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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

IMPROVING THE EFFECTIVENESS OF ORTHOPEDIC TREATMENT WITH ACRYLIC-BASED REMOVABLE DENTURE CONSTRUCTIONS

Specialty: 3226.01 – Dentistry

Science field: Medicine

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GENERAL CHARACTERISTICS OF THE RESEARCH

The relevance of the topic and the degree of completion. The widespread occurrence of dental arch defects increases the demand for partial and complete removable denture constructions in orthopedic treatment. Among the middle-aged population, the need for removable plate dentures ranges from 9% to 45%, while overall, 20% to 38% of the population requires complete removable plate dentures[1].

In modern prosthodontics dentistry, 98% of removable plate dentures are made of acrylic resin. This is due to the low cost, easy availability, biocompatibility, and convenience of the manufacturing process of acrylic. However, the presence of free residual monomer after polymerization has a negative effect both locally on the mucous membrane of the denture-bearing area and on the body as a whole. It has been confirmed that even a small amount of this residual monomer can lead to a decrease in the lysozyme titer in saliva, which may cause inflammation of the mucous membrane, blastomatous growth of the epithelial tissue, and the development of both local and systemic allergic reactions[2]. Another drawback of acrylic base resin is the presence of micropores on its surface after polymerization, which facilitates the adhesion of microorganisms within these pores.

To improve the quality of prosthodontic treatment and eliminate the negative effects of plate dentures, various modifications of the denture base have been employed. These include improving the composition of the material by incorporating various additives, such as aramid fibers, hydroxyapatite crystals, nylon, the use of high-quality coating technologies, and the application of bioresorbable medicinal coatings[3].

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Lesions of the oral mucosa caused by the impact of acrylic dentures are observed in more than one-third of the patients studied[4]. To enhance the antibacterial effectiveness of dental materials, various forms of silver have been used, including silver ions (Ag^+), silver nanoparticles (AgNPs), and Ag-polymer complexes[5]. However, the practical application of Ag^+ is limited due to its instability. To address this issue, the Ag^+ membrane can be protected with a polymer matrix. The main advantage of AgNPs is their large surface area with a low mass ratio during use.

Thanks to advancements achieved through the application of nanotechnology, AgNPs have demonstrated promising results, including broad-spectrum bactericidal, virucidal, and fungicidal effects[6]. Oral pathogenic microflora can colonize the surface of acrylic base materials, leading to inflammation of the denture base mucosa. When silver nanoparticles are incorporated into acrylic resin, they inhibit the growth of certain bacterial groups such as Streptococcus mutans, Escherichia coli, and Staphylococcus aureus[7]. The addition of silver nanoparticles to acrylic resin significantly enhances its antibacterial effectiveness and also exhibits high antifungal activity.

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When silver nanoparticles are incorporated into acrylic resin, they inhibit the growth of certain bacterial groups such as *Streptococcus mutans, Escherichia coli*, and *Staphylococcus aureus*. The addition of silver nanoparticles enhances the antibacterial effectiveness of acrylic resin and also provides high antifungal activity. As a result, it reduces the adhesion of *Candida albicans* and prevents the accumulation of pathogenic microorganisms on the denture base[8]. Furthermore, silver nanoparticles can increase the flexural strength and elastic modulus of the acrylic base. In addition, they improve the thermal conductivity and compressive resistance of the dentures[9]. Numerous studies have shown that AgNPs are effective[10] against *Candida albicans*, as they slow down the formation of microbial colonies in membrane pores and disrupt membrane potential, leading to ion leakage and the penetration of other substances. This results in apoptosis and ultrastructural changes in the fungal cells.

Considering the points mentioned above, in our opinion, the most promising method for solving this problem could be the electrochemical silver-coating of the denture base. The most commonly used method for silver-coating the inner surface of the denture base involves vacuum sputtering of a silver-palladium alloy onto the acrylic resin base. However, despite its beneficial anti-inflammatory and oligodynamic properties, colloidal silver is not considered a durable coating, as it completely degrades and enters the body within 2–3 weeks[11].

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As a promising approach, we selected the method of spraying nanoscale silver nanoparticles onto the surface of the acrylic base resin. Our research was initiated to increase the conversion rate of monomer molecules after the polymerization process, enhance the colonization resistance of the resin, and reduce the number of microbial colonies on its surface.

Object and subject of the research. The study involved 124 patients wearing removable acrylic dentures, who were divided into two groups: the main group consisted of 58 patients (46.8%) wearing removable acrylic dentures enriched with silver nanoparticles, and the comparison group included 66 patients (53.2%) wearing conventional removable acrylic dentures without the addition of silver nanoparticles. Both groups included a combination of patients with complete and partial edentulism: complete edentulism of the maxilla and mandible; complete edentulism of the maxilla combined with partial edentulism of the mandible; partial edentulism of the maxilla combined with complete edentulism of the mandible; and partial edentulism in both the maxilla and mandible.

A comparative assessment was conducted to evaluate the effectiveness of orthopedic treatment using removable acrylic-based dentures with and without the addition of silver nanoparticles.

The study aimed to enhance the effectiveness of orthopedic treatment in patients wearing removable plate dentures by silver-coating the inner surface of the acrylic denture base.

Objektives of the study:

1. Development of a method for the deposition of silver nanoparticles onto the inner surface of removable denture bases;
2. Comparative study of the hygienic condition of acrylic-based dentures fabricated using traditional and improved methods;
3. Investigation of the local microbiological status of patients using the above-mentioned types of denture constructions;
4. Comparative investigation of the degree of bone tissue atrophy in the denture-bearing area and the complications in the mucous membrane after orthopedic treatment with acrylic-based denture constructions enriched and not enriched with silver nanoparticles;

5. Investigation of the most common complications observed in patients wearing removable acrylic dentures with and without the addition of silver nanoparticles;
6. Investigation of the impact of both types of dentures on patients' quality of life.

Research methods

- Clinical methods;
- Laboratory methods performed by dental technicians;
- Method for depositing silver nanoparticles onto the inner surface of the denture;
- Bacteriological methods;
- Determination of the hygienic condition of the dentures using the Ulitovsky-Leontyev method;
- Assessment of quality of life (QoL) using the OHIP-14 questionnaire (Slade G.D., 1995);
- Statistical analysis (using Statistica software, ANOVA, t-test, and Odds Ratio - OR - methods).

