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CLINICAL, RADIOLOGICAL, AND IMMUNOLOGICAL FEATURES OF DENTAL PULP DAMAGE IN PATIENTS WITH CHRONIC PERIODONTITIS

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Abstract Chronic generalized periodontitis is frequently accompanied by inflammatory and degenerative changes in the dental pulp due to the anatomical communication between periodontal tissues and the root canal system. Early identification of pulp involvement remains a diagnostic challenge because conventional clinical and radiographic methods often fail to detect initial pathological changes. The present prospective comparative study aimed to evaluate the clinical, radiological, functional, and immunological characteristics of dental pulp lesions in patients with chronic generalized periodontitis and to determine the diagnostic value of an integrated examination approach. A total of 154 participants were enrolled, including 124 patients with chronic generalized periodontitis complicated by pulp involvement and 30 periodontally healthy individuals serving as controls. Clinical periodontal indices, cone-beam computed tomography (CBCT), electroodontodiagnostics (EOD), and enzyme-linked immunosorbent assay (ELISA) were used to assess periodontal status, pulp vitality, radiological changes, and cytokine concentrations (IL-1β, IL-6, TNF-α, and IL-10). The results demonstrated that chronic fibrous pulpitis was the predominant form of pulp pathology, while CBCT detected extensive alveolar bone destruction and accessory canal involvement in the majority of patients. EOD revealed impaired pulp vitality closely associated with periodontal pocket depth and bone resorption. Immunological analysis showed significantly elevated levels of IL-1β, IL-6, and TNF-α together with reduced IL-10 concentrations, indicating a pronounced local inflammatory imbalance. The integrated application of CBCT, electroodontodiagnostics, and cytokine profiling significantly improved the early diagnosis of retrograde pulp involvement compared with conventional diagnostic methods. Comprehensive assessment of clinical, radiological, functional, and immunological parameters provides a reliable basis for selecting appropriate treatment strategies and improving the prognosis of patients with chronic periodontitis complicated by pulp lesions.

Key words: chronic periodontitis, dental pulp, endo-periodontal lesions, cone-beam computed tomography, electroodontodiagnostics, cytokines, IL-1β, IL-6, TNF-α, IL-10.

Introduction Chronic generalized periodontitis is one of the most pressing issues in modern therapeutic dentistry. According to numerous epidemiological studies, the prevalence of periodontal disease in the adult population reaches 70–90%, with severe forms often leading to premature tooth loss, reduced quality of life, and significant treatment costs. Combined damage to the periodontal tissues and dental pulp is of particular clinical significance, as the development of an inflammatory process in these two anatomically interconnected structures significantly complicates diagnosis and the selection of appropriate treatment strategies.

The anatomical connection between the periodontal tissues and the pulp is established through the apical foramen, lateral, accessory, and deltoid canals, as well as dentinal tubules exposed by progressive resorption of root cementum. These structures serve as pathways for the retrograde

penetration of microorganisms, their toxins, and inflammatory products into the dental pulp. As a result, microcirculation is disrupted, tissue hypoxia develops, oxidative stress increases, innate immune cells are activated, and proinflammatory cytokines are released, leading to progressive destruction of the neurovascular bundle.

In recent years, particular attention has been paid to the role of the local immune response in endodontic and periodontal lesions. Proinflammatory cytokines IL-1β, IL-6, and TNF-α are considered key inflammatory mediators that promote osteoclast activation, increased alveolar bone resorption, and the progression of the inflammatory-destructive process. Concurrently, a decrease in the level of the anti-inflammatory cytokine IL-10 indicates depletion of compensatory mechanisms of local immune defense. Determining the cytokine profile of gingival fluid allows for an objective assessment of the activity of the inflammatory process and can be used as an additional diagnostic criterion when choosing a treatment strategy. Despite the introduction of modern imaging techniques, timely detection of pulpal lesions in patients with chronic periodontitis remains challenging. Traditional intraoral radiography only provides a two-dimensional image of the examined area and does not always detect early signs of bone destruction, especially in the bifurcation and trifurcation areas of the roots. Cone beam computed tomography (CBT) provides three-dimensional visualization of dental structures, allowing for the true extent of the inflammatory process to be determined and the anatomical pathways of retrograde pulp infection to be identified.

