Original Research

https://doi.org/10.36377/ET-0197

New approach to the comparative assessment of the effectiveness of therapeutic and preventive measures in patients with chronic periodontitis

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Abstract

INTRODUCTION. The prevalence of periodontal diseases remains very high today and is considered one of the main causes of tooth loss in the adult population. The existing methods for evaluating the effectiveness of periodontal treatment are outdated, have significant drawbacks and do not reflect the condition of periodontal tissues and the pulpo-periodontal complex. There is an urgent need to develop new methods for evaluating the effectiveness of periodontal treatment.

AIM. The aim of the study is to develop a new method for evaluating the effectiveness of therapeutic and preventive measures in patients with chronic periodontitis.

MATERIALS AND METHODS. For a comparative assessment of the effectiveness of therapeutic and preventive measures, a comprehensive indicator *Web of effectiveness of periodontal treatment* was developed, which takes into account the values of bleeding and gingival inflammation, the depth of periodontal probing, dynamic mobility of teeth, the condition of the dental pulp and the level of oral hygiene.

RESULTS. The method of calculating the indicator *Web of effectiveness of periodontal treatment* and evaluating its effectiveness in a clinical trial is described.

CONCLUSION. A new comprehensive diagnostic indicator *Web of effectiveness of periodontal treatment* is proposed for a comparative assessment of the effectiveness of therapeutic and preventive measures in patients with chronic periodontitis, as well as visualization of the results of a clinical study. The proposed indicator has high practical significance and reflects the condition of not only periodontal tissues, but also the pulp-periodontal complex.

Keywords: endo-periodontal lesions, diagnosis of periodontitis, periodontitis, treatment, prevention

Article information: received – 17.01.2026; revised – 01.03.2026; accepted – 14.03.2026

Conflict of interests: The authors declare no conflict of interests. The sponsor had no role in the design, conduct, interpretation, or preparation of the study.

Acknowledgments: There are no funding and individual acknowledgments to declare.

Ethics Statement: The study was approved by the Local Ethics Committee of Tver State Medical University (Extract from Protocol No. 5 dated June 19, 2020).

For citation: Moiseev D.A., Taylakova D.I., Kazakova N.N., Khozhiev Kh.Kh., Varilidi A.D., Perfilov M.S., Savich A.A., Danilchenko A.A. New approach to the comparative assessment of the effectiveness of therapeutic and preventive measures in patients with chronic periodontitis. *Endodontics Today.* 2026;24(2):330–339. https://doi.org/10.36377/ET-0197

Новый подход к сравнительной оценке эффективности лечебных и профилактических мероприятий у больных хроническим пародонтитом

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Резюме

ВВЕДЕНИЕ. Распространенность заболеваний пародонта на сегодняшний день остается очень высокой рассматривается, как одна из основных причин потери зубов у взрослого населения. Существующие методы оценки эффективности пародонтологического лечения устарели, имеют существенные

недостатки и не отражают состояние тканей пародонта и пульпо-пародонтального комплекса. Существует острая необходимость разработки новых методов оценки эффективности пародонтологического лечения.
ЦЕЛЬ. Разработать и клинически апробировать интегральный показатель для количественной оценки эффективности лечения хронического пародонтита.
МАТЕРИАЛЫ И МЕТОДЫ. Разработан комплексный показатель «Паутина эффективности пародонтологического лечения», объединяющий шесть параметров: кровоточивость и воспаление десны, глубину пародонтального зондирования, подвижность зубов, состояние пульпы и гигиену полости рта.
РЕЗУЛЬТАТЫ. Описана методика расчета показателя «Паутина эффективности пародонтологического лечения», оценка его эффективности в клиническом исследовании.
ЗАКЛЮЧЕНИЕ. Разработанный интегральный диагностический показатель «Паутина эффективности пародонтологического лечения» предназначен для сравнительного анализа результативности различных лечебно-профилактических схем при хроническом пародонтите. Данный инструмент также обеспечивает наглядное графическое представление динамики клинических показателей. Предложенный показатель отражает состояние не только тканей пародонта, но и пульпо-пародонтального комплекса, что делает его клинически значимым инструментом.

