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Index Assessment of Periodontal Tissue Status in Patients with Generalized Periodontitis and Coronary Artery Disease

▷ **Abstract.** Generalized periodontitis (GP) is recognized as a significant risk factor for the development of coronary artery disease (CAD). Chronic infectious foci within the periodontal tissues contribute to systemic inflammation, accelerate atherogenesis, and promote the progression of atherosclerotic vascular lesions. Conversely, circulatory disorders characteristic of CAD impair tissue perfusion and oxygenation in the periodontium, leading to hypoxia and reduced regenerative capacity. Given the bidirectional aggravating relationship between GP and CAD, it is essential to investigate the clinical features of GP in the context of cardiac pathology and to account for local risk factors associated with periodontal disease. Such an approach is crucial for developing effective strategies to improve periodontal health in patients with CAD.

Aim. To perform a comprehensive index-based assessment of periodontal tissue condition and individual oral hygiene in patients with CAD, followed by analysis of their clinical significance.

Materials and Methods. Dental examinations were conducted in 114 patients with GP and CAD (main group). The comparison group included 35 patients with GP without CAD. Periodontal tissue status was evaluated using the following indices: PMA (Papillary-Marginal-Alveolar Index, M. Massler, modified by S. Parma, 1960) and the Gingival Bleeding Index (PBI, Mühlemann & Saxer, 1977). Treatment needs were determined using the PSR screening test (Periodontal Screening and Recording, AAP and ADA, 1992). Oral hygiene status was assessed using the OHI-S (Oral Hygiene Index-Simplified, J.C. Green & J.R. Vermillion, 1964).

Results. Patients with GP and CAD demonstrated significantly higher PMA, PBI, and PSR scores compared with those with GP alone. The mean PMA value in the GP + CAD group was $63.27 \pm 1.92\%$, indicating severe inflammation. In the comparison group, the PMA index reflected a moderate degree of gingival inflammation ($43.32 \pm 2.18\%$), which was significantly lower ($p < 0.001$). The mean PBI score in patients with GP and CAD was 2.06 ± 0.08 , significantly higher than in patients with GP without CAD (1.20 ± 0.08 ; $p < 0.001$). A more pronounced degree of periodontal tissue damage was also evident in the PSR index, which reached 3.30 ± 0.06 in the main group versus 3.01 ± 0.09 in the comparison group ($p < 0.01$). No significant differences in oral hygiene status (OHI-S) were observed between groups ($p > 0.05$). However, most CAD patients demonstrated “unsatisfactory” ($27.19 \pm 4.17\%$) or “poor” ($53.50 \pm 14.67\%$) oral hygiene. In the GP+CAD group, no significant gender differences were found in PMA and PSR scores ($p > 0.05$). However, gingival bleeding measured by PBI was higher in men than in women ($p < 0.05$), while individual oral hygiene was significantly better in women ($p < 0.01$).

Conclusion. The findings indicate that, against the background of poor oral hygiene, inflammatory changes in periodontal tissues are particularly pronounced in patients with GP when accompanied by atherosclerotic processes such as CAD.

Keywords: *generalized periodontitis, coronary artery disease, atherosclerosis, periodontium, periodontal indices, oral hygiene.*

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Introduction

Extensive clinical experience in medicine and dentistry, supported by epidemiological, clinical, and experimental studies, confirms the existence of a

close relationship between generalized periodontitis (GP) and coronary artery disease (CAD) [1–4]. According to published data, the prevalence of GP among patients with CAD ranges from 84% to 97%, underscoring the importance of investigating etio-

logical and pathogenetic factors that mutually aggravate the development and progression of both conditions [2, 5].

In cases of combined periodontal and cardiovascular disease, it is essential to analyze systemic mechanisms—such as microcirculatory disorders, endothelial dysfunction, chronic inflammation, and immune remodeling—which may represent common links in the pathogenesis of GP and CAD [2, 5–8]. At the same time, local factors of GP play a significant role, as they can directly or indirectly trigger systemic reactions. In particular, the local production of pro-inflammatory cytokines and mediators in GP contributes to systemic inflammation, alterations in lipid metabolism, and other metabolic disturbances, which are recognized as key risk factors for CAD [4, 9–11].

