



The Impact of Oral Hygiene Practices on the Prevention of Periodontal Diseases

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ABSTRACT

Periodontal diseases represent one of the most common oral health problems worldwide and are a major cause of tooth loss among adults. These diseases primarily result from the accumulation of dental plaque and pathogenic microorganisms that trigger inflammatory responses in the periodontal tissues. Effective oral hygiene practices play a crucial role in preventing the initiation and progression of periodontal diseases. This study aims to evaluate the impact of common oral hygiene practices, including tooth brushing, flossing, the use of antimicrobial mouth rinses, and regular dental visits, on the prevention of periodontal diseases.

A cross-sectional analytical study design used to assess the relationship between oral hygiene behaviors and periodontal health outcomes among adult participants. Data collected through clinical periodontal examinations and structured questionnaires assessing participants' oral hygiene habits. Key indicators such as plaque index, gingival index, probing depth, and bleeding on probing used to measure periodontal status. Statistical analyses conducted to determine associations between hygiene practices and periodontal health indicators.

The findings indicate that individuals who maintain consistent oral hygiene routines demonstrate significantly lower plaque accumulation and reduced gingival inflammation compared with those with irregular oral hygiene behaviors. Regular tooth brushing (twice daily or more), daily flossing, and the use of antimicrobial mouthwash were strongly associated with improved periodontal health outcomes. Furthermore, participants who attended routine dental checkups showed early detection and management of periodontal conditions.

The study highlights the essential role of preventive oral hygiene behaviors in maintaining periodontal health and reducing the risk of disease progression. Public health initiatives emphasizing oral hygiene education and preventive dental care can substantially decrease the global burden of periodontal diseases. These findings support the integration of preventive oral health strategies into community health programs to improve long-term dental health outcomes.

Introduction

Periodontal diseases are among the most prevalent chronic inflammatory conditions affecting the oral cavity worldwide. These diseases primarily involve the supporting structures of the teeth, including the gingiva, periodontal ligament, cementum, and alveolar bone.

When left untreated, periodontal diseases can lead to progressive destruction of these tissues, ultimately resulting in tooth mobility and tooth loss. In addition to their impact on oral health, periodontal diseases have been associated with several systemic conditions, including cardiovascular disease, diabetes mellitus, and adverse pregnancy outcomes.

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Consequently, understanding the preventive factors associated with periodontal health is an important public health priority.

The primary etiological factor in the development of periodontal diseases is the accumulation of dental plaque, a complex biofilm composed of bacteria and their metabolic products. Dental plaque forms naturally on tooth surfaces and, if not effectively removed, can trigger inflammatory responses in the gingival tissues. The earliest stage of periodontal disease is gingivitis, characterized by redness, swelling, and bleeding of the gums. Gingivitis is generally reversible with proper oral hygiene measures. However, when plaque accumulation persists over time, gingivitis may progress to periodontitis, a more severe condition involving the destruction of periodontal supporting structures and alveolar bone.

Oral hygiene practices play a fundamental role in controlling dental plaque and preventing periodontal diseases. Regular tooth brushing, flossing, and the use of antimicrobial mouth rinses are widely recognized as essential components of daily oral hygiene routines. Tooth brushing mechanically removes plaque from tooth surfaces, while dental floss helps eliminate plaque and food debris from interdental areas that are difficult to reach with a toothbrush. Mouth rinses containing antimicrobial agents can further reduce bacterial load within the oral cavity. Together, these practices contribute to maintaining a healthy oral environment and preventing the onset of periodontal inflammation.

Despite the well-established importance of oral hygiene practices, periodontal diseases remain highly prevalent across many populations. According to the World Health Organization, severe periodontal disease affects approximately 10-15% of the global adult population. Several factors contribute to the persistence of periodontal diseases, including inadequate oral hygiene behaviors, limited access to dental care, low awareness of oral health practices, and socioeconomic disparities. Behavioral factors such as irregular tooth brushing, infrequent flossing, smoking, and poor dietary habits also significantly increase the risk of periodontal disease development.

Education and awareness regarding oral hygiene practices are essential for improving periodontal health outcomes. Studies have shown that individuals who receive proper oral health education are more likely to adopt effective hygiene practices and maintain regular dental visits. Preventive dentistry emphasizes patient education, early diagnosis, and routine dental care as key strategies for controlling oral diseases. Dental professionals play an important role in educating patients about proper brushing techniques, interdental cleaning methods, and the importance of professional dental cleanings.

Another critical aspect of periodontal disease prevention is early detection. Regular dental checkups allow clinicians to identify early signs of gingival inflammation and periodontal pocket formation. Early intervention through professional cleaning, scaling, and patient education can significantly reduce the progression of periodontal diseases. Therefore, integrating preventive strategies into routine dental care is essential for improving oral health outcomes.

In recent years, there has been increasing interest in evaluating the effectiveness of different oral hygiene practices in preventing periodontal diseases. Researchers have explored the relationship between oral hygiene behaviors and clinical periodontal indicators such as plaque index, gingival index, probing depth, and clinical attachment loss. These indicators provide measurable evidence of periodontal health and allow researchers to assess the effectiveness of preventive strategies.

Moreover, advancements in dental research have highlighted the importance of patient compliance in maintaining periodontal health. Even when effective oral hygiene tools are available, their benefits depend largely on consistent and correct usage. Studies suggest that many individuals do not follow recommended oral hygiene guidelines, such as brushing twice daily or flossing regularly. As a result, dental plaque accumulates and increases the risk of periodontal disease development.

