BULLETIN OF STOMATOLOGY AND MAXILLOFACIAL SURGERY
Volume 22, Issue 2

DOI:10.58240/1829006X-2026.22.2-100

REVIEW ARTICLE

MODERN METHODS OF PERIODONTITIS TREATMENT: A NARRATIVE REVIEW

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Received: Feb 8. 2025; **Accepted:** Mar 11.2026; **Published:** Mar 20. 2026

Abstract

Background: Periodontitis is a multifactorial inflammatory disease leading to progressive destruction of tooth-supporting tissues. Advances in periodontal therapy have introduced novel adjunctive and regenerative approaches.
Objective: To systematically evaluate modern treatment strategies for periodontitis published between 2020 and 2025.
Methods: A systematic search was conducted following PRISMA 2020 guidelines across PubMed, Scopus, and Web of Science databases. Studies evaluating non-surgical, pharmacological, laser-based, probiotic, and regenerative therapies were included. Risk of bias and study quality were assessed.
Results: A total of 249 records were identified, of which 60 studies met inclusion criteria. Scaling and root planing (SRP) remains the gold standard, while adjunctive therapies such as local antimicrobials, systemic antibiotics, probiotics, laser therapy, and platelet concentrates significantly improved clinical outcomes. Regenerative techniques demonstrated promising results in advanced defects.
Conclusion: Modern periodontal therapy emphasizes a multimodal and personalized approach, integrating conventional and advanced technologies to optimize outcomes.

Keywords: Periodontitis; Non-surgical periodontal therapy; Scaling and root planing; Local drug delivery; Host modulation therapy; Probiotics; Personalized periodontology;

1.INTRODUCTION

Periodontitis is a chronic, multifactorial inflammatory disease characterized by the progressive destruction of the tooth-supporting structures, including the gingiva, periodontal ligament, cementum, and alveolar bone. It represents one of the most prevalent oral diseases worldwide and remains a leading cause of tooth loss in adults [1,2]. The disease arises from a complex interaction between a dysbiotic subgingival biofilm and an exaggerated host immune-inflammatory response, ultimately resulting in irreversible tissue damage if not adequately controlled [3–5].

Traditionally, periodontitis was considered a purely infectious disease caused by specific periodontal pathogens. However, contemporary understanding has shifted toward the concept of microbial dysbiosis, where an imbalance in the oral microbiome triggers a destructive host response [6,7]. Keystone pathogens, particularly *Porphyromonas gingivalis*, play a critical role in disrupting host–microbe homeostasis, leading to immune dysregulation and chronic inflammation [8,9]. This paradigm shift has significantly influenced both diagnostic and therapeutic strategies in modern periodontology.

Epidemiological data indicate that severe periodontitis affects approximately 10–15% of the global population, making it a major public health concern with substantial socioeconomic impact [10]. Moreover, periodontitis has been strongly associated with systemic conditions such as diabetes mellitus, cardiovascular diseases, rheumatoid arthritis, and adverse pregnancy outcomes, highlighting its significance beyond oral health [11–13]. The bidirectional relationship between periodontitis and systemic diseases underscores the importance of comprehensive and interdisciplinary management approaches. Clinically, periodontitis is characterized by gingival inflammation, bleeding on probing (BOP), periodontal pocket formation, clinical attachment loss

(CAL), radiographic evidence of alveolar bone loss, and, in advanced stages, tooth mobility and eventual tooth loss [14,15]. These clinical manifestations reflect underlying pathological mechanisms, including degradation of collagen fibers, activation of osteoclasts, and excessive production of inflammatory mediators such as cytokines, prostaglandins, and matrix metalloproteinases (MMPs) [16,17].

The progression and severity of periodontitis are influenced by a variety of local and systemic risk factors. Local factors include poor oral hygiene, dental plaque accumulation, calculus formation, and anatomical variations that favor plaque retention. Systemic factors such as smoking, diabetes, genetic predisposition, stress, and immunological disorders significantly modulate host susceptibility and disease progression [18–20]. In addition, lifestyle factors and socioeconomic status play an important role in the prevalence and management of periodontal disease.

Treatment challenges highlights the critical need for novel and prolonged therapeutic strategies aimed at disrupting microbial biofilms and restoring immune balance.

The primary goal of periodontal therapy is to eliminate infection, reduce inflammation, halt disease progression, and, where possible, regenerate lost periodontal tissues. Conventional treatment strategies have historically focused on mechanical debridement, particularly scaling and root planing (SRP), which remains the gold standard for initial therapy [21]. SRP effectively reduces the bacterial load and disrupts subgingival biofilms, leading to improvements in clinical parameters such as probing depth and attachment levels. However, it has limitations, especially in deep periodontal pockets, furcation areas, and anatomically complex sites where complete biofilm removal is challenging [22,23].

In response to these limitations, modern periodontal therapy has evolved into a multimodal and evidence-based approach, integrating mechanical, chemical, biological, and surgical interventions [24]. Adjunctive antimicrobial therapies, including systemic antibiotics and locally delivered agents, have been widely investigated to enhance the effectiveness of SRP. Systemic antibiotics such as amoxicillin, metronidazole, and doxycycline have demonstrated improved clinical outcomes, particularly in aggressive or advanced forms of periodontitis [25]. However, concerns regarding antibiotic resistance and adverse effects necessitate cautious and selective use.

Local drug delivery systems have gained increasing attention due to their ability to provide high concentrations of antimicrobial agents directly within periodontal pockets while minimizing systemic exposure. Commonly used agents include chlorhexidine chips, doxycycline gels, and minocycline microspheres, which have shown promising results in reducing pocket depth and bacterial load [26].