Electrodontodiagnostics offers additional diagnostic value, allowing for an objective assessment of the functional state of the dental vascular-nerve bundle and the identification of latent forms of degenerative changes not accompanied by pronounced clinical symptoms. The integrated use of clinical, imaging, functional, and immunological examination methods facilitates a more accurate diagnosis of endodontic and periodontal lesions, improves the effectiveness of treatment decisions, and improves the prognosis. The aim of the study was to investigate the clinical, radiological and immunological features of dental pulp damage in patients with chronic periodontitis, as well as to determine the diagnostic significance of the integrated use of clinical, functional, radiological and immunological research methods.

Research Materials and Methods

The study was conducted at the Department of Therapeutic Dentistry at Samarkand State Medical University from 2022 to 2025. This prospective, comparative clinical study aimed to examine the clinical, radiological, and immunological features of dental pulp damage in patients with chronic periodontitis.

The study included 154 subjects, of whom 124 patients with chronic generalized periodontitis complicated by pulp damage constituted the main clinical sample. To determine reference values for immunological parameters, 30 apparently healthy individuals with intact periodontium were additionally examined, forming a control group.

Inclusion criteria were: age 35–44 years, presence of moderate to severe chronic generalized periodontitis, clinical and instrumental signs of pulp damage, and voluntary informed consent to participate in the study. Exclusion criteria included acute infectious diseases, decompensated somatic diseases, decompensated diabetes mellitus, pregnancy and lactation, use of immunomodulatory medications, and previous endodontic treatment of the teeth studied.

Depending on the treatment method used, patients were divided into two comparable groups.

The study group included 62 patients treated according to a developed comprehensive protocol. After mechanical treatment of the root canals, passive ultrasonic irrigation (PUI) was performed with a 0.1% alexidine solution using an Ultra-X (Eighteeth) endoactivator operating at a frequency

of 45 kHz. Ultrasonic activation created a pronounced cavitation effect and acoustic streams, facilitating the penetration of the antiseptic into the lateral canals, dentinal tubules, and hard-to-reach areas of the root canal system. After irrigation, final obturation was performed using a bioactive calcium silicate sealer, which exhibits high biocompatibility, sealing properties, and the ability to stimulate reparative processes.

The comparison group consisted of 62 patients treated according to a traditional endodontic protocol. Medication was performed using a 3% sodium hypochlorite solution and 2% chlorhexidine solution without ultrasonic activation. Calcium hydroxide-based preparations were used for temporary filling, after which standard root canal obturation was performed.

The patients in both clinical groups were comparable in age, gender, severity of chronic periodontitis, and initial periodontal tissue condition ($p>0.05$). Women predominated among the patients examined: 66 (53.2%); men constituted 58 (46.8%). The clinical examination included a review of complaints, anamnesis, physical examination, and assessment of the oral mucosa and periodontal tissues. The most common complaints were bleeding gums and discomfort during eating (91.2%), intermittent aching pain (84.6%), and a feeling of pressure and distension in the region of the affected tooth (72.1%). Pain radiating along the trigeminal nerve branches was observed in 38.7% of patients, indicating pulp involvement in the pathological process.

To quantify inflammatory changes, the papillary-marginal-alveolar index (PMA), periodontal index (PI), Müllemann bleeding index, and Schiller-Pisarev test were used, as well as the depth of periodontal pockets and the degree of pathological tooth mobility.

The functional state of the pulp was assessed using electroodontodiagnostics (EOD). The study allowed us to determine the pulp's electrical excitability threshold, assess the viability of the vascular-nerve bundle, and identify hidden forms of degenerative changes. The obtained results were interpreted according to generally accepted diagnostic criteria.

Radiographic examination was performed using cone-beam computed tomography (CBCT) with a voxel size of 0.2 mm. The depth of alveolar bone resorption, the condition of the cortical plate, the severity of periapical changes, the presence of foci of bone destruction in the furcation area, the degree of involvement of accessory canals, and the morphological features of the root canal system were analyzed.

