COMPARATIVE EVALUATION OF OXYGEN-RELEASING FORMULA (BLUE M GEL) AND CHLORHEXIDINE GEL (HEXIGEL) AS AN ADJUNCT WITH SCALING AND ROOT PLANING IN THE MANAGEMENT OF CHRONIC PERIODONTITIS:

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ABSTRACT:

Background: Chronic periodontitis continues to burden oral health worldwide, with mechanical debridement alone often falling short in deeper pockets. While chlorhexidine remains the benchmark antimicrobial adjunct, oxygen-releasing formulations present an innovative approach by targeting the anaerobic microenvironment that harbors pathogenic bacteria.

Objective: This trial compared the clinical effectiveness of an oxygen-releasing gel (Blue M Gel) against a chlorhexidine gel (Hexigel) when used alongside scaling and root planing (SRP) in patients with chronic periodontitis.

Methods: A single-blind, split-mouth randomized controlled trial enrolled 20 systemically healthy patients with chronic periodontitis. Each participant presented at least two non-adjacent sites with probing pocket depth (PPD) ≥5 mm. Sites were randomly assigned to either Group A (SRP + Blue M Gel) or Group B (SRP + Hexigel). Clinical parameters—gingival index (GI), probing pocket depth (PPD), and clinical attachment loss (CAL)—were assessed at baseline, 15 days, and 1 month. The examiner remained blinded to group allocation throughout the study.

Results: Both treatment arms showed meaningful improvements across all measured parameters from baseline to 1 month ($p < 0.05$). However, Group A demonstrated statistically superior outcomes: GI reduction of 1.60 ± 0.28 versus 1.30 ± 0.25 ($p < 0.001$), PPD reduction of 2.27 ± 0.48 mm versus 1.83 ± 0.42 mm ($p < 0.001$), and CAL gain of 1.90 ± 0.52 mm versus 1.40 ± 0.48 mm ($p < 0.001$). Inter-group comparisons at 15 days and 1 month consistently favored the oxygen-releasing formulation.

Conclusion: Blue M Gel outperformed chlorhexidine gel as an adjunct to SRP, delivering greater improvements in gingival health, pocket depth reduction, and clinical attachment gain. These findings position oxygen-releasing gels as a promising alternative in non-surgical periodontal therapy.

Keywords: Chronic periodontitis, scaling and root planing, oxygen-releasing gel, Blue M Gel, chlorhexidine gel, Hexigel, local drug delivery, split-mouth design, anaerobic bacteria

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COMPARATIVE EVALUATION OF OXYGEN-RELEASING FORMULA (BLUE M GEL) AND CHLORHEXIDINE GEL (HEXIGEL) AS AN ADJUNCT WITH SCALING AND ROOT PLANING IN THE MANAGEMENT OF CHRONIC PERIODONTITIS:

Introduction

Periodontitis stands as one of the most widespread chronic inflammatory conditions affecting humanity, gradually eroding the very structures that anchor teeth in place—the gingiva, periodontal ligament, and alveolar bone. [1] The 2018 Global Burden of Disease Study revealed that severe periodontitis afflicts roughly 796 million people globally, making it the sixth most prevalent human disease. [2] At its core lies a dysbiotic microbial biofilm that colonizes the subgingival space, inciting a destructive host immune response that ultimately dismantles the periodontal apparatus. [3]

The foundation of periodontal care rests on mechanical biofilm disruption through scaling and root planing (SRP). [4] Yet this approach carries inherent limitations, particularly when confronting pockets deeper than 5 mm. Instrument access becomes challenging in root concavities, furcation areas, and deep interproximal sites, leaving behind residual calculus and bacterial deposits that can rekindle disease activity. [5] Moreover, microorganisms embedded within dentinal tubules and cementum lacunae often survive mechanical debridement, serving as a reservoir for rapid recolonization and compromising the durability of treatment gains. [6]

To bridge these gaps, clinicians have turned to adjunctive therapies ranging from systemic antibiotics to locally delivered antimicrobial agents. [7] Among these, chlorhexidine gluconate has occupied the central stage for decades. Its broad-spectrum antimicrobial coverage, prolonged substantivity within the oral cavity, and proven plaque-inhibitory properties have cemented its status as the reference standard. [8] Nevertheless, chlorhexidine is not without its baggage—unsightly tooth staining, transient taste disturbances, and the potential to disrupt the commensal oral microbiome have prompted the search for gentler yet equally effective alternatives. [9]