The main provisions submitted to the defense of the dissertation:

-Deposition of silver nanoparticles onto the inner surface of removable denture bases significantly improves the hygienic condition of the dentures.

-The use of dentures fabricated by the improved method reduces the amount of pathogenic microflora on the denture base mucosa.

-A statistically significant reduction in complications was observed in patients using dentures fabricated with the proposed method compared to the comparison group.

-Using removable acrylic dentures enriched with silver nanoparticles statistically significantly improves oral health-related quality of life indicators.

Scientific novelty of the study

A method for depositing silver nanoparticles onto the inner surface of acrylic removable denture constructions used in prosthodontics dentistry has been developed. Its superiority over conventionally fabricated removable denture constructions has been confirmed in terms of hygienic index and microbiological status indicators, as well as its

statistically significant role in preventing complications that may arise in the denture-bearing area.

Practical significance

The incorporation of nanoparticles into removable acrylic-based dentures facilitates faster adaptation to the dentures during orthopedic treatment, thereby improving patients' quality of life.

Approbation

The main points of the dissertation were presented at the following scientific-practical conferences: International Congress on "Current Issues of Medicine 2020" dedicated to the 90th anniversary of Azerbaijan Medical University (Baku, 2020); International Scientific Congress on "Modern Problems of Pharmacy" dedicated to the 90th anniversary of Azerbaijan Medical University and the 80th anniversary of higher pharmaceutical education (Baku, 2021); Collection of Scientific Papers: "Modern Methods of Diagnosis, Prevention and Treatment of Major Dental Diseases" (Odessa, 2021); Scientific-practical conference "The Wise Season of Life" dedicated to the 80th anniversary of Sabir Jahan oglu Aliyev (Baku, 2024).

The dissertation was presented and discussed at the Meeting No. 46 of the Department of Prosthodontic Dentistry of Azerbaijan Medical University held on February 12, 2025, as well as at the Meeting No. 13 of the Scientific Seminar of the ED 2.50 Dissertation Council under Azerbaijan Medical University held on April 11, 2025.

Implementation of the research results

The findings of the dissertation have been incorporated into the educational process of the Department of Prosthodontic Dentistry at Azerbaijan Medical University (AMU), as well as into the workflow of the University Dental Clinic.

The name of the organization where the dissertation was carried out.

Department of Prosthorontic Dentistry, Azerbaijan Medical University

Publications. A total of 13 scientific papers and abstracts related to the dissertation topic have been published (9 articles and 4 abstracts). Of

these, 5 articles and 3 abstracts were published in local journals, while 4 articles and 1 abstract appeared in international publications.

Volume and structure of the dissertation. The dissertation consists of 185 pages (210.481 characters) of computer-typed text and includes the following sections: Introduction (14,345 characters), Chapter I – Literature Review (51,022 characters), Chapter II – Materials and Methods (19,449 characters), Chapters III (30,393 characters), IV (40,963 characters), and V (24,844 characters) – Personal Research Findings, Conclusion (24,855 characters), Results (3,656 characters), and Practical Recommendations (954 characters). The bibliography includes 206 references. The dissertation also contains 13 charts, 39 tables, and 8 photograph.

MATERIALS AND METHODS OF THE RESEARCH

A total of 124 patients with partial or complete edentulism participated in the study.

The inclusion criteria were as follows: patients with partial or complete edentulism in the mandible or maxilla who wore removable acrylic dentures.

Exclusion criteria: patients who were unable to clearly describe their complaints; patients with diseases of the oral mucosa or severe comorbid somatic conditions.

The mean age of the patients was 60.9 ± 6.14 (range: 36–67 years). The study included 56 male and 68 female participants. Complete edentulism of both the maxilla and mandible was observed in 27 patients (21.8%), complete edentulism of the maxilla and partial edentulism of the mandible in 28 patients (22.6%), partial edentulism of the maxilla and complete edentulism of the mandible in 34 patients (27.4%), and partial edentulism of both jaws in 35 patients (28.2%). A total of 58 patients (46.8%) used removable acrylic dentures containing silver nanoparticles in the denture base, while 66 patients (53.2%) used conventional removable acrylic plate dentures without silver nanoparticles. The group of patients using acrylic dentures with silver nanoparticles (n=58) was designated as the main group, while those using traditional removable

acrylic plate dentures (n=66) were designated as the comparison group. The patients were followed for a period of 3 years.

The evaluation of clinical effectiveness was based on the following criteria: assessment of the quality of the removable denture and its fixation characteristics based on survey results; objective examination of the oral mucosa of the denture-bearing area; evaluation of the hygienic analysis results of the surface condition of the prosthetic construction and the findings of microbiological studies.

For the prosthetic restoration of missing teeth, dentures made from Meliodent acrylic resin (STOMA ASC, Turkey) were used. This included 116 complete removable plate dentures for cases of total tooth loss and 97 partial removable dentures for partial tooth loss. Among the partial dentures, 36 were clasp-retained removable plate dentures and 61 were removable dentures with precision attachment fixation.

Preparation of solutions for obtaining silver nanoparticles.

Solution 1: To a solution of 10 g of $AgNO_3$ in 50 ml of distilled water, 25% ammonia (NH_3) solution is added drop by drop while stirring slowly. This process is continued until the dark precipitate completely dissolves and a clear solution is obtained. If an excessive amount of ammonia has been added, the balance can be restored by adding a small amount of $AgNO_3$. The prepared solution acquires a light brownish color. It is left to stand for a while (about 1 hour), then filtered and diluted with distilled water to a final volume of 1 liter.

Solution 2: A solution is prepared by dissolving 20 g of glucose and 20 g of sodium potassium tartrate (seignette salt) in 200 ml of distilled water. To the resulting solution, a solution of 8 g of $AgNO_3$ dissolved in 20 ml of water is added, and the mixture is boiled for several minutes. After boiling, the solution is diluted with water to a final volume of 1000 ml.

Silver-coating process: Before silver coating, the inner surface of the prepared denture is sprayed with a $ZnCl_2$ solution and dried. Then, a $PdCl_2$ solution is sprayed onto the same surface and left for 10-15 minutes. Afterward, solutions 1 and 2 are mixed in equal proportions in a sprayer and applied to the surface of the dentures by spraying.