Public health initiatives aimed at improving oral hygiene behaviors can play a significant role in reducing the burden of periodontal diseases. Community-based education programs, school oral health campaigns, and accessible preventive dental services show to improve oral hygiene awareness and practices. These programs can help individuals develop healthy habits that contribute to long-term oral health.

Given the widespread prevalence of periodontal diseases and their potential impact on overall health, it is important to investigate the effectiveness of different oral hygiene practices in preventing these conditions. Understanding how daily oral hygiene behaviors influence periodontal health can help guide preventive strategies and inform public health policies.

Therefore, the purpose of this study is to examine the impact of various oral hygiene practices—including tooth brushing frequency, dental floss use, mouth rinse use, and regular dental visits—on the prevention of periodontal diseases. By analyzing the relationship between oral hygiene behaviors and periodontal health indicators, this study aims to provide evidence-based insights into the role of preventive oral care in maintaining periodontal health and reducing disease risk.

Literature Review

The prevention of periodontal diseases is a cornerstone of modern dentistry, emphasizing the transition from curative to preventive care. Periodontal diseases, primarily gingivitis and periodontitis, are chronic inflammatory conditions initiated by the accumulation of dental plaque. The literature extensively documents that the primary driver of periodontal tissue destruction is the host immune response to the pathogenic bacteria residing within the sub gingival biofilm. Therefore, the majority of research in this field focuses on various methods of biofilm disruption and the factors that influence the efficacy of these methods.

The Role of Dental Plaque and Biofilm Management

The consensus in periodontal research is that dental plaque is the essential etiological factor. Biofilm is not merely a random collection of bacteria but a highly organized community protected by an extracellular matrix. This matrix renders the bacteria more resistant to the host's immune system and systemic antibiotics. Consequently, mechanical disruption remains the most effective way to manage plaque. Studies by Loe et al. (1965) established the landmark "Experimental Gingivitis in Man" model, proving that the withdrawal of oral hygiene leads to plaque accumulation and subsequent gingival inflammation within days, which is then reversible upon the resumption of hygiene practices. This foundational knowledge has since guided decades of research into the frequency and technique of tooth brushing.

Mechanical Plaque Control: Brushing and Interdental Cleaning

Tooth brushing is the most widely practiced oral hygiene habit globally. Literature suggests that brushing twice daily for at least two minutes significantly reduces plaque scores compared to once-daily or shorter durations. However, mechanical brushing alone often fails to reach the interproximal surfaces, where many periodontal lesions begin. The importance of interdental cleaning using dental floss, interdental brushes, or water flossers is a recurring theme in recent systematic reviews. Research indicates that while flossing is technically demanding and often shows low compliance, interdental brushes are often more effective for plaque removal in patients with open embrasures or existing attachment loss. The literature emphasizes that the "gold standard" of oral hygiene must include some form of interdental cleaning to address the high-risk areas between the teeth.

Chemical Adjuncts in Periodontal Prevention

In addition to mechanical methods, chemical agents extensively studied as adjuncts. Antimicrobial

mouth rinses, particularly those containing chlorhexidine gluconate, essential oils, or cetylpyridinium chloride (CPC), have demonstrated the ability to reduce bacterial counts and inhibit plaque formation. However, researchers caution that these should not replace mechanical cleaning but rather supplement it, especially in populations with physical limitations or high disease susceptibility. Longitudinal studies have shown that the long-term use of essential oil-based rinses can significantly decrease gingival bleeding and plaque indices without causing significant shifts in the oral microbiome's ecological balance.

Professional Intervention and Maintenance

The literature also highlights that self-care alone is often insufficient for individuals with a history of periodontitis. Professional mechanical plaque removal (PMPR), involving scaling and root planning, is necessary to remove calcified deposits (calculus) that provide a niche for further biofilm growth. Maintenance therapy, or supportive periodontal therapy (SPT), is critical. Studies suggest that patients who attend regular professional cleanings every 3 to 6 months maintain higher levels of clinical attachment and experience lower rates of tooth loss compared to those who rely solely on home care. The "Recall System" is thus a vital component of the preventive framework, ensuring that early signs of disease recurrence managed promptly.

Behavioral and Socioeconomic Factors

Recent literature has shifted its focus toward the behavioral psychology of oral hygiene. It is not enough to know *how* to brush; patients must be *motivated* to do so. Theoretical models, such as the Health Belief Model and the Theory of Planned Behavior, used to explain why some individuals maintain excellent hygiene while others do not. Furthermore, socioeconomic status (SES) remains a significant predictor of periodontal health. Individuals with lower SES often face barriers such as limited access to dental education, higher stress levels (which can exacerbate inflammation), and reduced access to preventive professional care. Research continues to explore how community-based programs and public health policies can bridge this gap to provide equitable periodontal prevention.

The Systemic Link and Global Burden

Finally, the "Perio-Systemic Link" has become a major area of study. The chronic inflammatory nature of periodontal disease allows bacteria and inflammatory cytokines to enter the bloodstream, potentially affecting systemic health. Evidence links poor oral hygiene and subsequent periodontitis to exacerbated diabetes, increased cardiovascular risk, and even neurodegenerative diseases like

Alzheimer’s. This elevates the importance of periodontal prevention from a localized dental issue to a significant component of general health and well-being. The global burden of periodontal disease is high, and as the population ages, the focus on preserving natural dentition through rigorous oral hygiene practices becomes increasingly critical.

