J Clin Periodontol 2005; 32 (Suppl. 6): 214–228

Journal of Clinical Periodontology

A systematic review of the effectiveness of self-performed mechanical plaque removal in adults with gingivitis using a manual toothbrush

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van der Weijden GA, Hioe KPK. A systematic review of the effectiveness of self-performed mechanical plaque removal in adults with gingivitis using a manual toothbrush. J Clin Periodontol 2005; 32 (Suppl. 6): 214–228. © Blackwell Munksgaard 2005.

Abstract

Objective: To assess the effectiveness of self-performed mechanical plaque removal in adults with gingivitis using a manual toothbrush with respect to the level of plaque and gingivitis in controlled studies of at least 6 months duration.

Search: Medline-PubMed up to and including September 2004.

Results: Out of 3223 titles and abstracts, 33 trials were found for data extraction. A meta-analysis was conducted of studies ($n = 9$) in which, for the manual toothbrush group at baseline, only a professional prophylaxis provided. The weighted mean differences (WMD) between baseline and end-trial for the Quigley & Hein plaque index was 0.28 and 0.21 for the Gingival Index ($p < 0.05$).

Eight studies provided both a professional OHI and prophylaxis at baseline. The WMD for the Silness & Löe Plaque Index was 0.10 (ns). The WMD of the proportion of bleeding sites was 5.84% ($p < 0.05$).

Conclusion: In adults with gingivitis the quality of self-performed mechanical plaque removal is not sufficiently effective and should be improved. Based on studies $\geqslant 6$ months of duration, it appears that a single oral hygiene instruction, describing the use of a mechanical toothbrush, in addition to a single professional 'oral prophylaxis' provided at baseline, had a significant, albeit small, positive effect on the reduction of gingivitis.

Key words: plaque; gingivitis; bleeding; manual toothbrush; systematic review; oral hygiene

Accepted for publication 1 April 2005

Introduction

The clinical concepts established in the 1950s remain valid. Namely, that the maintenance of an effective plaque control is the cornerstone of any attempt to prevent and control periodontal diseases. Supragingival plaque is exposed to saliva and to the natural self-cleansing mechanisms existing in the oral cavity. However, although such mechanisms may eliminate food debris, they do not adequately remove dental plaque. Therefore, regular personal oral hygiene is a pre-requisite for proper supragingival plaque elimination. The most widespread mechanical means of controlling plaque at home is toothbrushing. There is substantial evidence that shows that through toothbrushing and other mechanical cleansing procedures, plaque and gingivitis can be controlled most reliably, provided that cleaning is sufficiently thorough and performed at appropriate intervals. Optimal oral hygiene requires not only the appropriate motivation and instruction of the patient but also the adequate tools.

Excellent reviews on the various aspects of oral hygiene are available in the literature (Axelsson 1994, Jepsen 1998, Echeverria & Sanz 2003, Sicilia et al. 2003a). It was not the intention of the present review to exceed those. Especially since, in the use and design of manual toothbrushes over the last decades, no major steps forward have been achieved.

Toothbrushes date back nearly 1000 years. Forerunners of today's brushes

were developed in the 1930s. These nylon toothbrushes with a plastic handle were easy to manufacture, and therefore were more affordable. This made toothbrushing a common practice in our western society. Since that time, much imagination and inventiveness have been applied to toothbrush design. Today, there are numerous manual toothbrushes available on the market. There is however, still insufficient evidence that one specific toothbrush design is superior to another. Modern toothbrushes have bristle patterns designed to enhance plaque removal from hard-to-reach areas of the dentition, in particular from proximal areas. These designs are based on the premise that the majority of the subjects in any population use a simple horizontal brushing action. The design of the brush head has been changed and multiple tufts of bristles, sometimes angled in different directions, are now used. Today, a modern toothbrush has a handle size that is appropriate to the hand size of the prospective user, and much emphasis has been placed on new ergonomic designs (Jepsen 1998, Löe 2002).

Twice daily brushing with a fluoride toothpaste is now an integral part of most people's daily hygiene routine. The efficacy of brushing with regard to plaque removal is dictated by three main factors: the design of the brush, the skill of the individual using the brush and the frequency and duration of use (Frandsen 1985). Although numerous studies have monitored the actual time of toothbrushing in controlled clinical settings, what actually occurs in real life may vary. Patients usually believe they spend more time than they actually do. The best estimate of actual manual brushing time seems to range between 30 and 60 s (Van der Weijden et al. 1993).

Enthusiastic use of the toothbrush is not, however, synonymous with a high standard of oral hygiene. It appears that most patients are not able to achieve total plaque control at each cleaning. De la Rosa et al. (1979) studied the pattern of plaque accumulation and removal with daily toothbrushing during a 28-day period following prophylaxis. On average, about 60% of the plaque was left after brushing. Morris et al. (2001) reported on the 1998 UK Adult Dental Health survey. The mean proportion of teeth with plaque increased from 30% in the 25–34-year age group to 44% in those aged 65 years and above.

At the Academic Centre for Dentistry Amsterdam, a study was conducted that assessed the efficacy of a single 1-min. brushing exercise in subjects adhering to their customary brushing method (Van der Weijden et al. 1998a). Two observations from this study stood out. One of these, not reported in the paper, was that almost half of the subjects complained that they had never brushed this long. This emphasizes what has been addressed above concerning brushing time (Van der Weijden et al. 1993). The other reported observation was that after the 1 min. of brushing, approximately 39% of the plaque had been removed.

The results of these studies indicate that on average people are not effective brushers and probably live with large amounts of plaque on their teeth constantly, even though they brush once every day.

Clearly most individuals find it difficult to maintain an effective level of plaque control. This remark by itself is surprising as it is not uncommon that scientific papers start with a statement like. ''There is substantial evidence that manual toothbrushes are effective in removing bacterial plaque and preventing gingivitis''. This seems to be in conflict with the studies mentioned above. These indicate that most commonly approximately 40–55% of the plaque is removed. Is this level of plaque control sufficient to maintain health? How should the results of studies like that of Moritis et al. (2002) be interpreted? They compared a powered toothbrush with a soft-bristled manual toothbrush with respect to plaque removal. In their population, this particular powered toothbrush achieved a mean plaque reduction of 36% after 2 min. of brushing. In comparison, with the manual toothbrush, a reduction of 26% was obtained. Despite their apparent efforts, adults appear not as efficient at plaque control as might be hoped (Morris et al. 2001). Regarding this in the light of the high prevalence of periodontal diseases, there is clearly some room for improvement.

The present review was initiated to assess the effect of mechanical plaque control. It was refined to address the effect of manual toothbrushing on gingivitis. It systematically searched for papers that investigated the effect of mechanical oral hygiene with respect to gingivitis and plaque control in subjects without periodontitis in studies of at least 6 months duration.

Material and Methods

Focused question

To assess the effectiveness of self-performed mechanical plaque removal in adults with gingivitis using a manual toothbrush with respect to the level of plaque and gingivitis in controlled studies of at least 6 months duration.

Following the search, two post-hoc questions were raised. What is the effect of a professional prophylaxis delivered at baseline either with or without an OHI on the level of plaque and gingivitis at the end of the study?

Search strategy

This review was conducted using the methodology developed by the Cochrane Collaboration. One source of evidence was selected in search of appropriate papers for this study purpose: The National Library of Medicine, Washington DC (MEDLINE-PubMed).

This search was performed attempting to be inclusive for any study that, evaluated the effect of various forms of plaque control in gingivitis subjects in studies of $\geqslant$6 months duration. In those trials, the manual toothbrush group (frequently the control group) could serve to provide data with regard to the effectiveness of self-performed mechanical plaque control. The data were analysed depending on the (baseline) intervention, being either professional oral hygiene instructions, a prophylaxis or both. The comprehensive search in a systematic review process ensures inclusion of all suitable papers that address the review question. The database was searched up to and including September 2004 using the following terms for the search strategy:

- (Intervention) [MeSH terms] Oral hygiene/all subheadings OR Oral Hygiene Index/all subheadings OR [Text Words] mechanical plaque control OR plaque removal OR plaque control OR dental plaque control OR dental plaque removal OR mechanical plaque removal OR toothbrusing OR toothbrush OR oral hygiene.