Prior to prosthetic treatment, all patients underwent planned oral cavity sanitation, and none of them had taken antibiotics during the examination period. The microflora growing on nutrient media in the oral mucosa was recorded before the use of removable dentures, as well as 10 days and 1 month after their use. Microorganisms were identified using the PCR method.

The condition of the mucosa in the denture-bearing area was assessed according to the Supple classification. The degree of atrophy in the completely edentulous maxilla was evaluated based on the Schröder classification, while the degree of mandibular atrophy in complete edentulism was assessed using the Keller classification.

To assess the hygienic condition of the dentures, the modified Ulitovsky-Leontyev method was used.

The Oral Health Impact Profile (OHIP-14) questionnaire was employed to evaluate the patients' quality of life (QoL).

For statistical analysis of the results, Statistica version 16.0 for MS Windows (USA) was used to calculate the mean and standard deviation. One-way ANOVA was employed to determine whether there were statistically significant differences between the means of the test groups. The Student's t-test was used to identify differences between the groups. The odds ratio (OR) was calculated to determine the likelihood of complications depending on the type of removable denture. A p-value of <0.05 was considered statistically significant.

RESEARCH RESULTS AND THEIR DISCUSSION

Complications following prosthetic treatment with removable dentures in patients with partial and complete edentulism.

During the study, we investigated complications in 66 patients (comparison group) wearing conventional removable acrylic dentures. A total of 92 removable dentures were fabricated. Of these, 35 (38.0±5.1%) were complete maxillary dentures, 23 (25.0±4.5%) complete mandibular dentures, 16 (17.4±3.9%) partial maxillary dentures, and 18 (19.6±4.1%) partial mandibular dentures. Among the 92 delivered dentures, 58 (63.0%) were complete dentures, and 34 (37.0%) were partial dentures,

both in the maxilla and mandible. According to the Supple classification, the condition of the oral mucosa in edentulous jaws was determined as follows: Class I was observed in 30 patients (45.4%), Class II in 24 patients (36.4%), and Class III in 12 patients (18.2%). In 45.4% of patients with acrylic dentures, the mucosa was atrophic and thickened, while in 18.2% of cases, it was fragile. Among the edentulous maxilla (n=22) and mandible (n=19), two main types were predominantly observed. According to the Schröder classification, the following types were identified based on the degree of atrophy in the maxilla: Type I in 11 patients (31.4%), Type II in 20 patients (57.1%), Type III in 4 patients (11.4%).

According to the Keller classification, mandibular atrophy was observed as follows: Type I atrophy in 12 patients (52.2%), Type II in 6 patients (26.1%), Type III in 3 patients (13.0%), and Type IV in 2 patients (8.7%).

During the study, 0 to 2 complications were observed per patient in the comparison group. In 4 patients (6.1±2.9%), no complications were recorded. A single complication was observed in 35 patients (53.0±6.1%; $t=7.01$; $P<0.001$), while two complications were noted in 27 patients (40.9±6.0%; $t=5.19$; $P<0.001$). In addition, insufficient denture stabilization was observed in 25.8±4.6% of patients. Other complications included dysfunction of the peripheral seal (18.2±4.1%) and irritation or deformation of the oral mucosa.

Thus, in 54.6% of the 66 patients wearing conventional acrylic-based complete maxillary and partial mandibular dentures, the oral mucosa was found to be atrophic with a high degree of fragility. Moderate alveolar ridge atrophy was observed in the edentulous maxilla (57.1%), while pronounced and uniformly distributed atrophy was noted in the mandible (52.2%). Among the patients, denture destabilization was observed in 25.8%, pain during narrowing of the peripheral seal in 18.2%, and irritation or alteration of the oral mucosa in 18.2%. No statistically significant differences were found between the types of prostheses and the incidence of complications ($P>0.05$). Compared to other patients in the comparison group, the highest number of complications was observed

in those wearing conventional complete dentures in both the maxilla and mandible.

In 58 patients, removable acrylic dentures with silver nanoparticles were fabricated, including 37 complete and 21 partial dentures. A total of 79 silver nanoparticle-enriched removable acrylic dentures were made for this group. Of these, 51 were complete dentures containing silver nanoparticles — 27 for the maxilla and 24 for the mandible. Moreover, 28 partial dentures were fabricated, with 14 for the mandible and 14 for the maxilla. The majority of patients used complete maxillary and mandibular dentures containing silver nanoparticles. Complete dentures were also fabricated in combination with partial dentures for either the maxilla or mandible. Silver nanoparticle-containing dentures were fabricated in the following combinations: partial maxillary with complete mandibular dentures, partial mandibular with complete maxillary dentures, and complete dentures for both the maxilla and mandible — with 7 prostheses produced in each category.

According to Supple's classification, the condition of the denture-bearing mucosa was assessed as Class I in 26 patients (44.8%), Class II in 21 patients (36.2%), and Class III in 11 patients (19.0%). Based on Schröder's classification, the degree of alveolar ridge atrophy in 27 complete denture wearers was identified as Type II. According to Keller's classification, the most commonly observed degree of atrophy in 24 complete maxillary denture wearers was also identified as Type II.

In the main group, irritation and variability frequently observed in the mucosa were noted in 15.5% of cases. Poor stabilization of the denture was identified in 12.1% of patients. Pain and discomfort were reported equally in 13.8% of patients. Complications were observed in 11 out of 50 patients (19.0%) in this group. Among 47 patients, a single complication was found in 26 (55.3%), while two complications were identified in 21 (44.7%) patients. When evaluating the centric relation of the alveolar ridge and jaw (n=40), the centric relation was normal (correct) in 22 patients, while variability was detected in the remaining 18 patients.

Thus, among 58 patients wearing acrylic dentures containing silver nanoparticles, in cases of complete edentulism in the maxilla and

mandible, atrophy, induration, and loosening of the oral mucosa were observed in 55.2% of cases. In these patients wearing the same type of dentures, the height of the alveolar ridge was of moderate level, while pronounced alveolar ridge atrophy was observed in the edentulous maxilla in 59.3% of cases and in the mandible in 50.0% of cases. The most frequently observed complications were irritation or variability in the oral mucosa (15.5%), as well as discomfort (13.8%) and pain (13.8%).

