GT Terézhalmy
AR Biesbrock
PA Walters
JM Grender
RD Bartizek

Clinical evaluation of brushing time and plaque removal potential of two manual toothbrushes

Authors' affiliations:
Géza T. Terézhalmy, University of Texas Health Science Center at San Antonio Dental School, San Antonio, TX, USA
Aaron R. Biesbrock, *Patricia A. Walters*, *Julie M. Grender*, *Robert D. Bartizek*, Procter & Gamble, Mason, OH, USA

Correspondence to:
Aaron Biesbrock
Procter & Gamble MBC
8700 Mason-Montgomery Road
Mason, OH 45040 USA
Tel.: +1 513 622 0316
Fax: +1 513 622 3870
E-mail: biesbrock.ar@pg.com

Dates:
Accepted 27 May 2008

To cite this article:
Int J Dent Hygiene **6**, 2008; 321–327
Terézhalmy GT, Biesbrock AR, Walters PA, Grender JM, Bartizek RD. Clinical evaluation of brushing time and plaque removal potential of two manual toothbrushes.

Abstract: *Aim:* To compare plaque removal efficacy of Oral-B CrossAction (CA) used for 1 min with an American Dental Association (ADA) manual toothbrush used for 2 or 5 min in an examiner-blind, three-treatment, six-period crossover study. *Materials and Methods:* After refraining from all oral hygiene procedures for 23–25 h, subjects were randomly assigned to one of nine possible six-period (visit) treatment sequences. Plaque was assessed at baseline (Rustogi Modified Navy Plaque Index). Post-brushing scores were recorded after brushing with a marketed dentifrice and the assigned toothbrush for the specified duration. The same procedure was followed at each of six subsequent visits. Clinical measurements were carried out by the same examiner. *Results:* Forty subjects completed the study. All three treatments effectively removed plaque from the whole mouth, along the gingival margin and from approximal surfaces. Whole mouth and gingival margin plaque removal scores with CA for 1 min did not differ significantly from scores with the ADA toothbrush used for 2 min. The ADA brush used for 5 min showed significantly greater whole mouth ($P < 0.001$) and gingival margin ($P < 0.001$) plaque reduction than the two other treatments. Approximal plaque removal scores did not differ between the three treatments. *Conclusions:* Efficient plaque removal can be achieved after 1 min of brushing with CA. The amount of plaque removed did not differ significantly from that achieved with the ADA brush after 2 min of brushing. Greater whole mouth and gingival margin plaque removal scores were seen with the ADA brush after 5 min.

Key words: clinical trial; oral hygiene; plaque control; tooth brush electric/manual; toothbrushing methods/techniques

Introduction

Dental disease can be prevented and controlled by adequate mechanical removal of dental plaque (1–6). This can be achieved by regular brushing with a manual toothbrush, but only if users adopt an appropriate technique and brush for long enough (7–9). Manufacturers of manual toothbrushes have helped to overcome inconsistent and varied toothbrush motion by introducing novel brush head designs aimed at achieving good plaque removal even with inadequate brushing technique (10). However, toothbrush manufacturers (11–13) continue to promote the need to brush for a sufficient length of time (i.e. 2 min twice a day) to reinforce good hygiene habits.

The relative merits of advances in manual toothbrush design can be readily assessed in clinical studies that compare brushes for their effectiveness in removing plaque from all regions of the mouth, including the approximal surfaces and gumline areas (gingival margins) that are known to be hard to reach during routine brushing and hence susceptible to plaque accumulation. Typically, these clinical studies compare the plaque removing effectiveness of different manual brushes over a fixed time interval, generally 1 min, and the results of such comparisons serve to define the relative efficiency of novel brushes as they are introduced for use by the general population (14–16). Results of these standard plaque removal studies are typically expressed as 'Brush A removed x% more plaque than Brush B'. The relevance of this type of comparison, however, may be difficult to interpret.

