KPKJ Hioe
GA van der Weijden

The effectiveness of self-performed mechanical plaque control with triclosan containing dentifrices

Authors' affiliations:
KPKJ Hioe, *GA van der Weijden*, Academic Centre for Dentistry Amsterdam, ACTA, Amsterdam, The Netherlands

Correspondence to:
Fridus van der Weijden
Department of Periodontology
Academic Centre for Dentistry Amsterdam
ACTA, Louwesweg 1
1066 EA Amsterdam
The Netherlands
Tel.: +31 20 518 8307
Fax: +31 20 518 8512
E-mail: ga.vd.weijden@acta.nl

Dates:
Accepted 1 August 2005

To cite this article:
Int J Dent Hygiene **3**, 2005; 192–204
Hioe KPKJ, van der Weijden GA.
The effectiveness of self-performed mechanical plaque control with triclosan containing dentifrices

Abstract: *Objective:* To assess the effectiveness of self-performed mechanical plaque control with triclosan (5-chloro-2-(2,4 dichlorophenoxy)phenol) containing dentifrice. *Search strategy:* An electronic search of the National Library of Medicine, Washington DC (Medline-PubMed; up to and including March 2005) was performed using specific search terms to identify clinical trials of ≥6 months in duration, which assessed the effect of various forms of plaque control in gingivitis subjects. In those trials the manual toothbrush group (frequently the control group) served to provide data for the assessment of the effectiveness of self-performed mechanical plaque control with a triclosan-containing dentifrice. The data were analysed depending on the (baseline) intervention, being either a professional oral hygiene instructions, a prophylaxis, or both. *Data collection and analysis:* Two reviewers extracted information (KPKJH and GAW). Where appropriate plaque and gingivitis data for baseline and end-trial were used to calculate weighted mean differences (WMD) with the appropriate 95% confidence intervals (CI) using a random effect models. *Main results:* Of 105 titles and abstracts, 18 trials were found suitable for clinical data were extracted. Meta-analysis were conducted. In studies ($n = 9$) evaluating a triclosan/copolymer dentifrice, plaque control [Quigley and Hein (1962) *Journal of American Dental Association*, Vol. 65: pp. 26–29] was significantly improved compared with a control fluoride dentifrice, with a WMD of −0.48 (95% CI: −0.73 to −0.24). For gingival inflammation as assessed with the gingival index [Löe and Silness (1963) *Acta Odontologica Scandinavica*, Vol. 21: pp. 533–551] a significant WMD of −0.24 (95% CI: −0.35 to −0.13) was found. From studies ($n = 6$) evaluating the Triclosan zinc/citrate dentifrices a small but significant WMD for plaque

control [Silness and Löe (1964) *Acta Odontologica Scandinavica*, Vol. 22: pp. 121–135] was observed in favour of the test group as compared with the standard fluoride dentifrice formulations (WMD −0.07, 95% CI: −0.10 to 0.05). While at baseline the proportion of bleeding was comparable, at the end of the studies a significant −10.81% WMD (95% CI: −12.69 to −8.93) in favour of the triclosan/zinc citrate dentifrice was observed. *Conclusion:* This systematic review indicates, based on studies ≥6 months of duration in adults with gingivitis, that the effectiveness of self-performed mechanical plaque control with a triclosan-containing dentifrice, had a significant albeit small positive effect on the reduction of plaque and gingivitis.

Key words: bleeding; gingivitis; manual toothbrush; meta-analysis; oral hygiene; plaque; systematic review; triclosan

Introduction

Improved control of bacterial plaque deposits on teeth in humans is both necessary to maintain oral health and, to the individual, socially desirable. In the absence of any oral hygiene measures or professional dental intervention, the dentition becomes largely covered with bacterial plaque deposits. Consequently gingivitis develops within several days (1) and the risk of differential bacterial growth, selection of periodontal pathogenic microorganisms, and manifest periodontitis gradually increases. The importance of oral hygiene has been known for centuries, although the role of plaque as the major aetiological factor in gingivitis was not recognized until Löe *et al.* (1) convincingly demonstrated the relationship in the first experimental gingivitis model study. Several studies have demonstrated that in both children (2) and adults (3) plaque control can be considerably improved by mechanical oral hygiene measures to the extent that gingivitis is almost eliminated. The major elements in the programme appear to be the frequent reinforcement of an oral hygiene regime, the interpersonal relationships and the skills of the oral hygiene instructors. Armed with this knowledge prevention became a major issue of dental treatment. Patients were urged to brush twice a day and the public was encouraged to improve their oral hygiene habits.

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.* (4) 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.* (5) reports on the 1998 UK Adult Dental Health survey. The mean proportion of teeth with plaque increased from 30% in the 25 to 34-year age group to 44% in those aged 65 years and above.

At ACTA a study was conducted which assessed the efficacy of a single 1-min brushing exercise in subjects adhering to their customary brushing method (6). 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 (7). 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, although they brush once every day.

The dentifrice, in addition to the toothbrush, forms an integral part of most oral hygiene regimes and it is appropriate to consider the role of this aid in plaque control.

In an effort to improve the effectiveness of plaque control and periodontal health triclosan (5-chloro-2-(2,4 dichlorophenoxy)phenol), a broad-spectrum antibacterial agent, has been added to dentifrices. The most widely available antimicrobial dentifrices contain triclosan and these have been studied in the greatest detail. Being non-ionic, triclosan is compatible with dentifrice formulations and has reasonable substantivity. It is detectable on the oral mucosa and in dental plaque at least 3 and 8 h, respectively, after use (8). It is a broad-spectrum antimicrobial agent, active against all the major plaque

bacteria (9). The use of triclosan-containing products has been associated with very few adverse side-effects (10). Triclosan alone has only moderate antiplaque properties (11, 12). One approach to boost its clinical effectiveness was to increase the retention of triclosan in the mouth by the addition of either polyvinyl-methyl ether maleic acid copolymer, zinc citrate or pyrophosphate.

The present review was initiated to assess the effect of manual toothbrushing with a triclosan containing dentifrice on gingivitis. It systematically searched for papers, which investigated the effect of mechanical oral hygiene using a triclosan containing dentifrice, with respect to gingivitis and plaque control in subjects without periodontitis in studies of at least 6-month duration.