In the comparative analysis between the two groups, no significant difference was observed in the frequency of complications, except for denture stomatitis, which was more prevalent in the comparison group, indicating that this group was more susceptible—75.0% ($P>0.047$). In the comparison group, among patients with complete edentulism in the maxilla and partial edentulism in the mandible using acrylic dentures without silver nanoparticles, destabilization of the prosthesis was more frequently observed. Although other complications—such as mucosal variability, discomfort, pain, loss of artificial teeth, and speech disturbances—were more common among patients wearing silver nanoparticle-containing acrylic dentures, the statistical difference was minimal ($OR=1.167$, $p>0.05$). Thus, among 124 patients with acrylic removable dentures, prosthesis instability was observed in 19.3% of cases, irritation and variability of the mucosa in 16.9%, and pain in 6.1%. The frequency of complications such as denture stomatitis was identified in 75.0% of patients ($p=0.047$), and traumatic periodontitis in 77.6% of patients ($p=0.130$), both in the group of patients wearing silver nanoparticle-containing acrylic base complete and partial removable dentures, as well as in those using conventional acrylic base dentures.

Oral microbiota of patients with removable acrylic dentures

During the examination of patients wearing removable acrylic dentures with silver nanoparticles at different stages of denture use, the determination and analysis of the denture hygiene index according to Ulitovski-Leontyev showed a significant decrease in the poor index and an increase in the fair index (Table 1). In the main group, 20 days after prosthetics, the Ulitovski-Leontyev index was 16.75% lower compared to the comparison group ($\chi^2=1.364$, $p=0.243$). During the same observation period, in the main group, the fair index was 16.67% higher

compared to the comparison group (χ^2=1.654, p=0.199). The poor index in the main group was 18.84% lower than in the comparison group (χ^2=0.021, p=0.885). After 3 months, the main group had a 19.95% higher good index compared to the comparison group (χ^2=2.188, p=0.140); the fair index decreased slightly by 12.52% (χ^2=0.679, p=0.411); and the poor index in the main group was 50.94% lower than in the comparison group (χ^2=1.229, p=0.268).

Table 1

Dynamics of the Ulitovski-Leontyev denture hygiene index in patients of the study groups during the observation period

Research group	Wearing period	Ulitovski-Leontyev index					
		Good		Fair		Poor	
		number	%	Number	%	number	%
Main group (n=58)	20 days	30	51.7	24	41.4	4	6.9
	3 months	25	43.1	30	51.7	3	5.2
	6 months	24	41.4	28	48.3	6	10.3
Comparison group (n=66)	20 days	41	62.1	20	34.5	5	5.6
	3 months	20	34.5	39	59.1	7	10.6
	6 months	18	27.3	40	60.6	8	12.1

Six months after treatment, the proportion of patients in the main group with a good hygiene index was 34.01% higher compared to the comparison group (χ^2=2.743, p=0.098); the proportion with a fair index was 20.30% lower (χ^2=1.895, p=0.169); and the proportion with a poor index was 14.88% lower than in the comparison group (χ^2=0.097, p=0.756). No statistically significant differences were observed between the groups.

The comparative analysis of the Ulitovski-Leontyev index levels at different time points in the main group showed that three months after prosthetic treatment, the number of patients with a good index decreased by 16.63% compared to the situation after 20 days (χ^2=0.864, p=0.353), and by 19.92% after six months (χ^2=1.247, p=0.265). Conversely, the number of patients in the main group with a fair index increased. Thus, three months after prosthetic treatment, the fair index rose by 19.92% compared to the 20-day mark (χ^2=1.247, p=0.265), and after six months,

it increased by 14.29% compared to the 20-day level (χ^2=0.558, p=0.456). Among patients in the main group, the poor hygiene index decreased by 24.64% three months after prosthetic treatment compared to the initial (20-day) level (χ^2=0.152, p=0.697) but increased by 33.01% after six months (χ^2=1.084, p=0.298). Between 3 and 6 months, a slight decrease was observed in the good and fair index values in the main group by 3.94% (χ^2=0.035, p=0.851) and 6.58% (χ^2=0.138, p=0.711), respectively. After six months of prosthesis use, the poor index values increased by 49.51% compared to the three-month level (χ^2=1.084, p=0.298).

In the comparison group, the value of a good hygiene index showed a dynamic decrease 20 days after denture placement: it dropped by 44.44% compared to the 3-month level (χ^2=13.441, p<0.001) and by 56.04% compared to the 6-month level (χ^2=16.213, p<0.001). When comparing the good index levels at 3 and 6 months, it was 20.87% higher (χ^2=0.148, p=0.701) after 3 months. Alongside the decline in the good index values during the observation period, an increase in the fair index values was observed. A comparative analysis of fair index levels at 20 days and after 3 months revealed a 41.62% increase (χ^2=11.064, p<0.001). Besides, six months after prosthesis placement, an increase in the fair hygiene index was observed, amounting to 43.07% compared to the 20-day level (χ^2=12.222, p<0.001). The difference in fair index levels between 3 and 6 months was insignificant—only 2.48% (χ^2=0.032, p=0.860). Dynamic analysis of the poor hygiene index throughout the observation period showed an upward trend. Among patients with acrylic dentures without silver nanoparticles, the poor hygiene index increased by 47.17% three months after prosthesis placement compared to the 20-day level (χ^2=0.367, p=0.545), and by 53.72% after six months (χ^2=0.768, p=0.381). The difference in poor index levels between 3 and 6 months was also insignificant—12.40% (χ^2=0.075, p=0.784).

In the main group, among patients with complete dentures in the maxilla and partial dentures in the mandible, the hygiene index of the dentures was 19.7% (p>0.05) and 29.1% (p>0.05) at 20 days and 3 months, respectively. However, six months after the fabrication and delivery of this type of prosthesis, the denture hygiene index in the main

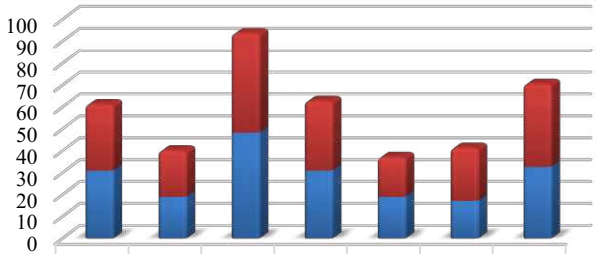
group was significantly higher by 27.7% compared to the comparison group ($p<0.05$).