Clinical studies of this kind have established Oral-B CrossAction (CA, Fig. 1) as a leading manual toothbrush for efficient plaque removal and hence good oral hygiene (17). Independent studies show benefits of approximately 10–40% for CA relative to several ordinary manual brushes (18). In an effort to further dimensionalize the relative performance of CA in a way that may be more meaningful to patients and professionals, new research was undertaken to look at the efficiency of plaque removal with brushing. The approach in this trial was to evaluate plaque reduction levels achieved with CA for 1 min versus those achieved using a traditional manual brush (ADA flat trim reference brush; Fig. 1) when that brush was used for a longer duration, specifically the recommended duration of 2 min. Although arguably unrealistic to expect individuals to brush for longer than 2 min, this study also included the use of an ADA manual brush when used for 5 min to explore the impact of longer brushing duration on plaque removal.

In this study, therefore, the effectiveness of CA relative to the effectiveness of the ADA manual brush was examined in three brushing regimens: CA for 1 min; ADA manual brush for 2 min; and ADA manual brush for 5 min. A six-period crossover design was used to control for residual effects and the Rustogi *et al.* Modified Navy Plaque Index (RMNPI) (19) was used to assess plaque removal as this index is widely used for scoring whole mouth plaque and also readily allows for plaque removal to be scored at specific surfaces (approximal and gingival margin), where plaque is most likely to accumulate (20).

Fig. 1. ADA manual toothbrush (left) and Oral-B CrossAction (right).

Materials and Methods

Ethical approval

The study protocol was approved by the University of Texas Health Science Center at San Antonio Institutional Review Board prior to the start of the study. All subjects gave signed informed consent and completed a medical history form before participation in the study, and were free to withdraw from the study at any time.

Subjects

Adult subjects from the San Antonio area were eligible for the study. For study inclusion subjects were required to be in good general health, between 18 and 70 years of age and with a minimum of 15 scorable teeth. The subjects were also required to be willing to refrain from all oral hygiene procedures and chewing gums (21) for at least 23–25 h prior to each study visit and from eating, drinking or smoking for 4 h prior to visits.

Any of the following criteria excluded subjects from participating in the study: having an orthodontic appliance or removable prosthesis; evidence of neglected dental health (e.g. obvious periodontal disease); five or more carious lesions requiring restorative treatment.

Study design and procedures

This was an examiner-blind, three-treatment (CA for 1 min; ADA manual toothbrush for 2 min; ADA manual toothbrush for 5 min), randomised, six-period (visit) crossover study. The order in which the three treatments were assigned was determined by nine different treatment sequences, e.g. ACBBCA, BACCAB, CBAABC, etc., and subjects were randomly assigned to one of the nine sequences (approximately 4 to 5 subjects per sequence).

Subjects who gave signed informed consent and who were eligible to participate in terms of the study inclusion and exclusion criteria were given a CA toothbrush for 3–5 days to become familiar with this brush. At the Period 1 visit, subjects who had refrained from all oral hygiene procedures and chewing gums for at least 23–25 h prior to the study visit and who had refrained from eating, drinking or smoking for 4 h prior to the visit swished with red disclosing solution to disclose their plaque. They then received a pre-brushing plaque examination. Plaque was scored using the RMNPI on each of nine sites on both the buccal and lingual tooth surfaces (i.e. for 28 teeth a total of 504 sites were scored). Plaque was scored as either present (score = 1) or absent (score = 0) for the whole mouth, along the gingival margin, and interproximally (i.e. the approximal surfaces) as defined in Fig. 2.

Subjects were then instructed to brush for their assigned brushing time with their assigned toothbrush and marketed toothpaste (Crest Cavity Protection, Procter & Gamble Company, Cincinnati, OH, USA) using a horizontal motion technique. Brushing was under supervision but unaided by access to a mirror. After brushing their teeth, the subjects again swished with the red disclosing solution to disclose the plaque and this was followed by a post-brushing plaque examination.