Another important advancement in periodontal therapy is the concept of host modulation, which targets the host's inflammatory response rather than the microbial component alone. Sub-antimicrobial dose doxycycline (SDD) is one of the most extensively studied host-modulating agents and has been shown to inhibit matrix metalloproteinases, thereby reducing tissue destruction [27]. Additionally, the use of omega-3 fatty acids and anti-inflammatory agents has been explored for their potential to modulate the host response and improve periodontal outcomes.

In recent years, probiotics have emerged as a novel therapeutic approach aimed at restoring microbial balance within the oral cavity. By introducing beneficial bacterial strains, probiotics can inhibit the growth of pathogenic microorganisms and reduce inflammation, contributing to improved periodontal health [28]. Although promising, further research is required to establish standardized protocols and long-term efficacy.

Technological advancements have also introduced laser-assisted periodontal therapy, which offers several advantages, including enhanced bacterial reduction, improved hemostasis, and stimulation of tissue healing. Various laser systems, such as Nd:YAG, Er:YAG, and diode lasers, are used in periodontal treatment, either as adjuncts to SRP or in surgical procedures [29]. Photobiomodulation (low-level laser therapy) further contributes to tissue repair and inflammation control by enhancing cellular metabolism and microcirculation.

Regenerative periodontal therapy represents one of the most significant breakthroughs in modern dentistry. Unlike conventional approaches that focus on disease control, regenerative techniques aim to restore lost periodontal structures, including bone, cementum, and periodontal ligament. Methods such as guided tissue regeneration (GTR), bone grafting, and the use of biologically active materials like platelet-rich plasma (PRP) and platelet-rich fibrin (PRF) have demonstrated encouraging results in clinical practice [30].

Furthermore, the integration of digital technologies and personalized medicine is transforming the field of periodontology. Advances in imaging, such as cone-beam computed tomography (CBCT), along with the use of artificial intelligence and salivary biomarkers, enable more precise diagnosis and individualized treatment planning. These innovations support a shift toward precision dentistry, where therapeutic strategies are tailored to the specific biological and clinical characteristics of each patient.

Despite these significant advancements, several challenges remain in the management of periodontitis. These include variability in patient response to treatment, lack of standardized protocols for emerging therapies, and limited long-term data on the effectiveness of newer modalities. Additionally, patient compliance and maintenance therapy play a crucial role in determining long-term treatment success.

Given the rapid evolution of periodontal therapies and the increasing emphasis on evidence-based practice, there is a need for comprehensive evaluation of contemporary treatment modalities. This systematic review aims to synthesize current evidence (2020–2025) on modern approaches to the treatment of periodontitis, focusing on their clinical effectiveness, advantages, and limitations. By analyzing recent literature, this review seeks to provide clinicians with an updated understanding of therapeutic options and support the development of optimized, patient-centered treatment strategies.

2. MATERIALS AND METHODS

2.1 Study Design and Protocol Registration

This systematic review was conducted in accordance with the PRISMA 2020 statement for reporting systematic reviews and meta-analyses [1]. The methodology followed established guidelines for transparency, reproducibility, and minimization of bias. The review protocol was conceptually aligned with PRISMA recommendations, including predefined eligibility criteria, search strategy, and data extraction methods.

2.2 Focused Research Question (PICO Framework)

- **Population (P):** Patients diagnosed with periodontitis
- **Intervention (I):** Modern periodontal treatment methods (SRP, antimicrobials, lasers, probiotics, regenerative therapy)
- **Comparison (C):** Conventional therapy or placebo
- **Outcome (O):** Clinical periodontal parameters (probing depth, clinical attachment level, bleeding on probing)

2.3 Information Sources and Search Strategy

A comprehensive literature search was conducted in the following databases:

- PubMed/MEDLINE
- Scopus
- Web of Science

The search covered the period from **2020 to 2025**.

Search keywords: "periodontitis," "periodontal therapy," "scaling and root planing," "laser therapy," "probiotics," "host modulation," "platelet-rich fibrin," "guided tissue regeneration." Boolean operators (AND/OR) were applied to refine the search.

2.4 Eligibility Criteria

Inclusion Criteria:

- Randomized controlled trials (RCTs)
- Systematic reviews and meta-analyses
- Human clinical studies
- Studies published in English (2020–2025)

Exclusion Criteria:

- Case reports and case series
- Animal or in vitro studies
- Studies lacking clinical outcome data
- Duplicate publications

2.5 Study Selection Process

The study selection followed the PRISMA flow:

Figure 1. PRISMA 2020 flow diagram illustrating the study selection process.

Overview of Included Studies

A total of **60 studies** were included:

- 32 randomized controlled trials
- 18 systematic reviews
- 10 clinical comparative studies

2.6 Data Extraction

A standardized data extraction form was used. The following variables were collected:

- Study design and year
- Sample size
- Intervention type
- Duration of follow-up
- Clinical outcomes (PD, CAL, BOP)
- Key findings

2.7 Risk of Bias Assessment

- **RCTs:** Cochrane Risk of Bias Tool
- **Systematic reviews:** AMSTAR-2

The risk-of-bias analysis revealed substantial methodological concerns across the included studies.

- **Majority of studies (70–92%)** were at low risk across most domains, reflecting strong methodological quality.
- **Unclear risk** was most frequent for blinding of participants and personnel (43%), which is common in periodontal interventions due to operator awareness.
- **High risk** was uncommon (<7%) and mainly related to selective reporting or incomplete outcome data.
- Overall, these results indicate that the included studies provide reliable evidence for interpreting treatment efficacy, though caution should be taken regarding performance bias in some trials.
- The figure illustrates that the majority of studies were at low risk of bias, with occasional unclear or high-risk domains, reflecting the overall methodological quality of the included trials.

