Clinical Note

Journal of INTERNATIONAL MEDICAL RESEARCH

Journal of International Medical Research
2017, Vol. 45(5) 1585–1596

DOI: 10.1177/0300060517705476
journals.sagepub.com/home/imr
SAGE

Distribution of dental plaque and gingivitis within the dental arches

Prem K. Sreenivasan[1] and Kakarla V.V. Prasad[2]

Abstract

Objective: The natural accumulation of supragingival plaque on surfaces of human teeth is associated with gingival inflammation and the initiation of common oral diseases. This study evaluated the distribution of dental plaque and gingivitis scores within the dental arches after prophylaxis.

Methods: Adult subjects from the Dharwad, India area representing the general population who provided written informed consent were scheduled for screening. Healthy subjects over the age of 18 years, not currently requiring any medical or dental care, and presenting with a complement of at least 20 natural teeth were recruited for this parallel design study. Enrolled subjects ($n = 41$) underwent oral examinations for dental plaque (PI) and gingivitis (GI) using the Turesky modification of the Quigley-Hein and the Löe-Silness Index, respectively, at the baseline visit, followed by a whole mouth dental prophylaxis. Subjects were given fluoride toothpaste for twice daily oral hygiene for the next 30 days. Subjects were recalled on days 15 and 30 for PI and GI examinations identical to baseline.

Results: Analyses indicated that mean scores for PI and GI on either arch and the whole mouth were higher than 2 and 1, respectively, during all examinations. Anterior surfaces consistently exhibited lower PI scores than posterior regions of either arch, or the entire dentition. Regional GI differences within the dentition were similar to PI scores, with lower scores on anterior than posterior teeth. Prophylaxis reduced both the frequency and mean scores of both PI and GI, irrespective of arch, with lower scores observed on anterior than posterior regions during all recall visits. Molar and lingual regions consistently exhibited higher PI and GI scores compared with anterior surfaces. At all examinations, mean scores for both plaque and gingivitis were higher on approximal vestibular than mid-vestibular surfaces.

Conclusions: Differences observed in PI and GI within the dentition have several practical implications: (a) there are advantages of whole mouth assessments for oral health (b) a need for oral hygiene formulations to reduce the larger deposits of dental plaque in the posterior region and resultant gingival inflammation, and (c) a requirement for ongoing oral hygiene education.

[1]Colgate-Palmolive Technology Center, Piscataway, NJ, USA
[2]Department of Community Dentistry, SDM College of Dental Sciences, Dharwad, India

Corresponding author:
Prem K. Sreenivasan, 909 River Road, Piscataway, NJ 08855. USA.
Email: Prem_Sreenivasan@colpal.com

Keywords

Arches, dental plaque, dentition, fluoride, gingivitis, prophylaxis, toothbrushing

Date received: 25 September 2016; accepted: 27 May 2017

Background

Endogenous organisms of the human mouth readily colonize exposed surfaces of the dentition to form dental plaque, a natural microbial biofilm.[1–3] Clinical studies in conjunction with microbiological analyses have evaluated the role of dental plaque in the initiation and progression of gingival inflammation and other oral diseases.[2] These assessments have been instrumental in identifying the organisms associated with caries, gingivitis and periodontal disease.[3,4] Based on the available evidence, current practices typically emphasize optimal plaque control for maintaining oral health.[1,4] Home-use plaque control measures comprise the most common means for routine plaque control. Benefits of plaque control include an opportunity to maintain a functional dentition and prevent the onset and progression of dental diseases. In addition, plaque control has several aesthetic benefits, including dental appearance and fresh breath.[1]

Recognition of the integral role of dental plaque in the progression of oral diseases has led to evaluations of dental plaque accumulations within the dentition.[1–5] A number of studies have examined plaque accumulation within the dentition. Taken together, these reports indicate that most individuals have a repeatable pattern of plaque accumulation within the dentition[5] with some areas tending to harbor low or high amounts of plaque. Additional research has elaborated on the influences of other factors, including diet,[6] local oxygen tension,[7] salivary factors[8] and tooth position,[9] all of which influence dental plaque accumulation. Other variables influencing plaque accumulation include habits and oral hygiene practices.[10]