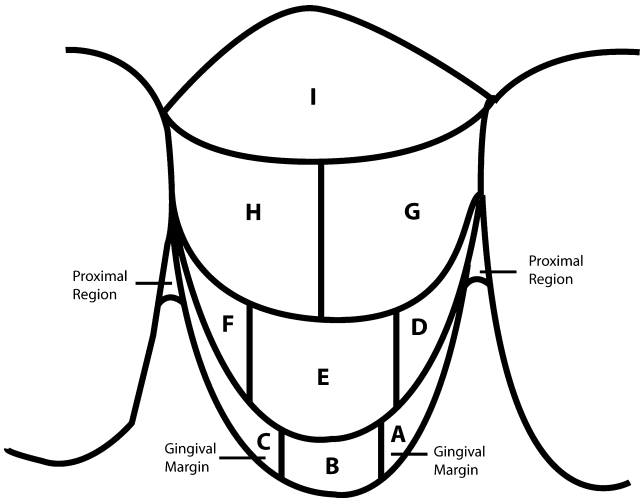

Fig. 2. Rustogi *et al.* Modification of the Navy Plaque Index (18). Disclosed plaque is scored in each tooth area as present (scored as 1) or absent (scored as 0) and recorded for both buccal and lingual surfaces. Whole mouth = areas A, B, C, D, E, F, G, H and I; along gingival margin (gumline) = areas A, B and C; interproximal (approximal surfaces) = D and F.

The following five visits were each separated by an interval of approximately 2–3 days during which subjects were instructed to brush their teeth as normal and with their usual brush. At each of the visits subjects were assigned brushes according to their treatment sequence. The procedure for disclosing, brushing and plaque grading was the same for each visit.

Data analysis

A sample size of 35 completed subjects in a six-period crossover study was estimated for this study based on previous plaque removal data from the examiner (GT), to ensure an 80% chance of detecting a treatment group difference of about 0.009 as measured by RMNPI.

The average whole mouth RMNPI scores were obtained at baseline and following brushing and the differences (baseline minus post-brushing) were calculated for each subject in each treatment period. To assess treatment effects, an analysis of covariance (ANCOVA) for a crossover design was applied to the differences, with terms in the model for subjects, treatment, period and the baseline score as the covariate. In addition to the analysis of average whole mouth scores, separate analyses were performed for average gingival margin scores and average approximal scores with the appropriate baseline score as the covariate. For each variable appropriate tests were conducted to assess carryover effects in this three-treatment, six-period crossover design. All comparisons were two-sided and used a significance level of $\alpha = 0.05$.

Results

In total 41 subjects were enrolled in the study and all except one of these subjects, who voluntarily withdrew at the fourth study visit, completed the study. Table 1 shows the demographic data for the 40 subjects included in the analyses.

The crossover ANCOVA revealed no statistically significant carryover effects ($P \geq 0.436$) for either whole mouth, gingival margin or approximal surfaces and this term was dropped from the final analyses of treatment group differences. Mean RMNPI pre-brushing (baseline) scores and mean post-brushing plaque reduction are shown for all three treatment groups in Table 2 together with *P*-values for overall treatment group differences in plaque removal, and where appropriate, comparisons between each treatment group.

Pre-brushing plaque scores did not differ significantly ($P > 0.05$) between treatment groups for either whole mouth, gingival margins, or approximal surfaces. The difference in whole mouth plaque removal between the CA used for 1 min and the ADA manual toothbrush used for 2 min was not statistically significant ($P = 0.914$). Whole mouth plaque removal with the ADA manual toothbrush used for 5 min was statistically significantly greater ($P < 0.001$) than with either the ADA manual toothbrush used for 2 min or CA used for 1 min. The adjusted mean plaque reduction score for the ADA manual toothbrush used for 5 min was about 10% greater than the reduction scores for the other two brushes.

Gingival margin plaque removal results were similar to those for whole mouth plaque removal. The difference between CA used for 1 min and the ADA manual toothbrush used for 2 min was not statistically significant ($P = 0.814$). Gingival margin plaque removal with the ADA manual toothbrush used for 5 min was statistically significantly greater ($P < 0.001$) than with either the ADA manual toothbrush used for 2 min or CA used for 1 min. The adjusted mean plaque reduction score for the ADA manual toothbrush used for 5 min was about 11% greater than the reduction scores for the other two brushes.