Material and Methods

Focused question

The aim of this study was to assess the effectiveness of self-performed mechanical plaque control with dentifrices containing triclosan in adults with gingivitis using a manual toothbrush with respect to the level of plaque and gingivitis in controlled studies of at least 6-month duration.

Search strategy

This review was conducted using the methodology developed by the Cochrane collaboration. One sources 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, which evaluated the effect of various forms of plaque control in gingivitis subjects in studies of ≥6-month duration. From those trials data were extracted with regard to the effectiveness of self-performed mechanical plaque control using a triclosan containing dentifrice in comparison to a control treatment. The data were analysed depending on the (baseline) intervention, being either a professional oral hygiene instructions, a prophylaxis, or both. The comprehensive search in a systematic review process ensures inclusion of all suitable papers which address the review question. The database was searched up to and including April 2005 using the following terms for the search strategy:

- (Intervention) [Mesh terms] Triclosan/all subheadings OR [Text Word] Triclosan
  AND
- (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 subheadings OR Gingival Hemorrhage/all subheadings OR [Text Words] gingivitis OR gingival hemorrhage OR gingival bleeding OR gingival disease.

Eligibility criteria were:

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

Only papers written in English language were accepted. Case reports, letters and historical reviews were not included in the search. Papers 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 to be able to investigate heterogeneity of the primary outcome across studies:

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

Screening and selection of papers

The papers were screened independently by two reviewers (KPKJH and GAW). 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-month duration,
- randomized controlled trial or controlled clinical trial,
- prospective clinical study,
- parameters mentioned: gingivitis, plaque,
- healthy subjects ≥18 years,
- manual toothbrushing (with or without interdental),
- triclosan dentifrice.

Statistical analysis

By data extraction mean values and standard deviations (SD) or standard error of the mean (SE) were collected. 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 1–4.

Results

The search strategy produced 105 citations, 18 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 18 trials were (randomized) controlled clinical studies and involved adults (aged 18 years or more) with plaque and gingivitis.

Tables 2, 3 and 4 show the results of the data extraction. Selected studies were 6–12 months of duration. Randomization procedures were not addressed in six papers. In 17 of the studies, participants in test and control group received a professional prophylaxis at the start of the study. In one study no prophylaxis was undertaken prior to commencement. Toothbrushing frequency was twice daily in all of the 18 studies.

In 12 trials the level of supragingival plaque was scored using the Quigley and Hein Plaque Index (13) Turesky modification (14) predominantly in combination with an assessment of gingival inflammation by the Löe and Silness Gingival Index (15) Talbott modification (16). In six studies the Silness and Löe Plaque Index was used, most frequently in combination with a bleeding score as the parameter for gingivitis (17, 18, 19).

The collective data of the studies allowed for various meta-analyses using a random effects model, as illustrated in Figs 1–4, studies 5, 12 and 18 were unsuitable for further analysis due to their choice of plaque and gingivitis indices and/or the lack of SD/SE. Figs 1 and 2 show the results for the triclosan/copolymer dentifrice ($n = 9$) (studies 2, 6, 7, 8, 9, 13, 15, 16, 17; Tables 2, 3 and 4). Figure 1 illustrates that the levels of plaque (Quigley and Hein) at baseline in the test and control group (standard fluoride dentifrice either NaF or MFP), both groups using a

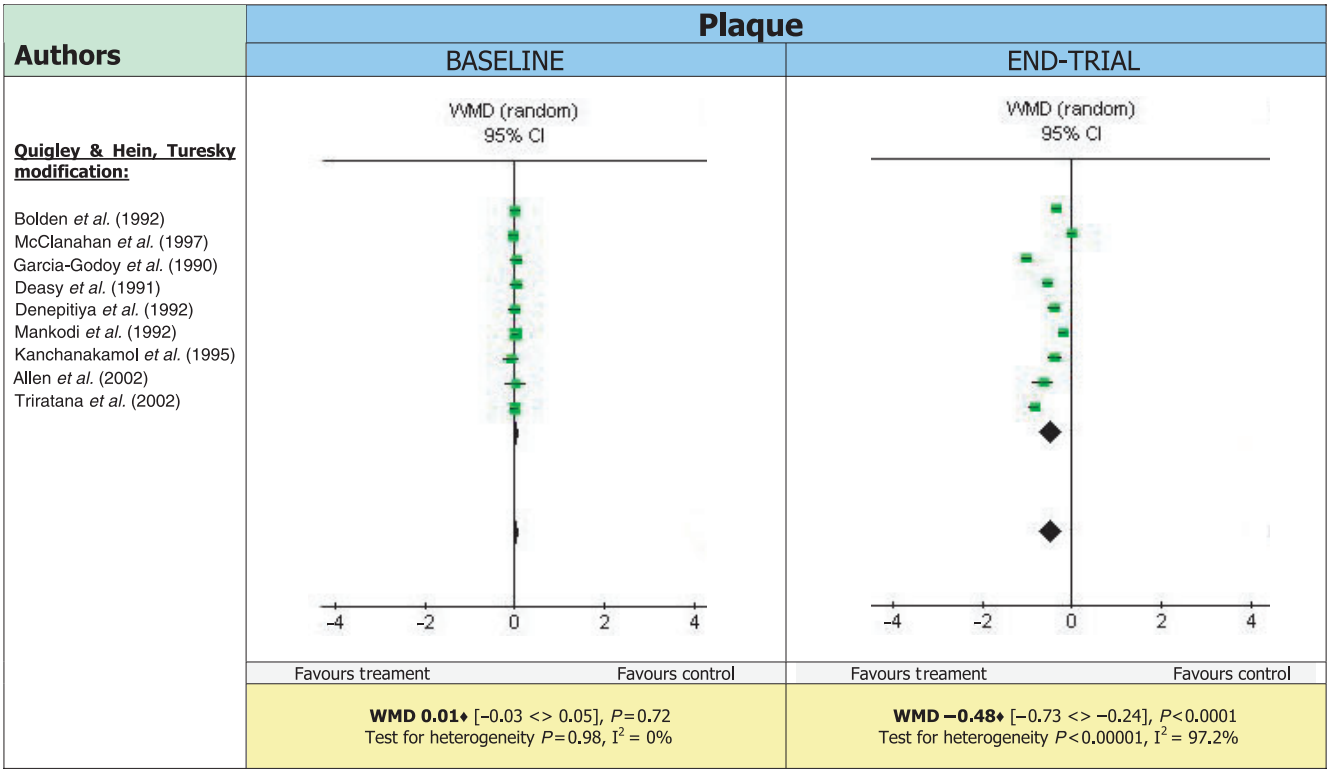

Fig 1. Plaque data for the studies using the Triclosan/copolymer dentifrice formulations. Forrest-plot demonstrating baseline and end values for the Quigley and Hein (13) Plaque Index (Turesky modification, 1970). The size of the box signifies the 'weight' or importance of the study. Weighted mean differences (WMD = ♦) between test and control group are provided including the 95% confidence interval (CI).