Although previous studies have examined the prevalence of plaque on the dentition, to our knowledge there have been no investigations of the distribution of dental plaque and gingivitis within the dental arches. The current study focused on evaluation of individual plaque scores and gingivitis frequencies within each arch, as well as providing discussion of previously published results.[11] Determinations of plaque and gingival scores in these distinct regions may have practical implications for the field, such as oral health examination practices or in clinical evaluations of specific treatments.[12]

Materials and methods

Subjects

This single site clinical study was conducted after the clinical protocol and informed consent forms were reviewed and approved by the institutional ethical review board at SDM College of Dental Sciences and Hospital, Dharwad, India. Adult subjects (18–70 years of age) from the local area who called the dental clinic in response to word-of-mouth and advertisement campaigns were scheduled for a pre-screening visit. During the pre-screening visit, study details were explained to prospective subjects. Subjects who provided voluntary written informed consent, indicated availability during the study duration and were able to comply with study procedures were scheduled for a screening visit that included an oral examination by a dentist. Enrolment criteria included availability for the entire duration of the study, good oral and systemic health with no signs of neglect. Exclusion criteria included cognitive disorders or chronic medical conditions, systemic conditions of the heart, kidneys, liver, or infectious diseases, including AIDS. Other exclusion criteria included self-reported pregnancy or lactation, drug or alcohol addition, and subjects with crowns, veneers, dentures or other chronic conditions including caries, periodontal disease or on prescription medications.

Study procedures

Enrolled subjects were scheduled for a baseline visit that included a whole mouth examination for dental plaque and gingivitis that excluded the third molars (as described in section below). A dentist provided each subject with a whole mouth prophylaxis followed by a disclosing episode to ensure removal of all dental plaque. Subjects were provided with a commercially available fluoride toothpaste (Colgate Dental Cream, Great Regular Flavor, New York, NY) and a soft-bristled toothbrush and instructed to brush twice daily. Following enrolment, subjects were instructed not to alter their daily diet or other habits, but were instructed to discontinue the use of all other dentifrices, mouthwashes, chewing gum and other oral hygiene formulations for the study duration. Subjects were recalled after 15 and 30 days of dentifrice use for clinical assessments that were identical to those during the baseline visit. Study personnel conducted follow-up telephone calls for subjects approximately every 10 days over the study duration. Follow-up over study duration was designed to address study-related questions and reinforce the subjects' adherence to study procedures and schedules. All subjects completed the study without adverse events.

Clinical scoring procedures

Clinical examinations for dental plaque and gingivitis were conducted under constant lighting conditions and included assessments for dental plaque and gingivitis using the Turesky Modification of the Quigley-Hein (TMQH)[13] and the Löe-Silness [LS][14] indices, respectively. Sites examined for dental plaque (PI) were also examined for gingivitis (GI) with gingivitis assessments preceding the dental plaque examination. One clinical examiner conducted all examinations for this study. PI and GI scores from each tooth were recorded in appropriate forms and subsequently compiled in Microsoft Excel for statistical analysis.

Statistical methods

Sample size determinations were based on an standard deviation (SD) for the response measure with a significance level of $\alpha = 0.05$ at an 80% level of power. Sample size calculations utilized historical data from previous studies to detect differences in clinical scores of 0.5 or less. Clinical scores for dental plaque and gingivitis from the entire mouth were compiled and analysed separately. Initial analyses included descriptive statistics for whole mouth scores from each plaque and gingivitis examination along with frequency distributions for each score. Additionally, plaque and gingival scores from the facial surfaces of the anterior teeth (6–11 and 22–27) and surfaces of posterior teeth (2–5, 12–15, 18–21, and 28–31) at each assessment were compiled for frequency distributions. Clinical scores were averaged by subjects in a two-way analysis of variance (ANOVA) including subjects and time (baseline, day 15 and day 30) as main effects. Statistically significant effects ($p < 0.05$) were further analysed using post-hoc Tukey's multiple comparison tests for pairwise differences among time points.

Paired t-tests compared results between different regions of the dentition at each assessment. Analyses were conducted using Minitab (Minitab Inc., State College PA), and statistical significance was determined with a 95% confidence interval and p-value less than 0.05.