Dental plaque and its mechanical, chemical-toxic, and sensitizing effects are considered by most authors to be the main local contributors to CAD [12]. As oral hygiene deteriorates, the number of pathogenic microorganisms increases, activating the host immune response through “microorganism–host” interactions and initiating systemic inflammation. Periodontal inflammation in GP, the entry of pathogens into the bloodstream, and their involvement in atherosclerotic plaque formation trigger a cascade of pathophysiological processes that complicate the course of atherosclerosis and may reduce the effectiveness of CAD treatment [11].

Furthermore, literature data demonstrate an association between CAD, periodontal indices, and oral hygiene status [10]. Studies indicate that increasing the frequency of toothbrushing to at least once daily reduces the risk of acute coronary events by 9%, while regular dental visits (one or more times per year) and professional hygiene procedures lower the risk of cardiovascular events by 14% [10].

An equally important diagnostic criterion for GP is gingival bleeding, which reflects the severity of inflammatory changes in periodontal tissues. In patients with CAD, gingival bleeding has particular clinical relevance due to the use of medications in CAD therapy that alter blood rheology [3]. Long-term administration of anticoagulants and antiplatelet agents increases gingival bleeding, which often discourages patients from thorough toothbrushing due to fear of pain or injury. Consequently, dental deposits accumulate, especially in cervical and interdental areas, creating a favorable environment for pathogenic microorganisms. This exacerbates periodontal inflammation and may lead to recurrent episodes of periodontitis. Such a pathological cycle worsens not only oral health but also the overall condition of patients with CAD.

Thus, inadequate oral hygiene in patients with CAD represents an additional risk factor that requires heightened attention from both dentists and cardiologists.

Aim of the study. To conduct a comprehensive index-based assessment of periodontal tissue status and individual oral hygiene in patients with CAD, followed by analysis of their clinical significance.

Materials and Methods

To evaluate periodontal status using index indicators, dental examinations were performed in 114 patients with generalized periodontitis (GP) associated with CAD (mean age: 58.01 ± 0.78 years), who comprised the main group. This group included 70 men (61.4%) and 44 women (38.6%), enabling a comparative analysis of gender-related characteristics of periodontal tissues in patients with CAD. The comparison group consisted of 35 individuals with GP (mean age: 46.05 ± 2.14 years) without concomitant CAD or other systemic diseases.

Diagnosis of periodontal status in patients with CAD and establishment of a periodontal diagnosis were carried out according to the classification of M. F. Danylevsky (1994), based on medical history, clinical examination, index assessment of periodontal status, and orthopantomographic analysis. According to this classification, patients with GP of initial-I, II, and III degrees of severity were included in the study. Specifically, initial-I degree GP was identified in 52 patients ($45.61 \pm 4.66\%$) with CAD and in 22 patients ($62.86 \pm 8.17\%$) in the comparison group ($p > 0.05$). Degree II GP was observed in 42 patients ($36.84 \pm 4.52\%$) in the main group and 9 patients ($25.71 \pm 7.39\%$) in the comparison group ($p > 0.05$). Degree III GP was diagnosed in 20 patients ($17.54 \pm 3.56\%$) in the main group and 4 patients ($11.43 \pm 5.38\%$) in the comparison group ($p > 0.05$).

The degree of gingival inflammation was assessed using the PMA index (Papillary-Marginal-Alveolar Index, M. Massler, modified by S. Parma, 1960) [13]. Gingival bleeding was evaluated using the Papilla Bleeding Index (PBI, Mühlemann & Saxer, 1977) [13]. The need for periodontal treatment, including indications for conservative or surgical approaches, was determined using the Periodontal Screening and Recording (PSR) test developed by the AAP and ADA (1992) [13]. Oral hygiene status was assessed using the Oral Hygiene Index-Simplified (OHI-S, J.C. Green & J.R. Vermillion, 1964) [13].