Table 1. **Demographic characteristics**

Patients (*n*)	40
Age (years)	
Mean	44.2
Minimum–maximum	23–65
Gender (*n*)	
Males	11
Females	29
Ethnicity (*n*)	
Caucasian	12
Hispanic	26
Asian	2

Approximal plaque removal results revealed no statistically significant difference among the treatment groups ($P > 0.1$).

The percentage reductions in plaque for the whole mouth, marginal and approximal surfaces were 58, 55 and 72%, respectively with CA used for 1 min; 58, 56 and 74%, respectively with the ADA manual brush used for 2 min; and 64, 62 and 79%, respectively with the ADA manual brush used for 5 min (Fig. 3).

No adverse events were reported during the study.

Discussion

The length of time spent brushing has been shown to be an important factor in determining brushing effectiveness. For example, in a comparative study of plaque removal with three electric toothbrushes and a manual brush (22), the teeth of dental students were brushed by an investigator in a series of experiments that differed only in terms of the time for the brushing procedure. The brushing times for the whole mouth ranged between 30 s and 6 min. Although efficacy differed between brushes and the interproximal areas were not cleaned as effectively as lingual and vestibular surfaces, the results served to illustrate that an increase in toothbrushing duration gave an increase in plaque removal.

Dental professionals and the oral hygiene industry generally recommend 2 min twice a day as the optimal brushing time (11–13). However, there is evidence of poor subject compliance with recommended brushing time. In a study using a powered toothbrush and electronic data loggers over a 2-month-period in patients with chronic periodontal disease (23), subjects were told to brush for 2 min in the morning and evening and to complete a brushing diary. From the manually completed diaries and data loggers, it was found that almost half of the brushing events (48%) were non-compliant (i.e. either 30 s above or below the instructed brushing time of 2 min).

Leading manufacturers of modern powered toothbrushes assist compliance by designing their brushes with timers (e.g. Oral-B Professional Care Series; Philips Sonicare; Philips Healthcare, Bothell WA, USA), which in some cases are programmable and incorporate beeps and pauses, all designed to help individuals achieve the appropriate brushing time in all sections of the mouth. However, users of manual toothbrushes or power brushes without timers are likely to rely on their own judgment for brushing duration and unfortunately it has been shown that individuals believe they brush their teeth for longer than the time they actually spend brushing, which on average is approximately 1 min rather than the

Table 2. **Pre-brushing plaque scores and post-brushing plaque reduction**

	Brush and comparison	Pre-brushing (mean ± SD)	Post-brushing plaque reduction (Adjusted mean ± SE)	Difference in plaque removal (*P*-value)
Whole mouth	CA 1	0.371 ± 0.038	0.215 ± 0.002	
	ADA 2	0.371 ± 0.039	0.215 ± 0.002	
	ADA 5	0.370 ± 0.033	0.237 ± 0.002	
	CA 1 vs ADA 2 vs ADA 5			($P < 0.001$)
	CA 1 vs ADA 2			0.0003 ($P = 0.914$)
	CA 1 vs ADA 5			−0.022 ($P < 0.001$)*
	ADA 2 vs ADA 5			−0.021 ($P < 0.001$)*
Gingival margin	CA 1	1.0 ± 0.0	0.554 ± 0.006	
	ADA 2	1.0 ± 0.0	0.556 ± 0.006	
	ADA 5	0.999 ± 0.001	0.616 ± 0.006	
	CA 1 vs ADA 2 vs ADA 5			($P < 0.001$)
	CA 1 vs ADA 2			0.002 ($P = 0.814$)
	CA 1 vs ADA 5			−0.062 ($P < 0.001$)*
	ADA 2 vs ADA 5			−0.060 ($P < 0.001$)*
Approximal	CA 1	0.109 ± 0.096	0.079 ± 0.002	
	ADA 2	0.106 ± 0.103	0.078 ± 0.002	
	ADA 5	0.107 ± 0.091	0.085 ± 0.002	
	CA 1 vs ADA 2 vs ADA 5			($P = 0.104$)
	CA 1 vs ADA 2			n.a.
	CA 1 vs ADA 5			n.a.
	ADA 2 vs ADA 5			n.a.