Results

Frequency distribution of PI scores on the upper and lower arches

Results from 41 adults (23 males and 18 females; age range 19–44 years) representing 6,756 surfaces examined at each clinical examination and their corresponding arches subsequently during the day 15 and 30 assessments are shown in Graph 1. On a percentage basis, surfaces with plaque scores of 2 and 3 were the most frequent, while those with scores of 0 and 5 were the least frequent. At each evaluation, less than 13% of the sites reported a plaque score of 4. A score of 5 was observed in approximately 4% of the surfaces at baseline, while less than 2% of the surfaces exhibited a score of 5 in evaluations following prophylaxis.

Comparison of mean PI scores on anterior and posterior surfaces from either arch

Table 1 shows the least squares mean scores for plaque on the anterior and posterior surfaces from each arch. Plaque scores were 2 or more at each evaluation, irrespective of arch. ANOVA revealed significant reductions from baseline to day 15 evaluations for the lower anterior and upper posterior surfaces of both arches ($p < 0.05$), reflecting the effects of prophylaxis. Irrespective of location, day 30 plaque scores corresponded with baseline scores.

Statistical comparisons of mean differences in plaque between the anterior and posterior regions of each arch over the study period are shown in Table 2. Regardless of arch, significantly higher mean PI scores were observed among posterior surfaces compared with anterior regions ($p < 0.003$). Prophylaxis reduced plaque scores from baseline to the first recall visit but demonstrated consistent increases from the first to the second recall visit. Mean scores from the second recall visit were similar to those observed at baseline.

Plaque scores within each region of the dentition

Mean plaque scores within each region of the dentition are shown in Table 3. At each evaluation, mean plaque scores for each region were greater than 2. All surfaces demonstrated reductions from baseline to the day 15 evaluation. These effects were statistically significant ($p < 0.05$) with the exception of the mid-vestibular surfaces

Table 1. Analysis of dental plaque scores on the anterior and posterior surfaces of the upper and lower arch (least squares means ± SEM at each evaluation).

	Anterior lower	Anterior upper	Posterior lower	Posterior upper
Day 0	2.34 ± 0.05	2.26 ± 0.04	2.56 ± 0.042	2.75 ± 0.04
Day 15	2.05 ± 0.05^{a}	2.15 ± 0.04	2.47 ± 0.042	2.58 ± 0.04^{a}
Day 30	2.31 ± 0.05^{b}	2.38 ± 0.04^{b}	2.65 ± 0.042^{b}	2.71 ± 0.04

[a] = significantly different from baseline
[b] = significantly different from day 15

Table 2. Comparison of dental plaque scores on anterior and posterior teeth of the upper and lower arch.

Arches	Treatment	Surfaces	Mean	SD	t–value	p-value
Upper arch	Baseline	Anterior	2.26	0.76	–7.50	0.0000§
		Posterior	2.75	0.67		
	15 days	Anterior	2.15	0.71	–7.38	0.0000§
		Posterior	2.58	0.56		
	30 days	Anterior	2.38	0.76	–5.61	0.0000§
		Posterior	2.71	0.53		
Lower arch	Baseline	Anterior	2.34	0.90	–2.90	0.0038§
		Posterior	2.56	0.76		
	15 days	Anterior	2.05	0.74	–6.64	0.0000§
		Posterior	2.47	0.66		
	30 days	Anterior	2.31	0.80	–5.22	0.0000§
		Posterior	2.65	0.62		

§ = Statistically significant.

Table 3. Plaque scores on distinct regions of the dentition (average ± standard deviation).

Surfaces	Baseline	Day 15	Day 30
Overall	2.50 ± 0.55	2.34 ± 0.46‡,†	2.54 ± 0.48§
All upper	2.54 ± 0.59	2.39 ± 0.51‡,†	2.57 ± 0.53§
All lower	2.47 ± 0.72	2.29 ± 0.60‡,†	2.50 ± 0.62§
All vestibular	2.38 ± 0.50	2.25 ± 0.41‡,†	2.41 ± 0.49§
All lingual	2.62 ± 0.58	2.43 ± 0.49‡,†	2.66 ± 0.44§
All approximal vestibular	2.55 ± 0.52	2.40 ± 0.42‡,†	2.58 ± 0.46§
All mid-vestibular	2.16 ± 0.47	2.04 ± 0.36†	2.21 ± 0.47§
All mid-lingual	2.51 ± 0.59	2.31 ± 0.51‡,†	2.56 ± 0.48§
Front	2.30 ± 0.67	2.10 ± 0.56‡,†	2.34 ± 0.64§
Premolar	2.33 ± 0.68	2.23 ± 0.61‡,†	2.40 ± 0.60
Molar	2.98 ± 0.64	2.82 ± 0.56‡,†	2.97 ± 0.47§
Ramfjord	2.40 ± 0.60	2.23 ± 0.49‡,†	2.46 ± 0.52§

‡ = Significantly different from baseline.
† = Significant differences between day 15 and day 30 evaluations.
§ = Not significantly different from baseline.