A compelling new direction has emerged: harnessing oxygen to transform the periodontal pocket from a haven for anaerobic pathogens into an inhospitable environment for disease-causing bacteria. The subgingival niche in periodontitis is marked by profoundly low oxygen tension, a condition that selectively favors the proliferation of obligate anaerobes such as *Porphyromonas gingivalis*, *Tannerella forsythia*, and *Treponema denticola*—the notorious "red complex" organisms. [10] By introducing active oxygen into this oxygen-starved milieu, therapeutic formulations may simultaneously suppress pathogenic flora and accelerate tissue repair through enhanced collagen deposition, neovascularization, and epithelial migration. [11]

Blue M Gel, developed by a Dutch research consortium, embodies this oxygen-releasing philosophy. Its formulation centers on sodium perborate as the primary oxygen-generating compound, complemented by lactoferrin, a suite of enzymes, and other bioactive ingredients that collectively deliver antimicrobial, anti-inflammatory, and wound-healing benefits. [12] The gel is engineered to release active oxygen in a controlled, sustained manner directly within the periodontal pocket, offering therapeutic coverage without the aesthetic and sensory drawbacks of traditional antiseptics. [13]

Despite its intriguing mechanism, clinical evidence directly pitting oxygen-releasing gels against chlorhexidine in the SRP setting remains sparse. [14] Most existing investigations have evaluated Blue M Gel either against SRP alone or in combination with other emerging therapies, leaving a critical void in head-to-head comparative data. [15] This trial was conceived to fill that void through a methodologically rigorous single-blind, split-mouth randomized design, leveraging the power of within-patient comparison to isolate the true adjunctive value of each agent.

2. Materials and Methods

This investigation adopted a single-blind, split-mouth randomized controlled trial format, conducted within the Department of Periodontology,Adtiya dental college. The protocol secured approval from the Institutional Ethics Committee and was prospectively registered with the Clinical Trials Registry. This study was approved by the Institutional Ethics Committee (Protocol No. IEC/2026/PERIO/03) and the CONSORT 2010 guidelines for transparent reporting of randomized trials.

Inclusion Criteria:

- Systemically healthy adults aged 25–60 years
- Confirmed diagnosis of chronic periodontitis with ≥2 non-adjacent teeth/sites exhibiting PPD ≥5 mm
- Minimum of 20 natural teeth present
- No periodontal intervention in the preceding 6 months
- No antibiotics or anti-inflammatory drugs within the past 3 months

Exclusion Criteria:

- Any systemic comorbidity (diabetes, cardiovascular disease, immunological disorders)
- Pregnancy or lactation
- Current or past tobacco use in any form
- Requirement for antibiotic prophylaxis
- Aggressive or necrotizing periodontal conditions

The split-mouth architecture assigned each patient as their own control. Two qualifying non-adjacent sites per patient were identified and randomly allocated to Group A (test) or Group B (control) via computer-generated randomization performed by an independent biostatistician. Allocation concealment was maintained through sequentially numbered, opaque, sealed envelopes opened only after SRP completion.

The trial was single-blind: the examiner recording all clinical outcomes remained unaware of site allocation throughout the study. The treating periodontist necessarily knew the assignment due to the physical nature of gel application but was excluded from outcome assessment. Calibration of the blinded examiner against a gold-standard periodontist ensured measurement reliability (inter-examiner kappa > 0.85).

Clinical Protocol

Phase I – Baseline Assessment and Hygiene Optimization:

A comprehensive periodontal examination was conducted at screening. The periodontal chart captured plaque index (PI), gingival index (GI), probing pocket depth (PPD), clinical attachment loss (CAL), bleeding on probing (BOP), and furcation status. Measurements were taken at six sites per tooth using a UNC-15 periodontal probe.

Patients received individualized oral hygiene coaching, including modified Bass brushing technique and interdental flossing. Full-mouth supragingival scaling was completed, and participants were recalled after 1 week for oral hygiene compliance verification.

Phase II – Subgingival Instrumentation and Local Drug Delivery:

At the second visit, 2% lidocaine with 1:100,000 epinephrine provided local anesthesia. Meticulous subgingival SRP was performed using Gracey curettes (Hu-Friedy) and piezoelectric ultrasonic scalers. Root surfaces were deemed adequately debrided when tactile exploration confirmed smooth, calculus-free surfaces.

