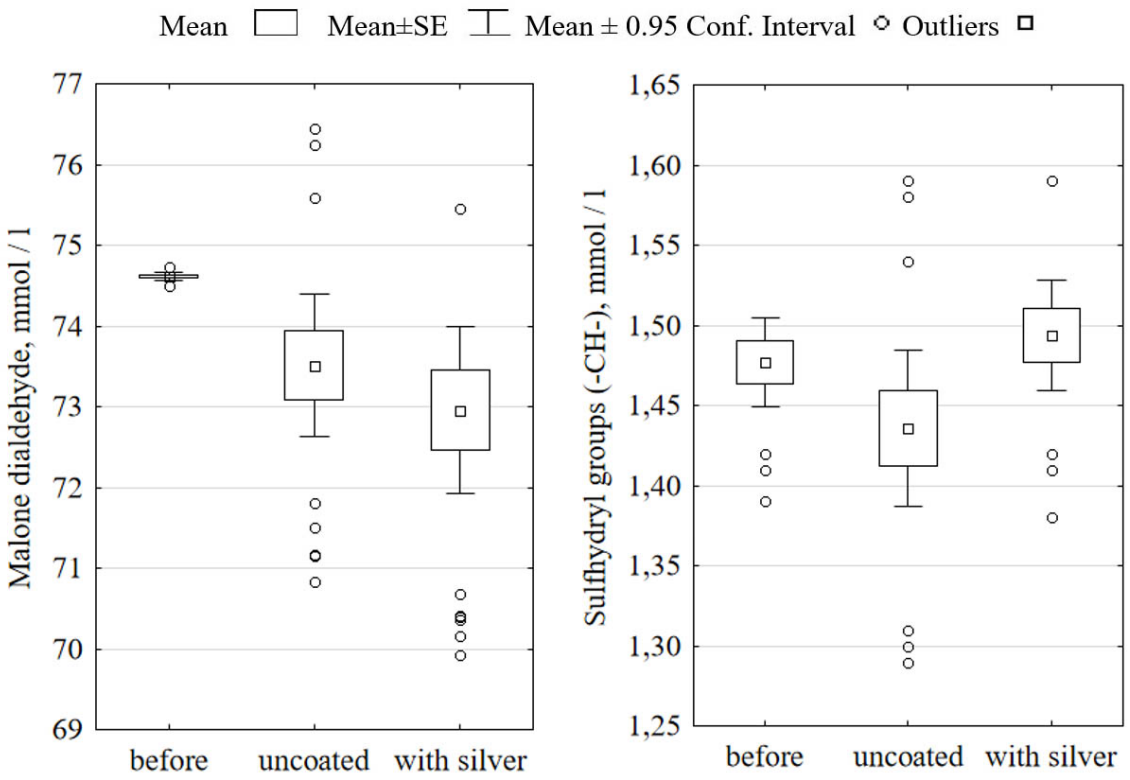

Fig. 4. Box Plots of Malone dialdehyde and Sulfhydryl groups (-CH-).

peroxides and hydroperoxides in the body, which damages the cells of the body.

Assessment of the obtained data of MDA levels in patients with clasp prostheses with and without silver electroplating showed no damaging effect on the cells of the body.

Free radical oxidation and generation of reactive oxygen species (ROS) are processes inherent in all living organisms. Excessive activation of free radical oxidation is a pathological process that occurs with various damaging effects on the patient's body, namely the toxic effects of structural materials.

The content of SH-groups plays an important role in the antioxidant status of the organism. Cells spend considerable energetic efforts to prevent non-specific thiol oxidation reactions while allowing the controlled formation of protein disulfide bonds or other oxidative thiol modifications that play physiologically relevant roles [28]. The catalytic properties of many factors are related to free SH- groups. Sulfhydryl groups are also the active principle of coenzyme A, which is involved in intermediate metabolism.

In our studies, the level of SH group in the blood serum did not change compared to their level at the beginning of the use of clasp prostheses in groups of patients with and without silver plating, which indicated the stability of the antioxidant system and no toxic load on patients.

Non-parametric Friedman test showed no significant difference between the indices, namely direct bilirubin, malonic dialdehyde and sulfhydryl groups.

Discussion

Discussing the results obtained by us of clinical and laboratory indicators of the state of the body: serum activity of ALT and AST (markers of damage to the hepatobiliary system), as well as POL markers, we note that most authors agree that silver does not have a toxic effect on the human body [29].