AND

- (Outcome) [MeSH terms] Gingivitis/all subheadings OR Gingivitis, Necrotizing Ulcerative/all subhead-

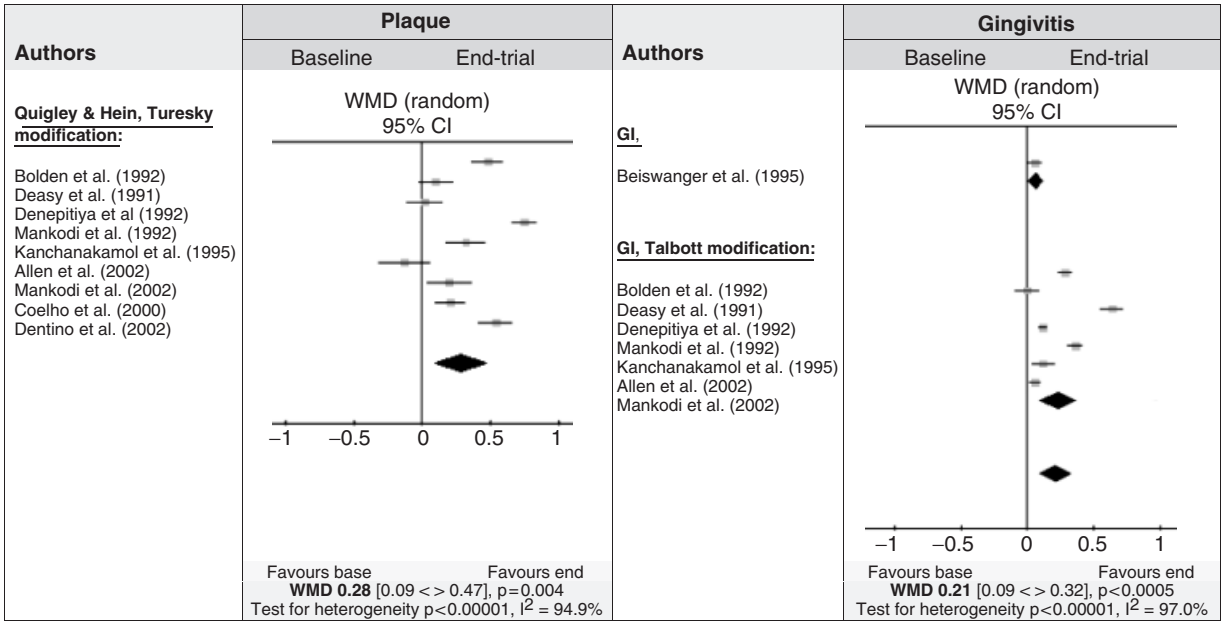

Fig. 1. Data for control groups receiving a professional prophylaxis at baseline but no oral hygiene instruction. Forrest plots demonstrating plaque Quigley & Hein (1962) (Turesky modification, 1970) and gingivitis (Loe & Silness 1963) (Talbott modification, 1977). The size of the box signifies the ''weight'' or importance of the study. Weighted mean differences (WMD = ◆) between baseline and end-trial are provided, including the 95% confidence interval (CI).

ings OR Gingival Haemorrhage/all subheadings OR [Text Words] gingivitis OR gingival haemorrhage OR gingival bleeding OR gingival disease*.

Eligibility criteria were:

- randomized-controlled trials and controlled clinical trials,
- studies at least 6 months in duration,
- no periodontitis and
- subjects ⩾18 years of age in good general health.

Only papers written in English language were included. Case reports, letters and historical reviews were not included in the search. Titles without abstracts of which the title suggested that they were related to the objectives of this review were selected to screen the full text.

Factors that were recorded in order to evaluate heterogeneity of the primary outcome across studies were as follows:

- evaluation period,
- number of subjects,
- mean age and range of subjects,
- oral hygiene instruction/reinforcement during the study examinations and
- prophylactic intervention.

Screening and selection of papers

The papers were screened independently by two reviewers (G.A.W. and K.P.K.J.H.). At first, they were screened by title and abstract. Then as a second step, full-text papers were screened and selected when they fulfilled the eligibility criteria for inclusion. Any disagreements between the two reviewers were resolved by discussion.

For full-text screening, the following criteria were taken into consideration:

- study of ⩾6 months duration,
- randomized-controlled trial or controlled clinical trial,
- prospective clinical study,
- parameters mentioned: gingivitis, plaque,
- healthy subjects ⩾18 years and
- manual toothbrushing only (with or without inter-dental).

Statistical analysis

Extracted data included mean values with either standard deviation (SD) or standard error of the mean (SE). Few papers provided data of increments during the experimental period. All other papers supplied data for baseline and end-trial assessments. Consequently, it was not possible to perform a meta-analysis on incremental data. Therefore, where appropriate, data for baseline and end trial were presented separately. An analysis for both time points was performed. Weighted mean differences (WMD) were calculated by means of the Review Manager 4.2 software of the Cochrane Collaboration using a random effect approach as presented in Figs 1 and 2.

Results

The search strategy produced 3223 citations, 33 of which were identified as eligible for inclusion in this review according to the defined criteria for study design, participants, interventions and outcomes (see Table 1). All 33 trials were (randomized-) controlled clinical studies and involved adults (aged 18 years or more) with plaque and gingivitis.

Tables 2–4 show the results of the data extraction. Selected studies were 6–18 months of duration. Randomization procedures were not addressed in 10 papers. In 27 of the studies, participants in the test and control groups received a professional prophylaxis at the start of the study. In two studies, supragingival calculus was removed, while in four studies, no prophylaxis was undertaken prior to commencement. Toothbrushing frequency was twice daily in 29 studies while the remaining studies did not