Ключевые слова: эндо-пародонтальные поражения, диагностика пародонтита, пародонтит, лечение, профилактика

Информация о статье: поступила – 17.01.2026; исправлена – 01.03.2026; принята – 14.03.2026

Конфликт интересов: Авторы сообщают об отсутствии конфликта интересов. Спонсор не принимал участия в разработке, проведении, интерпретации или подготовке исследования.

Благодарности: Финансирование и индивидуальные благодарности для декларирования отсутствуют.

Заявление об этическом одобрении: Исследование было одобрено этическим комитетом Тверского государственного медицинского университета (выписка из протокола № 5 от 19 июня 2020 г.).

Для цитирования: Моисеев Д.А., Тайлакова Д.И., Казакова Н.Н., Хожиев Х.Х., Варилиди А.Д., Перфилов М.С., Савич А.А., Данильченко А.А. Новый подход к сравнительной оценке эффективности лечебных и профилактических мероприятий у больных хроническим пародонтитом. *Эндодонтия Today.* 2026;24(2):330–339. https://doi.org/10.36377/ET-0197

INTRODUCTION

The prevalence of periodontal diseases remains high – ranging on average from 46% to 82% – and is regarded as one of the principal causes of tooth loss in the adult population [1–5].

The issue of combined (endo-periodontal) lesions has attracted increasing interest in both scientific and clinical settings. In such cases, the pathological process is sustained by infectious agents persisting within accessory canal systems and dentinal tubules. However, the lack of standardized diagnostic approaches and clearly defined therapeutic strategies continues to render this problem highly relevant [6–15].

Periodontitis constitutes a major public health concern due to its widespread and high prevalence. It may result in complete tooth loss, adversely affecting masticatory function and esthetics, contributing to social inequality, and significantly impairing quality of life [5; 16; 17].

Recent studies indicate that effective control of chronic inflammatory processes in periodontal tissues may represent a novel approach to reducing the risk of complications associated with systemic diseases [15; 18; 19].

Existing methods for evaluating the effectiveness of periodontal treatment are outdated, possess significant limitations, and fail to account for the condition of the pulp-periodontal complex.

There is a clear need for the development of advanced assessment methodologies aimed at optimizing periodontal therapy. Their implementation would contribute to improving preventive and therapeutic strategies for endodontic pathology in patients with periodontitis. Such an integrated approach is directed toward the prevention and elimination of chronic odontogenic infection foci, which represents a key factor in maintaining oral health and improving the overall quality of life of the population [4; 20–24].

AIM

To develop and clinically validate an integral index for the quantitative assessment of the effectiveness of chronic periodontitis treatment.

MATERIALS AND METHODS

For the comparative evaluation of the effectiveness of therapeutic and preventive interventions, we developed a composite index termed the *Periodontal Treatment Effectiveness Web* (PTEW; hereinafter referred to as the *Web*) [15].

The proposed index enables the assessment of periodontal treatment outcomes based on objective evaluation of key clinical parameters of dental status, including: bleeding on probing (BoP; Ainamo, Bay, 1975), the papillary–marginal–alveolar index (PMA; Parma C., 1960), electric pulp testing (EPT), Periotest values (PT), periodontal probing depth (PD), and the Silness–Löe plaque index (SL; Silness I., Löe H., 1964) (Fig. 1).

The calculation methodology of the PTEW index comprises several stages.

At the first stage, a baseline geometric framework is constructed in the form of a regular hexagon with a side length of 2 cm, plotted on a millimeter grid from a central reference point. Each vertex corresponds to one of the six diagnostic parameters.

