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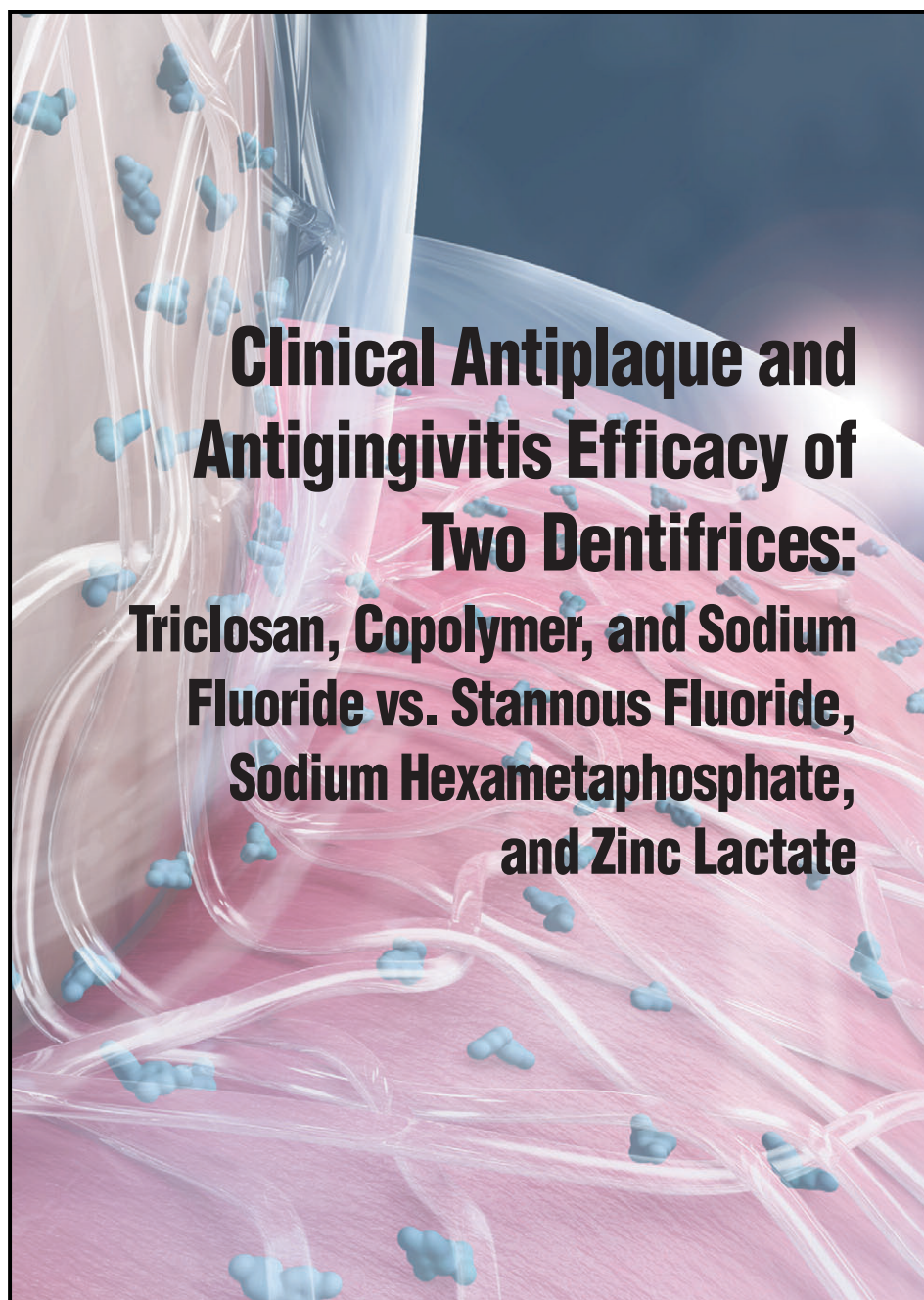
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On the Cover

Artist's rendition demonstrating how the PVM/MA copolymer facilitates the delivery and retention of triclosan on the surfaces of teeth and gums.

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Superior Management of Plaque and Gingivitis Through the Use of a Triclosan/Copolymer Dentifrice

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(J Clin Dent 2010;21[Spec Iss]:93–95)

Periodontal disease is a continuum of oral diseases of polymicrobial origin, characterized by a bacterial plaque (biofilm)-induced gingival inflammation which, if left untreated, may lead to chronic infection and loss of attachment.¹ The continuum of disease begins with gingivitis, which is inflammation of the gingiva in response to the bacterial biofilm on adjacent teeth. Clinically, the gingival tissue can be characterized by erythema, edema, and fibrous enlargement, and may bleed upon gentle probing. This early stage of periodontal disease, while quite prevalent in the general population, can be treated and prevented with appropriate home and supportive professional care. However, even with professional care and reinforcement of daily oral hygiene procedures, many patients continue to develop gingivitis. These patients are, therefore, at greater risk of developing more severe forms of periodontal disease. Topical antiseptics incorporated into dentifrices and mouthrinses may be of special value to these patients.

The importance of bacterial plaque to the onset and progression of periodontal diseases is well-accepted.¹ While more than 500 species of bacteria have been detected in the oral cavity, only a minority of pathogenic species, such as the gram anaerobes *Veillonella* species, *Fusobacteria* species, and *Porphyromonas gingivalis* produce products that can adversely affect the adjacent gingival tissues.² Microbial products can either directly or indirectly trigger a host soft tissue response by stimulating inflammatory mediator production, increasing the levels of inflammatory mediators within the gingival tissues, resulting in the presentation of clinical inflammation. Without intervention or treatment, supporting tissues may be destroyed, clinical pockets may form, bone resorption may occur, and ultimately, the tooth may be lost. Potentially more serious than tooth loss is the possibility that this local oral inflammatory process may negatively impact the rest of the body's immune response, and ultimately may affect overall health.³

Given the complexity of periodontal diseases and the importance of oral health, one of the critical questions is how to best prevent and treat periodontal infection. Professional procedures such as dental prophylaxis and scaling/root planing provide clinically proven and accepted benefits. Effective daily home oral care can help maintain a healthy oral environment and decrease

the occurrence of oral disease. However, dental professionals accept the fact that not all patients will consistently perform home oral care procedures at an acceptable level. Therefore, the dental profession will often recommend adjuncts to routine home oral care, such as the use of a product which has clinically proven antiplaque and antigingivitis properties, which may provide a unique and beneficial approach to the prevention and treatment of periodontal diseases via daily oral care procedures.

The delivery of an active ingredient with antiplaque and antigingivitis benefits can be through a dentifrice or a mouthrinse. The incorporation of such an ingredient into a dentifrice is a particularly attractive option to augment mechanical cleaning procedures, as dentifrices are typically used along with a toothbrush for routine oral hygiene. A unique dentifrice, Colgate® Total® (Colgate-Palmolive Co., New York, NY, USA), has been developed and clinically proven to provide antiplaque and antigingivitis benefits when compared to a conventional fluoride dentifrice.⁴ This dentifrice contains a broad-spectrum antibacterial agent, triclosan, and a polyvinylmethyl ether/maleic acid (PVM/MA) copolymer to ensure uptake and retention of triclosan on the oral hard and soft tissues. Effective levels of triclosan are retained in the oral cavity 12 hours after brushing the teeth, allowing prolonged control of the oral bacteria that form plaque, and can cause gingivitis, calculus, and oral malodor.⁴

Colgate Total also contains sodium fluoride at the maximum regulated level (1000–1450 ppm) to deliver cavity protection. This triclosan/copolymer/fluoride dentifrice has been proven to deliver statistically significant and clinically relevant benefits in the prevention of caries, the reduction of dental calculus buildup and oral malodor, as well as the control of dental plaque and the treatment of gingivitis.⁴ Independent reviews of the literature have established that Colgate Total is effective in reducing the formation of supragingival plaque, and for reducing the incidence of gingivitis when compared to a conventional fluoride toothpaste.^{5–7}

Colgate Total was the first, and remains the only toothpaste to be approved by the US Food and Drug Administration (under a new drug application process) and accepted by the American Dental Association (ADA) to fight plaque and gingivitis. Perhaps for this reason, Colgate Total is the toothpaste most often recommended and used by dentists and dental hygienists in the US.

