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# Application of vacuum-laser therapy in complex treatment of chronic gingivitis

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## ABSTRACT

The high prevalence of chronic forms of gingivitis among young individuals is an urgent problem of modern dentistry, the solution of which requires new approaches and methods.

Thus, this study aimed to investigate the clinical and functional state of the periodontium at the initial inflammatory processes in the tissues and its correction using physical methods of treatment.

Clinical examination, index assessment, laser Doppler flowmetry, and video registration of vacuum test in a patient with chronic gingivitis revealed an increase in gingival capillary resistance and improvement of microcirculation in the periodontium at the end of vacuum therapy combined with exposure to laser radiation of red wavelength on periodontal tissues in the complex of standard treatment measures.

The results of the functional methods of research after the end of physical influence on periodontal tissues are confirmed by the decrease of bleeding and increase of oral hygiene level according to the clinical instrumental examination and by the absence of patient complaints. Thus, the clinical case demonstrates the promising application of vacuum-laser therapy in the complex treatment of chronic gingivitis.

**Keywords:** vacuum-laser therapy; chronic gingivitis; vacuum test; laser Doppler flowmetry; LDF; clinical case.

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# Применение вакуум-лазерной терапии в комплексном лечении хронического гингивита

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## АННОТАЦИЯ

Высокая распространённость хронических форм гингивита у лиц молодого возраста является одной из наиболее актуальных проблем современной стоматологии, решение которой требует новых подходов и методов.

Цель данного исследования заключалась в изучении клинико-функционального состояния пародонта при начальных воспалительных процессах в тканях и способов его коррекции физическими методами лечения.

Методами клинического осмотра, индексной оценки, лазерной доплеровской флоуметрии и динамической вакуумной пробы у пациентки с хроническим гингивитом выявлены повышение стойкости капилляров десны и улучшение состояния микроциркуляции в пародонте по окончании вакуумной терапии, комбинированной с воздействием лазерного излучения в красной области спектра на ткани пародонта, в комплексе проведённых стандартных лечебных мероприятий.

В результате физического воздействия на ткани пародонта выявлены уменьшение кровоточивости и повышение уровня гигиены полости рта по данным клинического инструментального обследования, а также отсутствие жалоб со стороны пациентки. Таким образом, клинический случай демонстрирует перспективность применения вакуум-лазерной терапии в комплексном лечении хронического гингивита.

**Ключевые слова:** вакуум-лазерная терапия; хронический гингивит; вакуумная проба; лазерная доплеровская флоуметрия; ЛДФ; клинический случай.

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## BACKGROUND

Inflammatory periodontal diseases represent a major medical and social concern due to their direct impact on patient quality of life [1, 2]. Initial inflammatory changes in periodontal tissues begin at the stage of gingivitis, which affects up to 90% of the population [2–4]. The high prevalence of chronic gingivitis and its potential for progression have drawn increasing research interest toward identifying effective treatment strategies.

The polyetiological and multifactorial nature of periodontal inflammation, as noted by both Russian and international researchers, necessitates a variety of therapeutic approaches. Among these, etiological and pathogenesis-oriented therapy at the stage of reversible changes appears particularly promising [2, 5, 6]. Krechina et al. [8] and Shkurova et al. [7] emphasize the role of microcirculatory disorders in the pathogenesis of periodontal inflammation. The potential for therapeutic modulation of the vascular component—particularly through physiotherapeutic modalities—warrants detailed investigation in patients with chronic gingivitis.

The present clinical case evaluates the use of combined vacuum and laser therapy as part of a comprehensive treatment protocol for chronic catarrhal gingivitis. Advanced clinical and functional methods were applied to assess dynamic changes in periodontal microcirculation.

## CASE DESCRIPTION

In June 2022, a patient born in 1996, presented to the therapeutic department of the Dental Clinic at the Clinical Center for Maxillofacial and Plastic Surgery and Dentistry, University Hospital of the Russian University of Medicine, with the following complaints: gingival bleeding during toothbrushing and while eating solid foods, halitosis, and the presence of dental deposits.

The patient denied any harmful habits. Her allergy history was unremarkable, and she reported no comorbid conditions, including hereditary diseases.