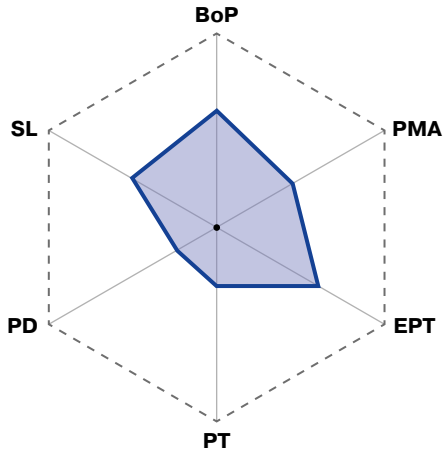

Fig. 1. Graphical model of the comprehensive diagnostic indicator *Web of effectiveness of periodontal treatment*

Рис. 1. Графическая модель интегрального диагностического показателя «Паутина эффективности пародонтологического лечения»

At the second stage, a graphical model *Web* is generated. Measured values are plotted along the axes corresponding to the sides of the hexagon. A distinctive feature of the method is that EPT values are plotted inversely – from the periphery toward the center. Sequential connection of the plotted points forms a closed polygon.

At the third stage, for each patient and for each segment group (test and comparison), the areas of the resulting polygons are calculated before and after the treatment course.

The final stage involves calculation of the composite PTEW index, defined as the difference between the polygon areas after and before treatment. The area, expressed in mm^2, is numerically equivalent to the index value in arbitrary units. Accordingly, a higher PTEW value indicates greater effectiveness of the therapeutic and preventive interventions.

To automate the calculations, a software script was developed in the R programming language. The script reproduces the geometric construction and calculates polygon areas using Gauss's area formula, thereby eliminating manual measurement errors. The algorithm ensures high reproducibility, rapid analysis, and the capability for batch data processing with automated graph generation. Digital implementation enhances the accuracy and objectivity of PTEW assessment. Alternatively, the constructions may be performed manually using the online application GeoGebra. Thus, the proposed approach to comparative evaluation of treatment and preventive efficacy in patients with chronic periodontitis can be implemented either through modern digital tools or via a conventional manual method.

List of evaluated parameters:

– BoP – bleeding on probing (0–100%);
– PMA – papillary-marginal-alveolar index (0–100%);
– EPT – mean electric pulp test value (0–20 μA);
– PT – mean Periotest value (0–20 units);
– PD – mean periodontal probing depth (0–15 mm);
– SL – Silness–Löe plaque index (0–3 units).

Scaling and justification of axis divisions:

1. BoP (0–100%).

Scale: 1 mm = 5%.

Rationale: A 100% range is linearly mapped onto a 20 mm axis (100/20 = 5% per mm), ensuring intuitive proportional visualization.

2. PMA (0–100%).

Scale: 1 mm = 5%

Rationale: Identical to BoP, allowing consistent representation of percentage-based indices.

3. EPT (0–20 μA).

Scale: 1 mm = 1 μA.

Rationale: A direct linear relationship (1 μA = 1 mm) is used for clarity. Since increased pulp excitation threshold corresponds to higher μA values, and the model assumes that worsening parameters extend away from the center, the EPT axis is inverted. Thus, a value of 1 μA (hyperexcitable pulp) is plotted at the outermost point (2 cm from the center). This inversion ensures that improvement in pulp condition (increase in EPT values) results in a reduction of the polygon area, visually reflecting positive treatment dynamics.

4. PT (0–20 units).

Scale: 1 mm = 1 unit.

Rationale: A linear 1 : 1 scale is used for simplicity and comparability. Increased Periotest values (indicating greater tooth mobility) extend the point outward, enlarging the web area.

5. PD (0–15 mm).

Scale: 1 mm = 0.75 mm probing depth.

Rationale: To fit the full range within 20 mm: 15/20 = 0.75 mm per mm of the grid, enabling adequate visualization of deep periodontal pockets.

6. SL (0–3 units)

Scale: 1 mm = 0.15 units.

Rationale: With a total range of 3 units, mapping onto 20 mm yields 3/20 = 0.15 units per mm, ensuring proportional representation within the defined axis length.