CA 1, Oral-B CrossAction used for 1 min; ADA 2, ADA manual used for 2 min; ADA 5, ADA manual used for 5 min; SD, standard deviation; SE, standard error from crossover ANCOVA; n.a. not applicable; *, In favour of ADA manual used for 5 min.

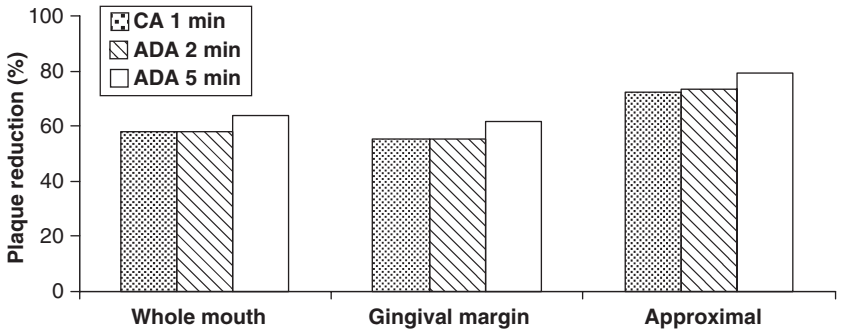

Fig. 3. Percent plaque reduction from baseline for whole mouth, gingival margins, and approximal surfaces with Oral-B CrossAction used for 1 min (CA 1 min), ADA manual used for 2 min (ADA 2 min) and ADA manual used for 5 min (ADA 5 min).

recommended 2 min. A difference of this magnitude has been consistently demonstrated. For example, a significant difference was found between the average estimated brushing time of 155 s and the average covertly timed actual brushing time of 57 s in a study with patients at a dental clinic in the US (24). In a Swiss study volunteers at a dental clinic showed a mean covertly recorded actual toothbrushing time of approximately 68 s, and in two further Swiss studies with soldiers or inhabitants of a town mean covertly recorded actual toothbrushing times were 83.5 and 72.8 s, respectively. Across the three Swiss studies, the estimated brushing time ranged between 134.1 to 148.1 s and in all studies there was a statistically significant difference between actual and estimated brushing times (25). Actual brushing times in the general population may be even shorter than 1 min. Based on the results from videotaped recordings of brushing behaviour at home in two independent studies, Beals *et al.* (10), concluded that an adult brushes on an average for 46 s.

The general population not only brush their teeth for a shorter than optimal time, but also adopt techniques during routine brushing that have limited effectiveness for removing plaque from certain tooth surfaces. These hard to reach areas are mainly the gingival margins and the approximal surfaces of the premolars and molars, and plaque accumulation in these

regions are associated with gum diseases such as gingivitis (5, 26, 27). Because of inadequacies in brushing technique, manual toothbrush manufacturers have introduced features into their designs aimed at improving plaque removal from all tooth surfaces regardless of brushing technique. The introduction of the CA toothbrush followed an extensive program of laboratory and ergonomic studies, which resulted in a uniquely designed brush head with tufts of angled bristles positioned to provide effective interproximal penetration and cleaning on brush strokes in both the forward and backward direction. Since its introduction in the year 2000, the superior effectiveness of CA for plaque removal and gingivitis control in comparison with other manual toothbrushes has been repeatedly demonstrated in a number of clinical studies and confirmed in a recent extensive review (14–17).