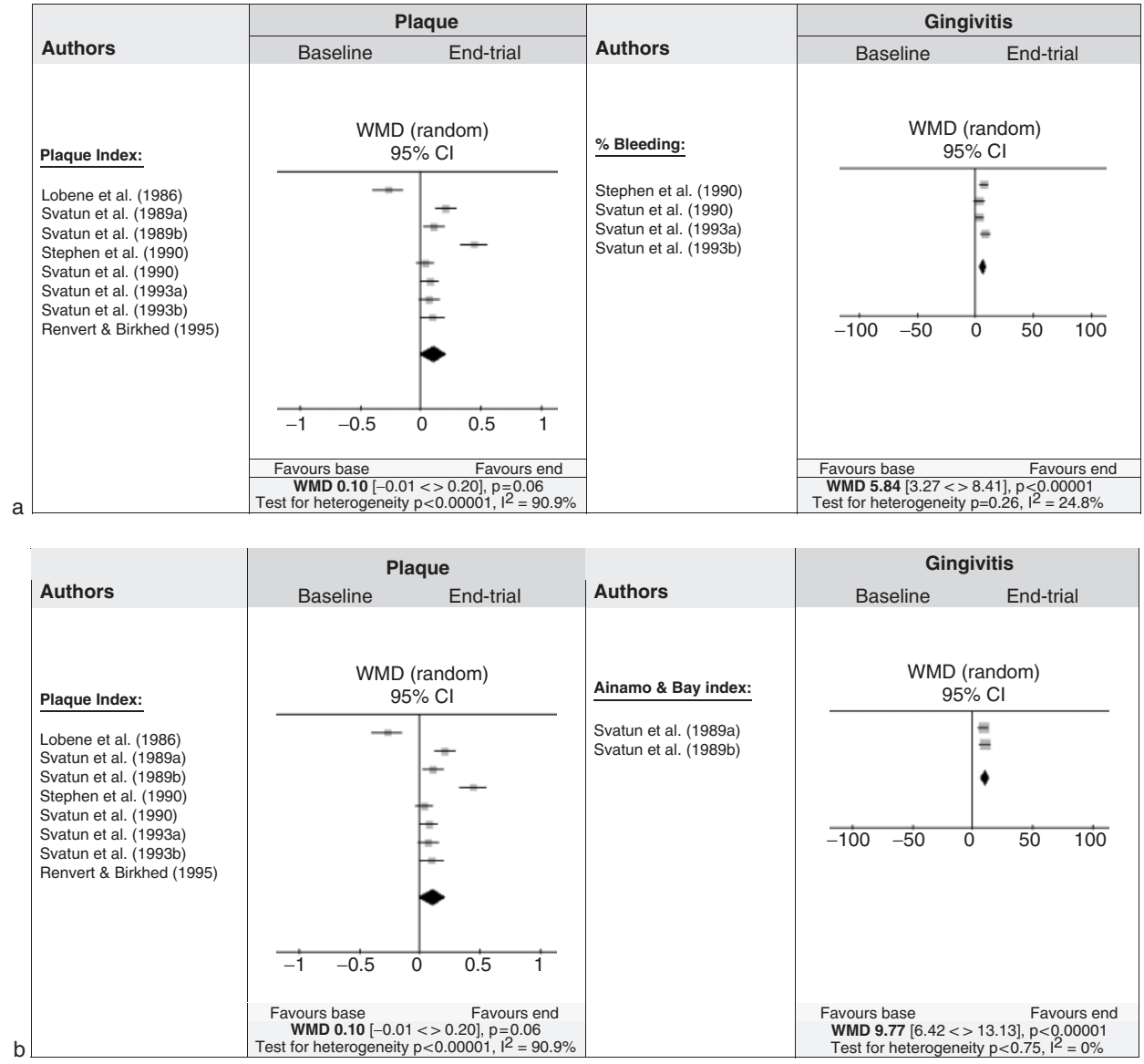

Fig. 2. (a) Data for control groups receiving an oral hygiene instruction and a professional prophylaxis. Forrest plot demonstrating plaque (Silness & Löe, 1964) and percentage bleeding on probing. The size of the box signifies the ''weight'' or importance of the study. Weighted mean differences (WMD = ◆) between baseline and end-trial are provided, including the 95% confidence interval (CI). Fig. 2 (b) Data for control groups receiving an oral hygiene instruction and a professional prophylaxis. Forrest plot demonstrating plaque (Silness & Löe, 1964) identical to Fig. 2a and gingivitis Ainamo & Bay Index (1975). The size of the box signifies the ''weight'' or importance of the study. Weighted mean differences (WMD = ◆) between baseline and end-trial are provided, including the 95% confidence interval (CI).

mention frequencies. None of the studies gave specific information about the strategy followed to provide professional oral hygiene instruction concerning the use of a manual toothbrush. What is clear is that the use of interdental cleaning aids was not part of these instructions. Some studies were not specific about the professional prophylaxis provided. Some stated that in their study population, supra- and subgingival plaque and calculus deposits were removed. The most extensive description was provided by Mankodi et al. (2002). In their study, subjects were given a complete 'oral prophylaxis', which included the removal of all supragingival plaque, calculus deposits and extrinsic stain. The teeth were then polished, and complete plaque removal was verified by the use of erythrosin.

In 18 trials, the level of supragingival plaque was scored using the Quigley & Hein Plaque Index (1962) (Turesky modification, 1970) predominantly in combination with an assessment of gingival inflammation by the Löe & Silness Gingival Index (1963) (Talbott modification, 1977). In 12 studies, the Silness & Löe Plaque Index was used, most frequently in combination with a bleeding score as the parameter for gingivitis (Ainamo & Bay 1975, Saxton & Van der Ouderaa 1989, Van der Weijden 1994).

The collective data of the studies allowed for meta-analyses using a random effects model, as illustrated in Figs 1 and 2. In total, 16 studies were unsuitable for further analysis because of their choice of plaque and gingivitis indices and/or the lack of SD/SE.

Table 1. Search results

Titles and abstracts	3223
Selected papers for full reading	92
Non-retrievable	8
Excluded for the following reason:	51 (in total)
• Review	1
• Non-human	1
• Too short a follow-up	13
• No brushing	7
• Electric toothbrush only	1
• Mouth rinse	6
• Periodontitis patients	2
• No plaque and gingivitis data	3
• Inadequate data presentation	12
• Cross-over design	1
• Subjects less than 18 years of age	3
• No control group	1
Final selection	33

Figure 1 shows the Forrest plots of the meta-analysis for the manual toothbrush control groups in studies that provided only a professional prophylaxis at baseline (Study # 9, 10, 11, 12, 18, 28, 30, 27, 29; Tables 2–4). The baseline plaque levels (Quigley & Hein) varied between 3.55 and 1.75 for the nine selected studies and reduced to levels ranging from 3.23–1.39 (Table 4). The Gingival Index (Löe & Silness) at baseline varied between 1.59 and 0.84 and reduced to 1.23–0.78 (Table 4). The WMD between baseline and end-trial for plaque was 0.28 and 0.21 for the Gingival Index. For both indices, this was found to be a statistically significant improvement from baseline (Fig. 1).

Figures 2a and b show the meta-analysis in terms of plaque and gingivitis for the manual toothbrush control groups in the eight trials that provided both a professional oral hygiene instruction and prophylaxis at baseline (Study # 1, 3, 4, 6, 7, 13, 14, 20; Tables 2–4). The Forrest plots for the level of plaque in both Figs 2a and b are identical. Figure 2a presents plaque according to Silness & Löe, with percentage bleeding as a measure of gingivitis. Figure 2b also presents plaque according to Silness & Löe but with the Ainamo & Bay Index as measure for gingival inflammation. The average baseline Plaque Index varied between 0.72 and 0.29 for the seven selected studies and changed to levels ranging from 0.98 to 0.21 (Table 4). The level of gingivitis assessed as the proportion of bleeding sites at baseline varied between 31% and 23% and reduced to 24–20% (Table 4, Study # 6, 7, 13, 14). The two studies that used the Ainamo & Bay Index for gingivitis showed a reduction from 25.6 to 29.8 at baseline to 16.3 and 19.4 at the end of these studies (Table 4, Study # 3, 4). For the Plaque Index, the WMD of 0.10 between baseline and end trial was not significant (Fig. 2). Figure 2a shows the results for gingivitis as percentage bleeding sites. The WMD of 5.84% was significant between baseline and end trial. Similarly, Fig. 2b shows the results for gingivitis in those trials that used the Ainamo & Bay Index. The significant WMD between baseline and end trial was 9.77.

In some of the meta-analyses performed, there was an obvious heterogeneity in the clinical outcome of the selected studies. In case the testing for heterogeneity was significant, the reader should exercise caution in using the WMD as the exact measure of the effect.

Discussion/Conclusions

Evidence-based medicine/dentistry has been defined as ''the collection, interpretation, and integration of valid, important and applicable patient-reported, clinician-observed, and research-derived evidence. The best available evidence, moderated by patient circumstances and preferences, is applied to improve the quality of clinical judgements and facilitate cost-effective health care. Evidence-based practice relies heavily on the availability of evidence from research for decision making. For this study, the National Library of Medicine was searched, which provided 3223 titles and abstracts to begin with.

The present systematic review was designed to assess the effectiveness of self-performed mechanical plaque control on gingival inflammation. The main challenge, which was apparent from the beginning, was the choice of a comparison. Should manual toothbrushing be compared with no oral hygiene at all? Instead, it was decided to systematically search the literature for controlled clinical trials of $\geqslant 6$ months in duration that assessed the effect of various forms of plaque control in gingivitis subjects. In those trials, the manual toothbrush group could serve to provide data that would be analysed depending on the (baseline) intervention being professional oral hygiene instructions or a prophylaxis. Baseline and end-trial data could than be compared with the effect of mechanical oral hygiene. It was expected that in most studies, the manual toothbrush group with standard fluoride toothpaste would be the control group, as indeed it turned out to be. In this respect, there were no negative control groups. It is therefore not possible to rule out that part of the effect that was observed was because of the Hawthorne effect, which affects panellists involved in clinical trials.