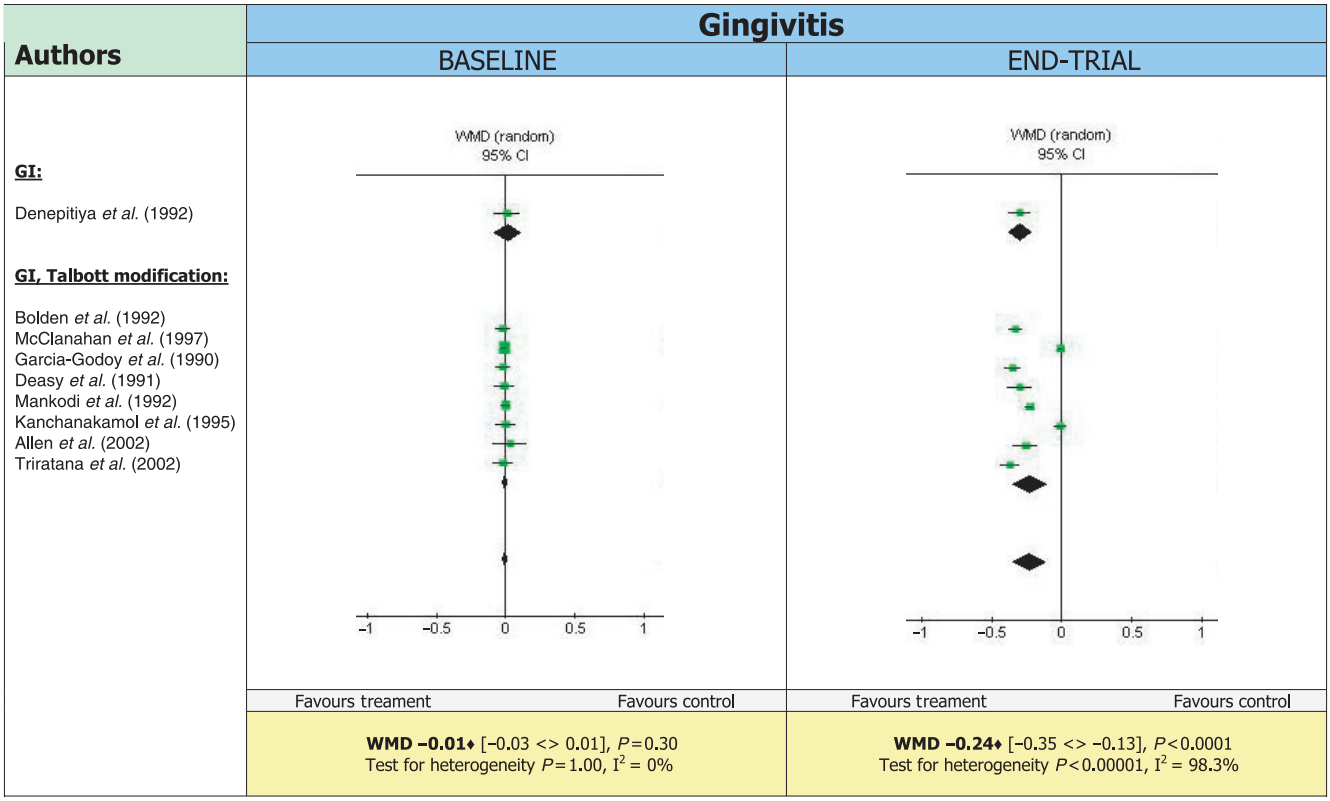

Fig 2. Gingivitis data for the studies using Tricolsan/copolymer dentifrice formulations. Forrest-plot demonstrating baseline and end values for the Gingival Index (15) (Talbott modification, 1977). The size of the box signifies the 'weight' or importance of the study. Weighted mean differences (WMD = ♦) between test and control group are provided including the 95% confidence interval (CI).

