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## ABSTRACT

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## ASSESSMENT OF THE EFFECT OF ORAL HYGIENE ON THE COURSE OF INFLAMMATION IN GENERALIZED PERIODONTITIS

**Introduction.** The modern paradigm considers inflammatory and inflammatory-dystrophic periodontal diseases not only as a local inflammation of the periodontal tissues, which is caused by the microflora of oral biofilm, but also as a reaction of the whole body to the action of a bacterial infection. Knowledge about the relationship between the organism and the microflora of the oral cavity obtained using an index assessment can improve methods of prevention and treatment of inflammatory and inflammatory-dystrophic periodontal diseases. Therefore, the aim of the work was a mathematical analysis of the influence of oral hygiene on the course of gingival inflammation in generalized periodontitis.

**Methods.** To achieve the goal, we assessed the dental status of 36 patients with stage I–II chronic generalized periodontitis (GP) against the background of the combined course of chronic cholecystitis (XX) and pancreatitis (CP) aged 17 to 64 years, who were being treated in the regional gastroenterological center of Poltava. Examination of patients with generalized periodontitis included generally accepted clinical methods. Objective criteria were used to study the periodontal status: the Schiller-Pysarev test, the PMA index according to Parma (1960), the periodontal index according to Russel (1956), the vacuum test of V.I. Kulazhenka (1960), thermometry of gingival papillae, ortho-pantomography of jaws. The state of oral hygiene was assessed using the Green-Vermillion index (1964). The diagnosis was made according to the classification of periodontal diseases by M.F. Danylevsky (1994). Statistical processing of the index assessment was carried out on a computer using the Microsoft Excel Office 2007 program. The reliability of the obtained results was analyzed according to the Student's test. Mathematical analysis was carried out using online calculators and the computer program Excel 2010. The data in

the groups had a normal distribution.

**Results.** With the help of online calculators for calculating geometric indicators, the angles between the found functions and the tangents of these angles were calculated. In our case, it could be used as an indicator to calculate the ratio of the functions of the OHI-S index and the PMA index. The obtained equations were equations of the first degree, that is, linear equations – equations of a straight line. This indicated that there was a linear relationship between the metrics that related to their function. That is, the parameters of inflammation depended on the conditions that changed in the oral microbiome in the form of a linear combination. Graphs obtained during preprocessing and immediately after processing had a negative slope. This indicated that the lines would point downwards and the functions these lines represented would also decrease. It means that during the treatment, the intensity of inflammation of the gums would decrease, and the state of the periodontal tissues would correspond to the state of "improvement". Graphs obtained immediately after treatment and 6 months after treatment had a positive slope. This indicated that the directions of the lines would increase, as well as the functions that these lines represented. That is, after treatment, inflammation of the gums in conditions of insufficient oral hygiene would intensify again, which was confirmed by the PMA index.

**Conclusions.** The analysis of numerical indicators of the ratio of the patient's body to the microbiota of the oral cavity can be used to predict the course and consequences of the disease, as well as to adjust the treatment.

The study of the relationship between microbiocenoses and their carriers with the involvement of mathematical methods that take into account the definition of the functional component between them will allow scientists and doctors to determine the integral component of the body's reactions in response to a change in the state of microbiocenoses under the conditions of medical interventions.

**Keywords:** oral biofilm, generalized periodontitis, hygienic indices, periodontal indices, mathematical analysis.

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## ОЦІНКА ВПЛИВУ ГІГІЄНИ ПОРОЖНИНИ РОТА НА ПЕРЕБІГ ЗАПАЛЕННЯ ПРИ ГЕНЕРАЛІЗОВАНОМУ ПАРОДОНТИТІ

**Вступ.** Сучасна парадигма запальні та запально-дистрофічні захворювання пародонта розглядає не тільки як локальне запалення тканин пародонта, яке викликане мікрофлорою оральної біоплівки, а як реакцію всього організму на дію бактерійної інфекції. Розуміння стосунків між організмом та мікрофлорою порожнини рота за допомогою індексної оцінки може покращити методи профілактики і лікування запальних та запально-дистрофічних захворювань пародонта. Тому метою роботи був математичний аналіз впливу гігієни порожнини рота на перебіг запалення ясен при генералізованому пародонтиті.