For the present review, a comparison with no oral hygiene was not considered to be appropriate because the role of plaque in the aetiology of gingivitis is well established. The pivotal study of Löe et al. (1965) clearly demonstrated that gingival inflammation consistently follows the build-up of plaque. Conversely, removal of plaque can reverse this process. Students with clinically healthy gingivae developed clinical symptoms of gingivitis within 2–3 weeks if dental plaque was allowed to accumulate freely. Once adequate tooth cleaning was resumed, the gingival inflammation subsided within a week and reverted to normal. This finding not only demonstrated the central role of supragingival plaque in the development of gingivitis but also that mechanical removal of plaque by oral hygiene practices can reverse these inflammatory changes.

If plaque is allowed to accumulate freely in the dento-gingival region, a sub-clinical sign of gingival inflammation in the form of an exudate from the gingival sulcus appears within 4 days (Egelberg 1964). The minimum toothbrushing frequency needed to prevent the development of gingivitis has been the subject of investigation. Lang et al. (1973) demonstrated that students who thoroughly removed plaque at least every second day, did not develop clin-

Table 2. Authors and titles

#	Author	Year	Duration	(Short) title	Dentifrice	Toothbrush	OHI*	Intervention	Random
1	Lobene et al.	1986	6 months	The effects of a sanuinaria dentifrice on plaque and gingivitis	A = sanguinaria B = vehicle control	Butler Sub G soft-bristled	Yes	Gross calculus removal	Yes
2	Mauriello & Bader	1988	6 months	Effects of a sanguinarine dentifrice on plaque and gingivitis	A = sanguinaria B = control	Soft-bristled toothbrush	?	Calculus removal	Yes
3	Svatun et al. (a)	1989	12 months	Study on the maintenance of gingival health by a dentifrice-containing a zinc salt and non-ionic antimicrobial agent	A = triclosan/zinc citrate B = MFP	?	Yes	Prof. prophy	?
4	Svatun et al. (b)	1989	1 year	Study of the efficacy of a dentifrice containing zinc citrate and triclosan to maintain gingival health	A = triclosan/zinc citrate B = MFP	?	Yes	Prof. prophy	?
5	Wolff et al.	1989	18 months	Effect of toothbrushing with 0.4% stannous fluoride and 0.22% sodium fluoride gel on gingivitis	A = MFP+SnF_2 gel B = MFP+NaF gel C = MFP+F-free gel	Py-Co-Pay Softex	No	Prof. prophy	Yes
6	Stephen et al.	1990	6 months	Control of gingivitis by a dentifrice containing a zinc salt and triclosan	A = triclosan/zinc citrate B = MFP	?	Yes	Prof. prophy	Yes
7	Svatun et al.	1990	6 months	Study of the effect of a dentifrice containing zinc citrate and triclosan on plaque gingival health	A = triclosan/zinc citrate B = MFP	?	Yes	Prof. prophy	?
8	Cubells et al.	1991	6 months	The effect of a triclosan/copolymer/fluoride dentifrice on plaque formation and gingivitis	A = triclosan/copolymer B = NaF	Soft-bristled adult toothbrush	No	Prof. prophy	Yes
9	Deasy et al.	1991	6 months	Effect of a dentifrice containing triclosan and a copolymer on plaque formation and gingivitis	A = triclosan/copolymer B = NaF	Soft bristled	No	Prof. prophy	?
10	Bolden et al.	1992	6 months	A dentifrice containing triclosan and a copolymer in a sodium fluoride silica base on plaque formation and gingivitis	A = triclosan/copolymer B = NaF	Soft bristled	No	Prof. prophy	Yes
11	Denepitiya et al.	1992	6 months	Effect upon plaque formation and gingivitis of a triclosan/copolymer/fluoride dentifrice	A = triclosan/copolymer B = NaF	Soft-bristled toothbrush	No	Prof. prophy	Yes
12	Mankodi et al.	1992	6 months	Clinical effect of a triclosan-containing dentifrice on plaque and gingivitis	A = triclosan/copolymer B = NaF	Soft bristled	No	Prof. prophy	?
13	Svatun et al. (a)	1993	7 month	The effects of three silica dentifrices containing triclosan on supragingival plaque and on gingivitis	A = triclosan/copolymer B = triclosan/zinc citrate C = NaF	Solidex soft	Yes	Prof. prohy	Yes
14	Svatun et al. (b)	1993	7 month	The effects of silica a dentifrice containing triclosan and zinc citrate on supragingival plaque and on gingivitis	A = triclosan/zinc citrate B = MFP	Solidex soft	Yes	Prof. prophy	Yes
15	Palomo et al.	1994	6 months	The effect of three commercially available dentrifices containing triclosan on supragingival plaque formation and gingivitis	A = triclosan/copolymer B = triclosan/zinc citrate C = NaF	Soft-bristled adult toothbrush	?	Prof. prophy	Yes
16	Van der Weijden et al.	1994	8 months	The long-term effect of an oscillating/rotating electric toothbrush on gingivitis	NaF	Butler GUM 311	Yes (3 ×)	Preventive programme+prof. prophy at 1-month assessment	Yes
17	Beiswanger et al.	1995	6 months	The clinical effects of dentifrices containing stabilized stannous fluoride on plaque formation and gingivitis	A = SnF_2-L B = SnF_2-H C = NaF	Their own	No	Prof. prophy	Yes
18	Kanchanakamol et al.	1995	6 months	Reduction of plaque formation and gingivitis by a dentifrice containing triclosan and copolymer	A = triclosan/copolymer B = their own†	Soft-bristled adult toothbrush	No	Prof. prophy	Yes

Table 2. (Contd.)

#	Author	Year	Duration	(Short) title	Dentifrice	Toothbrush	OHI*	Intervention	Random
19	Perlich et al.	1995	6 months	The clinical effect of a stabilized stannous fluoride dentifrice on plaque formation, gingivitis and gingival bleeding	A = SnF_2 B = NaF	Their own	?	Prof. prophy	Yes
20	Renvert & Birkhed	1995	6 months	Comparison between three triclosan dentifrices ion plaque, gingivitis and salivary microflora	A = triclosan/copolymer B = triclosan/zinc citrate C = MFP	TePe	Yes	Prof. prophy	?
21	Terezhalmy et al.	1995	6 months	Clinical evaluation of the effect of an ultrasonic toothbrush on plaque, gingivitis, and gingival bleeding	Their own†	Oral-B	No	No	Yes
22	Yankell et al.	1996	6 months	A 6-month clinical evaluation of the dentrust toothbrush	?	A = Dentrust 3-sided B = Oral-B P35	No	No	Yes
23	Van Swol et al.	1996	6 months	Clinical evaluation of an ionic toothbrush on the removal of established plaque and reduction of gingivitis	Their own†	A = ionic toothbrush – active B = ionic toothbrush – inactive	No	No	?
24	Ainamo et al.	1997	12 months	Assessment of the effect of an oscillating/rotating electric toothbrush on oral health	Pepsodent	Jordan soft manual	Yes	Prof. prophy	Yes
25	Beiswanger et al.	1997	6 months	The comparative efficacy of stabilized stannous fluoride dentifrice, peroxide/baking soda dentifrice and essential oil mouth rinse for the prevention of gingivitis	A = SnF_2 B = baking soda C = NaF	?	No	Prof. prophy	Yes
26	McClanahan et al.	1997	6 months	A comparison of stabilized stannous fluoride dentifrice and triclosan/copolymer dentifrice for efficacy in the reduction of gingivitis and gingival bleeding	A = triclosan/copolymer B = SnF_2 C = NaF	?	No	Prof. prophy	Yes
27	Coelho et al.	2000	6 months	Essential oils in an anti-plaque and anti-gingivitis dentifrice	A = essential oils B = control	?	No	Prof. prophy	?
28	Allen et al.	2002	6 months	The clinical efficacy of Colgate total fresh stripe toothpaste in the control of plaque and gingivitis	A = Triclosan/copolymer B = NaF	Adults soft-bristled toothbrush	No	Prof. prophy	?
29	Dentino et al.	2002	6 months	6 months comparison of powered *versus* manual toothbrushing	Crest	ADA reference toothbrush	No	Prof. prophy	Yes
30	Mankodi et al.	2002	6 months	Comparison of two dentifrices with respect to efficacy for the control of plaque and gingivitis	A = triclosan/copolymer B = SnF_2	Adult soft-bristled toothbrush	No	Prof. prophy	?
31	Triratana et al.	2002	6 months	Clinical effect of a new liquid dentifrice containing triclosan/copolymer on existing plaque and gingivitis	A = triclosan/copolymer B = NaF	Adult sized soft-bristled toothbrush	No	No	Yes
32	Van der Weijden et al.	2002	7 months	Effectiveness of an electrically active brush in the removal of overnight plaque and treatment of gingivitis	Their own†	A = electrically active B = Butler Gum 309	Yes	Prof. prophy	Yes
33	Winston et al.	2002	6 months	A clinical methods study of the effects of triclosan dentifrices on gingivitis	A = Triclosan/copolymer B = NaF	Colgate classic full head	Yes	Prof. prophy	Yes