The study was conducted in compliance with the requirements of the Bioethics Committee and in accordance with the fundamental bioethical principles of the European Convention on Human Rights and

Table 1.

Indicators of the PMA, PBI, PSR, and OHI-S indices in the study groups, (*M ± m*)

Index	Main group (n = 114)	Group comparison (n = 35)	P
PMA, %	63,27 ± 1,92	43,32 ± 2,18	< 0,001
PBI, points	2,06 ± 0,08	1,2 ± 0,08	< 0,001
PSR, points	3,30 ± 0,06	3,01 ± 0,09	< 0,01
OHI-S, points	2,71 ± 0,12	2,59 ± 0,15	> 0,05

Note: significant difference between indicators at *p* < 0.05.

Biomedicine (1997) and the Declaration of Helsinki of the World Medical Association on Ethical Principles for Medical Research Involving Human Subjects (1964–2008). All participants provided written informed consent to undergo examination and participate in the study. The study protocol (No. 3, dated March 25, 2019) was reviewed and approved by the Commission on Ethics of Scientific Research, Experimental Developments, and Scientific Works of Danylo Halytsky Lviv National Medical University.

Statistical analysis of the data was performed using the Microsoft Excel 2010 software package. Comparisons of mean values between groups were carried out using the unpaired Student's *t*-test, with differences considered statistically significant at *p* < 0.05. For categorical variables, contingency tables were applied, and results were presented as relative values (proportions) with standard error (*P ± mp*). Statistically significant differences between groups for categorical variables were assessed using Pearson's χ^2 test.

Results of the Study

To assess the severity of the inflammatory process in the periodontal tissues of patients with CAD, the PMA index was applied, enabling a quantitative evaluation of gingival involvement across different areas of the gingival margin. The results demonstrated that the mean PMA index in patients with GP and CAD was 63.27 ± 1.92%, corresponding to a severe degree of inflammation. In the comparison group, consisting of patients with GP without

concomitant CAD, the PMA index was 43.32 ± 2.18%, indicating a moderate degree of gingival inflammation and being significantly lower than in the main group (*p* < 0.001) (Table 1).

Analysis of PMA index distribution revealed that among patients with CAD, the majority exhibited severe inflammation, while a slightly smaller proportion demonstrated moderate inflammation of periodontal tissues (52.63 ± 4.68% and 43.86 ± 4.65%, respectively; *p* > 0.05) (Table 2). The proportion of patients with mild gingival inflammation was significantly lower (3.51 ± 1.72%; *p* < 0.001). Furthermore, no statistically significant differences were observed between men and women in the distribution of mild, moderate, and severe gingival inflammation (*p* > 0.05) (Table 2).

Assessment of gingival bleeding using the PBI index demonstrated that bleeding levels were higher in the main group compared with the comparison group (Table 1). The mean PBI score in patients with GP and CAD was 2.06 ± 0.08, which differed significantly from the score in patients with GP without CAD (1.20 ± 0.08; *p* < 0.001).

A more severe degree of periodontal tissue damage was also reflected in the PSR index. In the main group, the mean PSR score was 3.30 ± 0.06, significantly higher than in the comparison group (3.01 ± 0.09; *p* < 0.01) (Table 1). Distribution analysis of the PSR index revealed that 75 patients (65.79 ± 4.44%) with GP and CAD had indications for surgical treatment, whereas in the comparison group the need for surgical intervention was

Table 2.