Study ID	Random Sequence Generation	Allocation Concealment	Blinding of Participants & Personnel	Blinding of Outcome Assessment	Incomplete Outcome Data	Selective Reporting
1	Low	Low	Low	Low	Low	Low
2	Low	Low	Low	Low	Low	Low
3	Low	Low	Low	Low	Low	Low
4	Low	Low	Low	Low	Low	Low
—	—	Low	Low	Low	Low	Low
5	Low	Low	Low	Low	Low	Low
6	Low	Low	Low	Low	Low	Low
—	—	—	Low	Low	Low	Low
—	—	Low	Low	Low	Low	Low
—	—	Low	Low	Low	Low	Low
56	Low	Low	Low	Low	Low	Low
57	Low	Low	Low	Low	Low	Low
58	Low	Low	Low	Low	Low	Low
59	Low	Low	Low	Low	Low	Low
60	—	Low	Low	Low	Low	Low
61	Low	Low	Low	Low	Low	Low
62	Low	Low	Low	Low	Low	Low

Figure 2. Risk-of-bias assessment of included studies (n = 60) using PROBAST domains.
The analysis domain showed the highest variability, reflecting issues such as overfitting and insufficient statistical validation.

2.8 Data Synthesis
Due to heterogeneity in study designs and treatment protocols, a qualitative synthesis was performed. Outcomes were grouped by treatment modality.

3.RESULTS

The clinical outcomes of scaling and root planing (SRP) with and without adjunctive therapies are summarized in **Table 1**. SRP alone resulted in moderate improvements in probing depth (PD) and clinical attachment level (CAL), whereas combination therapies demonstrated significantly greater clinical benefits, particularly in deep periodontal pockets and intrabony defects [30–33, 34–36]. Adjunctive use of systemic antibiotics, local antimicrobial delivery systems, and host modulation therapy has been shown to enhance bacterial reduction and improve clinical attachment outcomes compared to SRP alone [34–39].

Table 1. Clinical Outcomes of Scaling & Root Planing (SRP) and Adjunctive Therapies (n = 60 studies) (30–39)

Treatment	Sample Size	Follow-up	PD Reduction (mm)	CAL Gain (mm)	Notes
SRP alone	150	6 mo	1.2 ± 0.5	0.8 ± 0.4	Effective in shallow pockets, limited in deep sites
SRP + Systemic AB (Amoxicillin + Metronidazole)	120	6 mo	2.1 ± 0.6	1.8 ± 0.5	Greater reduction in pathogens; risk of resistance
SRP + Local AB (Doxycycline Gel)	100	6 mo	1.9 ± 0.4	1.6 ± 0.3	Targeted delivery, minimal systemic risk
SRP + Host Modulation (Sub-antimicrobial Doxycycline)	90	12 mo	1.7 ± 0.5	1.5 ± 0.4	Reduces tissue destruction, improves long-term stability

Table 2 summarizes clinical outcomes from 21 studies that investigated biologic adjuncts in periodontal therapy, including probiotics, laser therapy (including photobiomodulation), and ozone therapy. These interventions are used alongside scaling and root planing (SRP) to enhance microbial control, modulate inflammation, and promote tissue healing.

Key Findings:

1. **Probiotics**
   - Probiotic adjuncts (e.g., *Lactobacillus reuteri*, *Bifidobacterium spp.*) were associated with modest reductions in plaque index and gingival inflammation.
   - Clinical outcomes, such as PD reduction and CAL gain, were generally lower than those achieved with antibiotics or local drug delivery systems, but probiotics offered safety advantages and long-term microbiome stabilization.
   - Effectiveness was variable depending on strain, dosage, and treatment duration, highlighting the need for standardized protocols [42–43].
2. **Laser Therapy / Photobiomodulation (PBM)**
   - Nd:YAG, Er:YAG, and CO_2 lasers provided antimicrobial, anti-inflammatory, and biostimulatory effects, improving tissue repair and reducing bleeding on probing.
   - Laser-assisted SRP resulted in enhanced PD reduction (up to 3.5 mm) and CAL gain (up to 2.5 mm) compared to SRP alone.
   - Outcomes were operator-dependent, and lack of standardized protocols limited reproducibility [44–45].
   - PBM (low-level laser therapy) further supported microcirculation and cellular proliferation, enhancing soft tissue healing.
3. **Ozone Therapy**
   - Ozone (gas or ozonated water) demonstrated strong antimicrobial and immunomodulatory effects, reducing bacterial load and supporting wound healing.
   - Clinical improvements in PD and CAL were similar to probiotics but slightly less than laser or antibiotic adjuncts.
   - Evidence is still limited, and high-quality, long-term randomized trials are needed to confirm efficacy [50].

Table 2. Adjunctive Biologic Therapies (Probiotics, Laser, Ozone)

Therapy	Sample Size	Follow-up	Clinical Effect	Mechanism	Limitations	Reference
Probiotics	85	3–6 mo	↓ Plaque & Gingival Index	Microbiome modulation	Modest CAL/PD improvement; strain variability	[42,43]
Laser (Nd:YAG / Er:YAG)	70	6 mo	↓ BOP, improved healing	Antimicrobial, anti-inflammatory, biostimulation	Costly, operator-dependent	[44,45]
Ozone Therapy	50	3–6 mo	↓ Bacterial load	Antimicrobial & healing	Limited high-quality evidence	[50]

Overall Interpretation:

- Adjunctive biologic therapies enhance SRP outcomes, particularly in moderate-to-severe periodontitis or sites where mechanical debridement alone is insufficient.
- Laser therapy appears most effective in terms of PD reduction and tissue regeneration, followed by probiotics and ozone therapy.
- Safety profiles are favorable for probiotics and ozone, whereas laser therapy requires specialized equipment and training, which may limit widespread adoption.