**Методи.** Для досягнення поставленої мети було проведено визначення стоматологічного статусу 36 пацієнтів із хронічним

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генералізованим пародонтитом (ГП) I та II ступенів тяжкості на тлі поєданого перебігу хронічного холециститу (ХХ) і панкреатиту (ХП) віком від 17 до 64 років, які знаходились на лікуванні в обласному гастроентерологічному центрі міста Полтава. Обстеження хворих на генералізований пародонтит включало загальноприйняті клінічні методи. При дослідженні пародонтального статусу використовували об'єктивні критерії: пробу Шиллера-Писарева, індекс РМА за Parma (1960), пародонтальний індекс за Russel (1956), вакуумну пробу В.І. Кулаженка (1960), термометрію ясенних сосочків, ортопантомографію щелеп. Стан гігієни порожнини рота оцінювали за допомогою індексу Гріна-Вермільона (1964). Діагноз ставили за класифікацією захворювань пародонта М.Ф. Данилевського (1994). Статистичну обробку індексної оцінки проводили на комп'ютері за допомогою програми Microsoft Excel Office 2007. Достовірність отриманих результатів було проаналізовано за критерієм Стьюдента. Математичний аналіз проведено за допомогою онлайн-калькуляторів та комп'ютерної програми Excel 2010. Дані у групах мали нормальний розподіл.

**Результати.** За допомогою онлайн-калькуляторів для розрахунку геометричних показників розраховано кути між знайденими функціями та тангенси цих кутів. У нашому випадку його можна використовувати як індикатор для розрахунку співвідношення функцій індексу ОНІ-S (спрощений індекс гігієни порожнини рота) та індексу РМА. Отримані рівняння є рівняннями першого ступеня, тобто лінійними рівняннями - рівняннями прямої. Це вказує на те, що існує лінійний зв'язок між показниками, який стосується їх функції. Тобто параметри запалення залежать від умов, які змінюються в оральному мікробіомі у вигляді лінійної комбінації. Графіки, отримані під час попередньої обробки та відразу після обробки, мають негативний нахил. Це вказує на те, що лінії будуть спрямовані вниз, і функції, які ці лінії представляють, також зменшаться. З цього випливає, що під час лікування зменшується інтенсивність запалення ясен і стан тканин пародонта відповідає стану «покращення». Графіки, отримані одразу після лікування та через 6 місяців після лікування, мають позитивний нахил. Це вказує на те, що напрямки ліній зростають, а також функції, які ці лінії представляють. Тобто після проведеного лікування запалення ясен в умовах недостатньої гігієни ротової порожнини знову посилюється, що підтверджує індекс РМА.

**Висновки.** Аналіз числових показників співвідношення організму пацієнта з мікробіотою ротової порожнини може бути використаний для прогнозування перебігу та наслідків захворювання, а також для корекції лікування.

Вивчення взаємозв'язку між мікробіоценозами та їх носіями із залученням математичних методів, що враховують визначення функціональної складової між ними, дозволить науковцям і лікарям-практикам визначити інтегральну складову реакцій організму у відповідь на зміну стану мікробіоценозів в умовах лікувальних втручань.

**Ключові слова:** оральна біоплівка, генералізований пародонтит, гігієнічні індекси, пародонтальні індекси, математичний аналіз.