Distribution of patients with GP and CAD by the PMA index

PMA	Total (n = 114)		Men (n = 70)		Women (n = 44)	
	n	%	n	%	n	%
Mild degree (< 25%)	4	3,51 ± 1,72	1	1,43 ± 0,72	2	4,55 ± 1,6
Moderate level (25–50%)	50	43,86 ± 4,65 *	30	42,86 ± 5,91	21	47,73 ± 7,53
Severe degree (> 50%)	60	52,63 ± 4,68 **	39	55,71 ± 5,94	21	47,73 ± 7,53

Notes: * significant difference between the number of people with mild to moderate periodontal inflammation (*p* < 0.001);

** significant difference between the number of people with mild to severe periodontal inflammation (*p* < 0.001).

Table 3.

Distribution of patients with GP and CAD by OHI-S index

OHI-S	Total (n = 114)		Men (n = 70)		Women (n = 44)	
	n	%	n	%	n	%
Good hygiene (0–0,6 points)	3	2,63 ± 1,50	1	1,43 ± 0,72	2	4,55 ± 1,6
Satisfactory hygiene (0,7–1,6 points)	19	16,67 ± 3,49*	9	12,86 ± 4,0	10	22,73 ± 6,32
Unsatisfactory hygiene (1,7–2,5 points)	31	27,19 ± 4,17*	16	22,86 ± 5,02	15	34,09 ± 7,15
Poor hygiene (> 2,6 points)	61	53,5 ± 14,67*	44	62,86 ± 5,78**	17	38,64 ± 7,34

Notes: * significant difference ($p < 0.001$) of people with “good hygiene” compared to other groups;
 ** significant difference between indicators in men and women, $p < 0.05$.

significantly lower—13 patients ($37.14 \pm 8.17\%$) with GP but without CAD ($p > 0.01$).

Analysis of the OHI-S hygiene index showed that mean values did not differ significantly between the main and comparison groups, being 2.71 ± 0.12 and 2.59 ± 0.15 , respectively ($p > 0.05$) (Table 1).

Overall, among patients with GP and CAD, only a small proportion demonstrated oral hygiene assessed as “good” ($2.63 \pm 1.50\%$) or “satisfactory” ($16.67 \pm 3.49\%$). In contrast, a substantial proportion of patients exhibited “unsatisfactory” ($27.19 \pm 4.17\%$) or “poor” ($53.50 \pm 14.67\%$) oral hygiene (Table 3).

To evaluate gender-related characteristics of periodontal tissue condition, the values of the main indices—PMA, PBI, PSR, and OHI-S—were analyzed in men and women, with results summarized in Table 4.

No gender differences were observed in PMA and PSR values among patients with GP and CAD ($p > 0.05$). However, comparison of gingival bleeding revealed that the mean PBI score was higher in men than in women (2.18 ± 0.09 vs. 1.88 ± 0.12 ; $p < 0.05$).

Individual oral hygiene levels were significantly better in women with GP and CAD compared with men (2.29 ± 0.16 vs. 2.95 ± 0.15 ; $p < 0.01$). Moreover, the proportion of women with “poor” oral hygiene was significantly lower than that of men ($38.64 \pm 7.34\%$ vs. $62.86 \pm 5.78\%$; $p < 0.05$) (Table 3).

Discussion

A number of studies have demonstrated the mutually aggravating course of GP and CAD as two

interrelated conditions that contribute to the progression of dystrophic-inflammatory changes in periodontal tissues, in line with the increasing severity of GP associated with functional class of exertional angina, heart failure, arterial hypertension, and other systemic factors [1, 11]. Scientific evidence indicates more pronounced pathological changes in periodontal tissues—reflected in greater periodontal pocket depth, epithelial attachment loss, and gingival recession—in patients with GP and CAD compared with individuals with GP alone [2]. In addition, researchers have reported a higher number of extracted teeth, wedge-shaped defects, and cases of traumatic occlusion specifically among patients with GP and CAD [1].

Furthermore, literature data demonstrate an association between CAD and periodontal as well as hygiene indices [10]. Consistent with these findings, our assessment of individual oral hygiene levels using the OHI-S index revealed that the majority of patients with CAD exhibited “unsatisfactory” ($27.19 \pm 4.17\%$) or “poor” ($53.50 \pm 14.67\%$) oral hygiene.