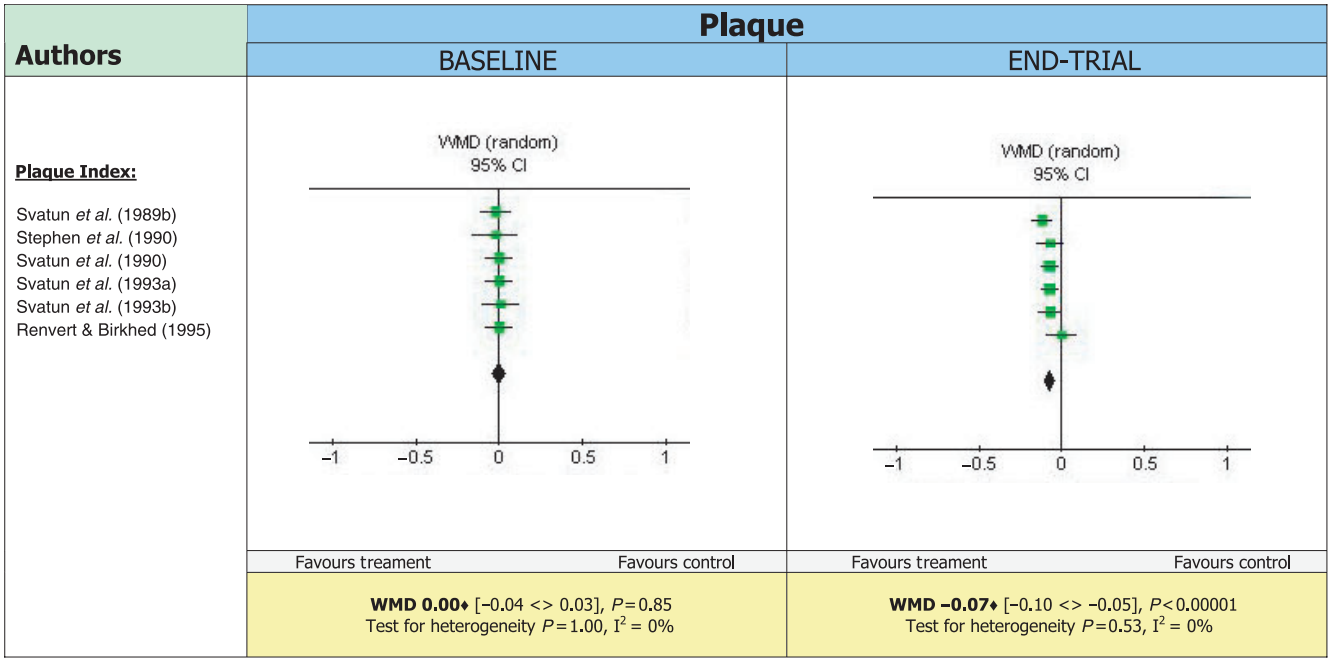

Fig 3. Plaque data for the studies using the Triclosan/zinc citrate dentifrice formulations. Forrest-plot demonstrating baseline and end values for the Plaque Index (59). The size of the box signifies the 'weight' or importance of the study. Weighted mean differences (WMD = ♦) between test and control group are provided including the 95% confidence interval (CI).

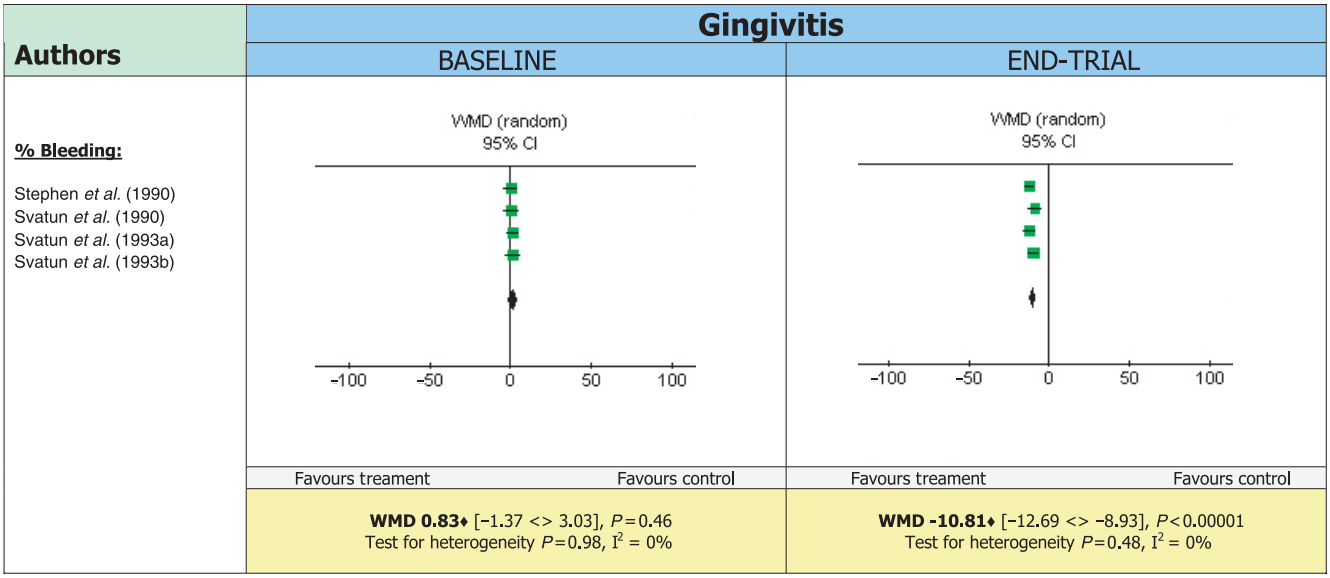

Fig 4. Gingivitis data for the studies using the Triclosan/zinc citrate dentifrice formulations. Forrest-plot demonstrating baseline and end values for the% bleeding on probing. The size of the box signifies the 'weight' or importance of the study. Weighted mean differences (WMD = ♦) between test and control group are provided including the 95% confidence interval (CI).

Table 1. **Search results**

Titles and abstracts	105
Selected papers for full reading	25
Excluded for the following reason	7 (in total)
Inadequate data presentation	5
No plaque and gingivitis data	1
No control group	1
Final selection	18

manual toothbrush, were comparable with a WMD of 0.01. At the end of the study duration the level of plaque improved in favour of the triclosan/copolymer group with a significant WMD of 0.48. The meta-analyses for the Gingival Index (Löe and Silness) as illustrated in Fig. 2 shows that the triclosan/copolymer dentifrice is more effective in reducing gingival inflammation compared with a fluoride dentifrice, with a significant WMD of 0.24.

Figure 3 shows the data and the Forrest-plot of the Plaque Index (Silness and Löe) in studies that assessed the effect of triclosan/zinc citrate dentifrice formulations ($n = 6$) (studies 1, 3, 4, 10, 11, 14; Tables 2, 3 and 4) and a small but significant WMD (0.07) was observed in favour of the test group when compared with the standard fluoride dentifrice formulations. Figure 4 show the results for the gingivitis assessments. While at baseline the proportion of bleeding was comparable, at the end of the studies a significant 10.81% WMD in favour of the triclosan/zinc citrate dentifrice was observed (Fig. 4 and Table 4; studies 3, 4, 10, 11).

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 take caution in using the WMD as the exact measure of the effect.

Discussion

Most individuals claim to brush their teeth at least twice a day. In spite of this, 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 prevent gingivitis and more severe forms of periodontal disease (20). The maintenance of an effective level of plaque control is clearly difficult using conventional mechanical procedures and dentifrices (5). From a global perspective, it is however the most realistic means of improving the periodontal health of communities and populations (21).

Usually in combination with toothbrushing a dentifrice is used. Fluoride is almost omnipresent in commercially available dentifrices. 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, anticalculus and desensitizing properties (21).