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## ABBREVIATIONS

Generalized periodontitis (GP), chronic cholecystitis (CC), chronic pancreatitis (CP), hygiene index (GI), periodontal index (PI), papillary-marginal-alveolar index (PMA), simplified oral hygiene index (OHI-S)

## INTRODUCTION

Among the most urgent problems of modern dentistry, periodontal diseases occupy one of the leading places. The modern paradigm considers inflammatory and inflammatory-dystrophic periodontal diseases not only as a local inflammation of the periodontal tissues, which is caused by the microflora of oral biofilm, but as a reaction of the whole body to the action of a bacterial infection [1, 2, 3].

Biology is considered the foundation of medicine. It is biology that provides a systematic and holistic approach to understanding pathological processes. This turned out to be possible thanks to the fact that the current level of knowledge development allows us to distinguish generalizing directions of science (developmental biology, ecology, genetics, theory of evolution). These directions play the most important role in considering a person as the main object of the professional activity of a doctor - a living organism [4].

The application of mathematics in biology has a long history. The use of mathematical methods contributed to a deeper understanding of many biological processes. At the same time, biology motivated mathematicians to create new theories that enriched mathematics itself [5].

In dentistry, there are various paraclinical diagnostic methods to determine the state of oral biofilm and its effect on the periodontium. These are hygiene indices, as well as gingival and periodontal indices [6]. If the hygienic indices determine the state of care of the oral cavity, the component of which is the microbiocenosis of the mucous membrane of the oral cavity, then the gingival and periodontal indices assess the state of the periodontal tissues and the development of a protective and adaptive reaction in them – inflammation [7]. Inflammation is the body's response to any stimulus, in particular, an infectious agent. Representatives of oral microbiocenosis can also become infected. In this case, they will appear as pathogenic microflora [8, 9, 10].

Understanding the relationship between the organism and the microflora of the oral cavity using an index assessment can improve methods of prevention and treatment of inflammatory and inflammatory-dystrophic periodontal diseases. This issue has always been and is relevant for medicine in general and dentistry in particular [11, 12].

**The aim of the work** is a mathematical analysis of the influence of oral hygiene on the course of gingival inflammation in generalized periodontitis.

**MATERIALS AND METHODS.** In order to achieve the goal, the dental status and treatment of 36 patients with chronic generalized periodontitis (GP) of the I and II degrees of severity against the background of the combined course of chronic cholecystitis (CC) and chronic pancreatitis (CP) aged from 17 to 64 years, who were on treatment in the regional gastroenterological center of the city of Poltava. Examination of patients with generalized periodontitis included generally accepted clinical methods. Objective criteria were used to study the periodontal status: the Schiller-Pysarev test, the PMA index according to Parma (1960), the periodontal index according to Russel (1956), the vacuum test of V.I. Kulazhenka (1960), thermometry of gingival papillae, orthopantomography of jaws. The state of oral hygiene was assessed using the Green-Vermillion index (1964) (OHI-S). The diagnosis was made according to the classification of periodontal diseases by M.F. Danylevsky (1994) [6].

Treatment of patients with generalized periodontitis with a combined course of chronic cholecystitis and pancreatitis was carried out using the herbal antiseptic «Timsal», the antibiotic «Tsifran ST», the synbiotic «Yogurt» and the osteotropic drug «Calcemin» [13].

Statistical processing of the index assessment was carried out on a computer using the Microsoft Excel Office 2007 program. The reliability of the obtained results was analyzed according to the Student's test. Mathematical analysis was carried out using online calculators and the computer program Excel 2010. The data in the groups had a normal distribution.

**RESULTS.** After the course of treatment, all patients showed a pale pink color of the gums, no bleeding, no dental deposits, and a significant decrease in tooth mobility. The depth of periodontal pockets decreased by 1.28 times ( $p < 0.001$ ) and remained stable after 6 ( $p < 0.01$ ) and 12 ( $p < 0.01$ ) months.

Beneficial dynamics of paraclinical indicators were also observed under the influence of our proposed method of treating GP.