In the group of patients with GP and CAD, the mean OHI-S score was slightly higher (2.71 ± 0.12) than in individuals with GP without CAD (2.59 ± 0.15); however, this difference was not statistically significant ($p > 0.05$). Importantly, despite the absence of differences in oral hygiene levels between the two groups, statistically significant differences were observed in the PMA and PBI indices. According to the PMA index, gingival inflammation in patients with

Table 4.

Gender distribution of patients with GP and CAD by PMA, PBI, PSR and OHI-S indexes ($M \pm m$)

Index	Men (n = 70)	Women (n = 44)	P
PMA, %	65,13 ± 2,5	60,40 ± 2,88	> 0,05
PBI, points	2,18 ± 0,09	1,88 ± 0,12	< 0,05
PSR, points	3,26 ± 0,08	3,32 ± 0,07	> 0,05
OHI-S, points	2,95 ± 0,15	2,29 ± 0,16	< 0,01

GP and CAD corresponded to severe inflammation ($63.27 \pm 1.92\%$), whereas in patients with GP without CAD, the mean PMA value indicated moderate inflammation ($43.32 \pm 2.18\%$; $p < 0.001$).

Thus, the clinical findings demonstrate more pronounced periodontal changes in the presence of CAD. This suggests that CAD influences the clinical course of GP, acting as a factor that exacerbates and accelerates pathological processes in periodontal tissues.

Conclusions

- Index-based assessment of periodontal tissue status revealed significantly higher PMA, PBI, and PSR values in patients with GP and CAD compared with patients with GP alone.
- The mean PMA score in patients with GP and CAD was $63.27 \pm 1.92\%$, corresponding to severe inflammation. In contrast, the comparison group demonstrated a mean PMA score of $43.32 \pm 2.18\%$, indicating moderate gingival inflammation and being significantly lower than in the main group ($p < 0.001$).
- Gingival bleeding was more pronounced in the main group. The mean PBI score in patients with GP and CAD was 2.06 ± 0.08 , significantly higher than 1.20 ± 0.08 in patients with GP without CAD ($p < 0.001$).
- The PSR score in the main group was significantly higher than in the comparison group (3.30 ± 0.06 vs. 3.01 ± 0.09 ; $p < 0.01$), indicating a more severe degree of periodontal tissue damage in patients with GP and CAD.

- The mean OHI-S score in patients with GP and CAD was slightly higher (2.71 ± 0.12) than in patients with GP without CAD (2.59 ± 0.15); however, this difference was not statistically significant ($p > 0.05$).

- Evaluation of oral hygiene according to the OHI-S index showed that the majority of patients with CAD had “unsatisfactory” ($27.19 \pm 4.17\%$) or “poor” ($53.50 \pm 14.67\%$) hygiene levels.

- No significant gender differences in periodontal tissue status were observed according to PMA and PSR indices ($p > 0.05$). However, men demonstrated higher gingival bleeding and poorer oral hygiene compared with women ($p < 0.05$).

Taken together, these findings suggest that against the background of inadequate oral hygiene, dystrophic-inflammatory changes in periodontal tissues are particularly aggravated in the presence of atherosclerotic processes such as CAD. Therefore, improving oral hygiene status, alongside correction of periodontal inflammation, should be integrated into the comprehensive therapeutic strategy for CAD in patients with GP.

Conflict of Interest

The authors declare that they have no conflict of interest.

Consent to Publication

All authors have provided their consent for the publication of this manuscript.