Immediately post-SRP, the assigned adjunctive gel was placed:

Group A (Blue M Gel + SRP): Blue M Gel was introduced into the pocket via a blunt-ended side-vent cannula, gently packed to coat the root surface and pocket epithelium. Excess material was removed, and patients were instructed to avoid rinsing or eating for 30 mintues.

Group B (Hexigel + SRP): Hexigel (1% chlorhexidine gluconate) was applied identically to the contralateral pocket.

figure 1a: Pre-operative clinical photograph at baseline showing generalized erythematous, edematous gingiva with visible plaque accumulation and bleeding on probing in the maxillary posterior region.

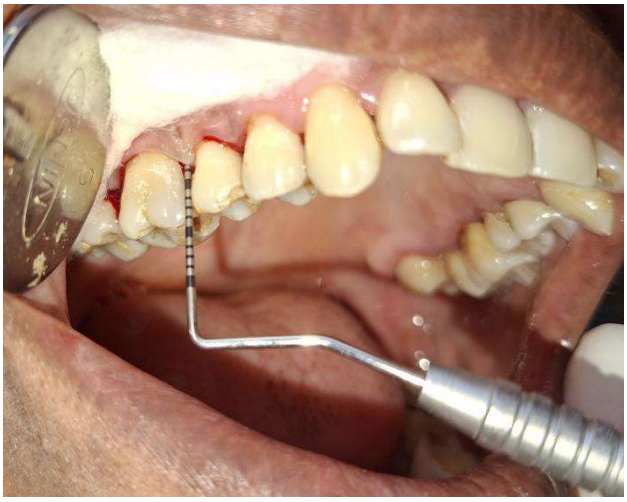


Figure 1b: Intraoral photograph showing application of Blue M Gel into the periodontal pocket using syringe following subgingival SRP. Note the gel filling the pocket space along the root surface

Figure 2a: Pre-operative clinical photograph at baseline demonstrating deep periodontal pocket (PPD 5.5 mm) with suppuration and severe gingival inflammation in the mandibular posterior region.

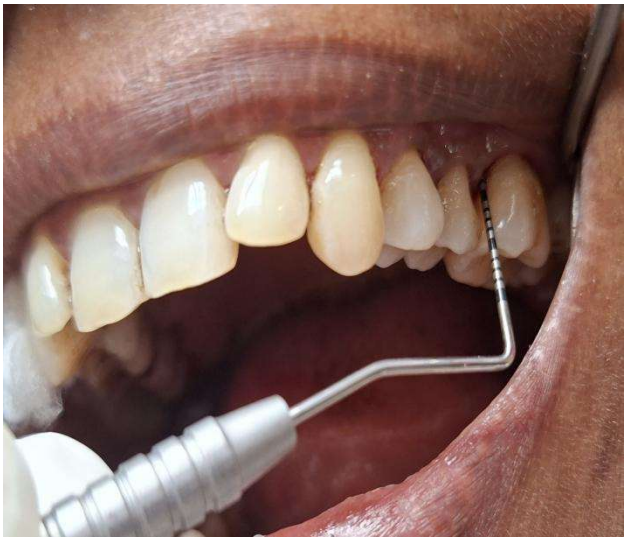


Figure 2b: Intraoral photograph demonstrating placement of Hexigel (1% chlorhexidine gluconate) into the contralateral periodontal pocket using identical technique.

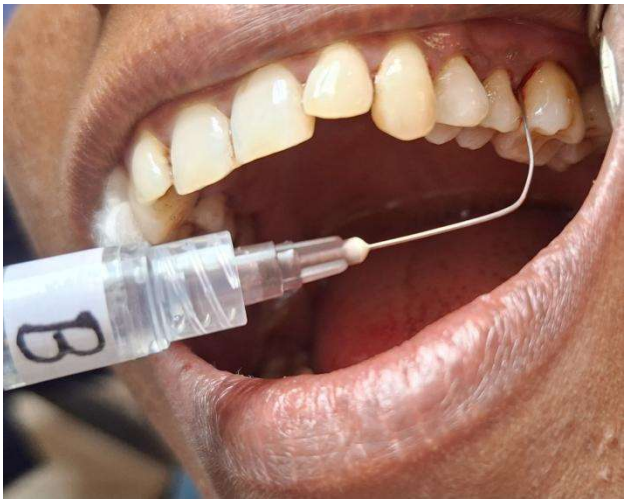


Figure 3a: Post-operative clinical photograph at 1-month follow-up showing marked resolution of gingival inflammation, reduced erythema, and restoration of gingival contour following SRP + Blue M Gel therapy.