Clinical comparisons between CA and other manual brushes typically compare effectiveness using brushing times of the same duration, i.e. 1 min (14–16). To determine whether CA delivers a level of plaque removal that differs from the level that could be achieved with a traditional manual brush, the present study extended brushing time for the ADA brush. Therefore, the present study compared plaque removal between CA for the brushing duration of 1 min, which, although sub-optimal, is a realistic duration in home use, and a traditional ADA manual brush when used for the duration that dental professionals consistently recommend to maximize effectiveness, i.e. 2 min. The inclusion of a 5 min brushing duration for the ADA manual brush allowed a useful comparison for evaluating the potential of this brush with a further extension to brushing duration. No difference was found for whole mouth or gingival margin plaque removal between CA when used for 1 min and the ADA manual brush when used for 2 min. When used for 5 min, the ADA manual brush removed significantly ($P < 0.001$) more plaque than the ADA manual brush used for 2 min or CA used for 1 min. Differences in plaque removal at approximal surfaces were not significant.

Furthermore, the results showed that with either the ADA manual toothbrush at 2 min or with CA at 1 min high-levels of plaque were removed not only from the whole mouth, but also from those areas that prove hard to clean during routine brushing, i.e. gingival margins and approximal surfaces. There was a lack of difference between CA when used for 1 min and the ADA manual brush when used for 2 min and this could be seen as relevant to home use given that routine brushing times may frequently be sub-optimal. Differences in favour of the ADA manual brush only became apparent when it was used for 5 min; statistically significantly superior whole mouth and gingival margin plaque reduction was seen in comparison with both the ADA brush when used for 2 min and CA when used for 1 min.

Summary and Conclusion

In this study, efficient plaque removal was achieved after 1 min of brushing with CA, and the amount of plaque removed did not differ significantly from that achieved with a standard ADA brush when used for 2 min. Greater plaque removal scores were seen with the ADA brush after 5 min of brushing, thereby demonstrating that the ADA brush has the potential to show similar or enhanced efficacy, but only provided the duration of brushing is extended considerably. This study showed the effectiveness of both CA and a traditional ADA manual toothbrush in removing plaque when used for sub-optimal (i.e. 1 min) and optimal (i.e. 2 min) brushing times, respectively, and it also demonstrated the potential of the ADA manual toothbrush when brushing time is extended. As plaque removal is highly correlated with brushing time for a given toothbrush, brushing for two min or longer should always be encouraged regardless of the brush used.

Acknowledgements

The authors thank Danielle Siebert for data management, and Dr Jane Mitchell, MWS Ltd, Staffordshire, UK for writing assistance. This study was supported by The Procter & Gamble Company.

Conflict of Interest

Dr Biesbrock, Ms Walters, Dr Grender are full-time employees of P&G. Mr Bartizek is a retired P&G employee.

Financial Support

This study was sponsored by Procter & Gamble.

References

1 Mandel ID. Dental plaque: Nature, formation, and effects. *J Periodontol* 1966; **37:** 357–367.
2 Briner WW. Plaque in relation to dental caries and periodontal disease. *Int Dent J* 1971; **21:** 293–301.
3 Jenkins GN. Current concepts concerning the development of dental caries. *Int Dent J* 1972; **22:** 350–362.
4 Frandsen A. Mechanical oral hygiene practices. State-of-the-science review. In: Löe H, Kleinman DV, eds *Dental Plaque Control Mea-*