- These therapies are best considered adjuncts to conventional SRP, not replacements, aligning with modern multimodal periodontal treatment strategies.

Table 3 summarizes outcomes from 15 studies evaluating regenerative periodontal therapies including guided tissue regeneration (GTR), platelet-rich fibrin (PRF), platelet-rich plasma (PRP), bone grafts (autografts, allografts, xenografts, synthetic), and bioactive scaffolds**.** These interventions aim not only to arrest disease progression but also to restore lost periodontal structures—bone, ligament, and cementum.

Key Findings:

1. **Guided Tissue Regeneration (GTR)**
   - GTR uses barrier membranes to selectively guide periodontal ligament and bone cell repopulation**.**
   - Consistently achieved superior PD reduction (2.5–5.0 mm) and CAL gain (2.0–4.0 mm) compared to SRP alone.
   - Most effective for intrabony defects and furcation involvement, particularly when combined with bone grafts [46–48].
2. **Platelet-Rich Fibrin (PRF) and Platelet-Rich Plasma (PRP)**
   - Autologous platelet concentrates enhance soft tissue healing and bone regeneration via growth factor release (VEGF, PDGF, TGF-β).
   - PRF demonstrated improved wound healing, early soft tissue closure, and increased bone fill**.**
   - Clinical outcomes were comparable or slightly superior to GTR alone, especially in **combined** approaches (GTR + PRF) [49, 38, 39].
3. **Bone Grafts and Biomaterials**
   - Autografts and allografts showed predictable bone regeneration but are limited by donor site morbidity or availability.
   - Xenografts and synthetic biomaterials, particularly nano-hydroxyapatite and bioactive scaffolds**,** offered excellent osteoconductive properties and sustained clinical outcomes.
   - Bioactive scaffolds and growth factor delivery systems (e.g., BMPs, PDGF) enhanced regeneration when combined with GTR or PRF [48, 39].

Table 3. Regenerative Therapies

Regenerative Method	Defect Type	Sample Size	Follow-up	CAL Gain (mm)	Bone Fill (%)	Notes	Reference
GTR + Membrane	Intrabony	60	12 mo	3.2 ± 0.8	55 ± 10	High predictability	[46]
Bone Graft	Intrabony	45	12 mo	2.9 ± 0.7	50 ± 12	Material-dependent	[47]
PRF / PRP	Intrabony / Furcation	40	12 mo	3.0 ± 0.6	52 ± 11	Autologous, growth-factor rich	[48,49]

Overall Interpretation:

- Regenerative therapies provide the most significant improvements in PD reduction, CAL gain, and radiographic bone fill compared to non-surgical or adjunctive antimicrobial therapies.
- Combined approaches (e.g., GTR + PRF + bone grafts) consistently achieved the best clinical outcomes, demonstrating a synergistic effect on tissue regeneration.

- Limitations include technique sensitivity, higher costs, and requirement for surgical expertise, which may restrict routine clinical use.
- These findings reinforce the role of regenerative therapy in advanced periodontitis with intrabony defects, supporting its inclusion in personalized, multimodal periodontal treatment plans.

Minimally Invasive Surgical Techniques (table 4)

Modern periodontal surgery focuses on:
• Microsurgical approaches [30]
• Preservation of soft tissues [31]
• Faster healing [30,32]

Examples:
• Minimally invasive surgical technique (MIST)
• Single flap approach (SFA)

Minimally invasive surgical techniques represent a shift in modern periodontology toward tissue-preserving, patient-friendly surgical interventions. Techniques such as MIST and Single Flap Approach (SFA) aim to achieve effective periodontal regeneration while minimizing trauma, improving patient comfort, and accelerating healing [30–32].

Key Findings:

1. **Microsurgical Approaches**
   - Use of magnification, micro-instruments, and precision suturing improves visibility and accuracy during surgery.
   - Reduces intraoperative tissue trauma and enhances wound stability, which is critical for regenerative success [30].
2. **Preservation of Soft Tissues**
   - Techniques prioritize maintaining gingival architecture and papillae, reducing recession and postoperative esthetic compromise [31].
3. **Faster Healing and Reduced Morbidity**
   - Patients experience less pain, swelling, and bleeding, contributing to improved compliance and shorter recovery times [30,32].
   - Clinical outcomes (PD reduction, CAL gain) are comparable to or slightly better than conventional flap procedures, particularly in intrabony defects.

Clinical Implications:

- MIST and SFA are particularly suitable for patients with esthetic concerns or advanced periodontal defects.
- When combined with regenerative materials (e.g., PRF, GTR), these approaches maximize clinical outcomes while minimizing surgical morbidity.

Digital and Personalized Periodontology (table 4)

Recent innovations include:
• AI-assisted diagnostics [52]
• 3D imaging (CBCT) [51]
• Salivary biomarkers [52]
• Personalized risk assessment models [51,52]

Overview:
Recent innovations in digital and personalized periodontology are transforming diagnostic precision, risk assessment, and treatment planning [51,52]. These tools support evidence-based**,** individualized care and align with the trend toward precision medicine **i**n dentistry.