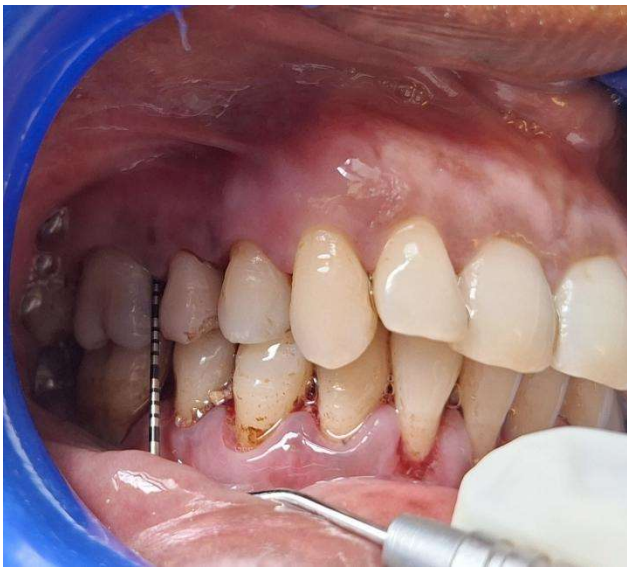
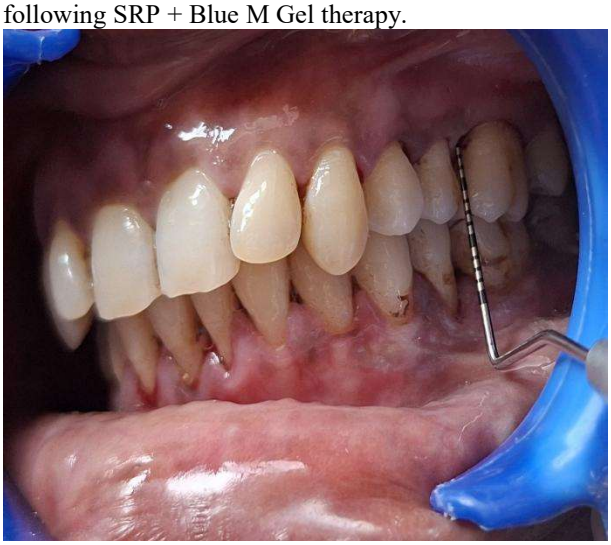


Figure 3b: Post-operative clinical photograph at 1-month follow-up showing significant reduction in pocket depth (PPD 3.8 mm), elimination of suppuration, and healthy gingival appearance following SRP + Blue M Gel therapy.



Follow-up Schedule

Clinical reassessment occurred at:

- **Baseline (T0):** Pre-treatment
- **15 Days (T1):** Early healing evaluation
- **1 Month (T2):** Primary endpoint

At each visit, oral hygiene was reinforced, and any adverse events were documented.

Outcome Measures

- Absolute and relative change in gingival index (GI)
- Absolute and relative change in probing pocket depth (PPD)
- Absolute and relative change in clinical attachment loss (CAL)

Data were analyzed using SPSS v27.0 (IBM Corp., Armonk, NY). Normality was verified via Shapiro-Wilk testing. Continuous variables were summarized as mean ± standard deviation. Intra-group temporal comparisons employed repeated-measures ANOVA with Tukey's post-hoc correction. Inter-group comparisons at each time point utilized paired t-tests (accounting for the split-mouth structure) and independent t-tests where appropriate. Statistical significance was declared at $p < 0.05$.

3. Results

Baseline Demographics and Clinical Equivalence

All 20 enrolled participants (11 men, 9 women) completed the trial without attrition. Mean age was 42.72 ± 7.98 years. As detailed in **Table 1**, no significant between-group differences existed at baseline for age, gender distribution, or any clinical parameter (GI, PPD, CAL; all $p > 0.05$), confirming successful randomization and group comparability.