Methodology

This study employed a cross-sectional analytical design to investigate the relationship between various oral hygiene practices and periodontal health indicators among an adult population. The primary objective was to quantify the impact of specific behaviors brushing frequency, flossing, use of mouthwash, and dental visit regularity on clinical markers of periodontal disease.

Participant Recruitment and Selection: A sample of 500 adult participants, aged 25 to 65, recruited from various community health centers and dental clinics. To ensure a representative sample, participants from diverse socioeconomic backgrounds were included. The exclusion criteria involved individuals with systemic diseases known to significantly alter periodontal status (e.g., uncontrolled diabetes), pregnant women, and individuals who had undergone professional scaling or antibiotic therapy within the past three months. Informed consent obtained from all participants prior to data collection.

Data Collection Instruments: Data collection divided into two main phases: a structured questionnaire and a clinical examination.

1. **Self-Reported Questionnaire:**
Participants completed a comprehensive survey assessing their oral hygiene habits. Key variables included the frequency of tooth brushing per day, the frequency of interdental cleaning (flossing or interdental brushes), the use of antimicrobial mouthwashes, and the time elapsed since their last professional dental visit. Smoking status and educational level also recorded as potential confounding variables.

2. **Clinical Periodontal Examination:** A single, calibrated examiner performed the clinical assessments using a standard North Carolina (NC-15) periodontal probe. Four key indicators were recorded:
✓ **Plaque Index (PI):** To measure the amount of soft debris.
✓ **Gingival Index (GI):** To assess the severity of gingival inflammation.
✓ **Probing Pocket Depth (PPD):** Measured at six sites per tooth to detect periodontal pockets.
✓ **Bleeding on Probing (BOP):** Recorded as a percentage of sites to indicate active inflammation.

Statistical Analysis

The collected data analyzed using Statistical Package for the Social Sciences (SPSS) version 26.0. Descriptive statistics used to summarize the demographic characteristics and hygiene behaviors of the sample. To test for associations, Chi-square tests applied for categorical variables, and Independent T-tests or One-way ANOVA used to compare mean clinical scores across different hygiene groups. A P-value of < 0.05 considered statistically significant. Multivariate linear regression analysis further conducted to determine the strongest predictors of periodontal health while controlling for age and smoking status.

Results

The analysis of data collected from 500 adult participants revealed significant associations between various oral hygiene practices and clinical periodontal health indicators. The findings highlight the critical role of consistent and effective self-care in preventing the onset and progression of periodontal diseases. The results presented in five distinct tables, each accompanied by a detailed interpretive analysis.

Table 1. Demographic Characteristics of Study Participants and Basic Oral Hygiene Habits

Characteristic	N (%)	Mean ± SD / Range
Gender	-	-
Male	230 (46%)	-
Female	270 (54%)	-
Age Group	-	-
25-35 years	150 (30%)	-
36-45 years	160 (32%)	-
46-55 years	110 (22%)	-
56-65 years	80 (16%)	40.5 ± 10.2 years

Education Level	-	-
High School or less	115 (23%)	-
Bachelor's Degree	235 (47%)	-
Postgraduate Degree	150 (30%)	-
Smoking Status	-	-
Non-smoker	380 (76%)	-
Current smoker	120 (24%)	-
Tooth Brushing Frequency	-	-
< 1 time/day	55 (11%)	-
1 time/day	120 (24%)	-
2 times/day	260 (52%)	-
> 2 times/day	65 (13%)	-
Flossing Frequency	-	-
Never	185 (37%)	-
Occasionally (1-3 times/week)	170 (34%)	-
Daily (>4 times/week)	145 (29%)	-
Mouth Rinse Use	-	-
Never	250 (50%)	-
Occasionally	140 (28%)	-
Daily	110 (22%)	-
Last Dental Visit	-	-
< 1 year ago	210 (42%)	-
1-2 years ago	160 (32%)	-
> 2 years ago	130 (26%)	-

Table 1 provides an overview of the demographic characteristics and self-reported oral hygiene habits of the 500 study participants. The sample demonstrated a slight female predominance, with 54% being female compared to 46% male. The age distribution was relatively even across the younger and middle-aged adult groups, with the largest proportion falling within the 36-45 years range (32%), followed by 25-35 years (30%). This indicates a study population predominantly consisting of adults in their most economically active and, potentially, highest stress-level years, which can affect health behaviors. The mean age of 40.5 years with a standard deviation of 10.2 years further confirms a broad representation of the adult age spectrum.

Regarding educational attainment, nearly half of the participants (47%) held a Bachelor's Degree, suggesting a reasonably well educated cohort, which might generally correlate with higher health literacy and better adherence to health recommendations. A substantial portion (30%) also held postgraduate

degrees, while 23% had high school education or less. This distribution allows for potential analysis of how education level might modulate oral hygiene practices and periodontal health outcomes in subsequent analyses.

Smoking status, a well-established risk factor for periodontal disease, showed that the majority of participants were non-smokers (76%), while 24% were current smokers. This proportion of smokers is relevant for later analyses as smoking can act as a significant confounding variable, independently influencing periodontal health regardless of hygiene practices. Control for this factor will be crucial in drawing accurate conclusions about the impact of oral hygiene.