sures and Oral Hygiene Practices. Oxford-Washington DC, IRL Press, 1986, 93–116.
5 Axelsson P, Lindhe J. Effect of controlled oral hygiene procedures on caries and periodontal disease in adults. *J Clin Periodontal* 1978; **5:** 133–151.
6 Cancro LP, Fischman SL. The expected effect on oral health of dental plaque control through mechanical removal. *Periodontol 2000* 1995; **8:** 60–74.
7 Yankell SL. Toothbrushing and toothbrushing techniques. In: Harris NO, Christen AG, eds *Primary Preventive Dentistry*. 3rd edn. Norwalk, CT, Appleton and Lange, 1991, 79–106.
8 Saxer UP, Yankell SL. Impact of improved toothbrushes on dental diseases I. *Quintessence Int* 1997; **28:** 513–525.
9 Saxer UP, Yankell SL. Impact of improved toothbrushes on dental diseases II. *Quintessence Int* 1997; **28:** 573–593.
10 Beals D, Ngo T, Feng Y, Cook D, Grau DG, Weber DA. Development and laboratory evaluation of a new toothbrush with a novel brush head design. *Am J Dent* 2000; **13:** (Special Issue) 5A–14A.
11 Oral-B. http://www.oralb.com/us/learningcenter/dailycare/brushing.asp. Last accessed September 9, 2008.
12 Colgate. http://www.colgate.co.uk/app/Colgate/UK/OralCare/OralHealthCenter/OralHygieneBasics/HowtoBrush.cvsp?Article=HowToBrush. Last accessed September 9, 2008.
13 Philips. http://www.homeandbody.philips.com/sonicare/gb_en/brushes/flexcare/c_flex_t1.asp. Last accessed September 9, 2008.
14 Sharma NC, Qaqish JG, Galustians HJ *et al*. An advanced toothbrush with improved plaque removal efficacy. *Am J Dent* 2000; **13:** (Special Issue) 15A–19A.
15 Cronin MJ, Dembling WZ, Low ML, Jacobs DM, Weber DA. A comparative clinical investigation of a novel toothbrush designed to enhance plaque removal efficacy. *Am J Dent* 2000; **13:** (Special Issue) 21A–26A.
16 Sharma NC, Qaqish JG, Galustians HJ, Cugini MA, Thompson MC, Warren PR. Plaque removal efficacy and safety of the next generation of manual toothbrush with angled bristle technology: Results from three comparative clinical studies. *Am J Dent* 2005; **18:** 3–7.
17 Cugini MA, Warren PR. The Oral-B CrossAction manual toothbrush: A 5-year literature review. *J Can Dent Assoc* 2006; **72**(4)**:** 323.
18 Haun J, Williams K, Friesen L *et al*. Plaque removal efficacy of a new experimental battery-powered toothbrush relative to two advance-design manual toothbrushes. *J Clin Dent* 2002; **13:** 191–197.
19 Rustogi KN, Curtis JP, Volpe AR, Kemp JH, McCool JJ, Korn LR. Refinement of the Modified Navy Plaque Index to increase plaque scoring efficiency in gumline and interproximal tooth areas. *J Clin Dent* 1992; **3**(Suppl. C)**:** C9–C12.
20 Furuichi Y, Lindhe J, Ramberg P, Volpe AR. Patterns of de novo plaque formation in the human dentition. *J Clin Periodontol* 1992; **19:** 423–433.
21 ADA Seal of Acceptance Program – Chewing Gum. Retrieved May 30, 2008 from http://www.ada.org/ada/seal/chewing_gum.asp.
22 van der Weijden FA, Timmerman MF, Snoek IM, Reijerse E, van der Velden U. Toothbrushing duration and plaque removing efficacy of electric toothbrushes. *Am J Dent* 1996; **9:** S31–S36.
23 McCracken GI, Janssen J, Steen N, DeJager M, Heasman PA. A clinical evaluation of a novel data logger to determine compliance with the use of powered toothbrushes. *J Clin Periodontol* 2002; **29:** 838–843.
24 Emling RC, Flickinger KC, Cohen DW, Yankell SL. A comparison of estimated versus actual brushing time. *Pharmacol Ther Dent* 1981; **6:** 93–98.
25 Saxer UP, Barbakow J, Yankell SL. New studies on estimated and actual toothbrushing times and dentifrice use. *J Clin Dent* 1998; **9:** 49–51.
26 Axelsson P. Needs-related plaque control measures based on risk prediction. In: Lang NP, Attström R, Löe H, eds *Proceedings of the European Workshop on Mechanical Plaque Control*. Chicago. Quintessence, 1998: 190–247.
27 Straub AM, Salvia GE, Lang NP. Supragingival plaque formation in the human dentition. In: Lang NP, Attstrom R, Löe H, eds *Proceedings of the European Workshop on Mechanical Plaque Control*. Chicago. Quintessence, 1998: 72–84.