Similarly, it has been approved by regulatory authorities and accepted by dental associations all around the world.

The scientific literature shows that dentifrices containing 0.454% stannous fluoride provide a benefit in reducing supragingival plaque formation and the incidence of gingivitis.^{8,9} In 2006, a dentifrice was introduced into the US marketplace claiming antigingivitis efficacy. The dentifrice, Crest® Pro-Health® (Procter & Gamble Co., Cincinnati, OH, USA) toothpaste, contains 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate.¹⁰ Stannous fluoride, like sodium fluoride, is an active ingredient used in dentifrices to reduce caries.

The five articles which follow this Introduction present a series of laboratory and patient-based studies that compare the efficacy of a dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride (Colgate Total) to a dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate (Crest Pro-Health) for the control of established supragingival plaque and gingivitis. A brief review of each of the five articles is provided, starting with a laboratory-based investigation entitled "Evaluation of Antibacterial Activity of Dentifrices on Human Oral Bacteria."¹¹

In vitro testing of antibacterial agents is an important tool in the evaluation hierarchy, and may provide interesting insights into their potential clinical efficacy. Agents with demonstrable *in vitro* antibacterial activity may be effective against the same microorganisms *in vivo*, whereas agents without demonstrable *in vitro* antibacterial activity are unlikely to exhibit *in vivo* antibacterial activity. In addition, these methods may also be useful in screening antibacterial agents in product formulations because such agents with both *in vitro* and *in vivo* activity may have reduced antibacterial effects when formulated into a dentifrice.

Accordingly, the first study in this Special Issue examined the *in vitro* and *ex vivo* antimicrobial activity of dentifrices containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate, or 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride. The results of these studies indicate that via different *in vitro* and *ex vivo* analyses, the dentifrice with 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride has significant antibacterial activity on oral bacteria, including species causing dental caries, periodontitis, and oral halitosis, and provides superior efficacy compared to the 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate dentifrice.

The second article, titled "Comparison of the Short-Term Antiplaque/Antibacterial Efficacy of Two Commercial Dentifrices,"¹² provides a summary of three separate short-term clinical studies which compared Colgate Total to Crest Pro-Health on the formation of dental plaque over a 24-hour period of time.

These studies utilized the Modified Gingival Margin Plaque Index (MGMPI), a validated and reliable clinical method for assessing the efficacy of products in reducing plaque build up.¹³ In all three clinical trials, Colgate Total significantly reduced plaque regrowth over a 24-hour time period compared to Crest Pro-Health, and demonstrated that Colgate Total delivers a superior antiplaque benefit over Crest Pro-Health after a single brushing.

The next two articles, titled "A Clinical Investigation of the Efficacy of Three Commercially Available Dentifrices for Con-

trolling Established Gingivitis and Supragingival Plaque,"¹⁴ and "A Comparison of the Efficacy of a Triclosan/Copolymer/Sodium Fluoride Dentifrice, a Stannous Fluoride/Sodium Hexametaphosphate/Zinc Lactate Dentifrice, and a Sodium Fluoride Dentifrice for the Control of Established Supragingival Plaque and Gingivitis: A Six-Week Clinical Study"¹⁵ provide the results from two separate six-week clinical studies.

The results from these two studies support the conclusion that a dentifrice containing 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride is efficacious for the control of established gingivitis and supragingival plaque as compared to a conventional fluoride dentifrice, and that it provides a greater level of efficacy for the control of gingivitis and supragingival plaque than does a dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate.

The final paper is titled "Comparative Investigation of the Efficacy of Triclosan/Copolymer/Sodium Fluoride and Stannous Fluoride/Sodium Hexametaphosphate/Zinc Lactate Dentifrices for the Control of Established Supragingival Plaque and Gingivitis in a Six-Month Clinical Study."¹⁶

The results of this study confirmed the outcomes demonstrated in the two six-week clinical studies, that a dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride provides a significant reduction in established supragingival plaque and gingivitis compared to a dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate when used over a period of six months.

In 2007, the ADA advised consumers that "use of an ADA-Accepted antimicrobial mouthrinse or toothpaste helps prevent and reduce plaque and gingivitis."¹⁷ Based on this statement, it is critical for dental professionals to know what products exist that meet this advice, and to know which products are proven most efficacious in reducing dental plaque and associated gingivitis, so that the public can receive the most beneficial effects from daily brushing.

To meet this need, the oral healthcare profession needs evidence to support a recommendation to their patients for the daily use of a fluoride dentifrice that is supplemented by an antimicrobial/antibacterial agent for the prevention of dental caries and gingivitis. The studies reported in this Special Issue demonstrate evidence, using valid and robust *in vitro*, *ex vivo*, and *in vivo* methods, that a dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride (Colgate Total) provides superior plaque and gingivitis reduction versus a dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate (Crest Pro-Health). Based on these studies, as well as previous research, it is evident that Colgate Total will help provide patients with the best protection against plaque and gingivitis when used as part of a daily oral hygiene regimen.

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References

1. Gu Y, Ryan ME. Overview of periodontal diseases: pathogenesis, and characteristics. In: *Periodontal Disease and Overall Health: A Clinician's Guide*,