Triclosan is a commonly used antimicrobial agent found in products such as acne creams, deodorants and hand soaps at

Table 2. **Authors and titles**

Reference	Duration	(Short) Title	Dentifrice	Toothbrush	OHI	Intervention	Random
Svatun *et al.* (41)	1 year	One-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	?
Garcia-Godoy *et al.* (42)	7 months	Effect of a triclosan/copolymer/ fluoride dentifrice on plaque formation and gingivitis	A = Triclosan/copolymer B = NaF	Soft bristled	Yes	Prof. prophy	Yes
Stephen *et al.* (33)	6 months	Control of gingivitis by a dentifrice containing a zinc salt and triclosan	A = Triclosan/zinc citrate B = MFP	?	Yes	Prof. prophy	Yes
Svatun *et al.* (43)	6 months	Six-month 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	?
Cubells *et al.* (44)	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
Deasy *et al.* (45)	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	?
Bolden *et al.* (46)	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
Denepitiya *et al.* (47)	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
Mankodi *et al.* (48)	6 months	Clinical effect of a triclosan-containing dentifrice on plaque and gingivitis	A = Triclosan/copolymer B = NaF	Soft bristled	No	Prof. prophy	?
Svatun *et al.* (39)	7 months	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. prophy	Yes
Svatun *et al.* (49)	7 months	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
Palomo *et al.* (40)	6 months	The effect of three commercially available dentifrices containing triclosan on supragingival plaque formation and gingivitis	A = Triclosan/copolymer B = Triclosan/zinc citrate C = NaF	Soft bristled adult toothbrush	?	Prof. prophy	Yes
Kanchanakamol *et al.* (50)	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. Continued

Reference	Duration	(Short) Title	Dentifrice	Toothbrush	OHI	Intervention	Random
Renvert and Birkhed (51)	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	?
McClanahan *et al.* (52)	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 = SnF2 C = NaF	?	No	Prof. prophy	Yes
Allen *et al.* (53)	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	?
Triratana *et al.* (54)	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
Winston *et al.* (55)	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

OHI, oral hygiene instruction
*A dentifrice of their own choice.

concentrations that range from 0.1% to 1%. Although introduced over 30 years ago, the application of triclosan has increased dramatically over the last 10 years. Among other things, it is currently incorporated into kitchen tiles, children's toys, cutting boards, toothbrush handles and athletic clothing. Triclosan is used in many products because it exhibits antibacterial as well as antifungal and antiviral properties (22). In addition, because of its non-ionic character, triclosan is compatible with other desirable ingredients in dentifrices (23).

The mechanisms of its antiseptic action is by acting on the microbial cytoplasmic membrane, inducing leakage of cellular constituents and thereby causing lysis of the microorganisms. Evidence has accumulated to suggest that triclosan in itself does not produce optimal plaque inhibitory effects without the addition of other chemicals which increase its antibacterial effect. One approach to boost its effectiveness has been to increase the retention of triclosan in the mouth by the addition of a polyvinyl-methyl ether maleic acid copolymer. *In vitro* studies demonstrated that the copolymer increased the uptake and retention of triclosan, and short-term studies demonstrated the potential of a formulation containing 0.3% triclosan and 2% copolymer to enhance plaque control and improve gingival health (24, 25).

An alternative approach to improve the antiplaque and antigingivitis effect of triclosan has been to combine zinc and triclosan. This combination is advantageous in dentifrice formulations because of the low toxicity and few reported side-effects of the agents when applied in therapeutic doses (26). The potential of the zinc ion as a plaque inhibitor has been demonstrated in several clinical mouthrinse studies using aqueous solutions (27). Zinc is highly substantive and is retained in the mouth for even longer periods than triclosan. Many commercially available dentifrices contain zinc citrate, and the effects have been evaluated in a number of studies (28, 29, 12, 30, 31, 32, 33, 34). A general conclusion is that zinc has a moderate inhibitory effect on plaque formation, most notably in individuals who are heavy plaque formers (31). Additive or synergistic effects have been proposed for a combination of zinc salts and antimicrobial agents and/or surfactants (35, 36, 37, 38), indicating different or complementary modes of action.

Both the triclosan/copolymer and triclosan/zinc citrate showed an effect on plaque and gingivitis (Figs 2–4) superior to the effect that was observed in the control group. It is difficult to come to a conclusion at a meta-analysis level as to which one of the two formulations is the most effective. The indices used in the studies were different which prevented the calculation of WMD through which products could be compared. There were however two studies that provided a

Table 3. **Subjects and conclusions**

Age (years)	Age range	Noz. of subjects	No. of dropouts	Brush frequency	Brushing duration	Authors' conclusions
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
A = 29.29 B = 27.30	A = 18–52 B = 18–63	A = 56 B = 56	4	2× daily	1 min	It was concluded that the twice daily use of a dentifrice containing 0.3% triclosan and 2% of a copolymer reduces supragingival plaque deposit formation and gingivitis to a highly significant degree, without any extrinsic stains observed
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
23	?	A = 48 B = 49	4	2× daily	?	A dentifrice containing triclosan and zinc citrate can contribute to oral care
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 an copolymer reduces supragingival plaque formation and gingivitis to a significant degree compared with a NaF base placebo dentifrice
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
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
A = 36 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
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 significant reduction in supragingival plaque formation and a significant improvement in gingival health
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
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.
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
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
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
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
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
38	20–60	A = 60 B = 59	5	2× daily	1 min	Compared with the placebo the triclosan copolymer dentifrice had a significant better ability to reduce plaque and gingivitis
A = 41.7 B = 40.5	?	A = 41 B = 36	?	2× daily	?	reviewers: No significant effect compared with NaF dentifrice