($p > 0.05$). An increase in plaque scores was observed for all surfaces from the day 15 to the day 30 evaluation ($p < 0.05$). With the exception of molar surfaces, there were no significant differences in plaque scores for any surface between baseline and the day 30 evaluations ($p < 0.05$). Mid-vestibular and molar regions consistently reported the lowest and highest scores at each evaluation, respectively ($p < 0.0000$). Additional analyses indicated significantly lower mean scores on mid-vestibular surfaces compared with approximal surfaces at each evaluation ($p \leq 0.0001$).

Frequency distribution of GI scores on the upper and lower arches

Graph 2 shows the frequency of each GI score on the upper and lower arches in relation to the entire dentition. Gingival scores of 1 and 2 were most common at the baseline evaluation. On a percentage basis, a gingival score of 2 was more frequent on the posterior surfaces of the lower arch than on the upper arch at baseline. A gingival score of 3 was found on 8.4–10.19% of the surfaces, and fewer than 1.5% of the surfaces were devoid of gingivitis. Prophylaxis reduced the number of surfaces reporting gingival scores of 2 and 3 with a concomitant increase in the number of sites reporting scores of 0 and 1. We observed reductions in gingival scores of surfaces in the two recall visits, with a score of 1 found at more than 69% of the sites, constituting the most frequent observation. At the first recall visit, 6.6–8.6% of the sites exhibited a score of 0, and less than 1% of surfaces reported a score of 3 with comparable observations during the final recall examination. Irrespective of arch, sites with a score of 3 were observed at less than 1% of all sites in both recall visits.

Comparisons of mean GI scores on anterior and posterior surfaces from either arch

Table 4 shows the least squares mean GI scores on the anterior and posterior surfaces from each arch. Mean scores irrespective of arch were 1 or more at each evaluation. by ANOVA revealed significant reductions from baseline to the day 15 evaluations for all evaluated arches and surfaces ($p < 0.05$). Irrespective of location, day 30 GI scores indicated additional reductions from the day 15 scores.

Table 5 shows the mean GI scores on anterior and posterior surfaces from either arch. On the upper arch, anterior surfaces demonstrated significantly lower mean GI scores than the corresponding posterior surfaces ($p < 0.05$). Although there were significant differences between the anterior and posterior regions of the lower arch at the two recall visits ($p < 0.001$), no differences were observed between these surfaces at baseline ($p = 0.7641$).

Mean gingival scores within each region of the dentition

Table 6 shows the mean gingival scores within each region of the dentition over the study period. At each evaluation, mean scores from each region were higher than 1, with the exception of mid-vestibular and mid-lingual regions during the recall visits. Surfaces demonstrated significant reductions in gingival scores from baseline to both recall visits ($p < 0.05$). Mid-vestibular and mid-lingual regions constituted the regions with the lowest scores compared with molar regions that

Table 4. Analysis of gingival scores on the anterior and posterior surfaces of the upper and lower arch (least squares means ± SEM at each evaluation).

	Anterior lower	Anterior upper	Posterior lower	Posterior upper
Day 0	1.71 ± 0.03	1.44 ± 0.027	1.70 ± 0.02	1.69 ± 0.026
Day 15	1.08 ± 0.03[a]	1.02 ± 0.027[a]	1.24 ± 0.02[a,b]	1.17 ± 0.026[a]
Day 30	1.04 ± 0.03[a]	1.05 ± 0.027[a]	1.14 ± 0.02[a]	1.10 ± 0.026[a]

[a] = significantly different from baseline
[b] = significantly different from day 30

Table 5. Comparison of gingival scores on anterior and posterior teeth of the upper and lower arch.