The self-reported oral hygiene practices revealed interesting patterns. A positive finding was that the majority of participants (52%) reported brushing their teeth twice daily, aligning with professional recommendations. An additional 13% reported brushing more than twice daily, indicating a significant portion of the sample is adhering to

optimal brushing frequency. However, a concerning 24% brushed only once a day, and 11% brushed less than once a day, signifying a subgroup at higher risk for plaque accumulation and subsequent periodontal issues.

Interdental cleaning habits, specifically flossing, showed less adherence to optimal recommendations. Only 29% of participants reported flossing daily, while 34% flossed occasionally (1-3 times/week), and a substantial 37% reported never flossing. This demonstrates a clear gap in interdental hygiene compliance, which is a common challenge in preventive dentistry given the technical difficulty and time commitment required for effective flossing. This subgroup of non-flossers is particularly relevant for evaluating its impact on interproximal periodontal health indicators.

Mouth rinse usage also showed a varied pattern. Exactly half of the participants (50%) reported never using a mouth rinse, while 28% used it occasionally, and 22% used it daily. This suggests that mouth rinses are not a universally adopted daily hygiene practice, possibly due to lack of awareness,

perceived necessity, or cost. The role of mouth rinse as an adjunct to mechanical cleaning further explored in relation to periodontal health.

Finally, the frequency of professional dental visits indicated that 42% of participants had visited a dentist within the last year, which generally considered good compliance for routine check-ups. However, 32% had visited 1-2 years ago, and 26% had gone more than 2 years without a dental check-up. This last group is at a higher risk for undetected or untreated periodontal conditions, emphasizing the importance of regular professional care for early diagnosis and intervention.

Overall, Table 1 establishes the demographic and behavioral landscape of the study population, providing the foundational data against which the specific impacts of oral hygiene practices on periodontal health indicators assessed in subsequent tables. The diverse range of habits and demographic factors allows for a robust analysis of the complex interplay between behavior and oral health.

Table 2. Relationship between Tooth Brushing Frequency and Periodontal Health Indicators

Brushing Frequency	N (%)	Plaque Index (PI) Mean ± SD	Gingival Index (GI) Mean ± SD	Probing Depth (PPD) Mean ± SD (mm)	Bleeding on Probing (BOP) Mean ± SD (%)	P-value (ANOVA)
< 1 time/day	55 (11%)	2.8 ± 0.3	2.5 ± 0.4	3.1 ± 0.5	65 ± 10	-
1 time/day	120 (24%)	2.1 ± 0.4	1.9 ± 0.3	2.7 ± 0.4	48 ± 8	< 0.001
2 times/day	260 (52%)	1.2 ± 0.3	1.0 ± 0.2	2.3 ± 0.3	22 ± 5	-
> 2 times/day	65 (13%)	0.8 ± 0.2	0.7 ± 0.1	2.1 ± 0.2	15 ± 4	-

Table 2 presents a compelling association between the frequency of tooth brushing and key periodontal health indicators, demonstrating a statistically significant impact across all measured parameters ($P<0.001$). The data clearly indicates that as brushing frequency increases, there is a consistent and notable improvement in periodontal health. For participants who reported brushing less than once a day ($n=55$), the mean Plaque Index (PI) was substantially high at 2.8 ± 0.3 , indicating widespread and heavy plaque accumulation. This group also exhibited the highest mean Gingival Index (GI) of 2.5 ± 0.4 , signifying severe gingival inflammation. Probing Pocket Depth (PPD) averaged 3.1 ± 0.5 mm, suggesting early pocket formation, and Bleeding on Probing (BOP) was an alarming $65\% \pm 10$, indicating active and widespread inflammation

in a vast majority of sites. These values collectively point to a population segment with poor oral hygiene and a high burden of active periodontal disease. Moving to the group brushing once a day ($n=120$), a discernible improvement in all indicators was observed. The mean PI dropped to 2.1 ± 0.4 , and the GI to 1.9 ± 0.3 , reflecting a reduction in plaque and inflammation compared to the previous group. PPD decreased to 2.7 ± 0.4 mm, suggesting less severe pocketing, and BOP significantly reduced to $48\% \pm 8$. While still indicative of moderate periodontal issues, these figures underscore the immediate positive impact of even minimal regular brushing. This highlights that even infrequent brushing offers some protective effect against severe disease progression, though it remains suboptimal.

The largest group in the study, those brushing twice a day (n=260), which aligns with standard recommendations, demonstrated significantly better periodontal health. Their mean PI was 1.2 ± 0.3 , representing a substantial reduction in plaque levels. The GI was commendably low at 1.0 ± 0.2 , indicating mild gingival inflammation. PPD averaged 2.3 ± 0.3 mm, suggesting that most sites remained within healthy limits or had very shallow pockets. Critically, the BOP rate was a low $22\% \pm 5$, signifying a much-reduced prevalence of active inflammation. These findings strongly support the two-times-daily brushing recommendation as a highly effective strategy for maintaining good periodontal health. The dramatic drop in BOP from the once-daily group to the twice-daily group is particularly noteworthy, emphasizing the role of consistent plaque removal in mitigating inflammation.

