DOI 10.26724/2079-8334-2026-1-95-277-280
UDC 616.314.19-002-085:54

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NANOCOMPOSITION FOR TREATMENT OF CHRONIC APICAL PERIODONTITIS AND BONE REPAIR

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This paper presents a clinical case of diagnosing the density of the alveolar bone of the mandible and its architectonics in a patient with chronic apical periodontitis. The density of the alveolar bone of the mandible was determined in the periapical areas of the affected teeth. The results were evaluated in Hounsfield units using the classification of bone tissue types by C. E. Misch. The clinical study evaluated the effectiveness of treating chronic apical periodontitis with a phosphate buffer using the proposed method. The article describes the mechanism of action of this composition, which stimulates bone mineralization and promotes the restoration of mineralized bone tissue structures. As a result of the chemical reactions between the two reagents, a nanocomposite structure forms. In 85.2 % of treatment cases, a positive result was obtained. We carried out the specified diagnostic algorithm for the individualized treatment of chronic apical periodontitis. Analysis of the obtained results (change in density from D4 to D3) indicates the effectiveness of phosphate buffer in the apical region of the periodontium. In further studies, it is planned to continue studying the density of bone tissue of the periapical structures of the upper jaw.

Key words: bone repair, chronic apical periodontitis, calcium chloride, phosphate buffer.

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НАНОКОМПОЗИЦІЯ ДЛЯ ЛІКУВАННЯ ХРОНІЧНОГО АПІКАЛЬНОГО ПЕРІОДОНТИТУ ТА ВІДНОВЛЕННЯ КІСТОК

У даній роботі представлено клінічний випадок діагностики щільності кісткової тканини альвеолярного відростка нижньої щелепи, її архітектоніки у пацієнта з хронічним верхівковим періодонтитом. Щільність кісткової тканини альвеолярного відростка нижньої щелепи визначали в періапікальних ділянках уражених зубів. Отримані результати оцінювали за одиницями шкали Гаунсвільда, з використанням класифікації типів кісткової тканини за C.E. Misch. У клінічному дослідженні вивчалася ефективність лікування хронічного апікального періодонтиту з використанням фосфатного буферу із застосуванням запропонованого методу. У статті описано механізм дії даної композиції, що стимулює мінералізацію кісткової тканини та сприяє відновленню мінералізованих кісткових структур. В результаті хімічних реакцій обох зазначених реагентів утворюється нанокомпозитна структура. Зазначений діагностичний алгоритм проводився нами для необхідного індивідуального лікування хронічного верхівкового періодонтиту. Аналіз отриманих результатів (зміна щільності від D4 до D3) свідчить про ефективність застосування фосфатного буферу в апікальній ділянці періодонту. В подальших дослідженнях планується продовження вивчення щільності кісткової тканини періапікальних структур верхньої щелепи.

Ключові слова: відновлення кісток, хронічний апікальний періодонтит, хлорид кальцію, фосфатний буфер.

Funding. *The work is a fragment of the research project "Development of pathogenetic prophylaxis of pathological changes in an empty company of individuals with internal ailments", state registration No. 0121U108263.*

Chronic apical periodontitis is one of the most common oral cavity pathologies, developing as a result of the inflammatory process in fibrous periodontitis caused by odontogenic infection. This disease is accompanied by the destruction of the bone tissue surrounding the top of the tooth root. The pathogenesis of apical periodontitis involves destructive processes that lead to osteoporosis of periodontal tissues. One of the main goals of treatment is to stimulate the restoration of bone tissue in affected areas and to control infection in the microchannels at the root, both of which are crucial for the healing process. An important part of this process is the presence of calcium phosphate, a key material for forming new bone structures through the mineralization of dental tissues [3, 10]. The mechanism of mineralization involves the interaction of phosphate buffer with calcium, which then precipitates from the surrounding bone tissue and dentin, forming biocompatible calcium phosphate [5].

Low-efficiency traditional methods of endodontic treatment have led to the search for new osteotropic nanopreparations with biological inertia and the ability to stimulate bone remodeling in the jaws [8].

