Efficacy of Tetracycline Fiber versus Oxygen-releasing Gel as Adjuncts to Scaling and Root Planing in Periodontitis: A Randomized Controlled Study

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Aim:
To evaluate and compare the clinical and microbiological effectiveness of tetracycline hydrochloride fiber and oxygen-releasing gel as adjuncts to scaling and root planing (SRP) in patients with periodontitis.

Material and Methods:
A randomized controlled clinical trial was conducted among 26 systemically healthy patients diagnosed with chronic periodontitis. Participants were randomly assigned into two groups: Group I received SRP with tetracycline hydrochloride fibers, and Group II received SRP with oxygen-releasing gel. Clinical parameters including Plaque Index (PI), Gingival Index (GI), Oral Hygiene Index-Simplified (OHI-S), Probing Pocket Depth (PPD), and Bleeding on Probing (BOP) were recorded at baseline, 1 month, and 3 months. Microbiological evaluation using colony-forming units (CFU) was performed at baseline and 1 month. Statistical analysis was carried out using repeated measures ANOVA and unpaired t-test, with significance set at $p < 0.05$.

Results:
Both groups demonstrated statistically significant improvements in all clinical parameters and reduction in CFU levels from baseline to follow-up periods ($p < 0.05$). However, intergroup comparison revealed no statistically significant difference between tetracycline fiber and oxygen-releasing gel groups at any time interval ($p > 0.05$).

Conclusion:
Tetracycline hydrochloride fibers and oxygen-releasing gel are equally effective as adjuncts to SRP in the management of periodontitis. Oxygen-releasing gel may serve as a promising non-antibiotic alternative.

Clinical Significance:
The use of oxygen-releasing gel offers an effective adjunctive treatment modality in periodontal therapy, potentially reducing dependence on antibiotics and minimizing the risk of antimicrobial resistance.

Keywords

(Tetracycline hydrochloride fiber , Oxygen-releasing gel , Probing pocket depth Colony-forming units . Non-surgical periodontal therapy)

Introduction

Periodontitis is a chronic inflammatory disease affecting the supporting structures of the teeth, characterized by progressive attachment loss, alveolar bone resorption, and ultimately tooth loss if left untreated. It results from a complex interplay between subgingival microbial biofilm and the host immune-inflammatory response **(1,2)**.Despite advances in understanding its pathogenesis, effective management of periodontal infections remains a clinical challenge, particularly in sites with deep periodontal pockets and complex root anatomy.Scaling and root planing (SRP) is considered the gold standard for nonsurgical periodontal therapy **(3)**. It aims to mechanically disrupt and remove subgingival biofilm and calculus, thereby reducing microbial load and inflammation. However, SRP alone may not always achieve complete debridement, especially in deep pockets, furcation areas, and inaccessible root surfaces. Residual bacteria in these sites can lead to recolonization and persistence of disease activity, necessitating adjunctive therapeutic approaches **(4)**.

Local drug delivery (LDD) systems have been developed to enhance the effectiveness of SRP by delivering antimicrobial agents directly into periodontal pockets. These systems provide high local concentrations of drugs with minimal systemic exposure and reduced risk of adverse effects **(5)**. Among them, tetracycline hydrochloride fibers have been widely used due to their broad-spectrum antimicrobial activity, substantivity, and additional host-modulating effects such as inhibition of collagenase and matrix metalloproteinases **(6,7)**.In recent years, there has been increasing interest in non-antibiotic therapeutic strategies due to the growing concern of antimicrobial resistance associated with repeated antibiotic use **(8)**. Oxygen-releasing gel represents one such novel approach. It acts by increasing oxygen tension within the periodontal pocket, thereby creating an unfavorable environment for anaerobic periodontal pathogens.

Additionally, enhanced oxygen availability may promote angiogenesis, fibroblast activity, and overall wound healing **(9)**.

Although both tetracycline fibers and oxygen-releasing gel have individually demonstrated beneficial effects as adjuncts to SRP, direct comparative clinical studies between these two modalities are scarce in the literature **(10)**. Most existing studies have evaluated these agents independently or compared them with other antimicrobial systems, leaving a gap in evidence regarding their relative effectiveness. There is limited evidence directly comparing antibiotic-based local drug delivery systems with non-antibiotic oxygen-based therapies in the management of periodontitis, particularly in terms of both clinical and microbiological outcomes. The present study is among the few randomized controlled clinical trials to directly compare tetracycline hydrochloride fibers with oxygen-releasing gel as adjuncts to SRP. It uniquely evaluates both clinical parameters and microbiological outcomes, thereby providing a comprehensive assessment of their therapeutic efficacy. Furthermore, by exploring a non-antibiotic alternative, the study contributes to the growing emphasis on antibiotic stewardship in periodontal therapy **(11)**.Therefore, the aim of the present study was to evaluate and compare the clinical and microbiological effectiveness of tetracycline hydrochloride fiber and oxygen-releasing gel as adjuncts to scaling and root planing in patients with periodontitis.

Materials and Methods

The present study was designed as a randomized, double-blinded, controlled clinical trial with a follow-up period of three months. The study protocol was reviewed and approved by the Institutional Ethical Committee of Sri Venkateshwaraa Dental College, Puducherry, and was conducted in accordance with the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to their inclusion in the study. A total of 26 systemically healthy patients diagnosed with chronic periodontitis were selected from the outpatient department of Periodontology. The sample size was determined using G*Power software, with a statistical power of 95% and a significance level of 5%, resulting in 13 subjects in each group. Patients aged between 30 and 60 years, presenting with at least one site exhibiting a probing pocket depth (PPD) of ≥5 mm, were included in the study. Patients who were smokers, tobacco users, pregnant or lactating women, those who had undergone periodontal therapy within the previous six months, or those who had received antibiotics or anti-inflammatory drugs within the last three months were excluded. Additionally, patients with systemic conditions known to influence periodontal health were not included.