The conducted studies confirm the anti-inflammatory and antioxidant properties of drugs with silver elements [30].

It can be assumed that the use of clasp prostheses with silver electroplating does not change the resistance of cell membranes, due to stable indices of the intensity of the LPO processes and the stability of the antioxidant defense system.

Conclusions

The dynamics of Schiller-Pisarev's test and the PMA index provide a possibility to draw a conclusion on the effectiveness of the silver plating. The use of silver electroplating reduces the degree, length and severity of periodontitis.

The revealed stability of biochemical parameters of blood in patients with solid removable prosthetic structures can serve as a justification for the administration of silver electroplating for prophylactic and therapeutic purposes.

The effectiveness of the use of silver plating in the treatment of partial defects of the dentition eliminates the clinical manifestations of the pathological condition and pre-

vents possible complications in the oral cavity. The effect of silver plating based on the pathogenic link of oxidative and antioxidant systems on the body on the background of the use of dentures with CCA with functional silver plating prevents the development of tissue hypoxia, metabolic acidosis and promotes transcapillary metabolism.

Author contributions

AN: (Supervision; Conceptualisation; Investigation) OS: (Writing – original draft; Methodology; Formal Analysis) NB: (Writing – review & editing; Investigation; Funding acquisition) NB: (Data curation; Formal Analysis; Resources) VK: (Methodology, Conceptualisation; Project administration) ZM: (Validation; Visualization; Software)

Conflict of interest

None to declare.