Finally, the group brushing more than twice a day (n=65) exhibited the best periodontal health outcomes across all measures. Their mean PI was 0.8 ± 0.2 , indicating minimal plaque accumulation. The GI was 0.7 ± 0.1 , reflecting very healthy gingival tissues with negligible inflammation. PPD was 2.1 ± 0.2 mm, consistently within the healthy range (typically <3 mm), and the BOP rate was the lowest at $15\% \pm 4$. While the incremental improvement from twice-daily to more-than-twice-

daily brushing was less dramatic than the jump from infrequent to twice-daily, it still represented a statistically significant enhancement in periodontal health. This suggests that while two times a day is generally sufficient, more frequent brushing, when performed correctly, can provide an additional marginal benefit in reducing plaque and inflammation, further solidifying the protective barrier against periodontal disease.

In summary, the statistical significance ($P < 0.001$) of the ANOVA results unequivocally demonstrates a robust dose-response relationship between tooth brushing frequency and improved periodontal health. Higher brushing frequencies directly correlated with lower plaque accumulation, reduced gingival inflammation, shallower probing depths, and significantly less bleeding on probing. These results underscore the fundamental importance of consistent mechanical plaque removal through regular tooth brushing as the primary strategy for the prevention and control of periodontal diseases. The findings serve as a strong evidence base for public health campaigns advocating for at least twice-daily tooth brushing.

Table 3. Impact of Interdental Cleaning (Flossing/Interdental Brushes) on Periodontal Health Indicators						
Interdental Cleaning	N (%)	Plaque	Gingival	Probing Depth	Bleeding on	P-value (ANOVA)
		Index (PI) Mean $\pm$ SD	Index (GI) Mean $\pm$ SD	(PPD) Mean $\pm$ SD (mm)	Probing (BOP) Mean $\pm$ SD (%)	
Never	185 (37%)	2.4 ± 0.4	2.2 ± 0.3	2.9 ± 0.4	55 ± 9	-
Occasionally	170 (34%)	1.8 ± 0.3	1.5 ± 0.3	2.6 ± 0.3	38 ± 7	< 0.001
Daily	145 (29%)	1.0 ± 0.2	0.9 ± 0.2	2.2 ± 0.2	18 ± 4	-

Table 3 provides critical insights into the impact of interdental cleaning practices, primarily flossing or the use of interdental brushes, on periodontal health indicators. The analysis reveals a highly significant statistical association ($P<0.001$) between the regularity of interdental cleaning and improved periodontal outcomes, independent of the effects of tooth brushing (though the two often occur concurrently).

The group that reported never engaging in interdental cleaning (n=185), representing 37% of the study population, consistently exhibited the poorest periodontal health. Their mean Plaque Index (PI) was 2.4 ± 0.4 , indicating significant plaque

accumulation, particularly in the interproximal areas, which are notoriously difficult to clean with a toothbrush alone. Correspondingly, their mean Gingival Index (GI) was 2.2 ± 0.3 , signifying substantial gingival inflammation. Probing Pocket Depth (PPD) averaged 2.9 ± 0.4 mm, suggesting that this group was at a higher risk for periodontal pocket formation. Most strikingly, the Bleeding on Probing (BOP) rate was a high $55\% \pm 9$, highlighting widespread active inflammation and compromised gingival health between the teeth. These findings underscore the severe consequences of neglecting interdental hygiene, as plaque and inflammation proliferate in these untouched areas.

Participants who engaged in occasional interdental cleaning (1-3 times per week, n=170), comprising 34% of the sample, demonstrated a measurable improvement in periodontal health compared to the “never” group. Their mean PI reduced to 1.8 ± 0.3 , indicating a noticeable decrease in overall plaque levels. The GI also improved to 1.5 ± 0.3 , reflecting a reduction in gingival inflammation. PPD showed a slight but significant reduction to 2.6 ± 0.3 mm, suggesting a positive impact on pocket depths. Furthermore, the BOP rate decreased to $38\% \pm 7$. While these improvements are clear, the “occasionally” group still presented with moderate levels of plaque and inflammation, suggesting that sporadic interdental cleaning, while better than none, is insufficient for optimal periodontal health. This highlights the need for consistent daily practice to achieve substantial preventive benefits.

The most profound improvements in periodontal health were observed in the group that reported daily interdental cleaning (n=145), accounting for 29% of the study participants. This group exhibited remarkably low periodontal disease indicators. Their mean PI was 1.0 ± 0.2 , indicating minimal plaque accumulation, particularly in the critical interdental regions. The GI was also exceptionally low at 0.9 ± 0.2 , signifying very mild, if any, and gingival inflammation. The PPD averaged 2.2 ± 0.2 mm, which is well within the healthy range and suggests excellent periodontal tissue support. Most

impressively, the BOP rate for this group was a mere $18\% \pm 4$, demonstrating very limited active inflammation. These results are indicative of excellent periodontal health and strongly advocate for the consistent, daily use of interdental cleaning aids.

The statistically significant P-value (< 0.001) for the ANOVA test across these three groups unequivocally confirms that daily interdental cleaning is a powerful preventive measure against periodontal disease. The progressive reduction in plaque, inflammation, and probing depths from no cleaning to occasional cleaning, and then to daily cleaning, establishes a clear dose-response relationship. This finding supports the long-standing recommendation from dental professionals that effective oral hygiene must extend beyond tooth brushing to include regular cleaning of the interdental spaces, which are prime sites for the initiation and progression of periodontal pathology. The impact on BOP, in particular, displays the effectiveness of interdental cleaning in reducing active inflammatory processes that could otherwise lead to irreversible tissue destruction.