Immunological examination was performed using enzyme-linked immunosorbent assay. Concentrations of the proinflammatory cytokines IL-1β, IL-6, and TNF-α, as well as the anti-inflammatory cytokine IL-10, were determined in the gingival fluid. The IL-1β/IL-10 index, reflecting the severity of local cytokine imbalance and the activity of the inflammatory process, was also calculated.

The obtained results were statistically processed using the IBM SPSS Statistics package. The distribution of quantitative data was checked before selecting the analysis method. For normal distributions, the Student's t-test for independent samples was used; for non-normal distributions, the Mann-Whitney test was used. Pearson's χ^2 test was used to analyze qualitative characteristics. Results were presented as the arithmetic mean and standard error of the mean ($M \pm m$). Differences were considered statistically significant at a significance level of $p < 0.05$.

Study Results

A comprehensive clinical, radiological, and immunological examination of patients with chronic generalized periodontitis allowed us to establish patterns in the development of dental pulp lesions and identify the main factors contributing to the retrograde spread of the inflammatory process from periodontal tissues to the pulpodentinal complex.

During the initial examination, most patients showed pronounced signs of chronic periodontal inflammation. The main complaints included bleeding gums when brushing and eating (91.2%), intermittent aching pain of varying intensity (84.6%), a feeling of fullness in the area of the affected tooth (72.1%), as well as bad breath and increased tooth sensitivity. More than a third of the patients (38.7%) reported pain radiating along the branches of the trigeminal nerve, indirectly indicating involvement of the dental neurovascular bundle in the pathological process.

Clinical characteristics of patients

An assessment of the initial periodontal tissue status revealed that patients in the study and comparison groups had no statistically significant differences in any clinical parameters studied ($p>0.05$), indicating their comparability.

The mean PMA index was 68.4±3.8% in the study group and 62.1±3.5% in the comparison group. High index values reflected severe inflammation of the marginal periodontium and the prevalence of the pathological process.

The intensity of inflammatory changes was confirmed by the results of the Schiller-Pisarev test, which were 2.6±0.12 and 2.4±0.11 points, respectively. These values indicated significant glycogen accumulation in the gingival epithelium and high inflammatory activity.

The average periodontal pocket depth reached 5.4±0.15 mm in the study group and 5.1±0.18 mm in the comparison group. Concurrently, the periodontal index was 6.2±0.3 and 5.8±0.3 points, respectively, indicating a severe inflammatory and destructive process. The Müllerman bleeding index also remained high, at 2.7±0.08 and 2.5±0.11 points, respectively. There were no intergroup differences ($p>0.05$), confirming the appropriateness of patient randomization.

Clinical and morphological forms of pulp damage

Analysis of the structure of pulp damage revealed a predominance of chronic inflammatory forms of the disease.

Chronic fibrous pulpitis was the most frequently diagnosed form, occurring in 42 patients (33.9%). Chronic gangrenous pulpitis was second, occurring in 29 cases (23.4%). Signs of pulp calcification and denticle formation were detected in 27 patients (21.8%).

Mixed forms of pulp damage were recorded in 14 patients (11.3%), while asymptomatic necrosis was detected in only 12 patients (9.6%). The obtained results indicate that in chronic periodontitis, long-term chronic forms of pulp damage predominate, while acute inflammatory processes are much less common.

Radiographic characteristics

One of the most informative examination methods was cone-beam computed tomography.

The use of three-dimensional visualization significantly expanded diagnostic capabilities compared to traditional intraoral radiography.

84.2% of patients examined showed pronounced vertical alveolar bone resorption, with the pathological process extending into the bifurcation and trifurcation areas of multi-rooted teeth.

CBCT revealed: destruction of the cortical plate; widening of the periodontal ligament space; foci of periapical destruction; disruption of the trabecular bone pattern; exposure of accessory and lateral canals; and spatial connection of the periodontal pocket with the root canal system.

Of particular interest were cases in which pronounced periapical changes were observed despite an intact crown. Such a radiographic image indicated retrograde infection through the periodontal tissue. A comparison of traditional radiography and CBCT data revealed that 3D imaging significantly outperforms 2D methods in terms of information content, allowing for the detection of early signs of bone destruction and an objective assessment of the extent of the inflammatory process.

Pulp Function

According to electroodontodiagnostics, signs of pulp dysfunction were detected in more than half of the patients examined.