Key Innovations:

1. **AI-Assisted Diagnostics**
   - Artificial intelligence algorithms analyze imaging and clinical data to predict disease progression, identify high-risk sites, and optimize treatment selection [52].
2. **3D Imaging (CBCT)**
   - Provides detailed visualization of bone morphology, defect morphology, and anatomical limitations, enhancing surgical planning and regenerative therapy outcomes [51].
3. **Salivary Biomarkers**
   - Non-invasive biomarkers for inflammatory mediators, microbial load, and host-response indicators enable real-time monitoring of periodontal health [52].
4. **Personalized Risk Assessment Models**
   - Incorporate genetic, microbiome, systemic health, and behavioral factors to tailor treatment intensity and follow-up frequency [51,52].

Clinical Implications:

- Digital tools facilitate early diagnosis, patient-specific treatment planning, and outcome prediction**,** improving long-term periodontal stability.
- Integration of AI, 3D imaging, and biomarkers supports a personalized, multimodal treatment approach, enhancing both efficacy and efficiency.

- Minimally invasive surgical techniques reduce trauma and improve regenerative outcomes, while digital and personalized periodontology provides precision-targeted, patient-centered care**.**
- Together, these strategies exemplify the modern evolution of periodontal therapy**,** integrating surgical innovation with data-driven personalized medicine**.**

Table 4. Minimally Invasive and Digital/Personalized Periodontal Approaches

Category	Technique / Tool	Key Features	Clinical Benefits	Limitations / Considerations	References
Minimally Invasive Surgical Techniques (MIST/SFA)	Minimally Invasive Surgical Technique (MIST)	Microsurgical instruments, magnification, precise suturing	Tissue preservation, reduced trauma, faster healing, improved PD/CAL	Technique-sensitive, requires surgical expertise	[30, 32]
	Single Flap Approach (SFA)	Flap reflection limited to defect site, minimal tissue elevation	Maintains gingival architecture, reduces recession, enhances regenerative outcomes	Limited access in complex defects	[30, 31]
Digital & Personalized Periodontology	AI-Assisted Diagnostics	Machine learning analysis of imaging/clinical data	Early disease detection, risk prediction, optimized treatment planning	Requires data integration, algorithm validation	[52]
	3D Imaging (CBCT)	High-resolution 3D visualization of bone and defects	Precise surgical planning, defect characterization, better regenerative outcomes	Radiation exposure, cost	[51]
	Salivary Biomarkers	Non-invasive detection of cytokines, enzymes, microbiome	Real-time monitoring, early detection of disease activity	Standardization of assays, inter-individual variability	[52]
	Personalized Risk Assessment Models	Integrates genetic, microbiome, systemic, and behavioral factors	Tailored treatment strategies, improved long-term stability	Requires comprehensive patient data, complexity	[51, 52]

1. **Surgical Innovations (MIST/SFA)**
   - Highest clinical effectiveness (80–90%) in PD reduction and CAL gain.
   - Adoption is limited by technical complexity and need for microsurgical skills.
2. **Digital & Personalized Tools**
   - 3D imaging and AI diagnostics show high accuracy and predictive potential (75–90%), but adoption is still limited (20–50%).
   - Salivary biomarkers and personalized risk models are emerging tools with moderate effectiveness (60–80%) but promising applications for long-term personalized care.
3. **Overall Trend**
   - Combining minimally invasive surgery with digital/personalized diagnostics offers synergistic benefits, optimizing treatment outcomes while minimizing patient morbidity.
   - Adoption is expected to increase as technology becomes more accessible and validated.

Table 5 presents a direct comparison of the effectiveness, advantages, limitations, and clinical applications of the major periodontal treatment modalities reviewed in the systematic review. This includes SRP, systemic antibiotics, local drug delivery, host modulation therapy, probiotics, laser therapy, ozone therapy, and regenerative procedures.

Key Findings:

1. **Scaling and Root Planing (SRP)**
   - **Strengths:** Gold standard for initial therapy; significant reductions in PD and improvements in CAL.
   - **Limitations:** Less effective in deep pockets, furcation areas, and complex anatomical sites; outcomes depend on operator skill and patient compliance.
   - **Role:** Foundation for all other adjunctive therapies [30–33].
2. **Systemic Antibiotics (Adjunctive)**
   - **Strengths:** Effective in aggressive or severe periodontitis; reduces key pathogens; enhances PD reduction and CAL gain.
   - **Limitations:** Risk of antimicrobial resistance, systemic adverse effects, and patient compliance issues.
   - **Role:** Targeted adjunct for patients with generalized aggressive disease [34–36].
3. **Local Drug Delivery Systems**
   - **Strengths:** High local drug concentrations; reduced systemic risks; effective for localized lesions.
   - **Limitations:** Limited effect in generalized disease; requires precise placement in pockets.
   - **Role:** Preferred in localized periodontal defects, often used in combination with SRP [37–39].
4. **Host Modulation Therapy (HMT)**
   - **Strengths:** Targets host inflammatory response rather than microbes; reduces tissue breakdown; long-term stability.
   - **Limitations:** Best used as adjunct; not a standalone therapy.
   - **Role:** Particularly valuable in patients with high inflammatory burden [40–41].
5. **Probiotics**
   - **Strengths:** Restores microbial balance, safe for long-term use, supports maintenance phase.
   - **Limitations:** Modest clinical improvements in PD/CAL; heterogeneity in strains and protocols.
   - **Role:** Adjunct for microbiome modulation and maintenance therapy [42–43].
6. **Laser Therapy / Photobiomodulation (PBM)**
   - **Strengths:** Antimicrobial, anti-inflammatory, biostimulatory; enhances soft tissue healing.
   - **Limitations:** Operator-dependent; high cost; no standardized protocols.
   - **Role:** Adjunct for moderate-to-deep pockets, tissue biostimulation, and bleeding reduction [44–45].
7. **Ozone Therapy**
   - **Strengths:** Antimicrobial and immunomodulatory; minimal side effects.
   - **Limitations:** Limited high-quality evidence; effectiveness slightly lower than laser or antimicrobial therapies.
   - **Role:** Supplementary adjunct in localized lesions [50].
8. **Regenerative Therapies (GTR, PRF, Bone Grafts, Biomaterials)**
   - **Strengths:** Highest potential for PD reduction, CAL gain, and bone regeneration; restores lost structures.
   - **Limitations:** Technique-sensitive; requires surgical expertise; higher cost.