MFP, monoflourophosphate; ADA, American Dental Association; prof. prophy, professional prophylaxis.
*Oral hygiene instruction.
†A dentifrice of their own choice.

Table 3. Subjects and conclusions

#	Age (years)	Age range	# Subjects	#Drop-outs	Brush frequency	Brushing duration	Authors conclusions
1	$A = 38.5$ $B = 37.9$	20–70	$A = 46$ $B = 54$	?	2 × daily	?	A dentifrice containing sanguinaria extract affects plaque and gingivitis
2	$A = 32$ $B = 32$	?	$A = 56$ $B = 59$	5	At least 2 × daily	?	No long-term reduction was demonstrated in plaque or gingival inflammation with the use of a sanguinarine-containing dentifrice
3	?	20–60	$A = 42$ $B = 47$	13	2 × daily	?	This investigation has demonstrated that a dentifrice containing zinc citrate and triclosan was able to prevent both the accumulation of plaque and the development of gingivitis
4	24	?	$A = 44$ $B = 46$	13	2 × daily	?	This work has demonstrated that a dentifrice containing zinc citrate and triclosan can be a useful oral hygiene aid
5	27.6	19–33	$A = 89$ $B = 87$ $C = 105$	?	2 × daily	?	The results of this investigation clearly indicate that 0.4% SnF_2 and 0.22% NaF are no more effective in reducing gingivitis than a placebo gel
6	29	16–49	$A = 74$ $B = 72$	15	2 × daily	?	This study demonstrated that a dentifrice containing zinc citrate and triclosan, used regularly over 6 months, promoted gingival health and inhibited calculus formation without affecting the balance of the oral flora
7	23	?	$A = 48$ $B = 49$	4	2 × daily	?	A dentifrice containing triclosan and zinc citrate can contribute to oral care
8	$A = 24.3$ $B = 22.4$	18–57	$A = 56$ $B = 52$	12	2 × daily	1 min.	Twice daily use of a dentifrice containing triclosan and copolymer reduces supragingival plaque formation and gingivitis to a significant degree compared with an NaF-based placebo dentifrice
9	$A = 35.9$ $B = 36.6$	18–64 18–65	$A = 58$ $B = 63$	3	2 × daily	1 min.	Twice daily use of the triclosan containing dentifrice provides statistically significant reductions in both supragingival plaque formation and gingivitis
10	$A = 32$ $B = 32$	18–62 18–61	$A = 154$ $B = 152$	19	2 × daily	1 min.	Twice daily use of a dentifrice containing triclosan copolymer over a 6-month period significantly reduced supragingival plaque formation and gingivitis
11	$\underline{A} = 36$ $\overline{B} = 35$	18–63 20–60	$A = 70$ $B = 75$	9	2 × daily	1 min.	This clinical study demonstrated that use of the triclosan/copolymer/fluoride dentifrice over a 6-month period provided a statistically significant and clinically beneficial effect on supragingival plaque formation and gingivitis, as compared with a placebo dentifrice
12	$A = 36$ $B = 37$	18–64 18–63	$A = 145$ $B = 149$	24	2 × daily	1 min.	Twice daily use of the triclosan containing dentifrice resulted in a significant reduction in supragingival plaque formation and a significant improvement in gingival health
13	$A = 26$ $B = 25$ $C = 24$	21–44 19–35 19–39	$A = 46$ $B = 46$ $C = 48$	?	2 × daily	?	Use of triclosan zinc citrate dentifrice over a 7-month period will provide a statistically significant and clinically relevant effect on supragingival plaque and control of gingivitis as compared with a control dentifrice
14	$A = 24$ $B = 24$	20–39 20–35	$A = 46$ $B = 47$	?	2 × daily	?	Use of the triclosan zinc citrate dentifrice over a 7-month period provided a statistically significant and clinically relevant benefit in controlling gingivitis compared with use of a control dentifrice
15	$A = 29$ $B = 30$ $C = 31$	18–63 18–65 18–52	$A = 42$ $B = 47$ $C = 44$	?	2 × daily	1 min.	Use of triclosan copolymer dentifrice of a 6-month period of time, after an oral prophylaxis, resulted in a statistically significant and clinically beneficial reduction in supragingival plaque formation and gingivitis, as compared with a placebo dentifrice
16	22.3	?	35	8	?	At least 2 min.	The Braun Plak Control is a safe and efficient home-care device. It proved to be more effective than a regular manual toothbrush
17	$A = 33.7$ $B = 34.5$ $C = 32.6$	18–68 19–67 19–64	$A = 140$ $B = 140$ $C = 136$	71	?	?	Stabilized stannous fluoride dentifrice can provide an important adjunct to the prevention and control of gingivitis when used in combination with regular personal oral hygiene procedures and professional care
18	$A = 35.7$ $B = 35.6$	18–53 18–55	$A = 62$ $B = 62$	16	2 × daily	1 min.	The triclosan copolymer dentifrice was better than the customary oral hygiene care in preventing supragingival plaque formation up to 6 months
19	$A = 37.25$ $B = 36.53$	19–69 19–70	$A = 174$ $B = 159$	55	At least 2 × daily	At least 1 min.	Twice daily use of a dentifrice containing stabilized stannous fluoride significantly reduced gingivitis relative to a NaF dentifrice
20	21.5	18–33	$A = 26$ $B = 31$ $C = 28$	8	2 × daily	?	A dentifrice containing a combination of triclosan and copolymer is effective in reducing supragingival plaque formation and gingival bleeding

Table 3. (Contd.)