Throughout the entire observation period, in the main group of patients wearing partial dentures in the maxilla and complete dentures in the mandible, the hygiene index of the dentures was higher compared to the comparison group by 18.3% ($p = 0.01$) after 20 days, 35.3% ($p = 0.001$) after 3 months, and 35.9% ($p = 0.001$) after 6 months.

In the main group of patients wearing partial dentures in both the maxilla and mandible, the hygiene index of the dentures was higher compared to the comparison group by 12.5% ($p < 0.05$) after 20 days, and significantly higher by 29.6% ($p = 0.01$) and 28.4% ($p = 0.001$) after 3 and 6 months, respectively.

In all patients of both the main and comparison groups, the examined materials were collected from the oral mucosa before the application of removable dentures.

When analyzing the microflora, attention was paid to its qualitative composition, the number of predominant microorganisms, and their ratio. Before treatment, the oral mucosa of patients in both groups was predominantly colonized by *enterococci, pneumococci*, fungi of the genus *Candida*, and *enterobacteria* (Graph 1).



	enterokok klar	lakto basilus	candida	enterobakter.	stafilokok klar	streptokok klar	pnevmokokklar
müqayisə qr. (n=66)	30,3	21,2	45,4	31,8	18,2	24,2	37,9
əsas qr. (n=58)	31	19	48,3	31	19	17,2	32,7

Chart 1. Incidence (%) of microorganisms colonizing the oral mucosa before the application of removable dentures in the study groups

Comparative analysis of incidence revealed yeast-like fungi of the genus *Candida* in 28 patients (48.3%) in the main group and in 30 patients (45.4%) in the comparison group (χ^2=0.099, p=0.754). Streptococcus pneumoniae (pneumococci) ranked next in frequency, was identified in 19 patients (32.7%) in the main group and in 25 patients (37.9%) in the comparison group (χ^2=0.354, p=0.553).

Enterobacteria were identified in 18 (31.0%) patients in the main group and in 21 (31.7%) patients in the comparison group (χ^2=0.009, p=0.926). *Enterococci* were detected in 18 (31.0%) patients in the main group and in 20 (30.3%) patients in the comparison group (χ^2=0.008, p=0.930). *Lactobacilli* were observed in 11 (19.0%) patients in the main group and in 14 (21.1%) patients in the comparison group (χ^2=0.097, p=0.756). The frequency of *staphylococci* detection did not differ significantly between the two groups (χ^2=0.013, p=0.911): they were found in 11 (19.0%) patients in the main group and in 12 (18.2%) patients in the comparison group. *Streptococci* were identified in 10 (17.2%) patients in the main group and in 16 (24.2%) patients in the comparison group (χ^2=0.913, p=0.340).

A comparative analysis of the initial frequency of microorganisms showed that in the main group, the relative prevalence of *enterococci* decreased by 44.5% (χ^2=3.013, p=0.083) after 7–10 days, by 66.8% (χ^2=7.665, p=0.006) after 30 days, and by 94.5% (χ^2=18.90, p<0.001) after 12 months compared to the initial value (Graph 2). The relative prevalence of *lactobacilli* decreased by 36.3% (χ^2=1.052, p=0.306) after 7–10 days, by 82.1% (χ^2=7.017, p=0.009) after 30 days, and by 72.6% (χ^2=5.199, p=0.023) after 6 and 12 months compared to the initial value.

The relative prevalence of Gram-negative *Enterobacteriaceae* decreased by 11.0% (χ^2 = 0.166, p = 0.684) after 7–10 days compared to the baseline level, by 38.7% after 30 days (χ^2 = 2.253, p = 0.134), and by 89.0% after 12 months (χ^2 = 15.467, p < 0.001). The relative

prevalence of bacteria from the *Staphylococcus* genus decreased by 18.4% ($\chi^2 = 0.242$, $p = 0.624$) after 7–10 days, by 45.8% after 30 days ($\chi^2 = 1.723$, $p = 0.190$), by 91.0% after 6 months ($\chi^2 = 9.295$, $p = 0.003$), and by 36.3% after 12 months ($\chi^2 = 1.052$, $p = 0.306$) compared to the initial values.

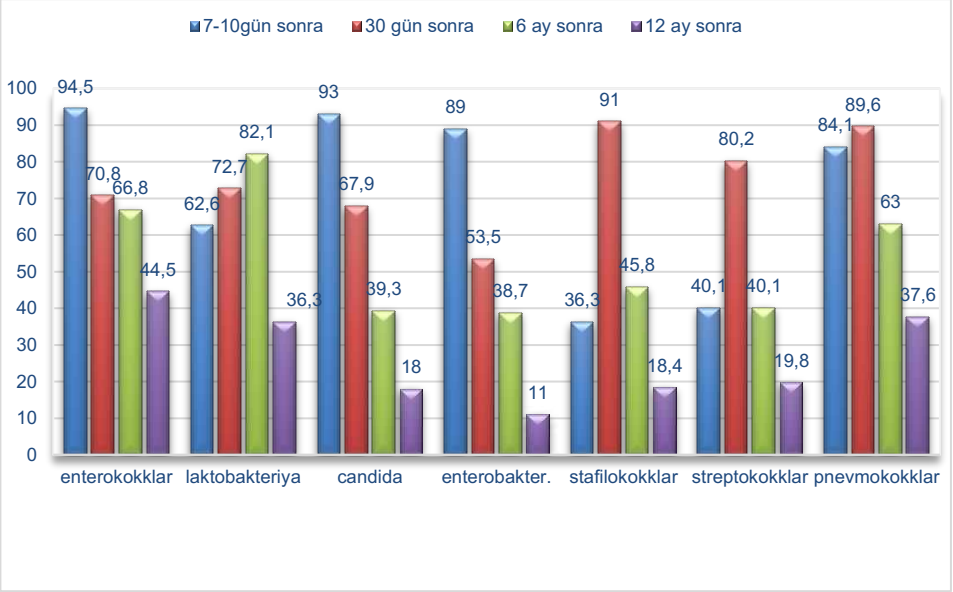


Chart 2. The relative prevalence of oral mucosal microflora (%) in patients of the main group (with removable acrylic dentures containing silver nanoparticles) at different observation periods compared to the baseline level

The relative prevalence of Gram-positive *streptococci* decreased by 19.8% ($\chi^2 = 0.263$, $p = 0.609$) after 7–10 days compared to the initial value, by 40.1% after 30 days ($\chi^2 = 1.160$, $p = 0.282$), by 80.2% after 6 months ($\chi^2 = 5.949$, $p = 0.015$), and by 40.1% after 12 months ($\chi^2 = 1.160$, $p = 0.282$). The relative prevalence of *pneumococci* decreased by 36.7% ($\chi^2 = 2.158$, $p = 0.142$) after 7–10 days compared to the initial value, by 63.0% after 30 days ($\chi^2 = 7.138$, $p = 0.008$), by 89.6% after 6 months ($\chi^2 = 16.804$, $p < 0.001$), and by 84.1% after 12 months ($\chi^2 = 14.360$, $p <$

0.001).