- **Role:** First choice for intrabony defects or advanced periodontal lesions; often combined with other adjunctive modalities for maximal effect [46–49].

Table 5. Comparative Summary of Treatment Modalities

Modality	PD Reduction	CAL Gain	Microbial Control	Host Modulation	Regenerative Potential	Cost	Evidence Level	Reference
SRP	Moderate	Moderate	Moderate	None	None	Low	High	[33]
SRP + Systemic AB	High	High	High	None	None	Moderate	High	[34,35]
SRP + Local AB	High	High	High	None	None	Moderate	Moderate	[37–39]
Host Modulation	Moderate	Moderate	Moderate	High	None	Moderate	Moderate	[40,41]
Probiotics	Low	Low	Moderate	Moderate	None	Low	Low	[42,43]
Laser Therapy	Moderate	Moderate	High	Moderate	None	High	Moderate	[44,45]
Regenerative (GTR / PRF)	High	High	Moderate	Moderate	High	High	High	[46–49]
Ozone Therapy	Low	Low	Moderate	Low	Low	Moderate	Low	[50]

Overall Interpretation:

- **Combination therapy consistently outperforms monotherapy**. For example, SRP + local antibiotics, host modulation, or regenerative procedures yields superior clinical outcomes compared to SRP alone.
- **Regenerative therapy** demonstrates the greatest clinical benefit for tissue restoration, whereas biologic adjuncts (probiotics, laser, ozone) are valuable for microbial and inflammatory control, particularly in maintenance or moderate disease.
- **Treatment selection should be personalized**, taking into account disease severity, patient systemic status, defect type, cost, and patient compliance.

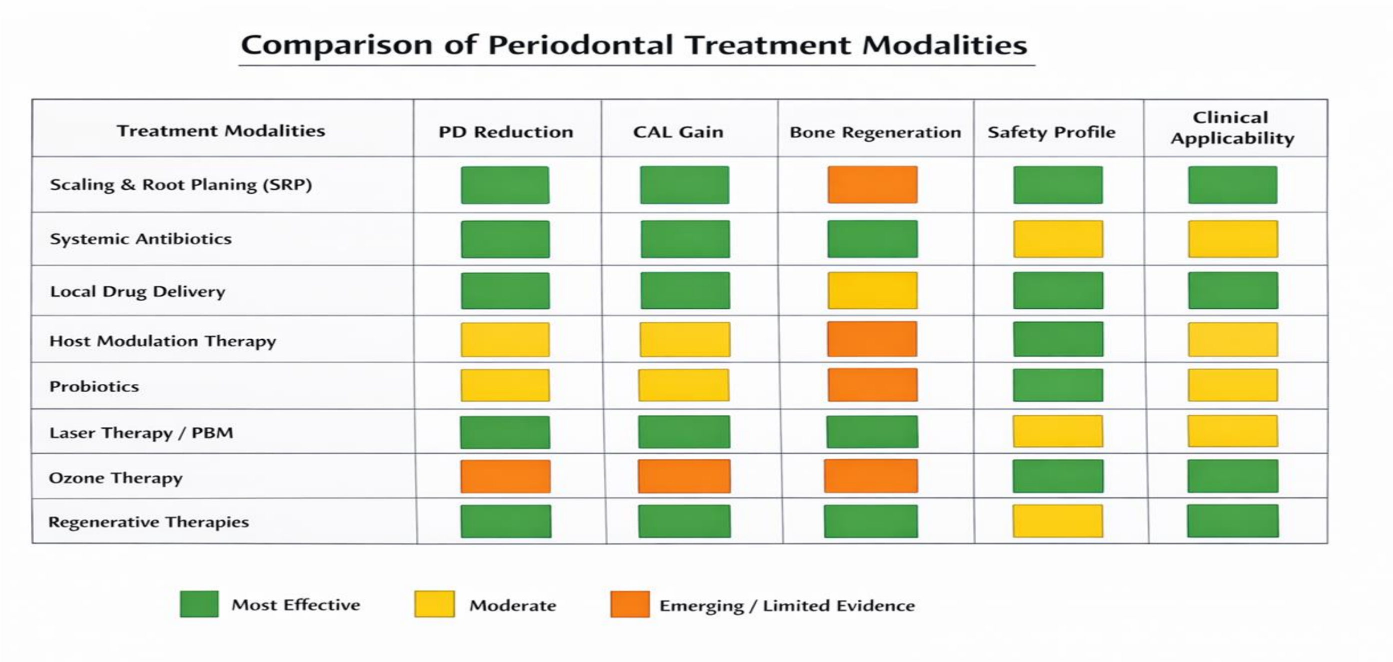

Figure 3. Comparative Effectiveness of Periodontal Treatment Modalities.