Statistical analysis

Statistical data processing was performed using *R* software (version 4.3.1). Normality of quantitative variables was assessed using the Shapiro–Wilk test. As most parameters demonstrated non-normal distribution, nonparametric methods were applied: the Mann–Whitney *U* test for comparisons between independent groups and the Wilcoxon signed-rank test for paired comparisons when analyzing within-group dynamics. Correlation analysis was conducted using Spearman's rank correlation coefficient (ρ). Differences were considered statistically significant at $p < 0.01$.

Validation of the normalization method for the Web parameters

To verify the validity of the selected normalization coefficients (axis scaling) and the sensitivity of the composite PTEW index to clinical changes, an analysis of a representative dataset was performed.

Assessment of range adequacy

Baseline data from all patients ($n = 95$) were analyzed to determine whether the values of all six parameters fell within the predefined *Web* ranges. In 100% of cases, the clinical parameter values were within the established limits, confirming their clinical relevance and suitability for the proposed model. No clinically significant values were truncated at the scale boundaries.

Evaluation of method sensitivity

The fundamental principle of the method is that improvement in any parameter (reduction in bleeding, probing depth, plaque index, tooth mobility, and normalization of EPT values) results in a decrease in the distance from the plotted point to the center of the *Web* and, consequently, a reduction in its total area. To assess whether the composite PTEW index (defined as the difference between areas "before" and "after" treatment) objectively reflects these changes, a correlation analysis was performed.

The following hypothesis was tested: deterioration in any individual parameter leads to an increase in the *Web* area, whereas improvement leads to its reduction.

Spearman's rank correlation coefficient (ρ) was calculated between the absolute change (Δ) of each individual parameter (defined as |post-treatment value – pre-treatment value|) and the change in the composite index (ΔPTEW). Since a reduction in area reflects a positive clinical outcome and ΔPTEW is calculated as $area_{before} - area_{after}$, positive ΔPTEW values indicate treatment effectiveness.

The results demonstrated statistically significant ($p < 0.01$) moderate to strong positive correlations:

– ΔPTEW vs ΔBoP: $\rho = +0.71$;
– ΔPTEW vs ΔPMA: $\rho = +0.69$;
– ΔPTEW vs ΔEPT: $\rho = +0.58$;
– ΔPTEW vs ΔPT: $\rho = +0.55$;
– ΔPTEW vs ΔPD: $\rho = +0.75$;
– ΔPTEW vs ΔSL: $\rho = +0.63$.

These positive correlations indicate that greater improvements in individual parameters (larger absolute changes) are associated with higher values of the composite index ΔPTEW, confirming its convergent validity and adequate sensitivity to clinically relevant changes.

Comparative sensitivity analysis

To demonstrate the advantages of the composite assessment, changes in PTEW were compared with changes in the standard Periodontal Index (PI) in a randomly selected subgroup of 20 patients. On average, the relative change in PTEW after treatment was 84%, whereas the relative change in PI was 65%. This suggests that PTEW, due to the inclusion of a broader set of clinically relevant parameters (including pulp status), represents a more sensitive tool for the integral evaluation of treatment effectiveness.

Study design and ethical considerations

The present study was designed as a multicenter, prospective, open-label, comparative, controlled study with a cross-over design and within-group control. The proposed composite index was applied for the comparative evaluation of a novel method for the treatment and prevention of pulp pathology in patients with chronic periodontitis [14; 15; 25].

The study was conducted at the following research centers: the Department of Periodontology of Tver State Medical University (Russia), the Department of Therapeutic Dentistry of the Institute of Dentistry at Pirogov Russian National Research Medical University (Pirogov University, Russia), and the Department of Therapeutic Dentistry of Bukhara State Medical Institute named after Abu Ali ibn Sina (Bukhara, Uzbekistan).

The object of analysis comprised clinical parameters characterizing the condition of oral tissues and organs. The study population included patients aged 22 to 72 years.