- Genco RJ, Williams RC, eds., Professional Audience Communications, Yardley, PA, pp. 5-23, 2010.
2. Socransky SS, Haffajee AD. The nature of periodontal diseases. *Ann Periodontol* 1997;2:3-10.
 3. Williams RC, Barnett AH, Claffey N, Davis M, Gadsby R, Kellett M, Lip GY, Thackray S. The potential impact of periodontal disease on general health: A consensus view. *Curr Med Res Opin* 2008;24:1635-1643.
 4. Panagakos F, Volpe AR, Petrone ME, DeVizio W, Davies RM, Proskin HM. Advance oral antibacterial/anti-inflammatory technology: A comprehensive review of the clinical benefits of a triclosan/copolymer/fluoride dentifrice. *J Clin Dent* 2005;16(Suppl):S1-19.
 5. Davies RM, Ellwood RP, Davies GM. The effectiveness of a toothpaste containing triclosan and polyvinylmethyl ether/maleic acid copolymer in improving plaque control and gingival health. A systematic review. *J Clin Periodontol* 2004;31:1029-1033.
 6. Gunsolley JC. A meta-analysis of six-month studies of antiplaque and antigingivitis agents. *J Am Dent Assoc* 2006;137:1649-1657.
 7. Blinkhorn AS, Bartold PM, Cullinan MP, Madden TE, Marshall RI, Raphael SL, Seymour GJ. Is there a role for triclosan/copolymer toothpaste in the management of periodontal disease? *Br Dent J* 2009;207:117-125.
 8. Paraskevas S. Randomized controlled clinical trials on agents used for chemical plaque control. *Int J Dent Hyg* 2005;3:162-178.
 9. Paraskevas S, van der Weijden GA. A review of the effects of stannous fluoride on gingivitis. *J Clin Periodontol* 2006;33:1-13.
 10. Mankodi S, Bartizek RD, Winston RL, Biesbrock AR, McClanahan SF, He T. Anti-gingivitis efficacy of a stabilized 0.454% stannous fluoride/sodium hexametaphosphate dentifrice: A controlled 6-month clinical trial. *J Clin Periodontol* 2005;32:75-80.
 11. Haraszthy VI, Zambon JJ, Sreenivasan PK. Evaluation of the antimicrobial activity of dentifrices on human oral bacteria. *J Clin Dent* 2010;21(Spec Iss):96-100.
 12. Barnes VM, Richter R, DeVizio W. Comparison of the short term anti-plaque/antibacterial efficacy of two commercial dentifrices. *J Clin Dent* 2010;21(Spec Iss):101-104.
 13. Xu T, Barnes VM. The development of a new dental probe and a new plaque index. *J Clin Dent* 2003;14:93-97.
 14. Singh S, Chaknis P, DeVizio W, Petrone M, Panagakos FS, Proskin HM. A clinical investigation of the efficacy of three commercially available dentifrices for controlling established gingivitis and supragingival plaque. *J Clin Dent* 2010;21(Spec Iss):105-110.
 15. Ayad F, Stewart B, Zhang YP, Proskin HM. A comparison of the efficacy of a triclosan/copolymer/sodium fluoride dentifrice, a stannous fluoride/sodium hexametaphosphate/zinc lactate dentifrice, and a sodium fluoride dentifrice for the control of established supragingival plaque and gingivitis: A six-week clinical study. *J Clin Dent* 2010;21(Spec Iss):111-116.
 16. Boneta AE, Aguilar MM, Romeu FL, Stewart B, DeVizio W, Proskin HM. Comparative investigation of the efficacy of triclosan/copolymer/sodium fluoride and stannous fluoride/sodium hexametaphosphate/zinc lactate dentifrices for the control of established supragingival plaque and gingivitis in a six-month clinical study. *J Clin Dent* 2010;21(Spec Iss):117-123.
 17. American Dental Association news release, May 23, 2007.

Evaluation of the Antimicrobial Activity of Dentifrices on Human Oral Bacteria

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Abstract

- **Objective:** *In vitro* testing of antimicrobial agents is an important tool in the testing hierarchy, and may provide interesting insights into their potential clinical efficacy. Agents with demonstrable *in vitro* antimicrobial activity may be effective against the same microorganisms *in vivo*, whereas agents without demonstrable *in vitro* antimicrobial activity are unlikely to exhibit *in vivo* antimicrobial activity. In addition, these methods may also be useful in screening antimicrobial agents in product formulations because such agents with both *in vitro* and *in vivo* activity may have reduced antimicrobial effects when formulated into a dentifrice. Accordingly, this study examined the *in vitro* and *ex vivo* antimicrobial activity of three commercial dentifrices: one formulated with 0.243% sodium fluoride (Crest® Cavity Protection Toothpaste-Regular); one with 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate (Crest® Pro-Health®), and one with 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride (Colgate® Total®).
- **Methods:** The minimum inhibitory concentration (MIC) of each dentifrice was determined for resident oral bacterial species, including bacteria that are associated with dental caries, periodontitis, and oral halitosis. Evaluations were performed on individual laboratory strains, and on oral bacteria from supragingival plaque samples obtained from 10 adults and from oral rinse samples obtained from 18 adults.
- **Results:** The lowest MICs against the oral strains and human samples, *i.e.*, greatest antimicrobial activity, were seen for the triclosan/copolymer dentifrice. There was, in general, a four-fold difference in MICs between the triclosan/copolymer dentifrice and the stannous fluoride/sodium hexametaphosphate/zinc lactate dentifrice. The triclosan/copolymer dentifrice significantly inhibited periodontal pathogens, such as *Aggregatibacter actinomycetemcomitans*, *Eikenella corrodens*, and *Fusobacterium nucleatum*. In *ex vivo* tests measuring antimicrobial effects, the triclosan/copolymer dentifrice substantially inhibited bacterial growth after 30-, 60-, and 120-second exposures compared to the sodium fluoride or stannous fluoride/sodium hexametaphosphate/zinc lactate dentifrices. Similarly, in *ex vivo* tests measuring antimicrobial effects on supragingival plaque biofilms, the triclosan/copolymer dentifrice substantially inhibited bacterial growth compared to the other test dentifrices.
- **Conclusion:** Different *in vitro* and *ex vivo* analyses show that the triclosan/copolymer dentifrice has significant antimicrobial activity on oral bacteria, including species causing dental caries, periodontitis, and oral halitosis, and it provides superior efficacy compared to the stannous fluoride/sodium hexametaphosphate/zinc lactate dentifrice.

(J Clin Dent 2010;21[Spec Iss]:96–100)

Introduction

A variety of microbiological techniques have been used to identify and characterize the microorganisms residing in the human oral cavity. This is an important activity in order to further knowledge of the microorganisms that colonize the human body, the microbiome,¹ because oral microorganisms can cause dental caries and periodontal disease, the most common infectious diseases in man. Ninety-two percent of people in the US 65 years of age and older have dental caries in their permanent teeth,² 50.3% of people in the US population 30 years or older have gingivitis,³ and 26% have destructive periodontitis.⁴ Microscopy, bacterial culture, and, most recently, nucleic acid sequencing are routinely used to identify microorganisms.⁵ Microbial susceptibility to antimicrobial agents is routinely evaluated by disk diffusion assays (Kirby-Bauer), broth and agar dilution assays, and combination assays, such as the spiral gradient endpoint method and E test.^{5,6}

Microbial susceptibility tests have obvious clinical applications in the prevention and treatment of infectious diseases.^{5,6} Of particular interest is the correlation between *in vitro* antimicrobial testing and *in vivo* efficacy. An agent that does not exhibit *in vitro* antimicrobial activity is unlikely to demonstrate *in vivo* antimicrobial activity. On the other hand, an antimicrobial agent that demonstrates significant *in vitro* antimicrobial activity may or may not exert similar levels of *in vivo* antimicrobial activity. These levels are typically expressed as the minimum inhibitory concentration (MIC) or the minimum bactericidal concentration (MBC).⁷ The MIC is the lowest concentration of a drug that inhibits growth, while the MBC is the lowest concentration that kills a microorganism. MICs are used to determine susceptibility or resistance of microorganisms to an antimicrobial agent, *i.e.*, what kind and how much of an antimicrobial agent to use in a particular clinical situation. Antibiotic breakpoints are defined based on the MIC and on the pharmacokinetics in healthy volunteers.^{5,6}

In this study, the MICs for commercial dentifrices formulated with stannous fluoride/sodium hexametaphosphate/zinc lactate, triclosan/copolymer/sodium fluoride, and sodium fluoride were determined for microorganisms commonly found in the human oral cavity, using both laboratory strains and samples obtained from adult subjects to determine the effects of different treatment durations on microbial viability.