The purpose of the study was to assess speakers' reparative processes in periapical tissues and restoration bones in the area of the root apex after endodontic treatment using compositions based on 10 % calcium chloride and phosphate buffer.

Materials and methods. The treatment was carried out at the Department of Postgraduate Education of Dentists of Poltava State Medical University. The study was conducted from October 2023 to December 2025. We present a clinical case of a patient who underwent the indicated treatment. Examination 11/23/2023.

Patient O., 53 years old, presented to the surgical dentistry clinic at the PDMU with complaints of aching pain in the lower right jaw tooth and slight tooth mobility, especially in the upper jaw.

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Complaints appeared a month ago. The patient immediately went to the dentist. The indicated tooth had previously been treated. After treatment, the tooth bothered the patient for two weeks, so the patient applied again. Objectively, there are remains of a destroyed crown of tooth 47; the filling does not meet the requirements. After removal of the filling, a deep carious cavity is present on the distal surface. When probing, the mouths of the distal and medial canals are filled. Percussion of the tooth is slightly painful; thermometry is negative.

The diagnostic process was carried out within the framework of clinical studies. Laboratory diagnostics were based on X-ray examination of the causative tooth and computed tomography. Before treatment, patients underwent additional research methods: targeted radiography and cone-beam computed tomography (CBCT).

Bone density indicators in the apical areas of the studied teeth were assessed using the Hounsfield scale, which enables quantitative determination of the degree of mineralization and bone tissue structure in the indicated anatomical areas.

Measurements were performed in the areas of the premolars and molars of the lower jaw on the left and right. The results were evaluated in the first 3–6 months after treatment. The obtained density values were analyzed according to the classification of C. E. Misch (1999), which takes into account not only the density and mineral saturation of the cortical and cancellous layers, but also their topographic ratio. The author distinguishes 4 types of bone: D1 – over 1250 HU (very dense bone, rarely found in the upper jaw);

– D2 – 850–1250 HU (moderately dense bone, mainly in the frontal region);

– D3 – 350–850 HU (moderately spongy bone, characteristic of the premolar-molar region);

– D4 – 150–350 HU (low-density spongy bone, mainly in the area of the floor of the maxillary sinus).

Upon completion of the treatment course, patients underwent selective CT and X-ray examinations to monitor the condition of the bone tissue in the affected area.

The obtained data were used to plan therapeutic intervention, assess the condition of the bone tissue, and predict treatment effectiveness.

It should be noted that “X-ray density” is the average value of radiation absorption by tissue; when assessing a complex anatomical and histological structure, its “X-ray density” is measured. The results obtained were evaluated in units of the Hounsfield scale (UH).

Our study was conducted on a VATECH PaX-Zenith 3D CT scanner in South Korea. Bone density was measured in the Ez3D2009 program using the “Profile” tool – measuring bone density between two points in Hounsfield units (HU) [9].

Additionally, targeted radiography was performed using a 5D2, 5kV, 7 mA dental X-ray device manufactured by Med Tech-Price and released in 1990.

The treatment at the first visit was carried out in two stages. In the first stage, instrumental and medicinal treatment of the root canals was performed using the Crown-down method and a 3 % sodium hypochlorite antiseptic solution, respectively. The root canals were thoroughly washed with distilled water and dried. At the second stage, according to the developed method, each root canal was irrigated with a 10 % calcium chloride solution for 1 minute.

The prepared root canals were filled with a paste based on white clay and phosphate buffer solution. The teeth were sealed with glass ionomer cement for 3 weeks to 6 months, depending on the degree of bone tissue destruction at the root apex. The absence of patient complaints and radiological control of the acquired bone density contributed to the subsequent completion of treatment. CT was performed selectively as needed.

The studies complied with the requirements of Good Clinical Practice (ICH E2 (R6) GCP) and the Declaration of Helsinki of the World Health Organization. Before the procedures began, the patient provided informed voluntary consent to participate in the study. Statistical processing of the results was performed using Microsoft Excel.