In the comparison group, the evaluation of the relative prevalence of *enterococci* after 1 week showed a 20.1% decrease compared to the initial value ($\chi^2 = 0.611$, $p = 0.435$), and a 57.1% decrease after 1 month ($\chi^2 = 6.212$, $p = 0.013$). As in the main group, *enterococci* were not detected after 6 months, however, after 12 months, their frequency was significantly lower—by 85.8%—compared to the initial value ($\chi^2 = 16.500$, $p < 0.001$). The relative prevalence of *lactobacilli* decreased by 20.8% after 7–10 days compared to the initial value ($\chi^2 = 0.444$, $p = 0.506$), by 78.7% after 30 days ($\chi^2 = 8.170$, $p = 0.005$), by 64.0% after 6 months ($\chi^2 = 4.980$, $p = 0.026$), and by 56.9% after 12 months ($\chi^2 = 3.771$, $p = 0.053$). The relative prevalence of *Candida* fungi decreased by 9.9% ($\chi^2 = 0.278$, $p = 0.599$) after one week compared to the initial value, by 33.3% after 30 days ($\chi^2 = 3.220$, $p = 0.073$), by 66.7% after 6 months ($\chi^2 = 14.348$, $p < 0.001$), and by 39.9% after 12 months ($\chi^2 = 4.714$, $p < 0.030$). The relative prevalence of *enterobacteria* decreased by 4.4% ($\chi^2 = 0.035$, $p = 0.851$) after 7–10 days compared to the initial value, by 23.7% after 30 days ($\chi^2 = 0.939$, $p = 0.333$), by 52.4% after 6 months ($\chi^2 = 5.101$, $p = 0.024$), and by 76.0% after 12 months ($\chi^2 = 12.261$, $p < 0.001$). The relative prevalence of *staphylococci* decreased by 17.0% ($\chi^2 = 0.218$, $p = 0.641$) after 7–10 days compared to the initial value, by 50.0% after 30 days ($\chi^2 = 2.316$, $p = 0.005$), by 83.5% after 6 months ($\chi^2 = 7.990$, $p = 0.005$), and by 17.0% after 12 months ($\chi^2 = 0.218$, $p = 0.641$).

The relative prevalence of *streptococci* decreased by 12.4% ($\chi^2 = 0.173$, $p = 0.678$) after 7–10 days compared to the initial value, by 43.8% after 30 days ($\chi^2 = 2.418$, $p = 0.120$), by 87.6% after 6 months ($\chi^2 = 12.608$, $p < 0.001$), and by 37.6% after 12 months ($\chi^2 = 1.724$, $p = 0.190$). The relative prevalence of *pneumococci* decreased by 12.1% ($\chi^2 = 0.297$, $p = 0.586$) after 7–10 days compared to the initial value, by 3.1% after 30 days ($\chi^2 = 2.866$, $p = 0.091$), by 83.9% after 6 months ($\chi^2 = 19.488$, $p < 0.001$), and by 72.0% after 12 months ($\chi^2 = 13.365$, $p < 0.001$).

The dynamic study showed that the relative prevalence of fungi of the genus *Candida* decreased by 18.0% ($\chi^2 = 0.875$, $p = 0.350$) after 7–10 days compared to the initial value, by 39.3% after 30 days ($\chi^2 = 4.393$, p

= 0.037), by 93.0% after 6 months ($\chi^2 = 30.394$, $p < 0.001$), and by 67.9% after 12 months ($\chi^2 = 14.326$, $p < 0.001$).

In both the main and comparison groups, no significant differences were observed in the qualitative and quantitative composition of microorganisms in the oral saliva of patients with complete dentures in the upper and lower jaws. However, in the main group, a statistically significant decrease was observed in *Candida* fungi and *enterobacteria* after 6 months—by 86.5% ($p = 0.019$) and 100.0% ($p = 0.008$), respectively. Moreover, in the main group, the frequency of *pneumococci* on the oral mucosa significantly decreased after 30 days, amounting to a 58.5% reduction compared to the comparison group ($p = 0.050$).

Based on the results obtained, a positive trend was observed in both groups of the survey. In patients from the main group—particularly those using partial dentures in the upper and lower jaws, i.e., removable acrylic dentures containing silver nanoparticles—a statistically significant reduction was recorded in the frequency of occurrence of *enterococci, lactobacilli, pneumococci,* and *streptococci.*

The incorporation of silver nanoparticles (AgNPs) into acrylic resin may affect its mechanical properties. Therefore, the impact of AgNPs included in acrylic resin for antimicrobial purposes was evaluated with regard to the mechanical properties of the material.

The patients were divided into three equal groups: Group I – 40 patients with removable acrylic dentures modified by the addition of 0.03% nanocrystalline silver by weight; Group II – 40 patients with removable acrylic dentures made from thermoplastic acrylic resin polymer powder (up to 5 g in weight) supplemented with 0.2% AgNPs; Group III– 40 patients with conventional removable plate acrylic dentures. The mean values and standard deviations for flexural strength, surface microhardness, and Young's modulus are presented in Table 2.

There were no significant differences in the mean values of flexural strength, surface microhardness, and Young's modulus among the samples from the studied groups. Statistical analysis revealed no significant differences between the test groups and the control group ($p>0.05$). Similarly, there were no significant differences among the test groups themselves ($p>0.05$). At the same time, the flexural strength in

Group I, where 0.03% AgNPs were added to the acrylic resin, tended to decrease, while in Group II, the value was almost comparable to that of the control group. However, the decrease observed in Group I was not statistically significant ($p>0.05$). A similar trend was noted for surface microhardness. All tested groups had Young's modulus values comparable to the control group, with no statistically significant differences observed between them ($p>0.05$).