Materials and Methods

Media, Chemicals, and Reagents

Bacteriological media were obtained from Becton-Dickinson (Sparks, MD, USA) and formulated in accordance with manufacturer's instructions. Buffers, chemicals, and laboratory reagents were obtained from Sigma Chemical Company (St. Louis, MO, USA) unless otherwise indicated.

Bacterial Strains

Oral bacteria were obtained from either the American Type Culture Collection (Manassas, VA, USA) or from the University at Buffalo School of Dental Medicine (Buffalo, NY, USA), and included oral and non-oral bacteria that can cause periodontal disease, dental caries, or oral halitosis. All bacteria were cultured on enriched tryptic soy agar, supplemented with 5% defibrinated sheep blood, 5.0 µg/mL hemin, and 0.5 µg/mL vitamin K₁.

Dentifrices

Commercially available dentifrices for this investigation included a 0.243% sodium fluoride toothpaste (Crest® Cavity Protection Toothpaste-Regular, Procter & Gamble, Cincinnati, OH, USA; henceforth F), a 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate toothpaste (Crest Pro-Health®, Procter & Gamble, Cincinnati, OH, USA; henceforth SnF₂), and a toothpaste containing 0.3% triclosan, 2.0% polyvinylmethyl ether maleic acid (PVM/MA) copolymer, and 0.243% sodium fluoride (Colgate® Total®, Colgate-Palmolive Company, New York, NY; henceforth TCN/C).

Laboratory Tests

Bacteria were tested against the F, SnF₂, and TCN/C toothpastes, each dispersed in sterile water. Various dilutions of toothpaste slurries were incubated with bacteria cultured in liquid media, and the MIC was defined as the lowest concentration (highest dilution) in which the bacteria failed to grow. Positive controls included bacteria without toothpaste slurry, and negative controls included toothpaste slurry without added bacteria.

Ex Vivo Tests

Supragingival plaque was collected from 10 adults, dispersed by sonication, and distributed onto solid media containing defibrinated sheep blood with different concentrations of toothpaste. Following anaerobic incubation at 37°C for five days, the number of viable bacteria (CFU/mL) were enumerated from the solid media. Oral rinse samples were obtained from 18 adults following informed consent and a one-week "washout" with a commercially available fluoride dentifrice. The subjects rinsed with 10 mL of sterile water for 10 seconds and expectorated into sterile tubes. The oral rinse samples were mixed with toothpaste

slurry for 30, 60, or 120 seconds, and distributed onto solid media containing defibrinated sheep blood.

The study protocol was approved by the Health Sciences Institutional Review Board at the University at Buffalo.

Statistical Analysis

Viable microorganisms recovered after antimicrobial treatments were evaluated by ANOVA and Tukey multiple comparison tests, with subjects and dentifrice in the model. Treatment effects are reported as significant at $p < 0.05$.

Results

The TCN/C dentifrice demonstrated significantly higher antimicrobial activity (Table I) than the other two dentifrices, with MICs to oral bacteria ranging from less than 0.94 µg/mL to 30 µg/mL. By comparison, there were higher MICs for the SnF₂ dentifrice, ranging from 1.8 to 75 µg/mL. There was especially notable antimicrobial activity for the TCN/C dentifrice toward periodontal pathogens, including *Aggregatibacter actinomycetemcomitans*, *Campylobacter*, *Eikenella corrodens*, and *Fusobacterium nucleatum*. For the SnF₂ dentifrice, the highest MICs were to *Capnocytophaga gingivalis* and *Actinomyces meyerii*, but were otherwise similar to the F dentifrice for most of the gram-positive and gram-negative test microorganisms.

Table I
Minimum Inhibitory Dentifrice Concentrations

Bacterial Species	Strain Number	Colgate Total	Crest Pro-Health	Crest Cavity Protection-Regular
Oral and Non-oral Microorganisms				
<i>Actinomyces meyerii</i>	ATCC 33972	15	75	30
<i>Actinomyces viscosus</i>	ATCC 43146	7.5	7.5	30
<i>Bacillus cereus</i>	ATCC 11778	7.5	15	30
<i>Bacillus subtilis</i>	ATCC 6051	15	>150	75
<i>Candida albicans</i>	ATCC 90028	30	150	75
<i>Escherichia coli</i>	ATCC 4157	7.5	150	>150
<i>Moraxella catarrhalis</i>	ATCC 8176	<0.94	3.5	7.5
<i>Staphylococcus aureus</i>	ATCC 6538	15	30	30
<i>Veillonella dispar</i>	ATCC 17748	15	30	75
<i>Veillonella atypica</i>	ATCC 27215	7.5	7.5	15
Periodontal Pathogens				
<i>Aggregatibacter actinomycetemcomitans</i>	ATCC 43717	<0.94	3.5	30
<i>Aggregatibacter actinomycetemcomitans</i>	ATCC 43718	1.8	3.5	30
<i>Capnocytophaga gingivalis</i>	ATCC 33124	3.5	75	15
<i>Campylobacter rectus</i>	ATCC 33238	1.6	7.5	15
<i>Eikenella corrodens</i>	ATCC 23834	<0.94	15	30
<i>Fusobacterium nucleatum</i>	ATCC 25586	1.8	7.5	15
<i>Porphyromonas gingivalis</i>	ATCC 53977	1.8	1.8	15
<i>Prevotella intermedia</i>	ATCC 25611	3.5	3.5	15
<i>Prevotella melanogenica</i>	ATCC 25845	3.5	3.5	30
<i>Prevotella nigrescence</i>	NCTC 9336	1.8	1.8	15
Cariogenic Bacteria				
<i>Streptococcus mutans</i>	ATCC 6538	7.5	7.5	30
<i>Streptococcus gordonii</i>	ATCC 10558	3.5	7.5	15
Oral Halitosis-Causing Bacteria				
<i>Solobacterium moorei</i>	J10654	30	30	30

Figure 1 shows individual reductions in supragingival plaque bacteria for each active formulation compared to the F dentifrice in 10 subjects. For all subjects, the greatest reductions were for the TCN/C dentifrice compared to the SnF₂ dentifrice. In the latter, five of 10 subjects showed increases in the number of supragingival plaque bacteria as compared to the F dentifrice. Treatment with the TCN/C dentifrice demonstrated significant reductions in the number of supragingival plaque bacteria from all samples when compared to the F dentifrice.

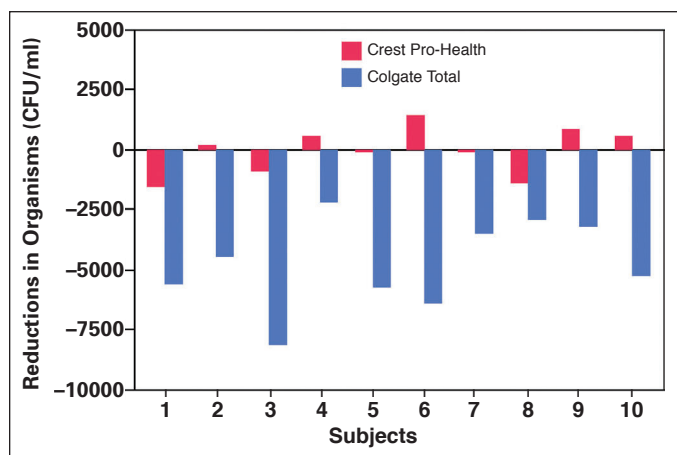


Figure 1. Effect of treatment by Crest Pro-Health and Colgate Total on supragingival plaque bacteria in comparison to Crest Cavity Protection Toothpaste-Regular. Bars indicate reductions (a negative value) or increments (a positive value) in viable organisms ($\times 10^4$ CFU/ml) from 10 subjects.