The study protocol was approved by the Ethics Committee of Tver State Medical University (Protocol No. 5, dated June 19, 2020). The study was conducted in accordance with the ethical principles for medical research involving human subjects as outlined in the Declaration of Helsinki of the World Medical Association. All participants provided written informed consent prior to inclusion in the study.

Study design and eligibility criteria

The study cohort included 95 patients of both sexes with a verified diagnosis of chronic periodontitis (ICD-10 code K05.31) who met the predefined eligibility criteria.

Inclusion criteria:

– age: 18–74 years (according to WHO classification);
– confirmed diagnosis of chronic periodontitis of any severity;
– ⩾2 dental segments with periodontal pockets (up to 6 mm) containing endodontically intact teeth;
– ⩾2 teeth with diagnosed dentin hypersensitivity.

Non-inclusion criteria:

– use of anti-inflammatory medications (NSAIDs, corticosteroids);
– history of hepatitis B/C or HIV infection;
– chemotherapy, radiotherapy, or cytokine therapy within 5 years prior to study initiation;
– individual intolerance to components of the applied medications;
– pregnancy or lactation;
– refusal to comply with the study protocol.

Exclusion criteria (*during the study*):

– voluntary written withdrawal from participation;
– occurrence of conditions associated with risk to the participant's life or health;
– development of diseases corresponding to non-inclusion criteria;
– clinical necessity for therapeutic interventions not provided for in the study protocol;
– violation of the medication regimen, including the use of prohibited drugs;
– any other conditions preventing continued adherence to the study protocol.

Group design

Each patient served as their own control: within the same individual, from 1 to 4 test (main) and control (comparison) dentoalveolar segments were identified, allowing for intra-individual comparative analysis.

For the assessment of dental status at baseline and follow-up stages, both primary and supplementary diagnostic methods were used:

1. Measurement of periodontal probing depth using a first-generation UNC-15 periodontal probe.
2. Assessment of oral hygiene using the Silness–Löe plaque index.
3. Evaluation of bleeding on probing using the BoP index.
4. Assessment of gingival inflammation using the PMA index.
5. Evaluation of tooth mobility using Periotestometry (Periotest S device, Medizintechnik Gulden, Germany).
6. Assessment of pulp status using electric pulp testing (EPT) with the "PulpEst L" device (Geosoft, Russia–Israel).

Description of the novel treatment and preventive method

The proposed method for the treatment and prevention of pulp pathology in patients with chronic periodontitis was implemented as follows [25].

The protocol of the first visit included standard conservative periodontal procedures followed by localized intervention. In the test segments (main group), the following therapeutic protocol was applied: after application of the paste-like preparation *Cupral* (Humanchemie GmbH, Germany), strips of aluminum foil (⩽1 mm in width) were placed into the same periodontal pockets. Stabilization of the isolating barrier was achieved by applying cyanoacrylate adhesive *Sulfacrylate* (NTO Medical Innovations, Russia) along the marginal gingiva.

In the comparison group, a gel containing 0.1% chlorhexidine and 1% metronidazole was applied into the periodontal pockets without the use of aluminum foil. The treatment course in both groups consisted of two sessions with an interval of 5–7 days.

At the final stage (fourth visit), following removal of adhesive dressings, the periodontal pockets were irrigated with distilled water. In the main group, an additional procedure was performed – impregnation of root surfaces using a two-component *Dentin Sealing Liquid* (Humanchemie GmbH, Germany).

RESULTS

Before and after treatment, clinical parameters of dental status were assessed, followed by calculation of the PTEW index. For each patient, two values of the composite index were determined (for dentoalveolar segments of the main group and the comparison group).

Comparative analysis of the dynamics of the integral *Effectiveness Web* index revealed statistically significant differences between the groups. Baseline area values in the main and comparison groups were comparable (5.91 and 6.01 mm^2, respectively, see Table 1), indicating the representativeness and homogeneity of the sample at the start of the study (Fig. 2).

Following the treatment course, a pronounced positive trend was observed in both groups. However, in the main group, the *Web* area decreased at a substantially higher rate, exceeding the corresponding changes observed in the comparison group (Fig. 3).