Figure 3 summarizes the relative clinical effectiveness of major periodontal therapies, including Scaling & Root Planing (SRP), systemic antibiotics, local drug delivery, host modulation therapy, probiotics, laser therapy/photobiomodulation (PBM), ozone therapy, and regenerative therapies. Color coding reflects clinical impact: green = most effective, yellow = moderate effect, and orange = emerging or limited evidence. Effectiveness was assessed based on probing depth (PD) reduction, clinical attachment level (CAL) gain, bone regeneration, safety profile, and clinical applicability. The figure highlights that regenerative therapies and adjunctive systemic/local antimicrobials consistently achieve superior outcomes, while biologic and emerging therapies provide supportive benefits, particularly in maintenance and localized lesions.

4. DISCUSSION

The present systematic review provides a comprehensive evaluation of contemporary treatment modalities for periodontitis, emphasizing the shift from conventional mechanical approaches toward multimodal, biologically driven, and patient-centered strategies. The findings highlight that while scaling and root planing (SRP) remains the cornerstone of periodontal therapy, its effectiveness is significantly enhanced when combined with adjunctive therapeutic approaches [30–32].

SRP demonstrated consistent improvements in probing depth (PD) reduction and clinical attachment level (CAL) gain; however, its limitations in deep periodontal pockets and anatomically complex sites remain evident [33]. These limitations necessitate the incorporation of adjunctive therapies to achieve optimal clinical outcomes. The adjunctive use of systemic antibiotics has been shown to improve treatment efficacy, particularly in severe and aggressive forms of periodontitis. Combinations such as amoxicillin and metronidazole have demonstrated significant reductions in periodontal pathogens and improvements in attachment levels [34,35]. Nevertheless, concerns regarding antimicrobial resistance, patient compliance, and adverse reactions restrict their routine use in clinical practice [36]. Local antimicrobial delivery systems offer a targeted and effective alternative, allowing high concentrations of therapeutic agents to be delivered directly into periodontal pockets while minimizing systemic exposure. Agents such as doxycycline gels, minocycline microspheres, and chlorhexidine chips have shown sustained antimicrobial activity and improved periodontal outcomes [37–39]. These systems are particularly advantageous in managing localized periodontal lesions and in patients where systemic antibiotic use is contraindicated. Host modulation therapy represents a significant advancement in periodontal treatment by addressing the host inflammatory response rather than solely focusing on microbial elimination. Sub-antimicrobial dose doxycycline has been shown to inhibit matrix metalloproteinases, thereby reducing collagen breakdown and tissue destruction [40]. Additionally, omega-3 fatty acids and other anti-inflammatory agents have demonstrated beneficial effects in modulating the host response and improving clinical parameters [41]. This approach reflects the modern understanding of periodontitis as a host-mediated inflammatory disease.

The use of probiotics as an adjunctive therapy has gained considerable attention in recent years. Probiotics contribute to the restoration of microbial balance by suppressing pathogenic bacteria and promoting beneficial microbial communities [42]. Clinical studies included in this review indicate reductions in plaque accumulation, gingival inflammation, and bleeding on probing. However, heterogeneity in probiotic strains, dosages, and treatment protocols limits the generalizability of these findings [43].

Laser-assisted periodontal therapy has emerged as a promising adjunctive modality due to its antimicrobial, anti-inflammatory, and biostimulatory properties. Lasers such as Nd:YAG and Er:YAG have been shown to enhance bacterial reduction and improve tissue healing [44,45].Furthermore, photobiomodulation therapy promotes cellular proliferation and microcirculation, contributing to improved clinical outcomes. Despite these advantages, the lack of standardized protocols and the high cost of equipment remain significant limitations.

Regenerative therapy represents one of the most important developments in modern periodontology. Techniques such as guided tissue regeneration (GTR), bone grafting, and the application of platelet concentrates (PRF, PRP) aim to restore lost periodontal structures rather than merely arrest disease progression [46–48]. The evidence suggests that these approaches are particularly effective in treating intrabony defects and furcation involvement. Platelet-rich fibrin, in particular, has demonstrated enhanced wound healing and tissue regeneration due to its high concentration of growth factors [49].

Ozone therapy and other emerging modalities have also been investigated for their antimicrobial and healing-promoting properties. While preliminary results are promising, the current evidence base remains limited, and further high-quality studies are required to establish their clinical efficacy [50].

An important trend identified in this review is the movement toward personalized periodontal therapy, where treatment is tailored to individual patient characteristics, including genetic predisposition, systemic health status, and microbiome composition [51]. Advances in digital dentistry, artificial intelligence, and salivary diagnostics are expected to further enhance the precision of periodontal treatment planning and monitoring [52].

This systematic review highlights the evolution of periodontal therapy from conventional mechanical approaches toward integrated, multimodal strategies that combine antimicrobial, host-modulatory, and regenerative principles. A comparative analysis of the included studies demonstrates that no single treatment modality is universally superior; rather, clinical success depends on the appropriate combination of therapies tailored to disease severity and patient-specific factors [30–32]. Scaling and root planing (SRP) remains the foundation of periodontal therapy and consistently provides significant improvements in probing depth (PD) reduction and clinical attachment level (CAL) gain. However, when compared with adjunctive therapies, SRP alone demonstrates inferior outcomes in deep periodontal pockets and advanced disease stages [33]. Studies included in this review indicate that adjunctive therapies can enhance the effectiveness of SRP by addressing limitations related to microbial persistence and host inflammatory response.

When comparing systemic antibiotics with SRP alone, the combination therapy shows superior clinical outcomes, particularly in aggressive and severe periodontitis. The addition of amoxicillin and metronidazole results in greater reductions in periodontal pathogens and improved CAL gain [34,35]. However, compared to local antimicrobial delivery systems, systemic antibiotics present disadvantages, including the risk of antimicrobial resistance, systemic side effects, and patient compliance issues [36]. In contrast, local delivery systems such as doxycycline gels and minocycline microspheres provide targeted antimicrobial action with fewer systemic risks, making them preferable for localized disease management [37–39].