Arches	Treatment	Surfaces	Mean	SD	t-value	p-value
Upper arch	Baseline	Anterior	1.44	0.48	–5.47	0.0000§
		Posterior	1.69	0.52		
	15 days	Anterior	1.02	0.39	–4.16	0.0000§
		Posterior	1.17	0.38		
	30 days	Anterior	1.05	0.26	–2.04	0.041§
		Posterior	1.10	0.30		
Lower arch	Baseline	Anterior	1.71	0.57	0.30	0.76¶
		Posterior	1.70	0.46		
	15 days	Anterior	1.08	0.45	–4.13	0.0000§
		Posterior	1.24	0.38		
	30 days	Anterior	1.04	0.31	–3.83	0.0001§
		Posterior	1.14	0.29		

¶ = Not significant.
§ = Statistically significant.

Table 6. Gingival scores on the distinct regions of the dentition (average ± standard deviation).

Surfaces	Baseline	Day 15	Day 30
Overall	1.64 ± 0.39§	1.14 ± 0.30	1.09 ± 0.21
All Upper	1.59 ± 0.45‡	1.11 ± 0.34	1.08 ± 0.24
All Lower	1.70 ± 0.46‡	1.17 ± 0.36	1.10 ± 0.25
All Vestibular	1.68 ± 0.42‡	1.19 ± 0.31	1.11 ± 0.21
All Lingual	1.61 ± 0.35‡	1.09 ± 0.28	1.06 ± 0.21
All Approximal vestibular	1.73 ± 0.39‡	1.25 ± 0.26	1.17 ± 0.18
All mid-vestibular	1.53 ± 0.40§	1.02 ± 0.33	0.99 ± 0.21
All mid-lingual	1.48 ± 0.35§	0.92 ± 0.30	0.91 ± 0.20
Front	1.58 ± 0.44§	1.05 ± 0.36	1.04 ± 0.25
Premolar	1.52 ± 0.42‡	1.07 ± 0.32	1.03 ± 0.24
Molar	1.87 ± 0.42‡	1.34 ± 0.35	1.22 ± 0.28
Ramfjord	1.63 ± 0.43‡	1.12 ± 0.32	1.06 ± 0.23

‡Surfaces with significant differences from baseline to each recall and between each recall visit.
§Surfaces with significant differences from baseline to each recall but no significant differences between the two recall visits.

consistently exhibited the highest scores at each evaluation ($p < 0.0000$). The surfaces of approximal vestibular and Ramfjord teeth tended to exhibit higher scores compared with other teeth. The statistical analyses indicated that mean scores on mid-vestibular surfaces were significantly lower than on approximal surfaces at each evaluation ($p \leq 0.005$).

Discussion

Routine oral hygiene measures are widely practiced globally, with historical accounts

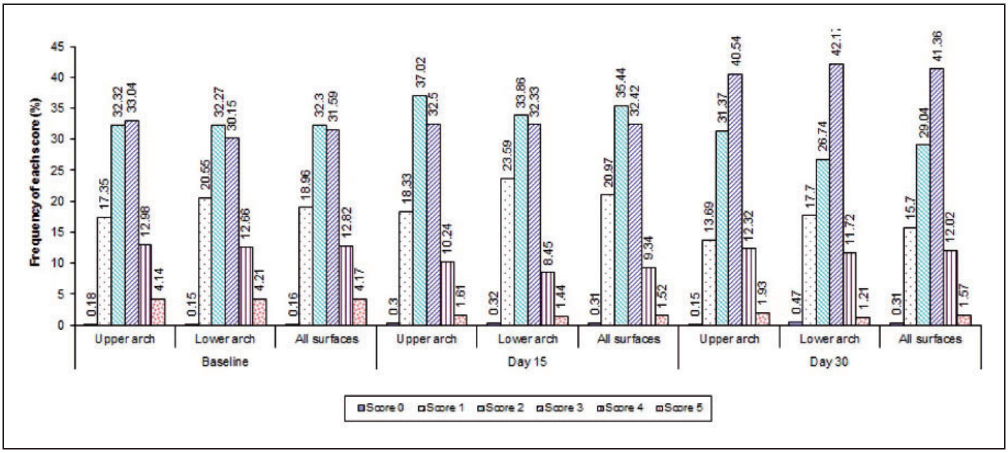

Figure 1. Frequency distribution for plaque scores on each arch and all surfaces over the study duration.