Table 4. **Study outcome**

	Plaque (PI)			Bleeding (BI)			Gingivitis (GI)		
SE/SD	Index	Score base	Score end	Index	Score base	Score end	Index	Score base	Score end
SE	PI, Silness and Löe (56)	A = 0.44 (0.04)† B = 0.46 (0.04)†	A = 0.17 (0.02)* B = 0.25 (0.02)	Ainamo and Bay (17)	A = 27.0 (1.9)† B = 25.6 (1.7)†	A = 11.0 (1.4)* B = 16.3 (1.5)			
SD	Quigley and Hein (13), Turesky Modification (14)	A = 2.49 (0.42)† B = 2.45 (0.39)†	A = 0.71 (0.25)* B = 1.73 (0.36)*				GI, Löe and Silness (15), Talbott modification (16)	A = 1.49 (0.11)† B = 1.51 (0.19)†	A = 0.81 (0.17)* B = 1.16 (0.13)*
SE	PI, Silness and Löe (56)	A = 0.70 (0.05)† B = 0.72 (0.05)†	A = 0.21 (0.03) B = 0.28 (0.03)	Ainamo and Bay (17)	A = 31.9% (1.7)† B = 31.8% (1.6)†	A = 12.2% (0.9)* B = 24.5% (1.5)			
SE	PI, Silness and Löe (56)	A = 0.31 (0.03)† B = 0.31 (0.03)†	A = 0.20 (0.02)* B = 0.27 (0.02)	Ainamo and Bay (17)	A = 24.2% (1.6)† B = 23.7% (1.7)†	A = 11.5% (1.2)* B = 20.1% (1.8)			
SD	Quigley and Hein (13), Turesky Modification (14)	A = 2.84 B = 2.86	A = 2.17 (0.46)* B = 2.89 (0.52)				GI, Löe and Silness (15) Talbott modification (16)	A = 1.41 B = 1.41	A = 1.16 (0.11)* B = 1.45 (0.36)
SD	Quigley and Hein (13), Turesky Modification (14)	A = 1.79 (0.36) B = 1.75 (0.35)	A = 1.11 (0.34)* B = 1.65 (0.39)				GI, Löe and Silness (15), Talbott modification (16)	A = 1.16 (0.19) B = 1.17 (0.20)	A = 0.87 (0.21)* B = 1.17 (0.30)
SD	Quigley and Hein (13), Turesky Modification (14)	A = 2.46 (0.49) B = 2.45 (0.50)	A = 1.63 (0.58)* B = 1.97 (0.53)				GI, Löe and Silness (15), Talbott modification (16)	A = 1.41 (0.22) B = 1.43 (0.22)	A = 0.81 (0.23)* B = 1.14 (0.25)
SD	Quigley and Hein (13), Turesky Modification (14)	A = 2.25 (0.41) B = 2.24 (0.42)	A = 1.82 (0.45)* B = 2.22 (0.42)				GI, Löe and Silness (15), Talbott modification (16)	A = 1.60 (0.28) B = 1.59 (0.29)	A = 0.65 (0.22)* B = 0.95 (0.26)
SD	Quigley and Hein (13), Turesky Modification (14)	A = 2.46 (0.39) B = 2.43 (0.35)	A = 1.48 (0.49) B = 1.68 (0.45)				GI, Löe and Silness (15), Talbott modification (16)	A = 1.29 (0.18) B = 1.29 (0.16)	A = 0.94 (0.13)* B = 1.17 (0.15)
SE	PI, Silness and Löe (56)	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 and Van der Ouderaa (18)	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)			

Table 4. **Continued**

	Plaque (PI)			Bleeding (BI)			Gingivitis (GI)		
SE/SD	Index	Score base	Score end	Index	Score base	Score end	Index	Score base	Score end
SE	PI, Silness and Löe (56)	A = 0.33 (0.04) B = 0.32 (0.04)	A = 0.18 (0.03)* B = 0.25 (0.02)	Saxton and Van der Ouderaa (18)	A = 29.7% (1.6) B = 28.3% (1.7)	A = 9.8% (1.0)* B = 19.6% (1.5)			
-	Quigley and Hein (13), Turesky Modification (14)	A = 3.00 B = 2.98 C = 3.00	A = 1.72* B = 2.05 C = 1.93				GI, Löe and Silness (15), Talbott modification (16)	A = 2.10 B = 2.14 C = 2.12	A = 0.96* B = 1.26 C = 1.21
SD	Quigley and Hein (13), Turesky Modification (14)	A = 3.47 (0.50) B = 3.55 (0.47)	A = 2.84 (0.48)* B = 3.23 (0.39)				GI, Löe and Silness (15), Talbott modification (16)	A = 1.34 (0.21) B = 1.34 (0.19)	A = 0.97 (0.11)* B = 0.98 (0.14)
SE	PI, Silness and Löe (56)	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 and Bay (17)	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)			
SE	Quigley and Hein (13), Turesky Modification (14)	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 and Silness (15)	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)
SD	Quigley and Hein (13), Turesky Modification (14)	A = 2.16 (0.51) B = 2.14 (0.43)	A = 1.63 (0.58)* B = 2.27 (0.40)				GI, Löe and Silness (15), Talbott modification (16)	A = 1.38 (0.29) B = 1.35 (0.24)	A = 0.97 (0.24)* B = 1.23 (0.12)
SD	Quigley and Hein (13), Turesky Modification (14)	A = 2.95 (0.21) B = 2.96 (0.29)	A = 1.57 (0.29)* B = 2.41 (0.31)				GI, Löe and Silness (15), Talbott modification (16)	A = 1.70 (0.19) B = 1.72 (0.20)	A = 1.07 (0.17)* B = 1.44 (0.20)
SD	Quigley and Hein (13), Turesky Modification (14)	A = 1.89 (0.39) B = 1.92 (0.36)	A = 1.09* B = 1.20				GI, Löe and Silness (15)	A = 0.97 (0.23) B = 1.04 (0.25)	A = 0.94 B = 0.93

*Significant difference between groups (or versus control).
†Pre-experimental data.

comparison of the two formulations (39, 40). Where the first of these studies showed the triclosan/zinc citrate formulation to be superior the latter showed the opposite. Only one paper was found regarding triclosan/pyrophosphate, but the data turned out to be inadequately presented for acceptation in this review.

The results as obtained with the meta-analyses of the triclosan/copolymer data are in agreement with those from a recent systematic review. This 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 which were also retrieved for the present review. Their WMD calculation for plaque (Quigley and Hein) using the end-trial data was −0.48 in favour of the triclosan product. The WMD reduction of gingivitis was −0.26. What however was missing in their publication is the comparison of the baseline data. The present review illustrates in Figs 2–4 that the baseline data for the studies involved showed no difference between test and control group. This strengthens the conclusion as drawn on the WMD between test and control group based on the data as obtained at the end of the trials.

Conclusions

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 dentifrices 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 might be beneficial. This systematic review indicates that, compared with a control fluoride dentifrice, a fluoride dentifrice containing triclosan formulations provides a more effective level of plaque control and gingival health.