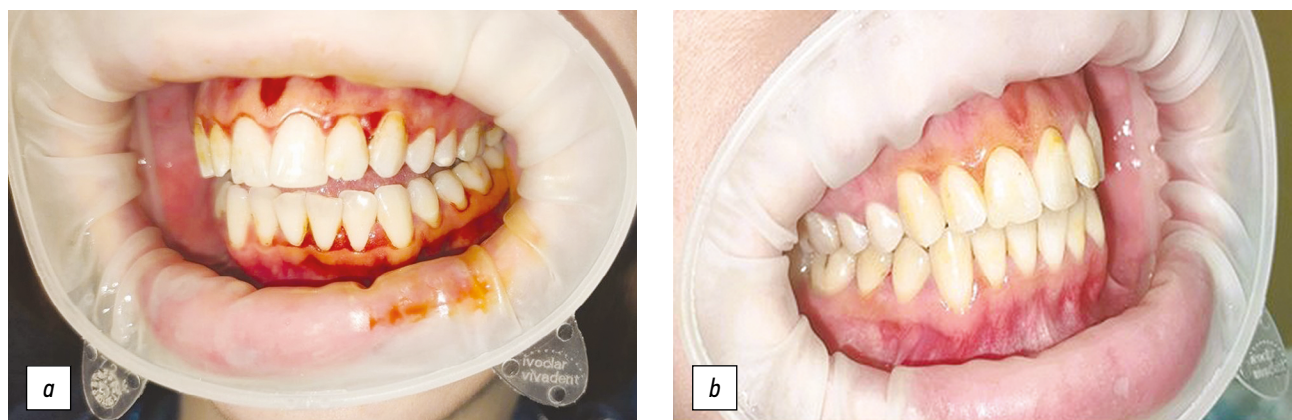
According to the patient, symptoms of gingival bleeding and halitosis had persisted for approximately one year. No previous dental treatment had been sought for these issues.

The author obtained the patient's written informed consent for publication of medical data and clinical photographs in the Russian Journal of Dentistry.

## Clinical and Functional Examination Results

The patient was examined in accordance with the 2018 clinical guidelines of the Russian Dental Association [9]. Oral hygiene status was assessed using the following indices: Simplified Oral Hygiene Index (OHI-S), Patient Hygiene Performance Index (PHP), and Approximal Plaque Index (API). The severity of gingival inflammation was evaluated using the Papillary-Marginal-Alveolar Index (PMA), Sulcus Bleeding Index (SBI), and Gingival Index (GI) (see Fig. 1). The index scores were as follows: OHI-S = 2.33; PHP = 3.5; API = 78.57%; PMA = 47.62%; SBI = 67.86%; GI = 1.5. These values indicate poor oral hygiene, moderate inflammation in the periodontal tissues, and moderate gingivitis.

The functional status of periodontal tissues was assessed using laser Doppler flowmetry (LDF) with fiber-optic probe positioned in a pre-fabricated silicone impression, employing the multifunctional laser diagnostic system LAKK-M (Scientific and Production Enterprise LAZMA, Russia). DIASTOM software [10] was used for data registration. Capillary resistance was assessed by measuring petechiae formation time on the oral mucosa using the KAP-PARODONTOLOG device (Trima, Russia) under a negative pressure of 0.35 bar (Patent No. 2799075) (see Fig. 2) [Error! Reference source not found.]. Pre-treatment LDF and dynamic vacuum test results were as follows: total microcirculatory index (TMI), reflecting erythrocyte velocity in the microvascular bed: TMI = 9.4 perfusion units (pu); perfusion variability ( $\sigma$ ) across all



**Fig. 1.** PMA index assessment: *a*, before treatment; *b*, 7 days after treatment.

frequency bands:  $\sigma = 1.4$  pu; petechiae formation time under vacuum:  $t = 5$  s. Compared to reference data from a previous study [11], where  $TMI = 26.25 \pm 2.93$  pu and  $\sigma = 3.74 \pm 0.52$  pu, the patient's baseline values were reduced by an average of 2.7-fold.

To evaluate the amplitude-frequency spectrum of microvascular blood flow, a wavelet transform algorithm was applied to the complex-modulated LDF signals. The patient's frequency spectrum was further analyzed to determine the peak amplitudes of the following oscillatory components: endothelial ( $A_E$ ), neurogenic ( $A_N$ ), myogenic ( $A_M$ ), respiratory ( $A_R$ ), and cardiac ( $A_C$ ) modulations. The results were as follows:  $A_E = 0.65$  pu;  $A_N = 0.44$  pu;  $A_M = 0.52$  pu;  $A_R = 0.38$  pu;  $A_C = 0.38$  pu; and the calculated shunt index ( $SI$ ) = 0.846 pu. The shunt index was used to assess the activity of arteriole-venular anastomoses. The data indicated a significant contribution of active regulatory mechanisms to blood flow modulation, with endothelial regulation playing a dominant role. The  $A_C/A_R$  ratio of 1.0 and a TMI below reference values reflected venous stasis in the periodontal tissues and decreased vascular tone.