No bioethics commission was held. Permission to publish the article has been granted: Minutes of the meeting of the Committee on Ethical Issues and Bioethics of Poltava State Medical University No. 246 dated 19 February 2026.

Results of the study and their discussion. Complaints appeared a month ago. The patient immediately went to the dentist. After treatment, the tooth bothered the patient for two weeks, so the patient applied again. Objectively, there are remains of the destroyed crown of tooth 47; the filling does not meet the requirements. After removal of the filling, a deep carious cavity is present on the distal surface. When probing, the filled mouths of the distal and medial canals are noted. Percussion of the tooth is slightly painful; thermometry is negative. CT scan protocol (Fig. 1).

In general, the results of our studies show that with age, mineralization of bone tissue in both jaws increases, as indicated by higher density values in Hounsfield units (HU): the average values were 512±63.22 and 563.6±41.15 in patients aged 18 to 65 years, respectively. The most dense area is the alveolar process of the frontal group of teeth of the upper and lower jaws: on average, 998±53.66 and 1197.41±63.12, respectively. In the molar region of both jaws, the average density was 652.74±68.61 and did not differ statistically between the jaws. The density of bone tissue in the area of the apex of the root of tooth 47 has a positive dynamic of densification before and after treatment, compared to other areas of the lower jaw.

Conclusion: CT results indicate age-related increases in jawbone tissue density with increasing age. The frontal areas of the upper and lower jaws are distinguished by the maximum density indicators in comparison with the areas of the molars. Bone density indicators in the area of tooth 47 differ in tissue structure but do not differ statistically. Additionally, the patient underwent an X-ray examination (Fig. 2).

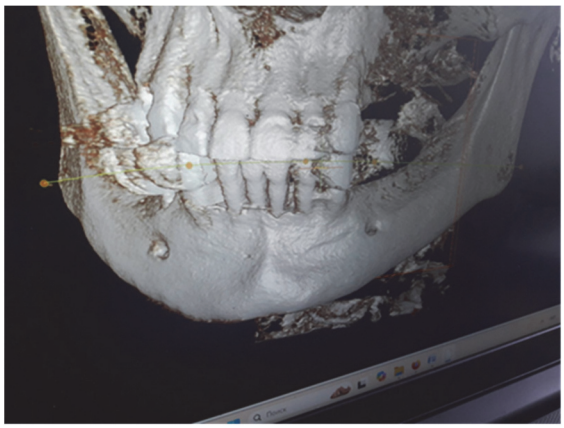

Fig. 1. 3D CT scan of the patient at the first visit.

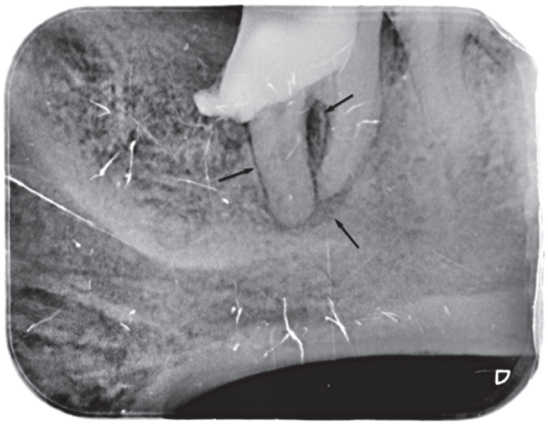

Fig. 2. Sighting X-ray Photo of tooth 47 in patient O., 53 years old. Condition of the tooth before treatment. Arrows indicate lower described changes in the structure of bone fabrics.

On the X-ray, the image shows a bent medial root of tooth 47. Contours of the root canal are almost not noticeable; the lower third is sclerosed. The distal root straight and has a wide canal. Along the entire perimeter of the periapical tissues, clear delimitation zones of destruction of bone tissues, especially in the area of the medial and distal roots.