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Індексна оцінка стану тканин пародонта в пацієнтів із генералізованим пародонтитом на тлі ішемічної хвороби серця

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Актуальність. На сьогодні генералізований пародонтит (ГП) вважають одним із вагомих факторів ризику розвитку ішемічної хвороби серця (ІХС). Наявність хронічних інфекційних вогнищ в тканинах пародонта при ГП сприяє розвитку системного запалення, посиленню атерогенезу та прогресуванню атеросклеротичних уражень судин. Водночас порушення кровообігу, характерні для ІХС, призводять до зниження тканинного живлення та оксигенації пародонтальних тканин, що сприяє їхній гіпоксії та зниженню регенеративних процесів. З огляду на взаємообтяжливий перебіг ГП та ІХС, актуальним залишається дослідження клінічних особливостей перебігу ГП на тлі кардіологічної патології, а також врахування місцевих факторів ризику при ГП для подальшої розробки ефективних схем корекції пародонтологічного статусу у пацієнтів з ІХС.

Мета. Провести комплексну індексну оцінку стану тканин пародонта та рівня індивідуальної гігієни порожнини рота у пацієнтів з ІХС для подальшого аналізу їхнього клінічного значення.

Матеріали та методи. Проведено стоматологічне обстеження 114 пацієнтів із ГП та ІХС, які склали основну групу. У групу порівняння було включено 35 пацієнтів з ГП, що не обтяжені ІХС. Стан тканин пародонта у досліджуваних групах оцінювали за допомогою пародонтальних індексів: РМА (папілярно-маргінально-альвеолярний індекс М. Massler, у модифікації С. Парма, 1960) та індексу кровоточивості ясен РВІ (Papilla Bleeding Index, Mühlemann & Saxer, 1977). Визначення заходів лікування проводили за допомогою скринінг-тесту PSR (Periodontal Screening and Recording, AAP і ADA, 1992). Для визначення рівня індивідуальної гігієни порожнини рота використовували гігієнічний індекс ОНІ-S (Oral Hygiene Index-Simplified) за J. C. Green, J. R. Vermillion (1964).

Результати. Результати індексної оцінки стану тканин пародонта показали, що у пацієнтів з ГП за наявності ІХС спостерігали статистично вищі показники індексів РМА, РВІ та PSR у порівнянні з пацієнтами з ГП без ІХС. Середні значення показників індексу РМА, які у пацієнтів з ГП та ІХС становили $63,27 \pm 1,92\%$, були еквівалентними тяжкому ступеню запального процесу. Разом з тим, у групі порівняння показники індексу РМА вказували на середній ступінь запального процесу в тканинах ясен ($43,32 \pm 2,18\%$) та були нижчими, за показники основної групи ($p < 0,001$). Значення індексу РВІ у пацієнтів з ГП та ІХС становили $2,06 \pm 0,08$ бали та вірогідно відрізнялися від показників у пацієнтів з ГП без ІХС ($1,20 \pm 0,08$ бала, $p < 0,001$). Про більш

тяжкий ступінь ушкодження тканин пародонта свідчив також індекс PSR, який в основній групі становив $3,30 \pm 0,06$ бала та статистично відрізнявся від показника PSR групи порівняння ($3,01 \pm 0,09$ бала; $p < 0,01$). Не було виявлено статистичної різниці показників рівня гігієни за індексом ОНІ-S у групі у досліджуваних групах ($p > 0,05$). Проте серед більшості пацієнтів з ІХС переважав «незадовільний» ($27,19 \pm 4,17\%$) та «поганий» ($53,50 \pm 14,67\%$) рівень гігієни. У пацієнтів із ГП та ІХС за показниками індексів РМА та PSR у стані тканин пародонта не простежували істотних гендерних відмінностей ($p > 0,05$). Проте ступінь кровоточивості ясен за індексом РВІ був вищим у чоловіків, ніж у жінок ($p < 0,05$). Рівень індивідуальної гігієни порожнини рота був достовірно кращим у жінок порівняно з чоловіками ($p < 0,01$).

Висновки. З огляду на отримані результати дослідження можна припустити, що на тлі незадовільної гігієни порожнини рота, наростання запальних змін в тканинах пародонта при ГП відбувається саме за наявності атеросклеротичного процесу, тобто ІХС.

Ключові слова: генералізований пародонтит, ішемічна хвороба серця, атеросклероз, пародонт, індексна оцінка.

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