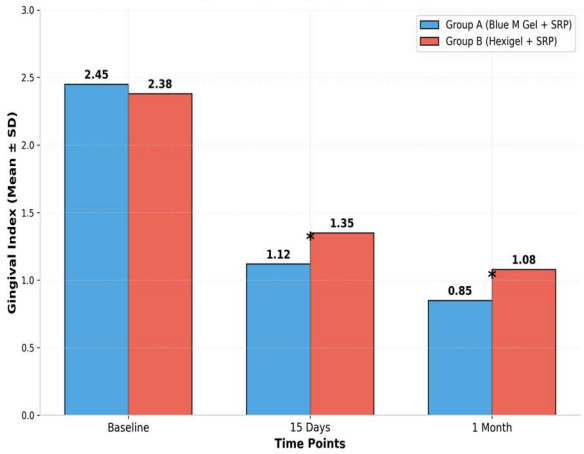
Table 1: Baseline Demographic and Clinical Characteristics of Study Participants

Parameter	Group A (Blue M Gel + SRP)	Group B (Hexigel + SRP)	p-value
Number of patients	20	20	—
Age (years) ± SD	42.35 ± 8.12	43.10 ± 7.85	0.78
Male/Female	11/9	10/10	0.74
Number of sites	60	60	—
Baseline GI ± SD	2.45 ± 0.32	2.38 ± 0.28	0.42
Baseline PPD (mm) ± SD	6.12 ± 0.85	6.08 ± 0.79	0.85
Baseline CAL (mm) ± SD	5.85 ± 0.92	5.78 ± 0.88	0.76
Smokers	0	0	—
Diabetes	0	0	—

Gingival Index (GI)

Both treatment arms achieved significant GI reductions from baseline across all follow-ups ($p < 0.05$). Yet Group A consistently outperformed Group B. At the 15-day mark, GI fell to 1.12 ± 0.18 in Group A versus 1.35 ± 0.22 in Group B ($p = 0.03$). By 1 month, this divergence widened: 0.85 ± 0.15 versus 1.08 ± 0.19 ($p = 0.01$). The mean total GI reduction favored Group A by a substantial margin (1.60 ± 0.28 vs. 1.30 ± 0.25; $p < 0.001$). **[Graph 1]**

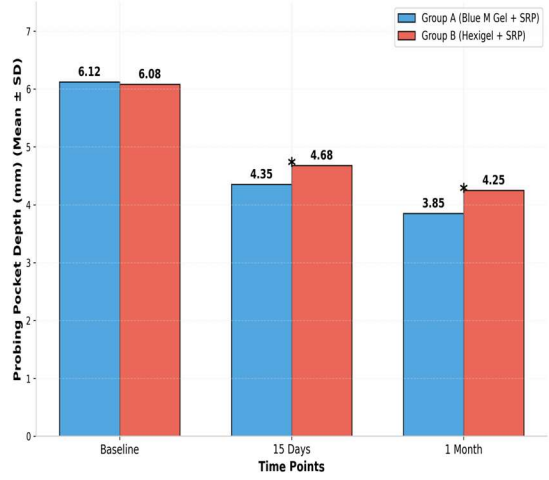
Figure 1: Comparison of Gingival Index Between Groups at Different Time Intervals
*** p < 0.05 (inter-group comparison)**



Probing Pocket Depth (PPD)

PPD diminished significantly in both groups over time ($p < 0.05$). Group A demonstrated a mean PPD reduction of 2.27 ± 0.48 mm at 1 month compared to 1.83 ± 0.42 mm in Group B ($p < 0.001$). At 15 days, mean PPD measured 4.35 ± 0.62 mm in Group A versus 4.68 ± 0.58 mm in Group B ($p = 0.04$). By the 1-month endpoint, these values reached 3.85 ± 0.55 mm and 4.25 ± 0.52 mm respectively ($p = 0.02$). **[Graph 2]**

Figure 2: Comparison of Probing Pocket Depth Between Groups at Different Time Intervals
*** p < 0.05 (inter-group comparison)**



Clinical Attachment Loss (CAL)