tracing these practices to antiquity. Whereas natural methods of oral hygiene continue to be utilized in different regions of the world, the use of a toothbrush and toothpaste represents a common approach.[12] While all Americans claim to own a toothbrush, and brush their teeth routinely, it is clear that most individuals fail to perform adequate oral hygiene on a routine basis. Studies indicate that ≈40–50% of plaque remains after a brushing episode, and the effects of plaque are represented in the widespread prevalence of common oral diseases, including caries, gingivitis and periodontal disease.[1,5]

The current study focused on a comparison of dental plaque and gingivitis within the dental arches. We evaluated subjects using two widely utilized clinical indices for dental plaque and gingivitis. These indices represent the ‘‘gold-standard’’ evaluation methods, and are commonly utilized to assess oral health and the effects of oral hygiene formulations.[13–20] Several advantages of these methods include their relative ease, history of use, and the large number of clinical investigators possessing practical experience with these methods.

Several steps were included in the study design to maintain generalizability of the current results. Clinical procedures and assessments were standardized for this investigation, and a calibrated clinical examiner with greater than 90% reliability for each clinical index conducted all examinations under constant lighting conditions. The clinical indices were used to examine six surfaces of all teeth, providing a comprehensive assessment of dental plaque and gingivitis in all examinations. Prospective subjects were screened for general health parameters and oral health. Adults from the general population in good health, with at least 20 natural teeth and no crowns or dentures, and currently not undergoing medical or dental treatments were enrolled. These design features were included to reduce physiological factors that influence the oral parameters, including dental plaque and gingivitis, that were the primary focus of this investigation. Several additional features were included in the study design to maintain the overall generalizability of the study. Subjects were not instructed to alter their diet or habits, to reduce the influence of these variables on the parameters we evaluated.[21] A new toothbrush and a commercially available fluoride toothpaste were issued to all subjects for standardized oral hygiene during the study. Subjects were

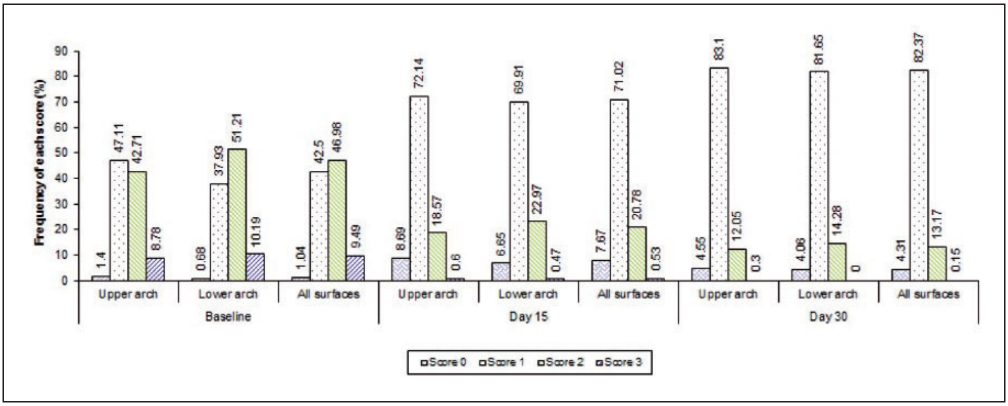

Figure 2. Frequency distribution for gingival scores on each arch and all surfaces over the study duration.

instructed to brush their teeth as per their usual techniques. Evaluation of 41 subjects resulted in the evaluation of 6,756 sites for dental plaque and gingivitis at each examination. Results from 20,268 data points for each clinical index were compiled, comprising a substantial data set for statistical analysis.

The most frequent plaque and gingival scores on either arch were 2, 3 and 1, 2 respectively. All remaining scores were observed on a smaller number of surfaces. Irrespective of arch, anterior surfaces demonstrated lower frequencies than posterior regions in all evaluations. Analyses of mean scores for both plaque and gingivitis on the anterior and posterior surfaces of either arch correspond to their respective frequency distributions, with significantly lower scores on anterior surfaces than posterior regions. For both clinical parameters, lower scores were consistently observed on anterior regions compared with the corresponding posterior sites. These results are in accord with previous studies examining the efficacy of oral hygiene, demonstrating that many more anterior surfaces were free of plaque than posterior regions.[10,22] Correspondingly, results from epidemiological studies indicate that posterior sites are prone to gingival inflammation and periodontal disease.[10] While the current results are in congruence with previous reports in the literature, they are in contrast with assessments of oral health provided by analyses of selected regions, such as the anterior teeth.[23] Thus, analyses of anterior surfaces appear to provide partial assessments of oral hygiene based on the consistently higher accumulations of dental plaque and resultant gingival inflammation in the posterior regions, irrespective of arch.