#	Age (years)	Age range	# Subjects	#Drop-outs	Brush frequency	Brushing duration	Authors conclusions
21	?	?	26	4	?	?	The ultrasonic toothbrush was significantly more effective than a conventional toothbrush in reducing overnight plaque formation, removing plaque and reducing gingivitis over a 6-month period and should be a safe and effective adjunct to professional instrumentation to maintain the health of the periodontium
22	?	18–60	*A* = 48 *B* = 45	20	?	?	The dentrust toothbrush can be said to significantly contribute to gingival health overall
23	*A* = 32.5 *B* = 33.2	18–60 19–67	*A* = 34 *B* = 30	7	2 × daily	?	The HyG ionic action toothbrush is a safe and effective oral cleaning device when used unsupervised on a regular basis for the removal of human dental plaque
24	37	?	56	0	2 × daily	2 min.	Results indicate that the Braun Oral-B Plak Control toothbrush is safe and more effective than a manual toothbrush in improving gingival health
25	*A* = 36.3 *B* = 36.5 *C* = 36.1	?	*A* = 267 *B* = 147 *C* = 140	16	2 × daily	–	Significant reductions of gingivitis with a stabilized stannous fluoride as compared with NaF and baking soda/peroxide dentifrices
26	*A* = 35.5 *B* = 37.3 *C* = 36.5	19–71 19–69 19–70	*A* = 155 *B* = 154 *C* = 174	89	2 × daily	1 min.	Superior clinical efficacy of a stabilized stannous fluoride dentifrice relative to a triclosan copolymer dentifrice in the control of gingivitis
27	*A* = 35 *B* = 37	18–63	*A* = 95 *B* = 94	?	2 × daily	1 min.	The essential oil-containing dentifrice group had statistically significant lower whole-mouth mean plaque, gingival and bleeding scores compared with the vehicle control.
28	*A* = 42 *B* = 43.5	18–70	*A* = 36 *B* = 36	1	2 × daily	1 min.	The triclosan copolymer dentifrice provided a statistically significant clinically relevant level of efficacy for the control of supragingival plaque and gingivitis
29	31.8	18–59	81	0	2 × daily	2 min.	The oscillating rotating toothbrush safely provides clinical benefits in plaque and calculus reduction over a manual brush even in subjects with no formal oral hygiene instruction
30	*A* = 33.7 *B* = 35.3	19–48 19–56	*A* = 55 *B* = 54	13	2 × daily	1 min.	The triclosan copolymer toothpaste provides a statistically significant, substantive advantage in efficacy for the control of plaque and gingivitis over SnF_2 toothpaste
31	38	20–60	*A* = 60 *B* = 59	5	2 × daily	1 min.	Compared with the placebo, the triclosan copolymer dentifrice had a significantly better ability to reduce plaque and gingivitis
32	21	18–26	*A* = 29 *B* = 31	6	2 × daily	At least 2 min.	Based on these results, it is concluded that there is no beneficial effect of the electrically active design feature compared with a regular manual toothbrush control
33	*A* = 41.7 *B* = 40.5	?	*A* = 41 *B* = 36	?	2 × daily	?	Reviewers: No significant effect compared with NaF dentifrice

ical signs of gingival inflammation over a 6-week period. This included the use of inter-proximal aids (dental floss and toothpicks) as well as the toothbrush. Bosman & Powell (1977) induced experimental gingivitis in a group of students. The signs of gingival inflammation persisted in those students who removed plaque only every 3rd or 5th day. In groups who properly cleaned their teeth once a day or every 2nd day, the gingivae healed within 7–10 days. As has been pointed out in the introduction, the majority of individuals, including periodontal patients, are usually not able to remove dental plaque completely as a result of daily brushing. From a practical standpoint, it is generally accepted that toothbrushing should be performed at least once a day. A recommendation to brush the teeth twice daily should be considered (Echeverria & Sanz 2003), particularly in patients showing gingival inflammation. In these cases, the condition of the soft tissues favours plaque accumulation (Ramberg et al. 1994). Kressin et al. (2003) evaluated the effect of oral hygiene practices on tooth retention in a longitudinal study with a 26-year follow-up. They observed that consistent brushing (>once a day) resulted in a 49% reduction of the risk of tooth loss compared with participants without consistent hygiene habits.

Despite the fact that most individuals claim to brush their teeth at least twice a day, it is clear from both epidemiological and clinical studies that mechanical oral hygiene procedures as performed by people in general are insufficient in themselves to control supragingival plaque formation and to completely prevent gingivitis and more severe forms of periodontal disease (Sheiham & Netuveli 2002). The maintenance of an effective level of plaque control is clearly difficult using conventional mechanical procedures and dentifrices (Morris et al. 2001). From a global perspective, it is, however, the most realistic means of improving the periodontal health of communities and populations (Davies et al. 2004).

In the 30-year prospective study by Axelsson et al. (2004), >80% plaque-free surfaces corresponded with long-term periodontal health and stability. The nine studies that were selected for the meta-analysis, as shown in Fig. 1, showed a level of plaque (Quigley & Hein) that ranged at baseline between 3.55 and 1.75. It is difficult to translate

Table 4. Study outcome

#	SE/SD	Plaque			Bleeding			Gingivitis		
		PI	PI score base	PI score end	BI	BI score base	BI score end	GI	GI score base	GI score end
1	SD	PI, Silness & Löe (1964)	*A* = 0.71 (0.30) *B* = 0.71 (0.23)	*A* = 0.86 (0.44) *B* = 0.98 (0.42)				GI, Löe & Silness (1963)	*A* = 0.63 (0.28) *B* = 0.69 (0.25)	*A* = 0.94 (0.52)** *B* = 1.18 (0.51)
2	SD	PI, Silness & Löe (1964)	*A* = 1.22 (0.33) *B* = 1.21 (0.34)	*A* = 1.09 (0.24) *B* = 1.05 (0.23)				GI, Löe & Silness (1963)	*A* = 0.76 (0.38) *B* = 0.78 (0.39)	*A* = 0.91 (0.27) *B* = 0.96 (0.24)
3	SD	PI, Silness & Löe (1964)	*A* = 0.33 (0.20) *B* = 0.35 (0.25)	*A* = 0.12 (0.12)** *B* = 0.24 (0.19)	Ainamo & Bay (1975)	*A* = 31.4 (12.6) *B* = 29.8 (13.0)	*A* = 7.7 (6.8)** *B* = 19.4 (12.3)			
4	SE	PI, Silness & Löe (1964)	*A* = 0.44 (0.04)† *B* = 0.46 (0.04)†	*A* = 0.17 (0.02)** *B* = 0.25 (0.02)	Ainamo & Bay (1975)	*A* = 27.0 (1.9)† *B* = 25.6 (1.7)†	*A* = 11.0 (1.4)** *B* = 16.3 (1.5)			
5	SD				Philstrom (1987)	*A* = 0.92 (0.45) *B* = 0.97 (0.50) *C* = 0.91 (0.52)	*A* = 0.85 (0.54) *B* = 0.90 (0.55) *C* = 0.89 (0.54)			
6	SE	PI, Silness & Löe (1964)	*A* = 0.70 (0.05)† *B* = 0.72 (0.05)†	*A* = 0.21 (0.03) *B* = 0.28 (0.03)	Ainamo & Bay (1975)	*A* = 31.9% (1.7)† *B* = 31.8% (1.6)†	*A* = 12.2% (0.9)** *B* = 24.5% (1.5)			
7	SE	PI, Silness & Löe (1964)	*A* = 0.31 (0.03)† *B* = 0.31 (0.03)†	*A* = 0.20 (0..02)** *B* = 0.27 (0.02)	Ainamo & Bay (1975)	*A* = 24.2% (1.6)† *B* = 23.7% (1.7)†	*A* = 11.5% (1.2)** *B* = 20.1% (1.8)			
8	SD	Quigley & Hein (1962), Turesky Modification (1970)	*A* = 2.84 *B* = 2.86	*A* = 2.17 (0.46)** *B* = 2.89 (0.52)				GI, Löe & Silness (1963), [9-2]Talbott Modification (1977)	*A* = 1.41 *B* = 1.41	*A* = 1.16 (0.11)** *B* = 1.45 (0.36)
9	SD	Quigley & Hein (1962), Turesky Modification (1970)	*A* = 1.79 (0.36) *B* = 1.75 (0.35)	*A* = 1.11 (0.34)** *B* = 1.65 (0.39)				GI, Löe & Silness (1963), [9-2]Talbott Modification (1977)	*A* = 1.16 (0.19) *B* = 1.17 (0.20)	*A* = 0.87 (0.21)** *B* = 1.17 (0.30)
10	SD	Quigley & Hein (1962), Turesky Modification (1970)	*A* = 2.46 (0.49) *B* = 2.45 (0.50)	*A* = 1.63 (0.58)** *B* = 1.97 (0.53)				GI, Löe & Silness (1963), [9-2]Talbott Modification (1977)	*A* = 1.41 (0.22) *B* = 1.43 (0.22)	*A* = 0.81 (0.23)** *B* = 1.14 (0.25)
11	SD	Quigley & Hein (1962), Turesky Modification (1970)	*A* = 2.25 (0.41) *B* = 2.24 (0.42)	*A* = 1.82 (0.45)** *B* = 2.22 (0.42)				GI, Löe & Silness (1963), [9-2]Talbott Modification (1977)	*A* = 1.60 (0.28) *B* = 1.59 (0.29)	*A* = 0.65 (0.22)** *B* = 0.95 (0.26)
12	SD	Quigley & Hein (1962), Turesky Modification (1970)	*A* = 2.46 (0.39) *B* = 2.43 (0.35)	*A* = 1.48 (0.49) *B* = 1.68 (0.45)				GI, Löe & Silness (1963), [9-2]Talbott Modification (1977)	*A* = 1.29 (0.18) *B* = 1.29 (0.16)	*A* = 0.94 (0.13)** *B* = 1.17 (0.15)
13	SE	PI, Silness & Löe (1964)	*A* = 0.28 (0.03)† *B* = 0.29 (0.03)† *C* = 0.29 (0.03)†	*A* = 0.17 (0.02) *B* = 0.14 (0.02)** *C* = 0.21 (0.02)	Saxton & Van der Ouderaa (1989)	*A* = 27.4% (1.9)† *B* = 28.5% (1.5)† *C* = 27.3% (1.4)†	*A* = 17.8% (1.7)** *B* = 11.7% (1.2)** *C* = 23.8% (1.7)			
14	SE	PI, Silness & Löe (1964)	*A* = 0.33 (0.04) *B* = 0.32 (0.04)	*A* = 0.18 (0.03)** *B* = 0.25 (0.02)	Saxton & Van der Ouderaa (1989)	*A* = 29.7% (1.6) *B* = 28.3% (1.7)	*A* = 9.8% (1.0)** *B* = 19.6% (1.5)			