Clinical attachment gain—the gold standard for periodontal regeneration—was markedly superior in Group A. At 1 month, CAL improved to 3.95 ± 0.58 mm in Group A versus 4.38 ± 0.55 mm in Group B ($p = 0.02$). The mean CAL reduction (gain) was 1.90 ± 0.52 mm in Group A compared to 1.40 ± 0.48 mm in Group B ($p < 0.001$). These differences were already apparent at 15 days (4.42 ± 0.68 mm vs. 4.75 ± 0.65 mm; $p = 0.05$). **[Graph 3]**

Figure 3: Comparison of Clinical Attachment Loss Between Groups at Different Time Intervals
*** p < 0.05 (inter-group comparison)**

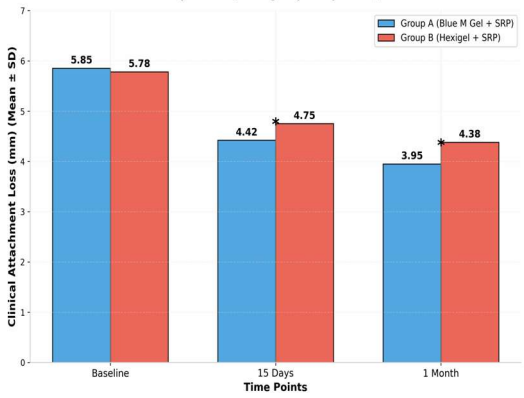


Table 2: Comparison of Mean Clinical Parameters at Different Time Intervals
*** p < 0.05 vs baseline; † p < 0.05 vs 15 days (intra-group comparison)**

Clinical Parameter	Time Point	Group A (Blue M Gel + SRP)	Group B (Hexigel + SRP)	Inter-group p-value
Gingival Index (GI)	Baseline	2.45 ± 0.32	2.38 ± 0.28	0.42
	15 Days	1.12 ± 0.18*	1.35 ± 0.22*	0.03
	1 Month	0.85 ± 0.15*†	1.08 ± 0.19*†	0.01
	Mean Reduction	1.60 ± 0.28	1.30 ± 0.25	<0.001
robing Pocket Depth (PPD) (m	Baseline	6.12 ± 0.85	6.08 ± 0.79	0.85
	15 Days	4.35 ± 0.62*	4.68 ± 0.58*	0.04
	1 Month	3.85 ± 0.55*†	4.25 ± 0.52*†	0.02
	Mean Reduction	2.27 ± 0.48	1.83 ± 0.42	<0.001
ical Attachment Loss (CAL) (	Baseline	5.85 ± 0.92	5.78 ± 0.88	0.76
	15 Days	4.42 ± 0.68*	4.75 ± 0.65*	0.05
	1 Month	3.95 ± 0.58*†	4.38 ± 0.55*†	0.02
	Mean Reduction	1.90 ± 0.52	1.40 ± 0.48	<0.001

Safety and Tolerability

Blue M Gel was universally well-tolerated; no adverse events were reported. In the Hexigel group, two patients noted mild extrinsic tooth staining and one reported transient dysgeusia. No mucosal irritation, allergic reactions, or patient discontinuations occurred.

4. Discussion

The results of this trial paint a clear picture: when paired with meticulous SRP, an oxygen-releasing gel delivers measurably better clinical outcomes than chlorhexidine gel across the key dimensions of periodontal health—gingival inflammation, pocket depth resolution, and tissue reattachment. These findings carry both immediate clinical relevance and broader implications for how we conceptualize adjunctive periodontal therapy.

The periodontal pocket in chronic periodontitis is not merely a space filled with bacteria; it is a carefully balanced ecosystem shaped by oxygen tension. As inflammation deepens the pocket, oxygen diffusion from the gingival margin becomes increasingly

restricted, creating a gradient that favors anaerobic and microaerophilic organisms. [17] The red complex pathogens—*P.* gingivalis, *T.* forsythi*a*, and *T.* denticola—are exquisitely adapted to these hypoxic conditions, employing sophisticated virulence mechanisms to thrive where oxygen is scarce. [18]

Blue M Gel disrupts this anaerobic sanctuary by introducing active oxygen directly at the site of disease. Sodium perborate, its core oxygen-releasing compound, reacts with tissue fluids to generate a sustained stream of molecular oxygen. [19] This oxygen surge achieves multiple therapeutic objectives simultaneously: it generates oxidative stress that damages bacterial membranes, enhances the respiratory burst capacity of recruited neutrophils and macrophages, and creates a microenvironment where anaerobic pathogens struggle to survive. [20]