Physiological electrical excitability (2–20 μA) was recorded in only 53 patients (42.7%).

In 46 patients (37.1%), EOD values were consistent with chronic pulp inflammation (20–60 μA).

Signs of profound degeneration of the vascular-nerve bundle (60–100 μA) were detected in 11 patients (8.9%).

Complete pulp necrosis (more than 100 μA) was diagnosed in 14 patients (11.3%). Analysis of the results revealed a direct correlation between periodontal pocket depth, the degree of bone resorption, and a decrease in pulp electrical excitability. Moreover, even in patients with normal EOD values, CBCT often revealed early signs of structural changes, confirming the need for a comprehensive use of functional and imaging diagnostic methods.

Immunological Indicators

A study of the local cytokine profile confirmed a high level of inflammatory activity in patients with chronic periodontitis.

Before treatment, IL-1β concentrations were more than three times higher than those in the control group, reaching 41.6±2.3 pg/ml in the treatment group and 40.8±2.1 pg/ml in the comparison group. IL-6 levels reached 25.6±1.9 and 24.8±1.7 pg/ml, while TNF-α levels were 33.4±2.1 and 32.9±1.8 pg/ml, respectively.

At the same time, a significant decrease in the concentration of the anti-inflammatory cytokine IL-10 was observed, reaching 5.8±0.6 and 6.1±0.5 pg/ml, respectively, compared to 14.2±1.2 pg/ml in apparently healthy individuals.

The IL-1β/IL-10 ratio deserves special attention: it reached 7.17 and 6.68 in the study groups, compared to 0.87 in healthy individuals. These results indicate a marked predominance of proinflammatory mechanisms and a depletion of local anti-inflammatory defenses.

Conclusion A comprehensive clinical, radiological, and immunological study allowed us to identify the characteristics of dental pulp lesions in patients with chronic generalized periodontitis and determine the diagnostic value of modern examination methods.

It was established that pulp lesions develop against the background of a pronounced inflammatory and destructive process in periodontal tissues and are closely related to the depth of periodontal pockets, the degree of alveolar bone resorption, and the extension of the pathological process into the bifurcation and trifurcation areas of the roots. The obtained data confirm the existence of a retrograde route of pulp infection through the apical foramen, lateral, and accessory root canals.

A clinical examination revealed that the most common form of pulp lesions was chronic fibrous pulpitis, detected in 33.9% of the patients examined. Chronic gangrenous pulpitis was diagnosed in 23.4% of cases, pulp calcification in 21.8%, mixed forms in 11.3%, and asymptomatic necrosis in 9.6%. The prevalence of chronic forms indicates a long-lasting latent inflammatory process and the need for its timely diagnosis.

Cone-beam computed tomography has significantly expanded diagnostic capabilities compared to traditional intraoral radiography. Signs of severe vertical alveolar bone resorption, furcation lesions, cortical plate destruction, and periapical changes inaccessible to a full assessment using two-dimensional radiography were detected in 84.2% of patients. This confirms the high informative value of CBCT in diagnosing combined endodontic and periodontal lesions.

According to electroodontic diagnostics, signs of pulp dysfunction were detected in 57.3% of patients. A direct correlation was observed between decreased pulp excitability, periodontal pocket depth, and the severity of bone resorption. In some patients with normal EOD values, CBCT already revealed early structural changes, indicating the need for a comprehensive assessment of the results of functional and radiological examinations.

Immunological testing revealed a significant imbalance in the local cytokine profile. Increased concentrations of IL-1β, IL-6, and TNF-α were accompanied by a significant decrease in IL-10 levels, reflecting the prevalence of proinflammatory mechanisms and decreased activity of local immune defense. The IL-1β/IL-10 ratio was almost eight times higher than the control group, suggesting it can be considered an additional laboratory criterion for inflammatory activity and a potential predictor of retrograde pulp damage. Thus, the use of a comprehensive diagnostic algorithm, including clinical examination, cone-beam computed tomography, electroodontodiagnostics and assessment of the local cytokine profile, ensures earlier and more accurate diagnosis of pulp damage in patients with chronic periodontitis, facilitates the timely selection of treatment tactics and creates the preconditions for increasing the effectiveness of complex treatment.

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