Anatomical and physiological features are likely contribute to the consistent abundance of dental plaque and corresponding gingival scores in molar and lingual regions. These surfaces are reported to consistently exhibit the largest amounts of plaque, and correspond to lower plaque removal from these regions[10,22] and higher susceptibility to gingivitis[10] in adults. Similar observations have been reported among teenagers[24] and after professional tooth cleaning.[19] These clinical observations have been substantiated by recent microbiological investigations reporting greater amounts of microbial DNA on posterior teeth.[9]

Mid-vestibular regions consistently exhibited significantly lower scores than approximal vestibular surfaces. These observations are relevant for oral health examinations in several ways. For example, while common indices remain the most widespread means of assessing oral health, some reports have highlighted specific deficiencies in these methods.[25] Approaches that attempt to improve on these methods include planimetric methods[26] and other techniques for examining dental plaque on anterior teeth using digital plaque imaging.[23] The current results demonstrate specific differences between and within the dentition for dental plaque and gingivitis. Additionally, the current results revealed that plaque levels on the facial surfaces of anterior teeth did not match the levels in approximal vestibular regions. Taken together, these findings suggest that anterior teeth are an insufficient substitute for accurately evaluating whole mouth plaque and gingivitis status.

The effect of prophylaxis was evident on all surfaces showing reductions in plaque and gingival scores from the baseline to the first recall visit. All surfaces exhibited increases in plaque scores from the first to the second recall visit, with no significant differences observed between the baseline and the second recall visit. In contrast, gingival scores maintained their broad reductions from the first to the second recall visit at the conclusion of the study. These results are in accord with those of a previous investigation examining the effects of prophylaxis on dental plaque and bleeding on probing (BOP) amongst a sample of 15 14–19-year-old male subjects.[27] In that study, significantly lower plaque levels were observed 15 days after prophylaxis along with reductions in BOP, however, both plaque and BOP levels demonstrated increases from day 15 to day 30. Subjects enrolled in this investigation were older than 18 years, and of mixed gender. Plaque scores on day 30 returned to baseline levels. However, gingival scores maintained broad reductions, revealing a divergence between these parameters. Taken together, these observations corroborate previous studies and expand on the available literature, demonstrating consistently lower PI and GI scores on anterior surfaces compared with posterior regions.

Conclusions

We found that PI and GI scores were lower on anterior teeth compared with posterior regions, irrespective of arch, in all evaluations over the study period. While dental prophylaxis reduced dental plaque and gingivitis scores at the day 15 and day 30 evaluations, posterior surfaces consistently registered higher scores than anterior regions. In addition to providing a reference point for the distribution of plaque and gingival inflammation on the dental arches, the current findings have practical relevance for oral hygiene, including the development of preventative programs that seek to reduce the incidence of common oral diseases. Correspondingly, an accurate assessment of oral health requires the incorporation of these regional differences in whole mouth examinations.

Authors' contributions

All authors contributed extensively to the work presented in this paper. PS provided the idea for the project and prepared the manuscript. KVVP recruited the participants, collected the data. All authors read and approved the final manuscript.

Declaration of conflicting interests

The authors declare that there is no conflict of interest.

Funding

This work was funded by Colgate-Palmolive Company. Prem K. Sreenivasan is an employee of Colgate-Palmolive Company.