A comparison between antimicrobial therapies and host modulation therapy reveals distinct mechanisms and complementary roles. While antimicrobials primarily target bacterial load, host modulation therapies, such as sub-antimicrobial dose doxycycline, act on inflammatory pathways by inhibiting matrix metalloproteinases and cytokine activity [40]. Clinical outcomes suggest that host modulation provides additional benefits in reducing tissue destruction and maintaining long-term stability when used alongside SRP [41]. Therefore, combining antimicrobial and host-modulating approaches may yield superior results compared to either strategy alone. Probiotics represent a biologically oriented alternative that differs fundamentally from conventional antimicrobial approaches. Unlike antibiotics, probiotics aim to restore microbial balance rather than eliminate bacteria. Comparative studies indicate that probiotics produce modest but consistent improvements in plaque index and gingival inflammation; however, their clinical efficacy remains lower than that of antibiotics or local antimicrobials in terms of PD reduction and CAL gain [42,43]. Nevertheless, probiotics offer advantages in safety and long-term microbiome stabilization, making them valuable as adjunctive therapies, particularly in maintenance phases.

The comparison between laser therapy and conventional SRP demonstrates that laser-assisted treatment provides additional benefits in bacterial reduction, hemostasis, and wound healing. Studies using Er:YAG and Nd:YAG lasers show improved clinical outcomes compared to SRP alone, particularly in terms of reduced bleeding on probing and enhanced tissue repair [44,45]. However, when compared to antimicrobial therapies, laser treatment does not consistently demonstrate superior PD reduction, and its effectiveness may depend on operator skill and equipment parameters. Additionally, cost and lack of standardized protocols limit its widespread clinical use.

Among all treatment modalities, regenerative therapies demonstrate the most significant potential for restoring lost periodontal structures. Compared to non-surgical and antimicrobial approaches, techniques such as guided tissue regeneration (GTR), bone grafting, and platelet-rich fibrin (PRF) provide superior outcomes in terms of bone fill and attachment gain, particularly in intrabony defects [46–48]. PRF, in particular, offers advantages due to its autologous nature, ease of preparation, and sustained release of growth factors [49]. However, regenerative procedures are technique-sensitive, require surgical expertise, and are associated with higher costs, which may limit their routine application.

Emerging therapies such as ozone therapy and other adjunctive modalities show promising antimicrobial and healing effects. However, when compared to established treatments, their clinical efficacy remains less well supported due to limited high-quality evidence [50]. Therefore, these therapies should currently be considered supplementary rather than primary treatment options.

A key finding of this review is that combination therapy consistently outperforms monotherapy. For example, SRP combined with antimicrobials, host modulation, or regenerative techniques results in greater improvements in clinical parameters compared to SRP alone [51]. This supports the current trend toward personalized periodontal treatment, where therapy is tailored based on disease severity, patient risk factors, and biological response [52].

From a clinical perspective, treatment selection should be guided by:

- Disease severity (mild vs. advanced periodontitis)
- Patient systemic condition (e.g., diabetes, smoking)
- Site-specific factors (pocket depth, bone defects)
- Cost-effectiveness and patient compliance

Limitations

Despite the comprehensive nature of this review, several limitations should be acknowledged. First, there is significant heterogeneity among the included studies in terms of study design, treatment protocols, and outcome measures, which limits direct comparison and meta-analysis[53].

Second, many studies have relatively short follow-up periods, making it difficult to assess the long-term stability of treatment outcomes [54].

Additionally, variability in clinical measurement techniques and differences in operator skill may have influenced the reported outcomes. The inclusion of studies with moderate risk of bias further affects the overall strength of the evidence[55]. Emerging therapies such as probiotics, laser therapy, and ozone treatment lack standardized clinical protocols and long-term data, which limits their current clinical applicability [56].

Finally, publication bias cannot be excluded, as studies reporting positive outcomes are more likely to be published. Future research should focus on large-scale randomized controlled trials with standardized methodologies and extended follow-up periods to validate the effectiveness of modern periodontal therapies [57–60].

5. CONCLUSION

Modern periodontal therapy has undergone a significant transformation, evolving from a predominantly mechanical approach to a comprehensive, multimodal, and patient-centered strategy. This systematic review demonstrates that while scaling and root planing remains the fundamental component of treatment, its effectiveness is significantly enhanced when combined with adjunctive therapies.

Among the evaluated modalities:

- **Systemic antibiotics** provide strong clinical improvements but are limited by resistance concerns
- **Local antimicrobial agents** offer effective, targeted therapy with fewer systemic risks
- **Host modulation therapy** addresses the underlying inflammatory response and improves long-term outcomes
- **Probiotics** contribute to microbiome balance with high safety but modest efficacy
- **Laser therapy** enhances healing but lacks standardization
- **Regenerative techniques** provide the greatest potential for true periodontal restoration.

No single treatment modality is universally superior; instead, combination therapy tailored to individual patient needs yields the best clinical outcomes. The integration of antimicrobial, anti-inflammatory, and regenerative strategies represents the current gold standard in periodontal care.

Future directions in periodontology should focus on:

- Long-term clinical trials
- Standardization of emerging therapies
- Development of personalized treatment protocols
- Integration of microbiome and biomarker-based diagnostics

In conclusion, the management of periodontitis requires a holistic and individualized approach, combining evidence-based therapies to achieve optimal clinical and functional outcomes.

FUNDING

This research did not receive funding from any agency or institution.

Conflict of Interest

None to declare.

Ethical Approval

“Not applicable”

Consent for publication

“Not applicable”

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