Figure 2 shows the average reduction in the number of supragingival plaque bacteria for each test dentifrice compared to the F dentifrice for the 10 test subjects. For the SnF₂ dentifrice group, the average reduction was less than 3×10^5 viable colony forming units per ml, while for the group using the TCN/C dentifrice the average reduction was greater than 4.5×10^7 colony forming units per ml.

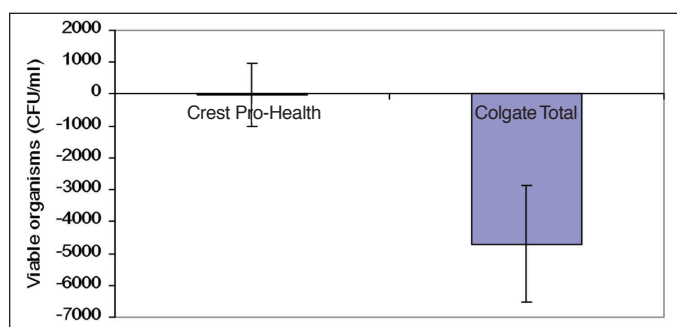


Figure 2. Average reductions in supragingival plaque bacteria for Crest Pro-Health and Colgate Total from the Crest Cavity Protection Toothpaste-Regular toothpaste. Graph indicates average reductions $\pm$ standard deviation ($\times 10^4$ CFU/ml) from 10 subjects.

Figure 3 shows the log transformed number of colony forming units per ml recovered after treatment with the F, SnF₂, or TCN/C dentifrices for the 10 test subjects; that is, the remaining number of supragingival plaque bacteria. The group treated with the TCN/C dentifrice exhibited the lowest mean number of remaining supragingival plaque bacteria, approximately 6.7 Log₁₀ CFU/ml, while those treated with the SnF₂ and the F dentifrices exhibited approximately 7.7 Log₁₀ CFU/ml after treatment.

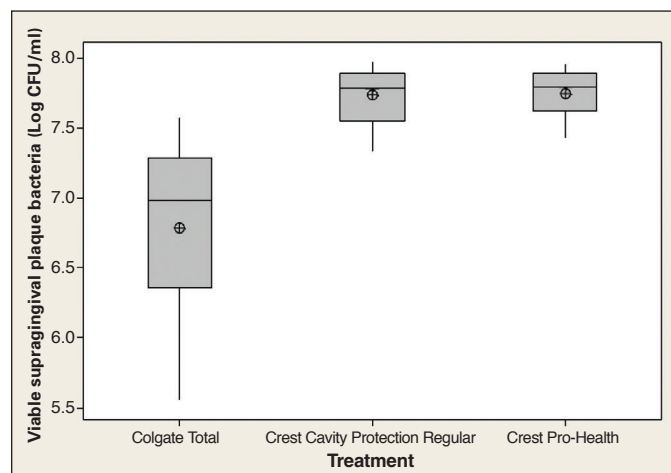


Figure 3. Effect of treatment with Crest Cavity Protection Toothpaste-Regular, Crest Pro-Health, or Colgate Total on supragingival plaque bacteria from 10 subjects. Box-plots indicate viable supragingival plaque bacteria recovered (Log CFU/ml) after each treatment. Horizontal line in box-plot is the median and symbol represents the average.

Average microbial viability after 30-, 60-, and 120-second exposures of oral rinse samples from the 18 adults is shown in Figures 4–6. After thirty seconds of dentifrice treatment (Figure 4) on oral bacteria collected from 18 adult volunteers, the lowest numbers of viable bacteria were seen in the samples treated with the TCN/C dentifrice, approximately 5.2 Log₁₀ CFU/ml compared to approximately 6.1 Log₁₀ CFU/ml and 6.1 Log₁₀ CFU/ml for the SnF₂ and the F dentifrices, respectively. For sixty seconds of dentifrice treatment (Figure 5), the lowest numbers of viable bacteria were also seen in the samples treated with the TCN/C dentifrice, approximately 5.2 Log₁₀ CFU/ml compared to approximately 6.1 Log₁₀ CFU/ml and 5.8 Log₁₀ CFU/ml for the SnF₂ and the F dentifrices, respectively. For 120 seconds of dentifrice treatment (Figure 6), the lowest numbers of viable bacteria were again seen in the samples treated with the TCN/C dentifrice, approximately 4.6 Log₁₀ CFU/ml compared to approximately 5.9 Log₁₀ CFU/ml and 5.5 Log₁₀ CFU/ml for the SnF₂ and F dentifrices, respectively.

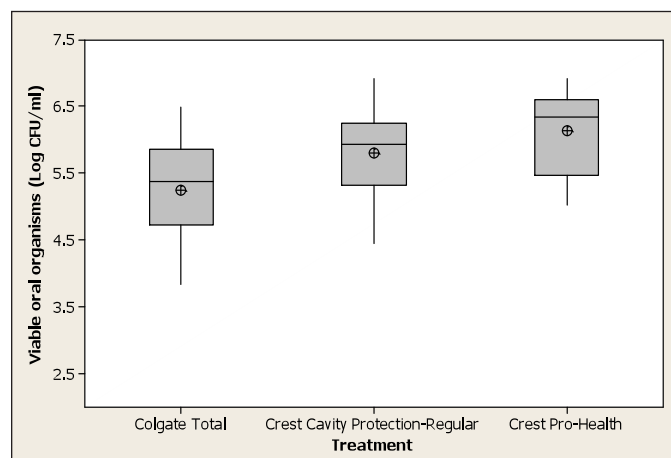


Figure 4. Effect of 30-second dentifrice treatments on oral organisms. Box-plots indicate viable organisms recovered (Log CFU/ml) from 18 subjects after each treatment. Horizontal line in box-plot is the median and symbol represents the average.

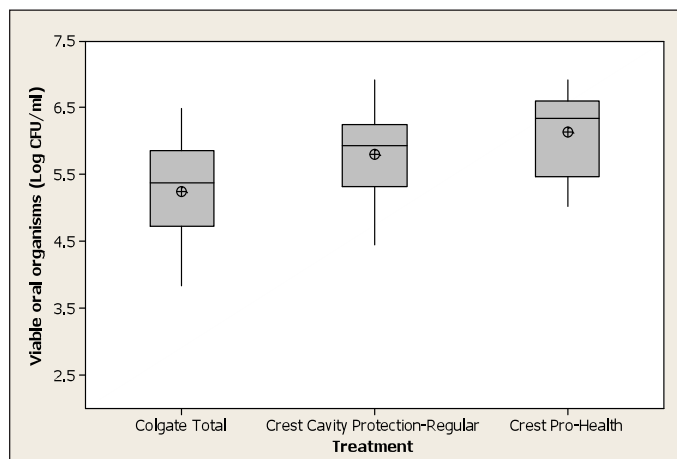


Figure 5. Effect of 60-second dentifrice treatments on oral organisms. Box-plots indicate viable organisms recovered (Log CFU/ml) from 18 subjects after each treatment. Horizontal line in box-plot is the median and symbol represents the average.

