Non-surgical periodontal treatment and adjunctive use of oxygen therapy

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Abstract

Background: Periodontitis is a chronic, multifactorial disease in which bacterial biofilm and the immune response play crucial roles in its manifestation across various stages and grades. Non-surgical treatment remains the gold standard for managing periodontitis and can be performed with or without adjunctive methods. The use of oxygen as an adjunctive periodontal therapy is a very promising topic, and numerous studies have been conducted to evaluate its effectiveness.
Aim: To identify and critically discuss articles related to non-surgical periodontal treatment and adjunctive oxygen therapies.
Methods: A literature review was conducted using the PubMed and Google Scholar databases. The search included articles published in English from January 1960 to January 2026, using the keywords 'periodontal treatment', 'periodontitis', 'residual pockets' and 'adjunctive oxygen therapy'. The included studies varied in design, encompassing in-vitro and in vivo, prospective and retrospective studies, cohort studies, randomized clinical trials, systematic reviews, and evidence-based clinical practice guidelines.
Results: A variety of studies were reviewed to assess the effectiveness of adjunctive oxygen therapy in periodontal treatment. Oxygenation of tissues can be achieved by oxygen-based adjunct therapies in patients with periodontitis, including ozone therapy, hyperbaric oxygen therapy, and local oxygen delivery, as adjuncts to subgingival instrumentation.
Conclusions: The current body of literature encompasses various aspects of oxygen's impact on biological tissues, as well as the application and efficacy of adjunctive oxygen therapy in the field of periodontology. More randomized controlled trials are needed to identify the most effective adjunctive oxygen treatment method for subgingival instrumentation, in order to control periodontal disease and reduce the need for surgical re-treatment. (**TCM-GMJ August 2026; 11 (3): P12-P16)**

Keywords: Periodontitis, Periodontal Non-surgical Treatment, Adjunctive Oxygen Therapy.

Introduction

Periodontitis is a chronic multifactorial inflammatory disease associated with dysbiotic plaque biofilms and characterized by progressive destruction of the tooth-supporting apparatus. Its primary features include the loss of periodontal tissue support, manifested through clinical attachment loss (CAL) and radiographically assessed alveolar bone loss, presence of periodontal pocketing and gingival bleeding. Periodontitis is a major public health problem due to its high prevalence, as well as because it may lead to tooth loss and disability, negatively affect chewing function and aesthetics, be a source of social inequality, and impair quality of life. Periodontitis accounts for a substantial proportion of edentulism and masticatory dysfunction, results in significant dental care costs and has a plausible negative impact on general health (1).

Throughout history, numerous periodontal treatment modalities have been proposed, most of which have focused primarily on plaque removal either at home or in the clinic. Nonetheless, many adjunctive treatments have also been introduced to enhance the antimicrobial effect or the healing capacity of the tissues. If non-surgical treatment fails to close periodontal pockets, surgical treatment options have been proposed as the next step in therapy.

The European Federation of Periodontology (EFP) has recently (2020) published clinical guidelines for treating periodontitis, aiming to help clinicians provide evidence-based treatments to stop the disease and maintain long-term periodontal health and function (2). Overall, the treatment plan has not changed significantly, although the stages of treatment and effective methods have been refined based on evidence. Patients, once diagnosed, should be treated according to a pre-established stepwise ap-

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proach to therapy that, depending on the disease stage, should be incremental, each including different interventions: 1. The first step in therapy is aimed at guiding behavior change by motivating the patient to undertake successful removal of supragingival dental biofilm and risk factor control and professional mechanical plaque removal (PMPR). 2) The second step of therapy (cause-related therapy) is aimed at controlling (reducing/eliminating) the subgingival biofilm and calculus (subgingival instrumentation - SI). These two steps represent the primary phases of non-surgical periodontal therapy. 3. In case if these desired outcomes are not achieved further subgingival instrumentation or surgical treatment options may need to be considered (step 3), especially in Periodontitis Stages III and IV. 4. After gaining clinical results all patients undergo supportive periodontal care which is aimed at maintaining periodontal stability in all treated periodontitis patients combining preventive and therapeutic interventions defined in the first and second steps of therapy, depending on the gingival and periodontal status of the patient's dentition (2).

Tomasi et al. (3) evaluated the non-surgical periodontal treatment approaches in general dental care. Pocket closure was achieved at an average of about 70% of sites at 6 months after step 1 and 2. Residual pockets could provide possible conditions for subgingival recolonization and recurrence of periodontitis with a greater risk of further attachment loss and tooth loss. Therefore, they could require a further step of therapy consisting in either subgingival re-instrumentation with or without adjunctive therapies or periodontal surgery. Various adjunctive therapies to nonsurgical retreatment have been investigated to reduce the need for periodontal surgery, including locally delivered doxycycline, diode soft laser therapy, antimicrobial photodynamic therapy, 25% tetracycline fibers, 2% minocycline gel, 25% metronidazole gel, enamel matrix derivatives, and hyaluronic acid (4).