References

1. Claydon NC. Current concepts in toothbrushing and interdental cleaning. *Periodontol 2000* 2008; 48: 10–22.
2. Löe H. Oral hygiene in the prevention of caries and periodontal disease. *Int Dent J* 2000; 50: 129–139.
3. Socransky SS and Haffajee AD. Dental biofilms: difficult therapeutic targets. *Periodontol 2000* 2002; 28: 12–55.
4. Ohrn K and Sanz M. Prevention and therapeutic approaches to gingival inflammation. *J Clin Periodontol* 2009; 36(Suppl 10): 20–26.
5. Cumming BR and Löe H. Consistency of plaque distribution in individuals without special home care instruction. *J Periodontal Res* 1973; 8: 94–100.
6. Liljemark WF and Bloomquist C. Human oral microbial ecology and dental caries and periodontal diseases. *Crit Rev Oral Biol Med* 1996; 7: 180–198.
7. Bowden GH and Hamilton IR. Survival of oral bacteria. *Crit Rev Oral Biol Med* 1998; 9: 54–85.
8. Stookey GK. The effect of saliva on dental caries. *J Am Dent Assoc* 2008; 139(Suppl): 11S–17S.
9. Haffajee AD, Teles RP, Patel MR, et al. Factors affecting human supragingival biofilm composition. II. Tooth position. *J Periodontal Res* 2009; 44: 520–528.
10. Axelsson P and Lindhe J. Effect of controlled oral hygiene procedures on caries and periodontal disease in adults. *J Clin Periodontol* 1978; 5: 133–151.
11. Sreenivasan PK, DeVizio W, Prasad KV, et al. Regional differences within the dentition for plaque, gingivitis and anaerobic bacteria. *J Clin Dent* 2010; 21: 13–19.
12. Hancock EB and Newell DH. Preventive strategies and supportive treatment. *Periodontol* 2000; 2001:25: 59–76.
13. Turesky S, Gilmore ND and Glickman I. Reduced plaque formation by the chloromethyl analogue of victamine C. *J Periodontol* 1970; 41: 41–43.
14. Löe H and Silness J. Periodontal disease in pregnancy. *Acta Odontol Scand* 1963; 21: 533–551.
15. Goodson JM, Palys MD, Carpino E, et al. Microbiological changes associated with dental prophylaxis. *J Am Dent Assoc* 2004; 135: 1559–1564.
16. Goyal CR, Qaqish JG, Sharma NC, et al. Plaque removal efficacy of a novel tooth wipe. *J Clin Dent* 2005; 16: 44–46.
17. He T, Biesbrock AR, Walters PA, et al. A comparative clinical study of the plaque removal efficacy of an oscillating/rotating power toothbrush and an ultrasonic toothbrush. *J Clin Dent* 2008; 19: 138–142.
18. Lindhe J, Rosling B, Socransky SS, et al. The effect of a triclosan-containing dentifrice on established plaque and gingivitis. *J Clin Periodontol* 1993; 20: 327–334.
19. Van der Weijden GA, Timmerman MF, Piscaer M, et al. Plaque removal by professional electric toothbrushing compared with professional polishing. *J Clin Periodontol* 2004; 31: 903–907.
20. Williams K, Ferrante A, Dockter K, et al. One- and 3-minute plaque removal by a battery-powered versus a manual toothbrush. *J Periodontol* 2004; 75: 1107–1113.
21. Signoretto C, Burlacchini G, Bianchi F, et al. Differences in microbiological composition of saliva and dental plaque in subjects with different drinking habits. *New Microbiol* 2006; 29: 293–302.
22. Terézhalmy GT, Biesbrock AR, Walters PA, et al. Clinical evaluation of brushing time and plaque removal potential of two manual toothbrushes. *Int J Dent Hyg* 2008; 6: 321–327.
23. White DJ. Effect of a stannous fluoride dentifrice on plaque formation and removal: a digital plaque imaging study. *J Clin Dent* 2007; 18: 21–24.
24. Sripriya N and Shaik Hyder Ali KH. A comparative study of the efficacy of four different bristle designs of tooth brushes in plaque removal. *J Indian Soc Pedod Prev Dent* 2007; 25: 76–81.
25. Matthijs S, Sabzevar MM and Adriaens PA. Intra-examiner reproducibility of 4 dental

plaque indices. *J Clin Periodontol* 2001; 28: 250–254.
26. Söder B, Johannsen A and Lagerlöf F. Percent of plaque on individual tooth surfaces and differences in plaque area between adjacent teeth in healthy adults. *Int J Dent Hyg* 2003; 1: 23–28.
27. Júnior ABN, de Souza SLS, Taba Jr M, et al. Control of gingival inflammation in a teenager population using ultrasonic prophylaxis. *Brazilian Dental Journal* 2004; 15: 41–45.