Table 1. The average values of the indicator *Web of effectiveness of periodontal treatment* area and the complex indicator for the study groups

Таблица 1. Средние значения площади показателя «Паутина эффективности пародонтологического лечения» и комплексного показателя для групп исследования

Indicators	Research groups		*p*-value
	Main (I)	Comparisons (II)	
The average area of the *Web* before, mm^2	5.91	6.01	0.342
The average area of the *Web* after, mm^2	0.86	1.93	<0.001
A comprehensive indicator	5.05	4.08	<0.001

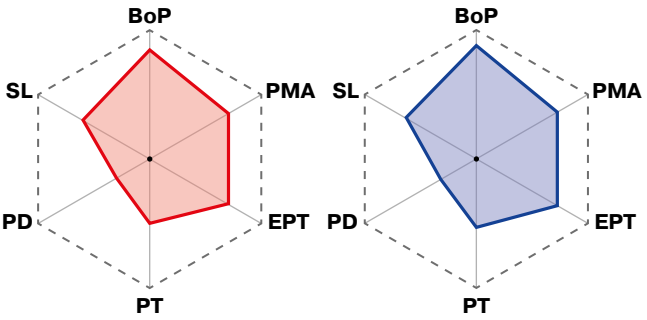

Fig. 2. View of the indicator *Web of effectiveness of periodontal treatment* for the main group (left) and the comparison group (right) before the therapeutic and preventive procedures

Рис. 2. Вид показателя «Паутина эффективности пародонтологического лечения» для основной группы (слева) и группы сравнения (справа) до проведения лечебных и профилактических процедур

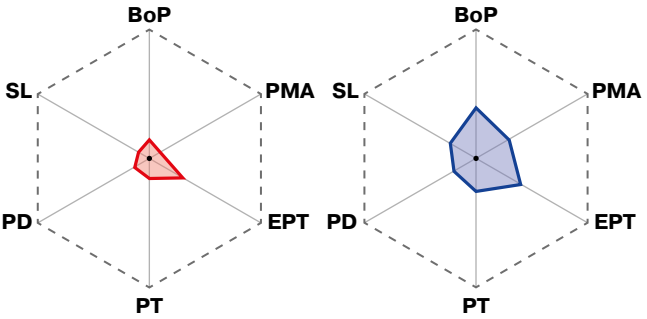

Fig. 3. View of the indicator *Web of effectiveness of periodontal treatment* for the main group (left) and the comparison group (right) after therapeutic and preventive procedures

Рис. 3. Вид показателя «Паутина эффективности пародонтологического лечения» для основной группы (слева) и группы сравнения (справа) после проведения лечебных и профилактических процедур

These findings indicate that the therapeutic protocol applied in the main group provided significantly greater clinical effectiveness, as confirmed by a statistically significant difference in the PTEW index values.

Clinical case

A 53-year-old patient (A.G.) presented for outpatient care with complaints of persistent halitosis and pronounced gingival bleeding occurring both during mechanical stimulation and spontaneously. According to the medical history, these symptoms had persisted for several years. During this period, the patient had not sought professional dental care and had relied on self-treatment, including periodic rinsing with chlorhexidine solution. Oral hygiene was irregular, limited to standard measures (medium-bristle toothbrush and therapeutic toothpaste).

Objective examination revealed abundant supra- and subgingival dental deposits. The gingival mucosa was hyperemic, edematous, and loose consistency; bleeding on probing was noted, along with mild tenderness on palpation.Serous-purulent exudate was detected from periodontal pockets in the regions of teeth 1.2, 2.2, 2.5, 2.6, 2.7, 3.8, and 4.8. Periodontal probing depths ranged from 4 to 6 mm. Gingival recession was observed: 1–4 mm in the anterior mandibular region and 1–5 mm in the posterior segments.