Table 4. Association between Mouth Rinse Use and Periodontal Health Indicators

Mouth Rinse Use	N (%)	Plaque	Gingival	Probing Depth	Bleeding on	P-value (ANOVA)
		Index (PI) Mean $\pm$ SD	Index (GI) Mean $\pm$ SD	(PPD) Mean $\pm$ SD (mm)	Probing (BOP) Mean $\pm$ SD (%)	
Never	250 (50%)	1.8 ± 0.4	1.6 ± 0.3	2.7 ± 0.4	35 ± 8	-
Occasionally	140 (28%)	1.4 ± 0.3	1.3 ± 0.2	2.5 ± 0.3	28 ± 6	< 0.001
Daily	110 (22%)	1.1 ± 0.2	1.0 ± 0.2	2.3 ± 0.2	20 ± 5	-

Table 4 investigates the association between the use of antimicrobial mouth rinses and periodontal health indicators, presenting a statistically significant relationship ($P<0.001$) that underscores the adjunctive benefits of chemical plaque control. It is important to note that these results observed within the context of participants’ varying tooth brushing and interdental cleaning habits, implying that mouth rinse use serves as an additional layer of hygiene rather than a standalone solution.

The largest group, comprising 250 participants (50%), reported never using mouth rinses. This group exhibited moderate levels of periodontal

disease indicators. Their mean Plaque Index (PI) was 1.8 ± 0.4 , indicating a notable presence of plaque, while the mean Gingival Index (GI) stood at 1.6 ± 0.3 , and reflecting moderate gingival inflammation. The average Probing Pocket Depth (PPD) was 2.7 ± 0.4 mm, suggesting that some sites might be approaching or exceeding healthy depths. The Bleeding on Probing (BOP) rate was $35\% \pm 8$, indicating a significant number of sites with active inflammation. These baseline figures provide a reference point for understanding the incremental benefits offered by mouth rinse usage. While this group might be engaging in some mechanical

cleaning, the absence of chemical adjuncts likely allows for higher bacterial loads and inflammation. Participants who used mouth rinses occasionally (n=140), representing 28% of the sample, showed improved periodontal health compared to non-users. Their mean PI reduced to 1.4 ± 0.3 , and the GI to 1.3 ± 0.2 , reflecting a modest but consistent reduction in plaque and inflammation. PPD also saw a slight decrease to 2.5 ± 0.3 mm, suggesting a positive impact on the stability of periodontal tissues. The BOP rate dropped to $28\% \pm 6$, indicating a reduction in active inflammatory sites. This improvement suggests that even irregular use of mouth rinses can provide some supplementary benefit, likely by reducing the bacterial load in the oral cavity and disrupting plaque formation between mechanical cleanings. It indicates that the antimicrobial action, even if not daily, contributes positively.

The most favorable periodontal health indicators observed among the 110 participants (22%) who reported daily use of mouth rinses. This group displayed the lowest mean PI of 1.1 ± 0.2 , suggesting effective suppression of plaque formation beyond mechanical removal. Their mean GI was commendably low at 1.0 ± 0.2 , indicative of healthy or very minimally inflamed gingival tissues.

The average PPD was 2.3 ± 0.2 mm, consistently within the healthy range. Furthermore, the BOP rate was the lowest at $20\% \pm 5$, demonstrating superior control over gingival inflammation and bleeding. These results highlight the efficacy of daily mouth rinse use as an adjunct in maintaining optimal periodontal health, likely due to continuous antimicrobial action that targets planktonic bacteria and nascent biofilm.

The statistically significant P-value ($P<0.001$) confirms a clear and progressive improvement in periodontal health indicators with increasing frequency of mouth rinse use. This supports the notion that while mechanical cleaning (brushing and flossing) forms the foundation of oral hygiene, daily use of an antimicrobial mouth rinse can provide an additional, quantifiable benefit by further reducing bacterial loads and inflammatory responses. This is particularly relevant for individuals who may struggle with perfect mechanical plaque removal or those seeking an enhanced preventive strategy. The findings endorse the recommendation of certain mouth rinses as a valuable complement to daily oral hygiene routines, especially for reducing gingival inflammation and maintaining lower plaque levels.

Table 5. Influence of Regular Dental Visits on Periodontal Health Outcomes

Last Dental Visit	N (%)	Plaque Index (PI) Mean $\pm$ SD	Gingival Index (GI) Mean $\pm$ SD	Probing Depth (PPD) Mean $\pm$ SD (mm)	Bleeding on Probing (BOP) Mean $\pm$ SD (%)	P-value (ANOVA)
> 2 years ago	130 (26%)	2.5 ± 0.4	2.3 ± 0.3	3.2 ± 0.5	60 ± 10	-
1-2 years ago	160 (32%)	1.8 ± 0.3	1.6 ± 0.3	2.8 ± 0.4	40 ± 8	< 0.001
< 1 year ago	210 (42%)	1.0 ± 0.2	0.9 ± 0.2	2.2 ± 0.2	18 ± 4	-

Table 5 critically examines the influence of regular professional dental visits on various periodontal health indicators, demonstrating a highly significant statistical relationship ($P<0.001$) between the recency of a dental visit and superior periodontal health. This finding underscores the indispensable role of professional intervention and maintenance in the comprehensive prevention and management of periodontal diseases, complementing daily home care.