Spongy bone tissue of the alveolar process in the area of the tip of the distal root of tooth 47 lost its clear boundaries and structure. Radiologically observed significant intensity shadows that indicate destructive periodontal tissue processes, and a periodontal cleft extended along the entire perimeter. Other plots of periodontal cracks also lack clear boundaries and are diffuse. In the zone: furcation roots; cortical plate absent; marked osteolysis.

Based on the clinical and radiological examinations, a diagnosis was established: exacerbation of chronic apical periodontitis of tooth 47.

The patient was treated according to proposed methods: mechanical and drug processing of the distal and medial canals roots. The medial canals could not be completely passed due to their Sclerosis. The distal canal root was successfully sealed with medicated paste. Carious cavity sealed with glass ionomer cement. In 4 months after patient treatment, complaints are absent (Fig. 3).

Objectively: in tooth 47, the filling corresponds to clinical requirements, clear ordinary color, palpation in the area projections to the roots, and Percussion of the tooth is painless. Radiologically, the destruction zone's spongy bone fabrics have decreased (Fig. 3). In the apical area, medial and distal roots are determined to have clear spongy structure bone fabrics with enlightenment almost along the entire perimeter of the periodontium, which confirms the process of its compaction and mineralization. The width of the periodontal furcation area is also within normal limits. has positive dynamics recovery, in the form of a reduction in area-intensity shadows compared to the previous one. Radiologically, a simultaneous restoration of apical periodontal bone tissue of the distal root and the corresponding apex of the problematic medial root.

Fig. 3. Sighting X-ray Photo of tooth 47 in patient O., 53 years old. Condition of the tooth after 4 months of treatment.

Analysis of clinical and radiological research fully confirms the results of earlier published works.

In 4 months after treatment, one can affirm the full absence of destructive processes in the bone tissues in the area of the medial and distal roots of tooth 47. In the near future, the patient is recommended to have a filling, root canals, composite endodontic material, and replacement temporary fillings with permanent fillings.

In general, the majority of patients experienced significant improvement in the condition of the periodontal tissues: on X-ray images, a reduction in areas of darkened plots, destruction of spongy and

lamellar bone structures, and overall improvement around the periodontal.

Chronic apical Periodontitis often occurs due to complications of caries and can lead to serious violations of the bone structures, if not treated. As a result, the treatment nanocomposition deep-seeps into the thickness of structural elements, spongy bone fabrics that radiologically manifest as mineralization and compaction of their structural elements. In the process, the treatment phosphate buffer stabilizes the dynamic ion balance between calcium and phosphorus, which affects bone mineralization [6, 4, 11].

A mixture of 10 % calcium chloride and phosphate buffer solution provides a stable alkaline environment that has bactericidal effects on the microflora in the focus of inflammation [1] and restores the mineralized nanocomposite substance [2]. Over a long period in the area, the root of this composition helps neutralize sour products and completely eliminates osteolysis. In older patients with severe somatic status, the treatment outcome was less pronounced [7].

The paper presents a clinical case and positive radiological findings, which confirm the results obtained. Specified clinical case confirms successful use of nanocompositions for the treatment of chronic apical periodontitis and recovery of spongy and lamellar bone fabrics in the jaws.

Limitations. The main limitation of the study is the lack of a clear picture of histological changes in bone tissue before treatment and at the study stages, although the results of radiological and computer studies confirm the positive morpho-functional dynamics of periodontal tissues.

Conclusion

Natural obturation of root channels contributes to a full-fledged restoration of hard tissues outside the apical foramina. Radiologically, a simultaneous restoration of apical periodontal bone tissue of the distal root and the corresponding apex of the problematic medial root. Trace note that, in the process, the treatment of the medial canals' roots did not go through completely. The proposed approach contributes to the formation of a naturally inert osteotropic material in the root area, thereby enabling effective, progressive remineralization of damaged bone tissue. Authors emphasize the need to conduct further research on remote-term treatment to evaluate the stability of restored bone tissue and the full elimination of relapse.

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Conflict of interest. The authors have no conflicts of interest to declare.

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Article received: 30.01.2025.