Table 4. (Contd.)

#	SE/SD	Plaque			Bleeding			Gingivitis		
		PI	PI score base	PI score end	BI	BI score base	BI score end	GI	GI score base	GI score end
15	–	Quigley & Hein 1962, Turesky Modification (1970)	$A = 3.00$ $B = 2.98$ $C = 3.00$	$A = 1.72^{**}$ $B = 2.05$ $C = 1.93$				GI, Löe & Silness, 1963, [9-2]Talbott Modification (1977)	$A = 2.10$ $B = 2.14$ $C = 2.12$	$A = 0.96^{**}$ $B = 1.26$ $C = 1.21$
16	SD	PI, Silness & Löe (1964)	1.51 (0.30)	0.73 (0.24)	BOMP, Van der Weijden (1994b)	1.56 (0.25)	0.89 (0.27)	MGI, Lobene (1986)	1.72 (0.18)	0.94 (0.26)
17	SE	PI, Silness & Löe (1964)	$A = 1.03$ (0.03) $B = 0.96$ (0.04) $C = 0.95$ (0.03)	$A = 0.71$ $B = 0.72$ $C = 0.73$				GI, Löe & Silness (1963)	$A = 0.68$ (0.02) $B = 0.69$ (0.02) $C = 0.71$ (0.02)	$A = 0.37^{**}$ $B = 0.37^{**}$ $C = 0.45$
18	SD	Quigley & Hein (1962), Turesky Modification (1970)	$A = 3.47$ (0.50) $B = 3.55$ (0.47)	$A = 2.84$ (0.48)** $B = 3.23$ (0.39)				GI, Löe & Silness (1963), [9-2]Talbott Modification (1977)	$A = 1.34$ (0.21) $B = 1.34$ (0.19)	$A = 0.97$ (0.11)** $B = 0.98$ (0.14)
19	SE	Quigley & Hein (1962), Turesky Modification (1970)	$A = 1.94$ (0.04) $B = 1.90$ (0.04)	$A = 2.16$ $B = 2.23$				GI, Löe & Silness (1963)	$A = 0.68$ (0.02) $B = 0.71$ (0.02)	$A = 0.41^{**}$ $B = 0.52$
20	SE	PI, Silness & Löe (1964)	$A = 0.5$ (0.03) $B = 0.5$ (0.03) $C = 0.5$ (0.03)	$A = 0.3$ (0.03)** $B = 0.4$ (0.03) $C = 0.4$ (0.04)	Ainamo & Bay (1975)	$A = 0.3$ (0.02) $B = 0.3$ (0.02) $C = 0.3$ (0.02)	$A = 0.2$ (0.01) $B = 0.2$ (0.01) $C = 0.2$ (0.02)			
21	SD	Quigley & Hein (1962), Turesky Modification (1970)	2.05 (0.36)	0.76 (0.27)	Eastman Bleeding Index, Caton & Polson (1985)	0.40 (0.29)	0.41 (0.24)	GI, Löe & Silness (1963)	0.89 (0.29)	0.33 (0.25)
22	SD							MGI, Lobene (1986)	$A = 2.39$ (0.42) $B = 2.41$ (0.29)	$A = 1.52$ (0.33)** $B = 1.71$ (0.35)
23	SD	Quigley & Hein (1962)	$A = 1.76$ (0.50) $B = 2.00$ (0.54)	$A = 1.13$ (0.44)** $B = 1.63$ (0.54)				GI, Löe & Silness (1963)	$A = 1.71$ (0.56) $B = 1.68$ (0.50)	$A = 0.82$ (0.40) $B = 1.18$ (0.51)
24	SD	Ainamo & Bay (1975)	56% (18)	39.6%				Ainamo & Bay (1975)	39% (13)	24.4%
25	SE	PI, Silness & Löe (1964)	$A = 0.73$ (0.02) $B = 0.73$ (0.03) $C = 0.67$ (0.03)	$A = 0.55$ (0.02) $B = 0.58$ (0.02) $C = 0.54$ (0.02)				GI Löe & Silness (1963)	$A = 0.86$ (0.02) $B = 0.89$ (0.02) $C = 0.84$ (0.02)	$A = 0.64$ (0.01)** $B = 0.74$ (0.02) $C = 0.78$ (0.02)
26	SE	Quigley & Hein (1962), Turesky Modification (1970)	$A = 1.88$ (0.04) $B = 1.94$ (0.04) $C = 1.90$ (0.04)	$A = 2.23$ (0.03) $B = 2.16$ (0.03) $C = 2.23$ (0.03)				GI, Löe & Silness (1963)	$A = 0.70$ (0.02) $B = 0.68$ (0.02) $C = 0.71$ (0.02)	$A = 0.51$ (0.01)** $B = 0.41$ (0.01)** $C = 0.52$ (0.01)
27	SD	Quigley & Hein (1962), Turesky Modification (1970)	$A = 2.73$ (0.47) $B = 2.62$ (0.38)	$A = 2.02$ (0.44)** $B = 2.41$ (0.41)	Saxton & Van der Ouderaa (1989)	$A = 0.17$ (0.07) $B = 0.15$ (0.07)	$A = 0.11$ (0.07)** $B = 0.17$ (0.07)	MGI, Lobene (1986)	$A = 2.08$ (0.15) $B = 2.06$ (0.12)	$A = 1.74$ (0.27)** $B = 2.06$ (0.16)
28	SD	Quigley & Hein (1962), Turesky Modification (1970)	$A = 2.16$ (0.51) $B = 2.14$ (0.43)	$A = 1.63$ (0.58)** $B = 2.27$ (0.40)				GI, Löe & Silness (1963), [9-2]Talbott Modification (1977)	$A = 1.38$ (0.29) $B = 1.35$ (0.24)	$A = 0.97$ (0.24)** $B = 1.23$ (0.12)