Beyond antimicrobial action, oxygen plays a fundamental role in wound healing biology. Hydroxylation of proline and lysine residues—essential steps in collagen cross-linking—is an oxygen-dependent enzymatic process. [21] Without adequate oxygen, fibroblasts produce structurally defective collagen, and angiogenesis stalls. By elevating local oxygen tension, Blue M Gel may directly accelerate the connective tissue repair that underlies clinical attachment gain. [22]

Blue M Gel's formulation includes lactoferrin, an iron-binding glycoprotein with multifaceted biological activity. Lactoferrin deprives bacteria of iron—a critical growth factor—while simultaneously disrupting biofilm architecture and modulating host immune responses. [23] In combination with oxygen release, lactoferrin creates a dual-pronged assault on the pathogenic biofilm: oxygen targets the anaerobic metabolic machinery, while lactoferrin starves the survivors and dismantles their protective matrix. [24] This synergism may explain why Blue M Gel outperformed chlorhexidine, which lacks any comparable pro-healing component.

Chlorhexidine's mechanism is straightforward and effective: it binds to bacterial cell walls, disrupts membrane integrity, and precipitates intracellular contents. [25] It excels at reducing bacterial load and suppressing plaque formation. However, chlorhexidine is essentially a "dumb bomb"—it kills indiscriminately, affecting commensal and pathogenic species alike, and it offers no direct stimulation of tissue repair. [26] Its well-documented side effects—staining, taste alteration, and occasional mucosal desquamation—can erode patient compliance, particularly during maintenance phases. [27]

In this trial, chlorhexidine gel produced meaningful improvements, yet it consistently fell short of the oxygen-releasing formulation. The gap was not merely statistical; it was clinically meaningful, with Blue M Gel achieving approximately 0.4–0.5 mm greater PPD reduction and CAL gain. In periodontal therapy, such increments can distinguish between a pocket that remains pathologically deep and one that becomes maintainable.

The split-mouth design deserves particular emphasis. By assigning contralateral sites within the same patient to different treatments, we eliminated the confounding influence of inter-individual variation in immune response, oral hygiene behavior, genetic susceptibility, and systemic factors. [28] This design is especially powerful in periodontal research, where host response heterogeneity often dwarfs treatment effects. The randomization of site allocation ensured that any arch- or quadrant-specific biases were evenly distributed.[29]

Single-blinding of the outcome examiner further strengthened internal validity. Periodontal probing, while objective, is susceptible to subtle examiner bias; blinding eliminated this threat. The calibration protocol (kappa > 0.85) ensured that observed differences reflected true biological variation rather than measurement inconsistency.

For clinicians managing chronic periodontitis, these findings suggest that oxygen-releasing gels merit consideration as first-line adjuncts, particularly in patients with deeper pockets where SRP alone is least effective. The absence of adverse effects and the added wound-healing benefits make Blue M Gel an attractive option for patients who cannot tolerate chlorhexidine or who require long-term maintenance therapy.

However, this trial's 1-month follow-up, while sufficient to capture early healing dynamics, cannot address long-term stability or microbiome shifts. [30] A 3-month or 6-month extension would clarify whether the early advantages of oxygen therapy translate into sustained periodontal stability. Additionally, microbiological sampling—quantitative PCR for red complex organisms—would illuminate the mechanistic basis for the clinical superiority observed.

5. Conclusion

Blue M Gel and Hexigel demonstrated significant clinical benefits when used as adjuncts to scaling and root planing (SRP) in the management of chronic periodontitis Within the limitations of this single-blind, split-mouth randomized controlled trial.However, Blue M Gel showed superior efficacy in reducing gingival inflammation, probing pocket

depth, and clinical attachment loss at both 15-day and 1-month follow-up periods. The oxygen-releasing properties of Blue M Gel appear to enhance periodontal wound healing while providing effective antimicrobial action. Furthermore, no adverse effects were reported with Blue M Gel, whereas chlorhexidine-based therapy may be associated with undesirable effects such as tooth staining and taste alteration. These findings suggest that oxygen-releasing formulations such as Blue M Gel represent a promising advancement in adjunctive periodontal therapy. Nevertheless, further large-scale clinical trials with longer follow-up periods and microbiological assessments are required to validate these results and establish standardized clinical protocols for their routine use in periodontal practice.

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