Green-Vermillion GI immediately after the course of treatment decreased by 2.95 times ( $2.46 \pm 0.11$  points before treatment vs.  $0.49 \pm 0.06$  points after it,

$p < 0.001$ ). After 6 months of observation, GI increased to  $1.02 \pm 0.05$  points relative to the results before treatment ( $p < 0.001$ ), and after 12 months – to  $1.01 \pm 0.12$  points ( $p < 0.001$ ).

The PMA index in patients decreased by 29.5 times (from  $43.08 \pm 3.26\%$  to  $1.46 \pm 0.27\%$ ,  $p < 0.001$ ). After 6 and 12 months of observation, the PMA index slightly increased, but had a significant difference in relation to the indicators before treatment ( $10.29 \pm 0.96\%$ ,  $p < 0.01$  and  $12.40 \pm 0.88\%$ ,  $p < 0.01$ ).

The Russel PI index after treatment decreased by 1.4 times ( $p < 0.01$ ) and remained stable for 12 months (Table 1).

Table 1 – Indicators of the OHI-S index and the PMA index in patients at different time intervals

Index	Before treatment	Immediately after treatment	After 6 months
OHI-S (scores)	2.46	0.49	1.02
PMA (%)	43.08	1.46	10.29

With the help of online calculators for calculating geometric indicators, the angles between the found functions and the tangents of these angles were calculated. The tangent is a function of the angle [14]. In our case, it can be used as an indicator to calculate the ratio between the functions of the OHI-S index and the PMA index. Thus, the angle between the functions of the OHI-S index and the PMA index in patients

before treatment and immediately after treatment was  $28.3^\circ$ , and the angle between the functions of the OHI-S index and the PMA index in patients immediately after treatment and 6 months after treatment was  $55.6^\circ$ .

As for trigonometric functions, their indicators were as follows: for an angle of  $28.3^\circ$ , the tangent was 0.54; for an angle of  $55.6^\circ$ , the tangent was 1.46. That is, digital indicators 0.54 and 1.46 can act as a measure when calculating the relationship between the host organism and its oral microbiota.

The obtained equations are equations of the first degree, that is, linear equations – equations of a straight line. This indicates that there is a linear relationship between metrics that relates to their function. That is, the parameters of inflammation depend on the conditions that change in the oral microbiome in the form of a linear combination.

With the help of the Excel 2010 program, these data were reproduced in graphs, and functions were calculated for them.

Graphs obtained within pretreatment and immediately after treatment have a negative slope. This indicates that the directions of the lines will be downward, and the functions that these lines represent will also decrease. It follows that during treatment, the intensity of inflammation of the gums decreases, and the state of the periodontal tissues corresponds to the state of «improvement».

Formulas of the functions of changes in indicators of the assessment of the condition of the oral cavity in patients before treatment and after treatment: PMA:  $y = -41.62x + 84.7$ ; OHI-S:  $y = -1.97x + 4.43$  (Fig. 1).

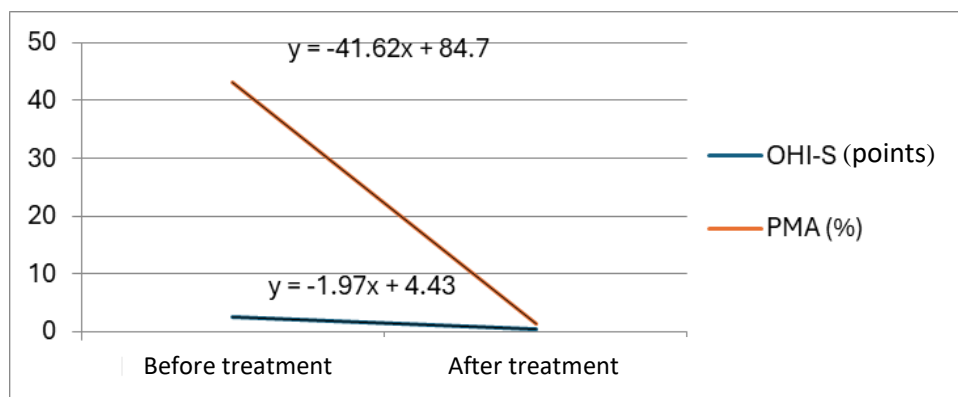


Figure 1 – Graphs and functions of OHI-S index and PMA index in patients before and after treatment

Graphs obtained immediately after treatment and 6 months after treatment have a positive slope. This indicates that the directions of the lines are increasing, and so are the functions that these lines represent. That is, after the treatment, inflammation of the gums in

conditions of insufficient hygiene of the oral cavity increases again, which confirms the PMA index.