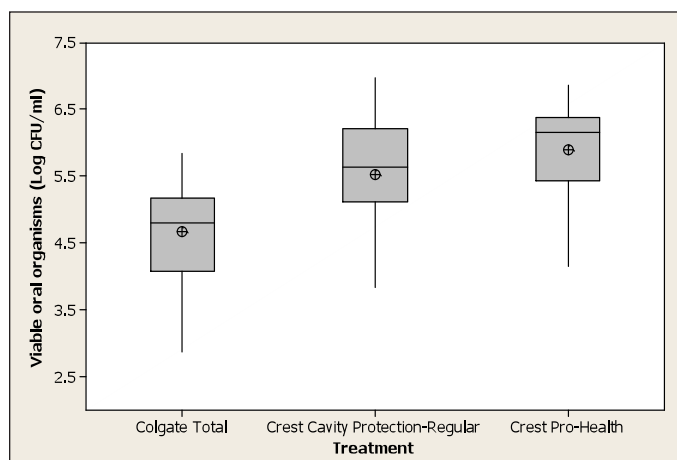


Figure 6. Effect of 120-second dentifrice treatments on oral organisms. Box-plots indicate viable organisms recovered (Log CFU/ml) from 18 subjects after each treatment. Horizontal line in box-plot is the median and symbol represents the average.

Two-way ANOVA at 30-, 60-, and 120-second treatment durations of oral rinse samples showed subjects and dentifrices were statistically significant ($p < 0.0005$). The TCN/C dentifrice was more effective than the other two dentifrices at both the 30- and 60-second post-treatment assessments ($p < 0.0005$), and the F dentifrice more effective than the SnF₂ dentifrice ($p = 0.0001$) at the 60-second post-treatment assessment. The TCN/C dentifrice was more effective at 120 seconds post-treatment than the other two dentifrices ($p < 0.0005$), but the F dentifrice was not significantly different from the SnF₂ dentifrice ($p = 0.058$).

Two-way ANOVA with subject and dentifrice as effects was used to examine microbial viability of the supragingival plaque samples following treatment, and while each dentifrice demonstrated significant effects ($p < 0.0005$), the TCN/C dentifrice demonstrated the greatest effect. It also demonstrated significantly higher bacterial growth inhibition by *post hoc* Tukey multiple comparison tests than the other dentifrices ($p < 0.0005$). There was no significant difference between the SnF₂ and F dentifrices ($p = 0.99$).

Discussion

This study examined the *in vitro* antimicrobial effects of three different commercially available toothpastes utilizing laboratory strains of oral and non-oral bacteria, and bacteria from supragingival plaque samples and oral rinse samples from adult volunteers. Use of well-characterized laboratory strains enables comparisons between antimicrobial tests performed at different times in the same laboratory, or performed in different laboratories.⁶ The use of bacteria obtained from supragingival plaque samples and from oral rinse samples recently obtained from human volunteers facilitates testing of “wild-type” bacterial strains that often differ significantly from laboratory strains in terms of virulence factors and pathogenicity.⁸ Bacteria in biofilms, such as dental plaque, are much less susceptible to antimicrobial agents, and demonstrate considerable physiologic variations within their organized structure compared to planktonic organisms.^{8,9} For example, fresh isolates of *Aggregatibacter actinomycetemcomitans* grow as rough adherent colonies in broth media, while laboratory strains grow as smooth, non-adherent colonies.¹⁰ Even strains of the same bacterial species isolated at the same time from the same individual, such as *Veillonella*, *Porphyromonas gingivalis* and streptococci, differ with regard to antimicrobial susceptibility and virulence.^{11,12} The use of oral rinse and dental plaque samples also facilitates identification of bacteria with intermediate susceptibility, or that are resistant to specific concentrations of dentifrice incorporated into the media. Nonetheless, *in vitro* testing in the present study was consistent in demonstrating significantly greater *in vitro* activity of the triclosan-containing dentifrice compared to the other two toothpastes, and in predicting clinical efficacy in inhibiting dental plaque and other oral bacteria. Differences between the F and SnF₂ toothpastes were less notable at post-treatment evaluations.

The prediction of clinical efficacy derived from the *in vitro* testing has been confirmed in a number of published clinical trials showing that Colgate Total reduces dental plaque and associated gingival inflammation. Fifteen published studies involving 2,500 patients^{7,13-26} found that Colgate Total was highly effective in reducing dental plaque and gingivitis. Reductions in dental plaque are reported to be as high as 59%, while reductions in gingivitis are reported to be as high as 51% compared to a regular fluoride dentifrice. For example, a random, double-blind, three-year clinical study by Rosling, *et al.*,¹⁶ examining the subgingival microbiota of adults with recurrent advanced periodontitis, found a significant reduction in the number of viable bacteria and probing pocket depth in subjects using Colgate Total. A random, double-blind, clinical study by Deasy, *et al.*,¹⁷ examining the effect of Colgate Total on plaque and gingivitis in 139 subjects, found a nearly 19% reduction in supragingival plaque and a 17% reduction in gingivitis in 139 subjects after three months of use, and a 32% reduction in supragingival plaque and a 26% reduction in gingivitis in 121 subjects after six months of use. A six-month, double-blind clinical study by Bolden, *et al.*²⁴ of 325 subjects found a 17% reduction in plaque and a 29% reduction in gingival inflammation in 155 subjects using Colgate Total, compared to 155 subjects using a control dentifrice. Thus for TCN/C, *in vitro* antimicrobial testing, demonstrating the inhibition of oral bacteria, was predictive of significant clinical

efficacy in inhibiting dental plaque and plaque-related gingival inflammation in human subjects.

Summary

Colgate Total, a dentifrice containing 0.3% triclosan, 2.0% copolymer, and 0.243% sodium fluoride, demonstrated the best broad-spectrum antimicrobial activity, that was approximately four-fold better than Crest Cavity Protection Toothpaste-Regular, a dentifrice formulated with 0.243% sodium fluoride, and Crest Pro-Health, a dentifrice formulated with 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate. Colgate Total significantly inhibited a variety of oral bacteria, including periodontal pathogens such as *Aggregatibacter actinomycetemcomitans*, *Eikenella corrodens*, and *Fusobacterium nucleatum*, cariogenic bacteria such as mutans streptococci, and bacteria-causing oral halitosis such as *Solobacterium moorei*. In addition to its broad-spectrum antimicrobial activity against laboratory strains of bacteria, Colgate Total demonstrated a substantially greater broad-spectrum inhibition of bacteria from oral rinse and dental plaque samples from adult subjects when compared to the Crest Cavity Protection Toothpaste-Regular or Crest Pro-Health toothpastes.

In summary, results from *in vitro* and *ex vivo* testing demonstrate that Colgate Total had significantly better antimicrobial activity on oral bacteria, including species causing dental caries, periodontitis, and oral halitosis.