The group comprising 130 participants (26%) who reported their last dental visit being more than two years ago exhibited the most compromised periodontal health among all categories. Their mean Plaque Index (PI) was notably high at 2.5 ± 0.4 , indicating significant accumulation of both soft and calcified plaque (calculus), which cannot be

removed by home care alone. Correspondingly, their mean Gingival Index (GI) was 2.3 ± 0.3 , reflecting widespread and severe gingival inflammation. The average Probing Pocket Depth (PPD) reached 3.2 ± 0.5 mm, suggesting that a considerable number of sites had developed periodontal pockets or were experiencing early attachment loss. Alarming, the Bleeding on Probing (BOP) rate was $60\% \pm 10$, indicating pervasive active inflammation and likely untreated or progressing periodontal disease. This group represents a population at high risk for irreversible periodontal damage due to a lack of professional cleaning, early detection, and timely intervention.

Participants who had visited a dentist between one and two years ago (n=160), accounting for 32% of the sample, showed a marked improvement in

periodontal health compared to those with longer gaps. Their mean PI decreased to 1.8 ± 0.3 , and the GI to 1.6 ± 0.3 , indicating reduced plaque and inflammation. The PPD averaged 2.8 ± 0.4 mm, which, while still suggesting some areas of concern, was an improvement from the neglected group. The BOP rate significantly dropped to $40\% \pm 8$, reflecting less active inflammation. These findings suggest that even infrequent professional care can offer some protective benefits, likely through the removal of accumulated calculus and the provision of oral hygiene instructions, albeit not as optimally as more regular visits. This group likely receives some benefit from intermittent professional intervention that delays the progression of periodontal issues.

The most impressive periodontal health outcomes consistently observed in the group of 210 participants (42%) who had undergone a dental visit within the last year. This group demonstrated exceptionally low periodontal disease indicators across the board. Their mean PI was 1.0 ± 0.2 , indicating minimal plaque and calculus. The mean GI was 0.9 ± 0.2 , reflecting very healthy gingival tissues. The average PPD was 2.2 ± 0.2 mm, consistently within the healthy range and suggesting stable periodontal support. Furthermore, the BOP rate was the lowest at $18\% \pm 4$, indicative of superior control over gingival inflammation. These results strongly advocate for the critical role of regular professional dental check-ups and cleanings, typically recommended annually or semi-annually, in maintaining optimal periodontal health. Regular visits enable early detection of issues, professional scaling and root planing to remove tenacious deposits, and reinforcement of effective home care practices.

The statistically significant P-value ($P < 0.001$) for the ANOVA test across these categories unequivocally establishes a direct correlation between the frequency and recency of dental visits and superior periodontal health. Regular professional care is not merely a reactive measure but a cornerstone of proactive periodontal disease prevention, effectively reducing plaque, inflammation, and the progression of probing depths. This reinforces the importance of integrated oral healthcare, where diligent home hygiene supported and enhanced by consistent professional oversight and intervention. The data suggests that professional visits are essential for addressing aspects of oral hygiene that self-care alone cannot manage, such as sub gingival calculus and early pathological changes, thereby preventing the escalation of periodontal disease.

Discussion

The findings of this study provide robust evidence for the profound impact of oral hygiene practices on the prevention and management of periodontal

diseases. By analyzing various behavioral factors alongside clinical indicators such as Plaque Index (PI), Gingival Index (GI), Probing Pocket Depth (PPD), and Bleeding on Probing (BOP), the results underscore a clear dose-response relationship between hygiene consistency and periodontal health. The primary objective of this discussion is to contextualize these findings within the existing body of literature and explore the physiological and public health implications of the data.

The Primacy of Mechanical Plaque Control

Our results regarding tooth-brushing frequency (Table 2) align perfectly with the foundational principles of periodontology. The significant reduction in PI and BOP observed in participants brushing twice daily compared to those brushing once or less confirms that frequent mechanical disruption of the biofilm is essential. Biofilm maturation is a time-dependent process; within 24 to 48 hours, a young, relatively harmless biofilm can shift toward a more pathogenic, anaerobic composition. By brushing twice daily, individuals disrupt this maturation process, preventing the shift toward gram-negative species that trigger the inflammatory cascade in the gingival tissues. The dramatic decrease in BOP (from 48% in once-daily brushers to 22% in twice-daily brushers) highlights that frequency is not just a habit but also a biological necessity for maintaining gingival homeostasis.

The Interdental Gap: A Critical Vulnerability

Perhaps the most striking finding of this study is the impact of interdental cleaning (Table 3). While 65% of participants brushed at least twice a day, only 29% flossed daily. The clinical data showed that those who neglected interdental cleaning had significantly higher PPD and BOP, even if they were regular brushers. This supports the “interproximal vulnerability” theory, which suggests that the areas between teeth are the primary sites for the initiation of periodontitis because they protected from the mechanical action of a toothbrush. Our data confirms that daily flossing or the use of interdental brushes is a powerful predictor of periodontal stability. The high prevalence of BOP (55%) in non-flossers suggests that even if the facial and lingual surfaces of teeth are clean, the interproximal inflammatory burden remains high enough to potentially lead to systemic inflammation or localized bone loss.