Objective diagnostic findings were as follows: EPT – 5 units; mean probing depth (PD) – 4.28 mm; BoP – 100%; PMA – 67%; Periotest value (PT) – 11 units; Silness–Löe index (SL) – 2 units.

Based on clinical, anamnestic, and additional diagnostic data, the diagnosis was established as follows: ICD-10: K05.3 Chronic periodontitis.

WHO classification: Chronic generalized periodontitis of moderate severity in the exacerbation phase.

Treatment

At the first stage, individualized oral hygiene instructions and product selection were provided. The visit concluded with professional oral hygiene under local anesthesia. Subsequently, medicamentous treatment was performed according to the proposed method for the treatment and prevention of pulp pathology in patients with chronic periodontitis using *Cupral* (Humanchemie GmbH, Germany), as described above. The patient was prescribed both local and systemic therapy for home use.

At the second stage (after 14 days), root surface impregnation was performed using *Dentin Sealing Liquid*.

At the follow-up visit after 5 months, the patient reported mild sensitivity in individual teeth. Re-evaluation of clinical parameters showed: EPT – 10.14 units; PD – 3.67 mm; BoP – 33%; PMA – 11%; PT – 3.67 units; SL – 0 units.

The *Web* configuration before treatment and 5 months after treatment is presented in Fig. 4.

The composite index was calculated as follows: S_1 (before treatment) – S_2 (after treatment) = = 5.52 – 0.49 = 5.03 mm^2.

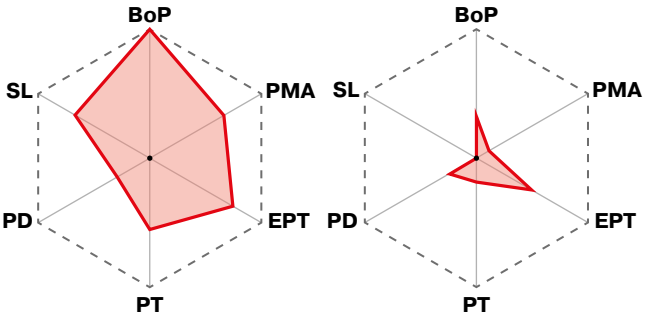

Fig. 4. View of the indicator *Web of effectiveness of periodontal treatment* before therapeutic and preventive measures (left) and 5 months after (right)

Рис. 4. Вид показателя «Паутина эффективности пародонтологического лечения» до лечебно-профилактических мероприятий (слева) и через 5 месяцев после (справа)

At the subsequent visit after 8 months, the patient reported no complaints. Reassessment demonstrated further improvement: EPT – 11.85 units; PD – 3.22 mm; BoP – 0%; PMA – 0%; PT – 6 units; SL – 0 units.

DISCUSSION

The development of the novel composite index, the *Periodontal Treatment Effectiveness We*b (PTEW), was driven by the objective need to overcome the methodological limitations inherent in existing assessment systems. Analysis of traditional periodontal indices revealed a number of systemic shortcomings that hinder comprehensive and objective evaluation of treatment outcomes, particularly in patients with combined periodontal and pulp pathology.

Classical indices, such as the Periodontal Index (PI) by Russell (1956) and the Ramfjord / Keche index (1975), while historically significant, are largely outdated. Their principal limitation lies in their inconsistency with current concepts of periodontal disease pathogenesis and classification [26; 27]. These indices often combine heterogeneous nosological entities (e.g., gingivitis and destructive forms of periodontitis) within a single scale and rely partly on subjective assessment of parameters such as tooth mobility, thereby reducing reproducibility and objectivity.

Indices widely used for epidemiological and screening purposes by the World Health Organization – such as the Community Periodontal Index of Treatment Needs (CPITN), the Community Periodontal Index (CPI), and the Periodontal Screening Index (PSI/PSR) – address the narrow task of disease detection but are not suitable for longitudinal monitoring or evaluation of treatment effectiveness [16; 28–31]. Their key limitations include:

1. Fragmentary assessment. Only a limited set of parameters (bleeding, calculus, probing depth) is considered, while critical aspects such as oral hygiene status (plaque index), tooth mobility, and, most importantly for the present study, the condition of the pulp-periodontal complex are not evaluated.