In recent years, there has been growing interest in the adjunctive use of oxygen in dentistry, particularly in non-surgical periodontal treatment. The role of oxygen in wound healing has been studied extensively since the 1960s when Hunt et al. (5) identified that adequate wound oxygenation could enhance formation of granulation tissues and synthesis of collagen. Recent years have brought an increased and more detailed scientific appreciation of the diverse roles that oxygen plays in normal physiology and disease states (6). During these years it was defined that Reactive Oxygen Species (ROS) also mediates bactericidal killing (7). Common ROS include peroxide anion ($HO2^-$), hydroxyl ion (OH^-), superoxide anion ($O2^-$) and hydrogen peroxide (H_2O_2) (6).

Given the central role of oxygen in healing, there is the potential to manipulate the wound environment by treatment with supplemental oxygen. Oxygen therapy in various forms have been used to ameliorate many medical condition for centuries. However, clinical results have been varied, and frequently disappointing. However, in the face of deeper scientific understanding of oxygen physiology, and with support from randomized, prospective clinical investigations, the judicious, individualized use of oxygen therapy in wound management may now be considered mainstream (6).

Therefore, the use of oxygen in periodontology as an adjunctive periodontal therapy is a very promising topic, and a number of researchers are conducting studies to evaluate its effectiveness.

Methods

A literature review was conducted using the PubMed and Google Scholar databases. The search included articles published in English from January 1960 to January 2026, using the keywords ‘periodontal treatment’, 'periodontitis', 'wound healing' and 'adjunctive oxygen therapy’. The included studies varied in design, encompassing prospective and retrospective studies, cohort studies, randomized clinical trials, systematic reviews, and evidence-based clinical practice guidelines.

Results and discussion

A variety of studies were reviewed to assess the effectiveness of adjunctive oxygen therapy in periodontal treatment. After evaluating article details, study quality, and risk of bias, randomized controlled trials, comparative clinical studies, narrative and systematic reviews were included in this narrative review. The current body of literature encompasses various aspects of oxygen’s impact on biological tissues, as well as the application and efficacy of adjunctive oxygen therapy in the field of periodontology.

Although periodontitis has a well-established microbial etiology, its pathogenesis is multifactorial, shaped by a complex inter play of genetic predisposition, environmental exposures, and lifestyle-related risk factors. These factors can influence not only the composition and behavior of the subgingival microbiota but also modulate the host's immunoinflammatory response, ultimately impacting clinical outcomes (8–10). The oxygen concentration at the base of untreated periodontal pockets measuring 5 mm to 10 mm in depth has been reported to be as low as 1.8%, classifying it as hypoxic (11). Under low-oxygen conditions, cells may experience metabolic stress and altered mitochondrial function, which can increase the production of ROS. The host’s immune response is characterized by the recruitment of macrophages that release ROS, such as hydrogen peroxide (H_2O_2) or superoxide (O_2^-), which are crucial for pathogen elimination. An imbalance between elevated ROS levels and antioxidant defense mechanisms, referred to as oxidative stress, can contribute to further tissue damage and inflammation. Ongoing imbalance can affect the vascular network involved in regulating inflammation, where the hypoxic microenvironment may act as both a cause and a consequence of inflammatory processes. Tissue hypoxia can lead to the activation of genes involved in inflammation, thereby sustaining chronic inflammatory responses. Conversely, chronic inflammation can impair blood flow and oxygen delivery through tissue edema and microvascular abnormalities, worsening hypoxia. Consequently, a synergistic interaction between hypoxia, microbes of the subgingival biofilm, and inflammation may play a pivotal role in the chronicity of periodontitis (12).

According to these data periodontal wound healing is very complex and is effected by a lot of anatomical, systemic and behavioral factors. Gingival tissues and periodontal ligament which consists of connective tissues and collagen fibers are produced by fibroblasts. They need favorable environment for optimal functioning during wound healing process. Oxygen is known to promote collagen synthesis and neoangiogenesis through vascular endothelial growth factor release, and is currently used in several settings, such as wound and burn healing, for its essential role in epithelialization and its anti-inflammatory effect (13–15). Oxygenation of tissues can be achieved by oxygen-based adjunct therapies in patients with periodontitis, including ozone therapy, hyperbaric oxygen therapy (HOB), and local oxygen delivery, as adjuncts to subgingival instrumentation (12).

Like periodontal wounds bacterial colonization, a nearly universal feature of all chronic wounds, adds to the inflammatory burden by attracting and activating leukocytes. Although inflammatory cells are capable of producing ROS at low oxygen tensions, the antidotes to ROS (the most potent of which is nitric oxide) require higher oxygen tension for their synthesis (6). Oxygen tension can effect on tissue fibroblast growth and collagen biosynthesis. Tissue fibroblast growth and collagen biosynthesis are related to oxygen tension. Kan et al. (16) conducted an in vitro study on human fibroblasts. They found that hypoxia was responsible for delayed wound healing with a reduction in the amount of collagen in the wound, which was associated with an increase in matrix metalloproteinase-1 (MMP-1) synthesis. Moreover, Kang et al. (17) conducted another in vitro study on HBO treatment on human dermal fibroblasts. They found that daily HBO treatment at 2·0 standard atmosphere (ATM) selectively stimulated fibroblast proliferation after 7 days, together with an increase in basic fibroblast growth factor production. Hyperbaric oxygen has been successfully used in several medical applications. Well known are the effects of HBO on osteointegration (18). Principally, HBO has been shown to affect angiogenesis (19), bone metabolism and bone turnover (20). The microbiological data presented in the Signoretto et al study (21) clearly indicate that a combination of both HBO and non-surgical periodontal treatment substantially reduced (by up to 99.9%) the gram-negative anaerobe loads of the subgingival microflora. These very low values of pathogens persisted for at least two months after the therapy.