Formulas of the functions of changes in indicators of the assessment of the condition of the oral cavity in patients immediately after treatment and 6 months after

treatment: PMA:  $y = 8.83x - 7.37$ ; OHI-S:  $y = 0.53x - 0.04$  (Fig. 2).

None of the calculated straight lines within the specified limits falls below the abscissa axis and is in the positive sector. None of the calculated straight lines

within the specified limits passes through the origin of the coordinates. This indicates that the functions they represent are constantly present and do not degenerate into their opposite.

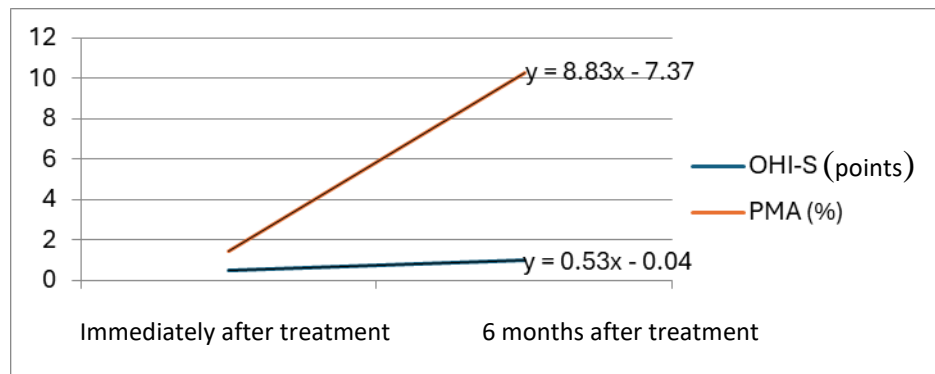


Figure 2 – Graphs and functions of OHI-S index and PMA index in patients immediately after treatment and 6 months after treatment

## CONCLUSION

In our case, we calculated the relationship between the degree of inflammation in the periodontal tissues and the state of oral hygiene using the above method. With the help of the obtained numerical indicators, it is possible to analyze the state in which there are relations between the patient's body and his oral microbiota. The analysis of numerical indicators of the relationship between the patient's body and his oral microbiota can be used to predict the course and consequences of the disease, as well as to correct the treatment.

Determining the nature of the clinical course predicting the development of the disease and its relationship with the general condition of the patient is a difficult task and requires further study. The study of the relationship between microbiocenoses and their carriers with the involvement of mathematical methods that take into account the definition of the functional component between them will enable scientists and practicing doctors to determine the integrated component of the body's reactions in response to changes in the state of microbiocenoses under the conditions of therapeutic interventions.

## AUTHOR CONTRIBUTIONS

Tetiana Moshel - acquisition, analysis and interpretation of data for the manuscript;  
 Andriy Zaitsev - compilation of the manuscript;  
 Natalia Kotelevska - a critical review of the important intellectual content of the manuscript;  
 Olga Boychenko - agreement to be responsible for all aspects of the job;  
 Igor Ivanytskyi - significant contribution to the conception and creation of the manuscript.

## CONNECTION WITH OTHER SCIENTIFIC RESEARCH WORKS

The work is a fragment of the scientific research work of the Department of Therapeutic Stomatology of the Poltava State Medical University (PDMU) – "Development of pathogenetic prevention of pathological changes in the oral cavity of people with internal diseases" (state registration number 0121U108263).

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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