29	SD	Quigley & Hein (1962), Turesky Modification (1970)	*A* = 1.93 (0.47)	*A* = 1.39 (0.36)*	Bleeding on probing (ref?)	25.1% (12.4)	15.5% (9.5)	MGI, Lobene (1986)	1.38 (0.37)	0.58 (0.23)
30	SD	Quigley & Hein (1962), Turesky Modification (1970)	*A* = 2.68 (0.37) *B* = 2.71 (0.46)	*A* = 2.04 (0.37)** *B* = 2.51 (0.42)				GI, Löe & Silness (1963), [9-2]Talbott Modification (1977)	*A* = 1.19 (0.10) *B* = 1.23 (0.12)	*A* = 0.91 (0.10)** *B* = 1.17 (0.11)
31	SD	Quigley & Hein (1962), Turesky Modification (1970)	*A* = 2.95 (0.21) *B* = 2.96 (0.29)	*A* = 1.57 (0.29)** *B* = 2.41 (0.31)				GI, Löe & Silness (1963), [9-2]Talbott Modification (1977)	*A* = 1.70 (0.19) *B* = 1.72 (0.20)	*A* = 1.07 (0.17)** *B* = 1.44 (0.20)
32	SD	Quigley & Hein (1962), Turesky Modification (1970)	*A* = 2.13 (0.68) *B* = 1.98 (0.53)	*A* = 2.41 (0.52)* *B* = 2.19 (0.50)	BOMP, Van der Weijden (1994b)	*A* = 0.59 (0.24) *B* = 0.62 (0.24)	*A* = 0.76 (0.30)* *B* = 0.65 (0.28)	MGI, Lobene (1986)	*A* = 0.59 (0.23) *B* = 0.69 (0.19)	*A* = 0.79 (0.16)* *B* = 0.76 (0.17)
33	SD	Quigley & Hein (1962), Turesky Modification (1970)	*A* = 1.89 (0.39) *B* = 1.92 (0.36)	*A* = 1.09* *B* = 1.20				GI, Löe & Silness (1963)	*A* = 0.97 (0.23) *B* = 1.04 (0.25)	*A* = 0.94 *B* = 0.93

PI, plaque index; GI, gingival index; BI, bleeding index; BOMP, bleeding on marginal probing; MGI, modified gingival index.
*Significant change as compared with baseline.
**Significant difference between groups (or *versus* control).
†Pre-experimental data.

these data into the percentage of surfaces covered with plaque but it does not seem unrealistic to state that these subjects had considerably more plaque. The nine studies, however, also provided data on the level of gingival inflammation as scored using the Gingival Index (Löe & Silness) and varied at baseline between 1.59 and 0.84. These levels of gingivitis are higher than observed by Löe et al. (1978), in Norwegian students and academicians, at their baseline observation in 1969–1970. The level of gingivitis ranged, depending on the age group, from 1.04 to 0.72. This group of subjects, with good to excellent oral hygiene and relatively healthy gingival, was followed and seen 26 years later (Hujoel et al. 1998). It turned out that in this Norwegian population, the tooth mortality risk from early adulthood until mid-life was low. In this respect, the populations of the nine selected studies (Table 4 and Fig. 1) clearly had some room for enhancement of their gingival condition and to improve their dental future.

Given these Norwegian baseline data, the present review has shown that only a limited improvement over a 6-month period can be expected from dental interventions in the form of a prophylaxis (Fig. 1) or a combination of professional oral hygiene instruction and a prophylaxis (Figs 2a and b). In those studies that provided a prophylaxis, only the Gingival Index (Löe & Silness) reduced from 1.59–0.84 to 1.23–0.78 (Table 4).

Thus, if the dental profession intends to establish improved gingival conditions in their patient population, other more effective measures appear to be necessary. This review also retrieved a paper in which, during an 8-month preventive programme, three professional oral hygiene instructions and a professional prophylaxis were provided (Van der Weijden et al. 1994b). Over time, the plaque index decreased steadily with approximately 52%, and, in concurrence, a 42% reduction of gingival bleeding on marginal probing was observed, showing the benefit of frequent oral hygiene instructions. The long-term beneficial effect of a preventive programme, based on professional and self-performed plaque control, not only with respect to periodontal diseases but also caries incidence, has been well established by Axelsson et al. (2004). Also, individuals who consistently brush ($>$once a day), floss and receive regular

dental prophylaxis are likely to retain more teeth (Kressin et al. 2003).

So, in the well-motivated and properly instructed individuals who are willing to invest the necessary time and effort, mechanical measures using traditional toothbrushes and adjunctive manual (inter-dental) devices are effective in controlling plaque. Maintaining a dentition close to plaque free is, however, not easy. New technologies have been developed that may enhance plaque removal and simplify the task of the individual who seeks to maintain good oral hygiene. Powered toothbrushes represent one such advance that has the potential to both enhance plaque removal and patient motivation. The new generation of electric brushes has proven to have better plaque removal efficacy and gingival inflammation control than conventional brushes, mostly in the approximal tooth surfaces (Egelberg & Claffey 1998, Van der Weijden 1998b). Electric toothbrushes are now generally regarded to be more efficacious than manual toothbrushes in removing plaque and maintaining or improving the gingival condition (Warren & Chater 1996, Saxer & Yankell 1997, Walmsley 1997). Dental professionals should be aware that oscillating/rotating and counter-rotational powered toothbrushes could be more effective in terms of reduction of plaque and gingival inflammation compared with manual brushes (Sicilia 2002, 2003a, Forrest & Miller 2004). This implies that these powered toothbrushes should be considered part of the regular oral hygiene armamentarium (Sicilia et al. 2003b).

Usually, in combination with toothbrushing, a dentifrice is used. Fluoride is almost omnipresent in commercially available toothpastes. The fluoride is beneficial in the prevention of caries. It has, however, not routinely exhibited efficacy in controlling gingival inflammation. For this reason, dentifrices have also included substances claiming antibacterial, anti-calculus and desensitizing properties (Davies et al. 2004). The present search strategy picked up on a substantial number of papers that assessed, in the test groups, the effect of triclosan dentifrices. Both the triclosan/copolymer and triclosan/zinc citrate showed an effect on plaque and gingivitis superior to the effect that was observed in the control groups. These observations are in agreement with those from a recent systematic review (Davies et al. 2004). This review addressed the effectiveness of triclosan/copolymer in comparison with fluoride dentifrices in improving plaque control and gingival health. As can be expected, their data were drawn from studies that were also retrieved for the present review. Their WMD calculation for plaque (Quigley & Hein), using the end-trial data, was -0.48 in favour of the triclosan product. The WMD reduction of gingivitis was -0.26.

In summary

The paramount role of supragingival plaque control in the prevention and control of periodontal disease is well documented. Procedures for control of supragingival plaque are as old as recorded history. Currently, the use of a toothbrush and fluoridated toothpastes is almost universal. When good oral hygiene is practiced, the mechanical action of toothbrushing can remove plaque most effectively. However, persistently effective brushing is uncommon, suggesting that, additionally, a chemotherapeutic approach could be beneficial.

In adults with gingivitis, the quality of self-performed mechanical plaque is not sufficiently effective and should be improved. Based on studies $\geqslant 6$ months in duration, it appears that a single oral hygiene instruction, describing the use of a mechanical toothbrush, in addition to a single professional ''oral prophylaxis'' provided at baseline, had a significant, albeit small, positive effect on the reduction of gingivitis.

Acknowledgements

The authors express their sincere gratitude to Ubele van der Velden, Spiros Paraskevas, Paula Versteeg and Fawn van der Weijden for their help in preparing this manuscript.

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