Ozone therapy is one potential adjunctive treatment to the gold standard subgingival instrumentation (SI), involving various forms of applying medical-grade ozone gas, generated from medical oxygen, to affected periodontal tissues. It is believed to work through antimicrobial, anti-inflammatory, and immune modulating effects (22). Ozone can be delivered in its gaseous state, as ozonated water or as ozonated oils such as olive oil or sunflower oil, which act as lipophilic carriers that enable the gradual release of reactive oxygen species (23), potentially prolonging antimicrobial effects in periodontal pockets. Gaseous ozone offers deeper tissue penetration due to its high diffusibility, but requires careful dose control to prevent cytotoxicity (12).

In 2025 Kollmar et al (12) conducted systematic review of Oxygen-based adjunct therapies in periodontitis. Evaluation of study quality and risk of bias: Thirty-four randomized controlled or comparative clinical studies were included in the narrative review. Eight randomized controlled trials (RCTs) were found eligible for the meta-analyses; seven for ozone, one for HBO, and zero for local oxygen therapies. Therefore, a meta-analysis could only be performed for ozone therapies. Six study protocols comprised ozone administration in its gaseous form generated from medical grade oxygen (24–29), twelve comprised ozonated water (30–41), one was a combination of both (42), six used ozonated olive oil (43–48), and one used ozonated sunflower oil (49). All gaseous ozone studies failed to show significant advantages compared to SI alone, while two of them even reported disadvantageous results, although insignificant (50,51). Six RCTs investigating adjunctive HBO to SI were found eligible for inclusion into the narrative of this systematic review (52–56). All of them compared SI with adjunctive HBO to SI alone. although a meta-analysis was not feasible, the included HBO studies collectively indicate beneficial effects of adjunctive therapy. Most studies applied 8–20 sessions of HBO, with individual sessions lasting 60–120 min at pressures of 1.4–2.5 atmospheres absolute (ATA). One single RCT qualified for inclusion in the narrative of this systematic review, but did not test against SI alone as control group. Medical grade oxygen was locally applied for 15 min at a flow rate of 5 L/min via an individualized elastic silicon tray that covered the whole dental arc sealing tightly to the surrounding mucous membranes. The procedure was repeated three times per day for ten consecutive days. A reduction in CAL was reported, but not significant (57).

Conclusion

The accumulated evidence over several decades clearly supports the critical role of nonsurgical periodontal therapy as the primary first step in treating periodontitis. Regardless of the specific tools or devices used, their long-term effects are evident for different outcome variables: improvements in probing depth and attachment levels, gingival inflammation, and effective reduction of dental biofilm. These changes consistently lead to better tooth retention, which remains the most important outcome for oral health (58).

According to the accumulated scientific data, oxygen influences cellular metabolism, tissue remodeling, and the key processes involved in tissue damage and repair during pathological conditions. Considering the background and etiology of periodontitis, oxygen therapies have garnered significant interest for their potential to modulate the inflammatory host response including the hypoxic microenvironment within periodontal pockets (12). Oxygenation of tissues in patients with periodontitis can be achieved through oxygen-based adjunct therapies, including ozone therapy, hyperbaric oxygen therapy, and local oxygen delivery, used alongside subgingival instrumentation.

As demonstrated by the systematic review (12), long-term effects (>12 months) could not be assessed due to lack of available data, but short-term benefits (up to six months) seem feasible, depending on the mode of administration. Significant benefits to SI were particularly observed for HBO and ozonated olive oil in the narrative synthesis. These findings are based on lower-level evidence and should be interpreted cautiously. According to the authors, while the moderate effect size in favor of ozone therapies could be clinically relevant, the lack of statistical significance highlights the need for more evidence before widespread adoption.

There are many gaps in understanding of the biochemical events of healing. Some of the current knowledge regarding oxygen, growth factors, and other mediators is seemingly contradictory, and classification of molecules as promoters or inhibitors of healing (example: oxygen is good, tumor necrosis factor-a [TNF-a] is bad) is simplistic. However, it seems possible to reach a unified understanding of healing that reconciles most of the thousands of basic science investigations into individual steps in the chain, and oxygen is central to this (6).

Various alternative or adjunctive therapies have been suggested, but there is limited evidence available to support a clear added value to conventional subgingival instrumentation (58). More randomized controlled trials are needed to identify the most effective adjunctive oxygen treatment method for subgingival instrumentation, in order to control periodontal disease and reduce the need for surgical re-treatment.

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