Chemical Adjuncts and Professional Synergy

The analysis of mouth rinse use (Table 4) suggests that antimicrobial rinses serve as a valuable “safety net.” While not a replacement for mechanical cleaning, daily mouthwash use was associated with lower GI and BOP scores. This likely due to the ability of liquid rinses to reach surfaces and niches that brushes might miss, reducing the overall

bacterial load (planktonic bacteria). However, the most significant clinical improvements seen when home care combined with regular professional dental visits (Table 5). Participants who attended a dental check-up within the last year had the lowest levels of plaque and inflammation. This highlights the necessity of professional prophylaxis to remove sub gingival calculus a substance that acts as a scaffold for more plaque and cannot be removed by the patient. Professional intervention also provides an opportunity for personalized oral hygiene instruction (OHI), which reinforces the behaviors discussed in this study.

Socioeconomic and Behavioral Considerations

While the clinical data is clear, the demographic breakdown (Table 1) points to broader challenges. The fact that a significant portion of the population still brushes only once a day or never flosses indicates a gap in health literacy. Higher education levels in our sample were generally associated with better practices, but not universally. This suggests that knowledge alone is insufficient; behavioral change requires motivation and the development of sustainable habits. Furthermore, the role of smoking as a confounding factor cannot be ignored. Smokers often present with less bleeding (due to vasoconstriction) but more severe attachment loss, which can mask the early signs of disease. This study reinforces the need for dental professionals to treat oral hygiene not just as a mechanical task, but as a behavioral intervention tailored to the patient's lifestyle and risk factors.

Implications for Public Health and Systemic Health

The prevention of periodontal disease is no longer just about "saving teeth." Given the well-documented link between periodontal inflammation and systemic conditions like cardiovascular disease and diabetes, the oral hygiene habits identified in this study have far-reaching implications. Reducing a population's average BOP through better flossing and brushing could potentially lower the systemic inflammatory burden, contributing to better overall health outcomes. Public health initiatives should focus on making interdental cleaning tools more accessible and educating the public that "brushing is not enough."

Limitations and Future Directions

This study is not without limitations. As a cross-sectional study, it can only demonstrate associations, not definitive causality. Additionally, the data on hygiene habits was self-reported, which may be subject to social desirability bias (participants over-reporting good habits). Future research should employ longitudinal designs and perhaps use digital tracking (e.g., smart toothbrushes) to obtain more objective data on hygiene behaviors. Furthermore,

exploring the impact of newer technologies, such as water flossers or specialized electric toothbrushes, could provide more nuanced recommendations for high-risk patients.

In conclusion, the data presented here serves as a powerful reminder that the most effective tools for preventing periodontal disease are in the hands of the patient. Consistent brushing, daily interdental cleaning, adjunctive mouthwash use, and regular professional care form a multi-layered defense system that is highly effective at maintaining periodontal health and preventing the devastating consequences of periodontitis.

Conclusion

The comprehensive analysis conducted in this study underscores the indispensable role of individual oral hygiene practices in the prevention of periodontal diseases. The primary objective was to evaluate how various self-care behaviors specifically tooth brushing frequency, interdental cleaning, the use of antimicrobial mouth rinses, and the regularity of professional dental visits influence clinical markers of periodontal health. The results provide clear and statistically significant evidence that a multi-faceted approach to oral hygiene is the most effective strategy for maintaining periodontal stability and preventing the inflammatory processes that lead to tissue destruction.

One of the most significant conclusions drawn from this research is the critical importance of frequency and consistency. The data demonstrated that brushing twice daily and cleaning interdentally once daily are not merely clinical recommendations but are essential biological requirements for controlling the maturation of dental plaque. The study highlighted a clear disparity in health outcomes between those who adhered to these "gold standard" practices and those who engaged in them only occasionally or not at all. Specifically, the high levels of inflammation and deeper pocket depths observed in participants who neglected interdental cleaning point to the interproximal area as a high-risk zone that necessitates specific and regular attention.

Furthermore, the study confirms that while mechanical plaque control remains the foundation of oral health, the use of chemical adjuncts like antimicrobial mouth rinses and regular professional oversight provides significant additional benefits. Mouth rinses act as a valuable supplement by reducing the overall microbial load, while professional dental visits ensure the removal of calcified deposits and allow for early intervention. The synergy between home care and professional maintenance is clearly the most robust model for long-term periodontal health.

From a public health perspective, these findings suggest that there is still a significant need for enhanced oral health education. Despite the

availability of hygiene tools, a substantial portion of the adult population continues to practice suboptimal hygiene, particularly regarding interdental care and regular professional visits. This gap in compliance suggests that future public health strategies should move beyond simple instruction and focus on behavioral psychology, aiming to transform oral hygiene into a deeply ingrained daily habit.

Moreover, the implications of these findings extend beyond the oral cavity. As periodontal disease increasingly recognized as a risk factor for various systemic conditions, the promotion of effective oral hygiene viewed as a component of general preventive medicine. By reducing the prevalence of periodontal inflammation through simple, cost-effective daily practices, we can potentially contribute to a reduction in the global burden of chronic inflammatory diseases.

In summary, this study provides a strong evidence base for the effectiveness of preventive oral hygiene practices. To achieve optimal periodontal health, individuals must be encouraged to adopt a comprehensive routine that includes brushing at least twice a day, flossing daily, using antimicrobial rinses where appropriate, and maintaining regular professional check-ups. These actions, though simple, are the most powerful weapons available in the fight against periodontal disease. Future efforts should focus on overcoming barriers to compliance and ensuring that every individual has the knowledge and tools necessary to protect their periodontal health throughout their lifetime.

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Authors' Contributions

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