Table 2

Changes in the mechanical properties of acrylic resin samples enriched with AgNPs

Indicators	Group I	Group II	Group III	t-test	P
Flexural strength, MPa	79.53±19.88	90.77±9.85	91.82±8.14	t1-0.57 t2-0.08 t3-0.51	p1=0.569 p2=0.935 p3=0.614
Surface microhardness, HV	22.80±1.01	23.68±1.71	23.47±1.66	t1-0.34 t2-0.09 t3-0.44	p1=0.731 p2=0.930 p3=0659
Young's modulus, GPa	3.48±1.04	3.40±0.58	3.38±0.55	t1-0.08 t2-0.03 t3-0.07	p1=0.932 p2=0.980 p3=0.947

Note: t1, p1 - Statistical difference between the values of Group I and Group III; t2, p2 - Statistical difference between the values of Group II and Group III; t3, p3 - Statistical difference between the values of Group I and Group II.

The obtained results showed that the addition of AgNPs did not significantly affect the mechanical properties of acrylic plastic, depending on the amount of AgNPs added. A slight decrease in the flexural strength values of the acrylic plastic was observed at a low concentration (0.03%) of AgNPs. However, no significant changes were observed in the surface microhardness and Young's modulus of the acrylic resin. This is most likely due to the low dispersion of particles and weak chemical interactions between polymethyl methacrylate and AgNPs at low concentrations, resulting in a decrease in flexural strength. It can be assumed that at a concentration of 0.03%, AgNPs act as a filler, which leads to a reduction in the mechanical strength of the polymer.

The impact of oral health on the quality of life in patients wearing removable acrylic dentures.

The analysis of the questionnaire scores revealed that the majority of patients reported discomfort related to their dentures (Table 3).

Table 3

The oral health-related quality of life of the patients in the study group based on the OHIP-14 questionnaire, after 3 years

Items	Group wearing removable dentures enriched with silver nanoparticles (n=58)		Group wearing conventional removable denture (without silver nanoparticles) (n=66)		$\chi 2$	P
	N	%	n	%		
Functional limitation						
Difficulty in pronunciation	27	46.6	32	48.5	0.046	0.830
Worsened taste sensation due to denture use	10	17.2	12	18.2	0.019	0.892
Physical pain						
Oral pain	17	29.3	20	30.3	0.015	0.905
Difficulty in eating related to the denture	15	25.9	17	25.8	0.000	0.900
Psychological discomfort						
Discomfort related to wearing dentures	30	51.7	48	72.7	7.512	0.001
Tension in communication due to dentures	9	15.5	14	21.2	0.663	0.416
Reluctance to eat due to dentures	11	19.0	15	22.7	0.264	0.608
Pauses during food intake	16	27.6	20	30.3	0.111	0.740
Difficulty during rest	5	8.6	7	10.6	0.139	0.710
Sense of embarrassment related to wearing dentures	4	6.9	6	9.1	0.200	0.656
Social distress						
Avoiding communication	16	27.6	22	33.3	0.480	0.489
Difficulty in performing daily tasks	8	13.8	11	16.7	0.196	0.658

Disability						
Loss of interest in life	2	3.4	2	3.0	0.017	0.896
Loss of functionality	2	3.4	2	3.0	0.017	0.896
Overall average score of OHIP	22.6±2.16		31.2±3.02		t=2.32	0.022

The analysis of the survey data showed that, on average, the group with silver nanoparticles exhibited a good quality of life (QoL) level, while the group without silver nanoparticles had a fair QoL level, with 48.5% of cases in this group showing a good QoL level.

In the group of patients wearing removable acrylic dentures with silver nanoparticles, the overall average score was statistically significantly lower compared to the group of patients without silver nanoparticles (p=0.022). In the group of patients wearing removable acrylic dentures with silver nanoparticles, the overall average score was 22.6±2.16, which, according to the OHIP-14 questionnaire results, corresponds to a good quality of life (QoL) level (14-28 points). In contrast, the group of patients wearing removable acrylic dentures without silver nanoparticles had an overall average score of 31.2±3.02, which falls within the fair QoL level range (28-56 points) according to the OHIP-14 results.

During the study, the appearance of the removable denture was evaluated. At the same time, in the group of patients wearing removable acrylic dentures with silver nanoparticles and the group without silver nanoparticles, good results were observed in 32 (55.2%) and 35 (53.0%) patients, respectively, while fair results were observed in 26 (44.8%) and 31 (47.0%) patients (p=0.812). For the fixation and stabilization of the dentures, good results were observed in 20 (34.5%) and 22 (33.3%) patients (p=0.893), fair results in 35 (60.3%) and 40 (60.6%) patients (p=0.977), and poor results in 3 (5.2%) and 4 (6.1%) patients (p=0.831) in the groups with and without silver nanoparticles, respectively.

In patients with maxillary and mandibular complete dentures containing silver nanoparticles, the mean score for the item “difficulty in pronunciation” was lower compared to the group without silver

nanoparticles; however, the difference was not statistically significant (t=0.75, p=0.468). The mean scores for the items "worsened taste sensation due to denture use" and "oral pain" also showed slight differences between the groups, with t=1.25, p=0.236 and t=0.14, p=0.892, respectively. According to the analyses, no significant differences were found between the groups in terms of "discomfort related to wearing dentures" (t=0.71, p=0.493), as well as for the item related to inadequate nutrition due to dentures (t=0.10, p=0.918) based on the calculated mean scores. The difference in mean scores for the item "difficulty in pronunciation" was also insignificant (t=0.50, p=0.628). One patient from the main group and two patients from the conventional group occasionally reported a worsened sense of taste related to denture use. However, there was no significant difference in the average score for this item (t=1.25, p=0.233). Patients in both groups reported experiencing pain in the denture-bearing area. At the same time, in the group of patients wearing dentures with silver nanoparticles, the pain was reported rarely and frequently in 14.3% of cases, respectively, while in the group without silver nanoparticles, the pain was reported rarely in 10.0% and frequently in 20.0% and moderately frequently in 10.0% of cases. Although the mean score was lower in the group with silver nanoparticles, the difference was not statistically significant (t=0.71, p=0.491). The differences in mean scores for the items "difficulty in eating" (t=0.75, p=0.466) and "discomfort" (t=0.71, p=0.491) were also insignificant. However, for the item related to discomfort caused by the denture, a statistically significant better level of oral health-related quality of life (OHQoL) was observed in the group enriched with silver nanoparticles ($p<0.05$).