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References

1. NIH Human Microbiome Project, <http://nihroadmap.nih.gov/hmp/>.
2. NIDCR website, Dental caries in permanent (adult) teeth. <http://www.nidcr.nih.gov/DataStatistics/FindDataByTopic/DentalCaries/DentalCariesAdults20to64.htm>.
3. NIDCR/CDC Dental, Oral and Craniofacial Data Resource Center, Oral Health, U.S. 2002 Annual Report, Section 3: Periodontal disease. http://drc.hhs.gov/report/3_1.htm.
4. NIDCR/CDC Dental, Oral and Craniofacial Data Resource Center, Data Tables for Oral Health Indicators, http://drc.hhs.gov/report/dqs_tables/dqs_3_2_1.htm.
5. Murray PR. *Manual of Clinical Microbiology*, 9th Ed. ASM Press, Herndon, VA, 2007.
6. Jorgensen JH, Ferraro MJ. Antimicrobial susceptibility testing: a review of general principles and contemporary practices. *Clin Infect Dis* 2009;49:1749-1755.
7. 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:S15-S26.
8. Fux CA, Shirtliff M, Stoodley P, Costerton JW. Can laboratory reference strains mirror "real-world" pathogenesis? *Trends Microbiol* 2005;13:58-63.
9. Schaudinn C, Gorur A, Keller D, Sedghizadeh PP, Costerton JW. Periodontitis: An archetypical biofilm disease. *J Am Dent Assoc* 2009;140:978-986.
10. Zambon JJ. *Actinobacillus actinomycetemcomitans* in human periodontal disease. *J Clin Periodontol* 1985;12:1-20.
11. Jain S, Darveau RP. Contribution of porphyromonas gingivalis lipopolysaccharide to periodontitis. *Periodontol* 2000 2010;54:53-70.
12. Beighton D. The complex oral microflora of high-risk individuals and groups and its role in the caries process. *Community Dent Oral Epidemiol* 2005;33:248-255.
13. Gaffar A, Nabi N, Kashuba B, Williams M, Herles S, Olsen S, Afflitto J. Antiplaque effects of dentifrices containing triclosan/copolymer/NaF system versus triclosan dentifrices without the copolymer. *Am J Dent* 1990;3:S7-S14.
14. 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.
15. Sharma NC, Galustians HJ, Qaush J, Galustians A, Rustogi KN, Petrone ME, Chaknis P, Garcia L, Volpe AR, Proskin HM. The clinical effectiveness of a dentifrice containing triclosan and a copolymer for controlling breath odor measured organoleptically twelve hours after tooth brushing. *J Clin Dent* 1999;10:131-134.
16. Rosling B, Dahlén G, Volpe A, Furuichi Y, Ramberg P, Lindhe J. Effect of triclosan on the subgingival microbiota of periodontitis-susceptible subjects. *J Clin Periodontol* 1997;24:881-887.
17. Deasy MJ, Singh SM, Rustogi KN, Petrone DM, Battista G, Petrone ME, Volpe AR. Effect of a dentifrice containing triclosan and a copolymer on plaque formation and gingivitis. *Clin Prev Dent* 1991;13:12-19.
18. 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.
19. Svaton 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;43:441-452.
20. 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;44:75-81.
21. Barnes VM, Richter R, Vandeven M, Xu T, DeVizio W. Clinical investigation of the antiplaque efficacy of a new variant of a commercially available triclosan/copolymer/fluoride dentifrice. *J Clin Dent* 2008;19:81-84.
22. Mateu FA, Boneta AE, DeVizio W, Stewart B, Proskin HM. A clinical investigation of the efficacy of two dentifrices for controlling established supragingival plaque and gingivitis. *J Clin Dent* 2008;19:85-94.
23. Cubells AB, 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.
24. Bolden TE, Zambon JJ, Sowinski J, Ayad F, McCool JJ, Volpe AR, DeVizio W. 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.
25. Renvert S, Birkhed D. Comparison between 3 triclosan dentifrices on plaque, gingivitis and salivary microflora. *J Clin Periodontol* 1995;22:63-70.
26. 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.
27. Hu D, Zhang J, Wan H, Zhang Y, Volpe AR, Petrone ME. Efficacy of a triclosan/copolymer dentifrice in the control of plaque and gingivitis: A six-month study in China. *Hua Xi Kou Qiang Yi Xue Za Zhi* 1997;15:333.

Comparison of the Short-Term Antiplaque/Antibacterial Efficacy of Two Commercial Dentifrices

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Abstract

- **Objective:** The objective of these three clinical trials was to compare the impact of two commercial products, Colgate® Total® and Crest® Pro-Health®, on the formation of dental plaque over a 24-hour period of time. The studies utilized the Modified Gingival Margin Plaque Index (MGMPI), a validated and reliable clinical method for assessing the efficacy of products in reducing plaque build-up.
- **Methods:** Colgate Total and Crest Pro-Health were the test products for all three clinical trials. Colgate® Great Regular Flavor (CR) was used as the universal washout product. Colgate Total, as the only toothpaste approved by the FDA under an NDA for antiplaque, antigingivitis, and anticaries benefits, contains 0.3% triclosan/2.0% PVM/MA copolymer for antigingivitis and antiplaque, as well as 0.243% sodium fluoride (NaF) for anticaries. Crest Pro-Health contains 0.454% stannous fluoride (SnF₂) as both a monographed anticaries agent and a monographed antigingivitis agent, along with sodium hexametaphosphate and zinc lactate. Twenty-five healthy subjects meeting all study criteria were included into each of the double-blind studies. Product assignment was randomized and a crossover design was implemented. Informed consent was obtained from all subjects prior to commencement of each of the studies. The studies followed published MGMPI procedures, which require subjects to receive a dental scaling/prophylaxis followed by a one-week washout period prior to use of test products. A baseline MGMPI score was calculated following use of the test products in the dental clinic. Subjects refrained from all oral hygiene for 24 hours following use of each test product, and returned to the clinic for a 24-hour MGMPI score. Following a washout period, subjects repeated the procedure with the other test product as per the crossover design. The differences (delta) between baseline plaque scores and 24-hour plaque scores were independently calculated for each study, and the delta values were compared for the two test products in each of the studies.
- **Results:** In all three clinical trials, Colgate Total significantly reduced plaque regrowth over a 24-hour time period ($p \leq 0.05$) compared to Crest Pro-Health. Existing differences were determined via a paired t-test, which confirmed that Colgate Total was statistically significantly different from Crest Pro-Health.
- **Conclusion:** These *in vivo* data support the antiplaque benefit of the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice. Additionally, the results support that Colgate Total provides superior efficacy in inhibiting the formation of dental plaque compared to Crest Pro-Health.

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Introduction

Plaque removal by way of a daily home care regimen has long been understood by the dental professional and consumers to be an important element of oral health. The use of a dentifrice in one form or another dates back to ancient Greek and Roman civilizations, commencing with powder formulations containing a myriad of interesting ingredients.¹ Dental plaque contributes to several concerns, both cosmetic and pathologic in nature. For instance, dental plaque contributes to caries, periodontal disease, and halitosis. Emerging evidence strongly suggests the oral inflammation caused by the bacteria living in the dental plaque may contribute to various systemic diseases, including, but not limited to diabetes, cardiovascular disease, low birth weight, preterm babies, and osteoporosis.²

Worldwide, many techniques and products designed to achieve improved oral health exist; toothbrushes, rinses, floss, and dentifrices, to name a few, are available for consumers to purchase. Numerous clinical studies have been conducted examining the efficacy of examples of each of the above-mentioned products with variable results. Many limitations exist in plaque removal

with a conventional brush and paste, including but not limited to manual dexterity, dental anatomy, and personal habits.³

Adjunctive products and procedures, as well as clinically proven chemotherapeutic products, have been suggested to improve the outcome, including improving the design of the toothbrush for improved mechanical removal, and improving the dentifrice to deliver an agent to retard plaque regrowth. One example was the development of the only FDA-approved and ADA-accepted dentifrice with anticaries, antiplaque, and antigingivitis benefits, containing 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride in a silica base (Colgate® Total®, Colgate-Palmolive Co., New York, NY, USA). Numerous clinical studies have been conducted worldwide documenting the efficacy of this product for anticaries, antiplaque, and antigingivitis effects.^{4–6} Among four published caries clinical studies, a 36-month controlled, double-blind study found Colgate Total (CT) to significantly reduce the formation of cavities compared to a control dentifrice containing fluoride alone.⁴ In several six- or seven-month double-blind studies, CT significantly reduced plaque accumulation and gingivitis when used twice daily, compared to a dentifrice containing sodium fluoride.⁶