Acknowledgements

The authors express their sincere thanks to Spiros Paraskevas and Meriane Natadarma for their help in preparing this manuscript.

References

1 Löe H, Theilade E, Jensen SB. Experimental gingivitis in man. *J Periodontol* 1965; **36:** 177–187.

2 Axelsson P, en Lindhe J. Effect of fluoride on gingivitis and dental caries in a preventive program based on plaque control. *Community Dent Oral Epidemiol* 1975; **3:** 156–160.

3 Axelsson P, en Lindhe J. Effect of controlled oral hygiene procedures on caries and periodontal disease in adults. *J Clin Periodontol* 1978; **5:** 133–151.

4 De la Rosa MR, Guerra JZ, Johnston DA, Radike AW. Plaque growth and removal with daily toothbrushing. *J Periodontol* 1979; **50:** 661–664.

5 Morris AJ, Steele J, White DA. The oral cleanliness and periodontal health of UK adults in 1998. *Br Dent J* 2001; **191:** 186–192.

6 Van der Weijden FA, Timmerman MF, Piscaer M, Ijzerman Y, Warren PR, van der Velden X. A comparison of the efficacy of a novel electric toothbrush and a manual toothbrush in the treatment of gingivitis. *Am J Dent* 1998; **11(Spec No):** S23–S28.

7 Van der Weijden GA, Timmerman MF, Nijboer A, Lie MA, Van der Velden U. A comparative study of electric toothbrushes for the effectiveness of plaque removal in relation to toothbrushing duration – Timerstudy. *J Clin Periodontol* 1993; **20:** 476–481.

8 Gilbert RJ, Williams PE. The oral retention and antiplaque efficacy of triclosan in human volunteers. *Br J Clin Pharmacol* 1987; **23:** 579–583.

9 Marsh PD. Microbiological aspects of the chemical control of plaque and gingivitis. *J Dent Res* 1992; **71:** 1431–1438.

10 Gjermo P, Saxton CA. Antibacterial dentifrices. Clinical data and relevance with emphasis on zinc/triclosan. *J Clin Periodontol* 1991; **18:** 468–473.

11 Jenkins S, Addy M, Newcombe R. Toothpastes containing 0.3% and 0.5% triclosan. I. Effects on 4-day plaque regrowth. *Am J Dent* 1989; **2(Spec No):** 215–219.

12 Saxton CA. The effects of a dentifrice containing zinc citrate and 2,4,4' trichloro-2'-hydroxydiphenyl ether. *J Periodontol* 1986; **57:** 555–561.

13 Quigley GA, Hein JW. Comparative cleansing efficiency of manual and powerbrushing. *J Am Dent Assoc* 1962; **65:** 26–29.

14 Turesky S, Gilmore ND, Glickman I. Reduced plaque formation by the chloromethyl analogue of victamine C. *J Periodontol* 1970; **41:** 41–43.

15 Löe H, Silness J. Periodontal disease in pregnancy. I. Prevalence and severity. *Acta Odontol Scand* 1963; **21:** 533–551.

16 Talbott K, Mandel ID, Chilton NW. Reduction of baseline gingivitis scores with repeated prophylaxes. *J Prev Dent* 1977; **4:** 28–29.

17 Ainamo J, Bay I. Problems and proposals for recording gingivitis and plaque. *Int Dent J* 1975; **25:** 229–235.

18 Saxton CA, Van der Ouderaa FJ. The effect of a dentifrice containing zinc citrate and triclosan on developing gingivitis. *J Periodontal Res* 1989; **24:** 75–80.

19 Van der Weijden GA, Timmerman MF, Saxton CA, Russell JI, Huntington E, Van der Velden U. Intra-/inter-examiner reproducibility study of gingival bleeding. *J Periodontal Res* 1994; **29:** 236–241.

20 Sheiham A, Netuveli GS. Periodontal diseases in Europe. *Periodontol 2000* 2002; **29:** 104–121.

21 Davies RM, Ellwood RP, Davies GM. The effectiveness of a toothpaste containing Triclosan and RVM/MA in improving plaque control and gingival health. A systematic review. *J Clin Periodontol* 2004; **31:** 1029–1033.

22 Rule KL, Ebbett VR, Vikesland PJ. Formation of chloroform and chlorinated organics by free-chlorine-mediated oxidation of triclosan. *Environ Sci Technol* 2005; **39:** 3176–3185.