References

1. Carr AB, Brown TD - McCracken's Removable Partial Prosthodontics. Mosby 13th edition 2015; 380.
2. Jiang CM, Duangthip D, Chan AK, Tamrakar M, Lo EC, Chu CH - Global research interest regarding silver diamine fluoride in dentistry: A bibliometric analysis. Journal of Dentistry. 2021 Okt; Volume 113, 103778, ISSN 0300-5712.
3. Shaha M, Varghese R, Atassi M - Understanding the impact of removable partial dentures on patients' lives and their attitudes to oral care. Br Dent J 2021 May; https://doi.org/10.1038/s41415-021-2949-4
4. Bharkhavy KV, Pushpalatha C, Anandakrishna L - Silver, the magic bullet in dentistry – A review, Materials Today: Proceedings 2020; Volume 50, Pages 181-186, ISSN 2214-7853, available at: https://doi.org/10.1016/j.matpr.2021.12.200.
5. Rosa CC, Narciso AM, Nunes MR, Masiero AV- Applicability of silver nanoparticles and innovation of magnetic nanoparticles in dentistry. In Woodhead Publishing Series in Electronic and Optical Materials 2022; Pages 317-348. ISBN 9780128228197. available at: https://doi.org/10.1016/B978-0-12-822819-7.00023-5.9
6. Durán N, Marcato PD, Conti RD - Potential use of silver nanoparticles on pathogenic bacteria, their toxicity and possible mechanisms of action. J. Braz. Chem. Soc 2012; Vol. 21(6):949-959.
7. Morozova NS, Protas SV, Ridnyiy SV - Problemnyie voprosyi ispolzovaniya nanochastits serebra v meditsine. Problemi bezperervnoyi medichnoyi osviti ta nauki. 2020; 2(38): 66-70.
8. Bapat RA, Chaubal TV, Joshi CP, Bapat PR, Choudhury H, Pandey M - An overview of application of silver nanoparticles for biomaterials in dentistry. Materials Science and Engineering 2018; Volume 91. Pages 881-898. ISSN 0928-4931. available at: https://doi.org/10.1016/j.msec.2018.05.069.
9. Noronha VT, Paula AJ, Durán G - Silver nanoparticles in dentistry. Dental Materials: Official Publication of the Academy of Dental Materials. 2017.
10. Krynychko VV, Rosiiskii PV, Lysenko VV - Some recommendations for improvement of dental training for dental implantation for the prevention of post-operative complications. PhOL - PharmacologyOnLine 2021; Vol.3 December. Pages 1454-1457. ISSN: 1827-8620.
11. Kutsevlyak VF - Indeksna otsinka parodontalnogo statusu. Sumi: VVP "Mriya". 2015; 104. (In Ukr.)
12. Smirnova O., Nikonov A., Pilipenko A - Thiocarbamide-citrate electrolytes as an alternative to cyanide electrolytes in solving the problems of environmental protection and prevention of emergency situations. Materials Science Forum. 2021; 1038: 185–192.
13. Copper electrolyte / Smirnova O. [et al.]. // Patent of Ukraine No. 121564, IPC C25D 3/38, 2017.
14. Smirnova OL - Peculiarities of electrolytic deposition of silver coatings from acidic thiourea-citrate solutions. Smirnova OL, Pylypenko OI, Brovin OU [et al.] Prospective materials and processes in applied electrochemistry - 2020: monograph. Edited by Barsukova VZ - Kyiv: KNUTD, 2020. - C. 80–90.
15. Patent of Ukraine No. 70525A
16. Kobzar' AI - Prikladnaya matematicheskaya statistika. Moscow: Fizmatlit, 2006; 816. (In Russ.)
17. Smirnova O, Pilipenko A, Pancheva H, Zhelavskyi A, Rutkovska K. - Study of anode processes during development of the new complex thiocarbamidecitrate copper plating electrolyte. Eastern-European Journal of Enterprise Technologies. 2018; 1(6 (91): 47–52. https://doi.org/10.15587/1729-4061.2018.123852
18. Smirnova O, Brovin A, Pilipenko A - Studying the kinetics of electrode reactions on copper, silver and gold in acid thiourea-citrate electrolytes. Materials Today: Proceedings. 2019; 6: 141-149.
19. Nikonov A, Breslavets N, Krychka N, Serhiienko M - Methods of the individual selection of dental structural metal alloys for the treatment of patients with teeth and dentition defects. International journal of scientific & technology research 2020; 9(01): 566-569.
20. Nikonov A, Zaytseva O, Serhiienko M, Krychka N, Breslavets N. Dynamics of the content of free amino acids in blood of patients during the long-term use of orthopedic dental metal prostheses. National Journal of Physiology, Pharmacy and Pharmacology 2017; 8: 118-123.
21. Dubick MA, Barr JL, Keen CL, Atkins JL. Ceruloplasmin and Hypoferremia: Studies in Burn and Non-Burn Trauma Patients. Antioxidants (Basel) 2015 Mar 6;4(1):153-69. doi: 10.3390/antiox4010153. PMID: 26785343; PMCID: PMC4665565.
22. Vladimirov YuA - Peroxidation of lipids in biological membranes. Vladimirov YA, Archkov AI - M.: Nauka, 1972.-320 p.
23. Folomeev VF - Photocolorimetric ultramethod of quantitative determination of sulfhydryl groups of protein and non-protein blood compounds. Folomeev VF - Lab. delo.-1981.-No.1. P.33-35
24. Ellman GL - Reprint of: Tissue Sulfhydryl Groups. Archives of Biochemistry and Biophysics 2022; Volume 726, 109245. ISSN 0003-9861.
25. Odud MP, Belyaev EV - The state of oral hygiene and indicators of biophysical studies of oral fluid in patients with dentition defects and when using partial removable lamellar prostheses in different periods of observation. Ternopil Dental Summit: scientific and practical materials. conf. with international participation. Ternopil, December 23-24, 2019. Ternopil, 2019, pp. 109-111.
26. Podopryhora AV - Analysis of the properties of basic plastics with the addition of nanosilver. System analysis and management in biomedical systems, 2011. Vol. 10., No. 1, p. 112-113.
27. Nikonov AY - Matematicheskiy analiz effektivnosti ispolzovaniya razlichnyih zaschitnyih pokryitiy na metallicheskih zubnyih protezah na baze dannyih biohimicheskih pokazateley krovi. Dentalnyie tehnologii 2009; 2: 66-74. (In Russ.)
28. Ulrich K, Jakob U - The role of thiols in antioxidant systems. Free Radic Biol Med. 2019; Aug 20;140:14-27.
29. Levitsky AP - Biochemical markers of inflammation and antioxidant protection in the tissues of the oral cavity of rats under the influence of liposaccharide and nanoparticles of gold and silver. Levitskyi AP, Trokhymchuk AK, Tkach OB - Bulletin of marine medicine.-2013.-No.3.-P.60-64.
30. Kosutic D, Uglesic V, Perkovic D et al. Preoperative antiseptics in clean/contaminated maxillofacial and oral surgery:prospective randomized study. Int.J. Oral Maxillofac. Surg.,2009-38(2):160-165