The selected participants were randomly allocated into two groups using a computer-generated randomization sequence. Allocation concealment was ensured using sequentially numbered, opaque, sealed envelopes. Both the examiner and the participants were blinded to the treatment allocation to minimize bias. Group I received scaling and root planing (SRP) followed by placement of tetracycline hydrochloride fibers, whereas Group II received SRP followed by application of oxygen-releasing gel.

All clinical parameters were recorded by a single calibrated examiner at baseline, one month, and three months using a UNC-15 periodontal probe. The parameters assessed included Plaque Index (Silness and Löe), Gingival Index (Löe and Silness), Oral Hygiene Index-Simplified (Greene and Vermillion), Probing Pocket Depth (PPD), and Bleeding on Probing (BOP). For microbiological evaluation, subgingival plaque samples were collected from the deepest periodontal pocket using sterile paper points. The samples were transferred to appropriate transport media and subjected to anaerobic culture techniques. Colony-forming units (CFU) were quantified to assess the microbial load at baseline and at one month.

All participants underwent full-mouth scaling and root planing using both ultrasonic and hand instruments under aseptic conditions. In Group I, tetracycline hydrochloride fibers were carefully placed into the periodontal pocket and secured with a periodontal dressing. In Group II, oxygen-releasing gel was applied into the periodontal pocket, followed by placement of periodontal dressing. Postoperative instructions were provided to all patients, and they were advised to maintain optimal oral hygiene. No systemic antibiotics or adjunctive antimicrobial mouth rinses were prescribed during the study period. Patients were recalled at one month and three months for follow-up evaluation, during which clinical parameters were reassessed and oral hygiene instructions were reinforced. The collected data were subjected to statistical analysis using SPSS software . Intragroup comparisons were performed using repeated measures ANOVA, while intergroup comparisons were analyzed using the unpaired t-test. A p-value of less than 0.05 was considered statistically significant.

Statistical Analysis

The collected data were analyzed using IBM SPSS Statistics. Results were expressed as mean ± standard deviation. Intragroup comparisons were performed using repeated measures ANOVA, while intergroup comparisons were analyzed using the unpaired t-test. A p-value < 0.05 was considered statistically significant.

Results

All 26 patients completed the study without any adverse events. Both groups showed statistically significant improvement in all clinical parameters, including Plaque Index, Gingival Index, OHI-S, Probing Pocket Depth, and Bleeding on Probing from baseline to 3 months ($p < 0.05$).Microbiological evaluation demonstrated a significant reduction in colony-forming units at 1 month in both groups ($p < 0.05$), indicating effective reduction in subgingival microbial load. Intergroup comparison revealed no statistically significant difference between the tetracycline fiber and oxygen-releasing gel groups at any time interval ($p > 0.05$).

Discussion

The present randomized controlled clinical trial evaluated the effectiveness of tetracycline hydrochloride fibers and oxygen-releasing gel as adjuncts to scaling and root planing (SRP) in patients with periodontitis. The findings demonstrated that both treatment modalities resulted in significant improvements in clinical and microbiological parameters; however, no statistically significant difference was observed between the two groups. The significant

reduction in Plaque Index, Gingival Index, and OHI-S scores in both groups can be attributed primarily to effective mechanical debridement combined with improved patient compliance and oral hygiene maintenance. These findings are consistent with established evidence that SRP, when combined with appropriate adjunctive therapy, enhances periodontal health by reducing microbial load and inflammation **(3,5)**.

The observed reduction in probing pocket depth (PPD) and bleeding on probing (BOP) in both groups indicates resolution of inflammation and improvement in periodontal tissue health. The adjunctive use of tetracycline fibers likely contributed to this outcome through sustained local release of the antimicrobial agent, leading to suppression of periodontal pathogens and inhibition of collagenase activity. This is in agreement with previous studies demonstrating the efficacy of tetracycline-based local drug delivery systems in reducing periodontal pocket depth and improving clinical attachment levels **(6,7)**. Similarly, the oxygen-releasing gel group showed comparable clinical improvements. The mechanism of action of oxygen-based therapy involves increasing oxygen tension within the periodontal pocket, thereby creating an unfavorable environment for obligate anaerobic bacteria. In addition, improved oxygen availability enhances fibroblast proliferation, collagen synthesis, and angiogenesis, all of which contribute to periodontal healing. These findings support earlier reports that oxygen-releasing agents can effectively reduce anaerobic bacterial load and promote tissue regeneration **(9)**.

Microbiological analysis in the present study revealed a significant reduction in colony-forming units (CFU) in both groups at one month, indicating effective suppression of subgingival microbial flora. However, the absence of a statistically significant difference between the two groups suggests that oxygen-releasing gel is as effective as tetracycline fibers in controlling periodontal pathogens. A key finding of this study is the comparable efficacy of a non-antibiotic modality (oxygen-releasing gel) with a conventional antibiotic-based local drug delivery system. This has important clinical implications in the current era, where concerns regarding antibiotic resistance and overuse are increasing **(8,12)**. The use of oxygen-releasing gel may provide a safer and sustainable alternative without the risk of developing resistant microbial strains. Despite these promising findings, certain limitations of the study must be acknowledged. The sample size was relatively small, and the follow-up period was limited to three months, which may not fully reflect long-term outcomes. Additionally, microbiological assessment was limited to total CFU counts rather than identification of specific periodontal pathogens. Future studies with larger sample sizes, longer follow-up durations, and advanced molecular microbiological techniques are recommended to validate and expand upon these findings **(10,11)**.

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