23 Van der Ouderaa FJ, Cummins D. Delivery systems for agents in supra- and subgingival plaque control. *J Dent Res* 1989; **68:** 1617–1624 (special issue).
24 Nabi N, Mukerjee C, Schmid R, Gaffar A. In vitro and in vivo studies on triclosan/PVM/MA copolymer/NaF combination as an anti-plaque agent. *Am J Dent* 1989; **2(Spec No):** 197–206.
25 Gaffar A, Afflitto J, Nabi N, Herles S, Kruger I, Olsen S. Recent advances in plaque, gingivitis, tartar and caries prevention technology. *Int Dent J* 1994; **44 (Suppl. 1):** 63–70.
26 Scheie AA. Modes of action of currently known chemical anti-plaque agents other than chlorhexidine. *J Dent Res* 1989; **68:** 1609–1616 (special issue).
27 Harrap GJ, Best JS, Saxton CA. Human oral retention of zinc from mouthwashes containing zinc salts and its relevance to dental plaque control. *Arch Oral Biol* 1984; **29:** 87–91.
28 Jones CL, Ritchie JA, Marsh PD, Van der Ouderaa F. The effect of long-term use of a dentifrice containing zinc citrate and a nonionic agent on the oral flora. *J Dent Res* 1988; **67:** 46–50.
29 Jones CL, Saxton CA, Ritchie JA. Microbiological and clinical effects of a dentifrice containing zinc citrate and Triclosan in the human experimental gingivitis model. *J Clin Periodontol* 1990; **17:** 570–574.
30 Saxton CA, van der Ouderaa FJ. The effect of a dentifrice containing zinc citrate and Triclosan on developing gingivitis. *J Periodontal Res* 1989; **24:** 75–80.
31 Saxton CA, Lane RM, van der Ouderaa F. The effects of a dentifrice containing a zinc salt and a non-cationic antimicrobial agent on plaque and gingivitis. *J Clin Periodontol* 1987; **14:** 144–148.
32 Saxton CA, Svatun B, Lloyd AM. Antiplaque effects and mode of action of a combination of zinc citrate and a nonionic antimicrobial agent. *Scand J Dent Res* 1988; **96:** 212–217.
33 Stephen KW, Saxton CA, Jones CL, Ritchie JA, Morrison T. Control of gingivitis and calculus by a dentifrice containing a zinc salt and triclosan. *J Periodontol* 1990; **61:** 674–679.
34 Svatun B, Saxton CA, Rolla G, Van der Ouderaa F. A 1-year study on the maintenance of gingival health by a dentifrice containing a zinc salt and non-anionic antimicrobial agent. *J Clin Periodontol* 1989; **16:** 75–80.
35 Giertsen E, Svatun B, Saxton A. Plaque inhibition by hexetidine and zinc. *Scand J Dent Res* 1987; **95:** 49–54.
36 Giertsen E, Scheie AA, Rolla G. Dose-related effects of ZnCl2 on dental plaque formation and plaque acidogenicity in vivo. *Caries Res* 1989; **23:** 272–277.
37 Giertsen E, Scheie AA, Rolla G. Plaque inhibition by a combination of zinc citrate and sodium lauryl sulfate. *Caries Res* 1989; **23:** 278–283.
38 Saxer UP, Muhlemann HR. Synergistic antiplaque effects of a zinc fluoride/hexetidine containing mouthwash. A review. *SSO Schweiz Monatsschr Zahnheilkd* 1983; **93:** 689–704.
39 Svatun B, Saxton CA, Huntington E, Cummins D. The effects of three silica dentifrices containing triclosan on supragingival plaque and calculus formation and on gingivitis. *Int Dent J* 1993; **43 (Suppl. 1):** 441–452.
40 Palomo F, Wantland L, Sanchez A, Volpe AR, McCool J, DeVizio W. The effect of three commercially available dentifrices containing triclosan on supragingival plaque formation and gingivitis: a six month clinical study. *Int Dent J* 1994; **44 (Suppl. 1):** 75–81.
41 Svatun B, Saxton CA, Rolla G, Van der Ouderaa F. One-year study of the efficacy of a dentifrice containing zinc citrate and triclosan to maintain gingival health. *Scand J Dent Res* 1989; **97:** 242–246.
42 Garcia-Godoy F, Garcia-Godoy F, DeVizio W, Volpe AR, Ferlauto RJ, Miller JM. Effect of a triclosan/copolymer/fluoride dentifrice on plaque formation and gingivitis: a 7-month clinical study. *Am J Dent* 1990; **3(Spec No):** 15–26. Erratum in: Am J Dent 1991; 4: 102.
43 Svatun B, Saxton CA, Rolla G. Six-month study of the effect of a dentifrice containing zinc citrate and triclosan on plaque, gingival health, and calculus. *Scand J Dent Res* 1990; **98:** 301–304.
44 Cubells A.B, Dalmau LB, Petrone ME, Chaknis P, Volpe AR. The effect of A Triclosan/copolymer/fluoride dentifrice on plaque formation and gingivitis: a six-month clinical study. *J Clin Dent* 1991; **2:** 63–69.
45 Deasy MJ, Singh SM, Rustogi KN et al. Effect of a dentifrice containing triclosan and a copolymer on plaque formation and gingivitis. *Clin Prev Dent* 1991; **13:** 12–19.
46 Bolden TE, Zambon JJ, Sowinski J et al. The clinical effect of a dentifrice containing triclosan and a copolymer in a sodium fluoride/silica base on plaque formation and gingivitis: a six-month clinical study. *J Clin Dent* 1992; **3:** 125–131.
47 Denepitiya JL, Fine D, Singh S, DeVizio W, Volpe AR, Person P. Effect upon plaque formation and gingivitis of a triclosan/copolymer/fluoride dentifrice: a 6-month clinical study. *Am J Dent* 1992; **5:** 307–311.
48 Mankodi S, Walker C, Conforti N, DeVizio W, McCool JJ, Volpe AR. Clinical effect of a triclosan-containing dentifrice on plaque and gingivitis: a six-month study. *Clin Prev Dent* 1992; **14:** 4–10.
49 Svatun B, Saxton CA, Huntington E, Cummins D. The effects of a silica dentifrice containing Triclosan and zinc citrate on supragingival plaque and calculus formation and the control of gingivitis. *Int Dent J* 1993; **43 (Suppl. 1):** 431–439.
50 Kanchanakamol U, Umpriwan R, Jotikasthira N et al. Reduction of plaque formation and gingivitis by a dentifrice containing triclosan and copolymer. *J Periodontol* 1995; **66:** 109–112.
51 Renvert S, Birkhed D. Comparison between 3 triclosan dentifrices on plaque, gingivitis and salivary microflora. *J Clin Periodontol* 1995; **22:** 63–70.
52 McClanahan SF, Beiswanger BB, Bartizek RD, Lanzalaco AC, Bacca L, White DJ. A comparison of stabilized stannous fluoride dentifrice and triclosan/copolymer dentifrice for efficacy in the reduction of gingivitis and gingival bleeding: six-month clinical results. *J Clin Dent* 1997; **8(Spec No):** 39–45.
53 Allen DR, Battista GW, Petrone DM et al. The clinical efficacy of Colgate Total Plus Whitening Toothpaste containing a special grade of silica and Colgate Total Fresh Stripe Toothpaste in the control of plaque and gingivitis: a six-month clinical study. *J Clin Dent* 2002; **13:** 59–64.
54 Triratana T, Rustogi KN, Volpe AR, DeVizio W, Petrone M, Giniger M. Clinical effect of a new liquid dentifrice containing triclosan/copolymer on existing plaque and gingivitis. *J Am Dent Assoc* 2002; **133:** 219–225.
55 Winston JL, Bartizek RD, McClanahan SF, Mau MS, Beiswanger BB. A clinical methods study of the effects of triclosan dentifrices on gingivitis over six months. *J Clin Dent* 2002; **13:** 240–248.
56 Silness J, Löe H. Periodontal disease in pregnancy. II. correlation between oral hygiene and periodontal condition. *Acta Odontol Scand* 1964; **22:** 121–135.