It should be noted that within three years after the delivery of removable dentures, the level of oral health-related quality of life (OHQoL) remained relatively good. Patients with partial removable dentures experienced minimal chewing difficulties, social compromises, and functional discomfort.

CONCLUSIONS

1. For the first time, a methodology for depositing silver nanoparticles onto the inner surface of the removable denture base was developed by us, and its advantages were confirmed using clinical, microbiological, and sociological methods [3,9,10].
2. During the observation period, the hygiene index in removable acrylic dentures enriched with silver nanoparticles was high. In patients wearing maxillary complete and mandibular partial removable acrylic dentures with silver nanoparticles, the denture hygiene index was 19.7% ($p<0.05$) and 29.1% ($p>0.05$) better at 20 days and 3 months, respectively, compared to patients wearing conventional removable acrylic base dentures. Six months after the delivery of the dentures, the hygiene index of removable dentures enriched with silver nanoparticles remained high—27.7% ($p<0.05$). Silver nanoparticles had a positive effect on the hygiene index of the dentures. Moreover, in patients wearing partial dentures in the maxilla and complete dentures in the mandible, the overall performance of the dentures with added silver nanoparticles was significantly better—18.3% ($p=0.01$) initially, 35.3% ($p=0.001$) after 20 days, and 35.9% ($p=0.001$) after 3 and 6 months [5,7,9].
3. *Candida* fungi were detected in 48.3% of patients wearing removable acrylic dentures with added silver nanoparticles and in 45.4% of those wearing conventional dentures ($p=0.754$); *pneumococci* were found in 32.7% and 37.9% of the respective groups ($p=0.553$); *enterobacteria* in 31.0% and 31.7% ($p=0.926$); and *enterococci* in 31.0% and 30.3% ($p=0.930$). The addition of silver nanoparticles to removable acrylic dentures significantly reduced the presence of *Candida* fungi, *pneumococci*, and *enterobacteria* in patients with complete edentulism in the maxilla and mandible [1,9,11].
4. According to the Supple classification, the condition of the denture-bearing mucosa in patients wearing removable acrylic dentures enriched with silver nanoparticles and those without enrichment was as follows: Type I denture base mucosa was observed in 44.8% and 45.4% of cases, respectively ($p>0.05$);

Type II denture base mucosa in 36.2% and 36.4% ($p>0.05$); and Type III denture base mucosa in 19.0% and 18.2% of cases, respectively ($p>0.05$).

In patients wearing removable acrylic dentures enriched with silver nanoparticles and conventional acrylic dentures, the degree of alveolar ridge atrophy according to the Schröder classification for the mandible was as follows: Type I atrophy was observed in 33.3% and 31.4% of cases, respectively; Type II in 59.3% and 57.1%; and Type III in 7.4% and 11.4%, respectively. According to the Keller classification for the maxilla, Type I atrophy was observed in 20.2% and 26.1% of cases, respectively; Type II in 50.0% and 52.2%; Type III in 6.7% and 13.0%; and Type IV atrophy in 4.2% and 8.7% of cases, respectively [7,10,12].

5. After orthopedic treatment in patients: the most common complications observed in patients with conventional removable acrylic dentures were denture instability (19.3%), irritation or changes in the mucous membrane (16.9%), and pain (16.1%). Compared to patients wearing AgNP-containing dentures, those with conventional removable acrylic dentures showed a higher incidence of denture stabilization disorders and denture stomatitis (56.8% ($p=0.037$) and 75.0% ($p=0.033$), respectively). In cases of complete edentulism in the maxilla and mandible, patients with conventional complete removable acrylic dentures more frequently developed denture stomatitis. The incorporation of silver nanoparticles into removable acrylic dentures in cases of secondary edentulism improves the condition of the mucosa of the denture-bearing area, significantly reduces pain syndrome, and decreases the severity of inflammatory processes [1,2,4].
6. The addition of silver nanoparticles to removable acrylic dentures improves the oral health-related quality of life. The overall mean score in patients wearing removable acrylic dentures with silver nanoparticles was 22.6 ± 2.16, whereas in patients wearing dentures without silver nanoparticles, it was 31.2 ± 3.02 ($p=0.022$). According to the OHIP-14 survey conducted three years later, the analysis of scores on the questionnaires assessing oral health-

related quality of life in the study group showed that the majority of patients in the comparison group continued to experience discomfort related to their dentures. However, in the main group, the quality of life level was statistically reliably assessed as good [6,8,13].

PRACTICAL RECOMMENDATIONS

1. To deposit silver nanoparticles onto the inner surface of a removable denture base, the silver nanoparticles should be obtained using the following method: 10 g of $AgNO_3$ should be dissolved in 50 ml of distilled water, and a 25% NH_3 solution should be added drop by drop. This process should be continued with slow stirring until the dark precipitate completely dissolves and a clear solution is obtained. After filtration, the solution should be diluted with distilled water to reach a total volume of 1 liter. For the second solution, 20 g of glucose and 20 g of sodium potassium tartrate should be dissolved in 200 ml of distilled water. To the resulting solution, a solution prepared by dissolving 8 g of $AgNO_3$ in 20 ml of water should be added and boiled for a few minutes, then diluted with water to reach a total volume of 1 liter.
2. To enhance the stability of silver nanoparticles on the inner surface of the removable denture, the inner surface should first be sprayed with a $ZnCl_2$ solution and allowed to dry before silvering. Then, a $PdCl_2$ solution should be sprayed onto the surface.
3. If any correction is made to the inner surface or borders of the denture, the methodology for depositing silver nanoparticles should be repeated.

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LIST OF ABBREVIATIONS

AgNP	Silver nanoparticles
CI	Confidence interval
QoL	Quality of life
OHIP-14	The Oral Health Impact Profile-14
OR	Odds ratio
PCR	Polymerase chain reaction

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