2. Reliance on index teeth. Assessment based on 6–10 representative teeth does not reflect the full extent and severity of disease in an individual patient.

3. Qualitative rather than quantitative nature. These indices categorize patients by severity but do not provide an integral quantitative measure suitable for precise comparison of pre- and post-treatment conditions.

Thus, existing methods do not allow for a fully objective comparative evaluation of therapeutic and preventive interventions, as also noted by McGuire and Nunn, who emphasized the difficulty of predicting treatment outcomes based on standard clinical parameters [20–22]. This limitation is particularly pronounced when assessing pulp status in patients with periodontitis, who are at increased risk of developing endo-periodontal lesions [6; 7; 10].

In contrast, the proposed PTEW index is integral and multiparametric, addressing the aforementioned limitations through:

1. Comprehensiveness. Simultaneous incorporation of six key parameters characterizing periodontal tissue status (BoP, PMA, PD, PT, SL) and pulp vitality (EPT), aligning with contemporary understanding of the close interrelationship within the pulp-periodontal complex [10; 11; 13].

2. Quantitative output. Results are expressed as an absolute numerical value (area in mm^2), enabling both visualization of treatment dynamics and robust statistical analysis of therapeutic effectiveness.

3. Objectivity and reproducibility. Only objectively measurable parameters are included, minimizing subjective bias.

4. Clarity and visualization. The *Web* format provides an intuitive graphical tool for clinicians to demonstrate patient status dynamics before and after treatment.

The results of the present study, demonstrating a statistically significant increase in the composite ΔPTEW index in the main group compared to the comparison group, confirm the practical applicability and sensitivity of the method. The higher clinical effectiveness observed in the main group – where the treatment protocol also targeted prevention of pulp pathology – was adequately captured by the proposed index, whereas conventional indices would not fully reflect these differences.

It should be emphasized that PTEW does not replace standard indices in their epidemiological and screening roles but rather complements them in clinical research and practical periodontology, where precise quantitative assessment of patient dynamics and integrated evaluation of the pulp-periodontal complex are required.

The implementation of the proposed composite index contributes to improved effectiveness in the treatment of periodontal diseases and prevention of pulp pathology in patients with periodontitis. The application of novel minimally invasive diagnostic approaches for assessing periodontal and pulp tissue status enables more accurate long-term prognostication of these tissues.

CONCLUSION

An integral diagnostic algorithm has been developed for the comparative evaluation of the effectiveness of periodontal treatment. The method enables clear visualization of the dynamics of clinical parameters. This approach is also applicable as an objective quantitative criterion for assessing the outcomes of therapy and prevention of pulpitis in patients with periodontitis. The algorithm is based on a comprehensive assessment of six complementary parameters, providing an exhaustive characterization of periodontal tissue status and pulp vitality, which is of fundamental importance for the prevention of endodontic-periodontal complications.

The diagnostic procedures, interpretative criteria, and scoring systems used within the methodology are based on the current scientific paradigm, reflecting contemporary understanding of the etiopathogenesis of periodontal diseases, and are fully consistent with international classification standards.

STUDY LIMITATIONS

Despite the obtained results, several limitations should be considered when interpreting the findings and planning future research.

1. The PTEW is an integral composite indicator and directly depends on the accuracy of measurement of the underlying clinical parameters (BoP, PMA, SL), some of which are partially subjective and operator-dependent. Although inter-center standardization of measurements was performed, residual variability between investigators across different centers may still be present.

2. The transformation of heterogeneous clinical parameters into a unified geometric model required the establishment of fixed scaling coefficients (axis weights). Although these coefficients were logically justified and supported by convergent validity analysis, they remain conditional. Alternative normalization approaches (e.g., logarithmic transformations or different scaling ranges) could theoretically yield different numerical outcomes.

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Все авторы одобрили окончательную версию статьи для публикации.