Based on clinical examination and functional diagnostics, the patient was diagnosed with chronic gingivitis (ICD-10 code K05.1).

### Treatment

Treatment included oral hygiene instruction with technique correction and plaque-control monitoring, dental prophylaxis, and vacuum-assisted laser therapy.

Vacuum-laser therapy was administered during the initial visit, following oral hygiene instruction and dental scaling. Physiotherapeutic exposure was applied to the gingival mucosa in the area of each tooth using a vacuum applicator and a fiber-optic light guide with a reflective element for laser therapy in the red wavelength range. These were components of the periodontal multifunctional device KAP-PARODONTOLOG (see Fig. 3). Negative pressure was initially set at 0.25 bar. The procedure duration started at 3 minutes, with laser beam modulation at 1 Hz in the red spectral range (wavelength 650 nm). The total course consisted of 5 daily sessions, with progressive increases in parameters: laser modulation was elevated to 10 Hz, negative pressure to 0.4 bar, and treatment time to 7 minutes by the final session.

## RESULTS

Following the comprehensive treatment course, improvements were observed in both oral hygiene and periodontal tissue status, as confirmed by clinical and functional assessments (see Table 1).

## DISCUSSION

Previous theses and scientific publications have investigated the combined effect of vacuum-laser therapy on periodontal tissues [122–144]. In the present clinical case, functional diagnostic findings support the existing evidence regarding the potential application of combined



**Fig. 2.** Video recording of the vacuum test using a prototype of the Oko capillaroscope adapted for dental research.





**Fig. 3.** Vacuum-laser therapy with the KAP-PARODONTOLOG device.

device-based physical therapy in the management of chronic gingivitis among young adults.

The application of vacuum-laser therapy using 650 nm red-light irradiation, as part of a multimodal treatment strategy, led to a 22.62% reduction in periodontal inflammation by the end of the therapy course, regression of moderate chronic gingivitis to a mild form, and a 21.44% decrease in gingival bleeding symptoms. Blood perfusion in the periodontal microvascular bed (MVB) improved by 24.47%, driven by a 50% increase in blood flow modulation and a 1.6-fold increase in capillary resistance. Increased amplitudes of neurogenic (81.81%), endothelial (29.23%), and myogenic (11.54%) oscillations in MVB were observed, along with an enhanced contribution of passive components—respiratory (up 47.36%) and cardiac (up 13.16%) rhythms—in microvascular regulation. The shunt index increased 1.6-fold, indicating a predominance of blood flow through arteriolo-venular anastomoses induced by vacuum-laser therapy, which promotes an increase in the number of functional capillaries. Additionally, increased tone of resistive vessels and enhanced arterial inflow into the MVB were noted, accompanied by elevated postcapillary blood volume and reduced transmural pressure, leading to venular dilation. A more pronounced increase in venous outflow was observed one week after therapy, as indicated by a 26.78% reduction in respiratory amplitudes. This finding is associated with enhanced transcapillary exchange and a decrease in the shunt index. These findings demonstrate that vacuum-laser

**Table 1.** Indicators of oral hygiene improvement and periodontal tissue condition at various time points after treatment

| Parameter | Value immediately after therapy | Value 7 days after therapy |
|-----------|---------------------------------|----------------------------|
| OHI-S     | 0.83                            | 0.50                       |
| PHP       | 1.33                            | 0.67                       |
| API       | 39.29%                          | 32.14%                     |
| PMA       | 25.0%                           | 5.95%                      |
| SBI       | 46.42%                          | 17.86%                     |
| GI        | 0.92                            | 0.42                       |
| TMI       | 11.7 pu                         | 12.8 pu                    |
| $\sigma$  | 2.1 pu                          | 1.7 pu                     |
| $A_E$     | 0.84 pu                         | 0.57 pu                    |
| $A_N$     | 0.80 pu                         | 0.83 pu                    |
| $A_M$     | 0.58 pu                         | 0.80 pu                    |
| $A_R$     | 0.56 pu                         | 0.41 pu                    |
| $A_C$     | 0.43 pu                         | 1.23 pu                    |
| SI        | 1.379 pu                        | 1.037 pu                   |
| t         | 8 s                             | 10 s                       |

Note: For abbreviations, see text.

therapy not only enhances perfusion immediately post-treatment but also sustains improvements in microcirculatory function over time.

## CONCLUSION

The findings suggest that incorporating device-based physical modalities into comprehensive treatment protocols for patients with chronic forms of gingivitis may shorten the treatment duration by improving the functional status of periodontal tissues. These results warrant further investigation in studies involving patients with various forms of periodontal pathology.

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## ADDITIONAL INFORMATION

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