Several short-term, 24-hour, and four-day clinical studies have consistently found formulations of 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride in a silica base to prevent the development of dental plaque more efficaciously than a dentifrice containing sodium fluoride or sodium monofluorophosphate (MFP) alone.⁷ The 24-hour studies employed the Modified Gingival Margin Plaque Index (MGMPI), a well-published methodology to examine the growth of dental plaque along the gingival margin over a 24-hour period following the use of an oral care product.⁸ The four-day studies utilized the Quigley Hein Plaque Index, with the published four-day plaque regrowth regimen.⁹

The unique nature of CT is found in the combination of the active ingredient, triclosan, in conjunction with the copolymer. Triclosan is a longstanding ingredient in consumer products, used safely and effectively for over 30 years. Triclosan has a rare and useful dual function. It serves as an antibacterial agent, as well as an anti-inflammatory agent.⁵ The copolymer ensures the delivery and retention of the triclosan, allowing for bioavailability in the oral cavity for 12 hours. This 12-hour bioavailability is instrumental for delivering the antiplaque and antigingivitis efficacy of CT. A plaque viability study, published by Amornchat, *et al.* in Thailand, documented the retention of triclosan in dental plaque and its sustained antibacterial effects 12 hours after a single brushing with CT, confirming the long-lasting antiplaque-bacteria benefit.¹⁰

Inflammation is the natural physiologic process to combat infection. Acute inflammation, if kept under control, aids in promoting initial tissue repair. Chronic inflammation, however, may lead to tissue destruction. Gingivitis, inflammation of the gingival tissue, if left untreated may become chronic and progress into the more destructive stages of periodontitis.¹¹ CT has been shown to be effective in treating gingivitis, the result of both the antibacterial effect and the anti-inflammatory effect of the triclosan found in the dentifrice. In laboratory studies, Modeer, *et al.* demonstrated that as IL-1 β was increased from 50 pg/ml to 200 pg/ml, the presence of triclosan at 1 μ g/ml prevented a significant increase of prostaglandin E₂ (PGE₂) production.¹²

Several short- and long-term, double-blind, randomized clinical trials, evaluating both antiplaque and antigingivitis efficacy of CT, were conducted. The duration of the studies ranged from one week to six months. CT was tested versus a placebo dentifrice. Plaque was scored using the widely accepted modified Quigley-Hein Plaque Index.¹³ The gingivitis scoring method used to assess gingivitis was the Löe-Silness Gingival Scoring Index.⁹ CT was found to consistently deliver a superior antiplaque and antigingivitis benefit over the placebo dentifrice.

A stannous fluoride-based dentifrice, containing 0.454% SnF₂ as both a monographed anticaries and antigingivitis agent, also containing sodium hexametaphosphate and zinc lactate, is marketed under the commercial name of Crest® Pro-Health® (CPH, Procter & Gamble Co., Cincinnati, OH, USA). Historically, use of stannous fluoride in dentifrices has been limited, in part due to its instability in aqueous formulae. Further, use of sodium hexametaphosphate has also limited long-term stability in aqueous vehicles. For this reason, Crest® Pro-Health® has been formulated in a low water silica-based dentifrice to stabilize

both the stannous fluoride and the sodium hexametaphosphate, and to mitigate other downsides of stannous fluoride, such as tooth staining.¹⁴ When tested against a placebo, both dentifrice and mouthrinse formulations were found to reduce both plaque and gingivitis. A 12-week monadic, unblinded clinical study examined subjects with average baseline Gingival Index (GI) scores of 0.48 (on the Löe-Silness GI scale of 0–3). Following a twice-daily regimen with the CPH product, the average post-treatment GI score fell 0.09 points to 0.39.¹⁵

The aim of this clinical research was to test, in three separate clinical studies, the ability of Colgate Total and Crest Pro-Health to prevent plaque formation, *in vivo*, over 24 hours.

Materials and Methods

Three products were used in the clinical studies: Colgate Total with 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride in a silica base; Crest Pro-Health with 0.454% stannous fluoride in a silica base with sodium hexametaphosphate and zinc lactate; and Colgate® Great Regular Flavor (Colgate-Palmolive Company, New York, NY, USA) as a washout product with 0.76% sodium monofluorophosphate. All toothbrushes were adult soft toothbrushes manufactured by the Colgate-Palmolive Company.

Three clinical studies were conducted utilizing the published Modified Gingival Margin Plaque Index (MGMPI). Each of the three studies used the same 25 healthy human subjects meeting the following criteria. All subjects ranged in age from 18–65, and were required to have a minimum of 15 healthy (uncrowned) teeth, excluding third molars. All subjects needed to provide written informed consent, and be willing to discontinue oral hygiene for 24 hours. Subjects with any known allergy to personal care or consumer products with ingredients relevant in any way to the test products (including tin) were excluded. Additional exclusion criteria included any conditions requiring pre-medication for dental visits, advanced periodontal disease, extensive untreated dental caries, and diseases of the hard or soft palate. Subjects wearing orthodontic appliances, or presenting with abnormal salivary flow, or taking drugs affecting salivary flow were also excluded. The use of antibiotics for one month prior to or during the study was also an exclusion criterion. Subjects taking over-the-counter medications (other than basic analgesics) and subjects participating in other clinical studies were excluded. Subjects currently pregnant or breastfeeding, as well as subjects suffering from immunocompromised states were excluded.

All three studies were conducted with the same clinical procedure. Subjects willing to sign the informed consent and meeting all inclusion and exclusion criteria were treated in the dental clinic. Dental scaling and prophylaxis were performed to completely remove dental plaque and dental calculus. Subjects were given washout products, Colgate Great Regular Flavor toothpaste and a Colgate soft manual toothbrush, with the instructions to use only these products and to brush twice daily for the washout period. Subjects returned to the dental clinic approximately one week after the commencement of the washout period. Study treatments were assigned via a randomized, incomplete block design using an alternating pattern starting with the first panelist enrolled. In the clinic, they brushed for one minute with a full ribbon of Colgate Great Regular Flavor. This brushing was

followed by a one-minute brushing, again with a full ribbon of the assigned test product. All products were blinded to both the subject and the examiner by way of an over-wrap. Following these brushing procedures, subjects were free to rinse with water and were then instructed to rinse with approximately 10 ml of a red commercial disclosing solution for 30 seconds. The dental examiner obtained the baseline MGMPi plaque score. Subjects were then instructed to refrain from all oral hygiene for 24 hours. Twenty-four hours later, the subjects returned to the dental clinic, rinsed with the disclosing solution, and the dental examiner obtained the final MGMPi plaque score.

The above procedure was repeated in accordance with the crossover design, so that both products could be tested by each individual in each of the clinical studies. One subject in study #1 did not complete the study due to antibiotic use at the start of the study. The need for the antibiotics was determined to be unrelated to the clinical study.

For each subject and each product, the baseline MGMPi plaque score was subtracted from the final MGMPi plaque score, rendering a delta value for the change in plaque score according to a previously published formula.⁸ This delta reflects the amount of plaque that developed over the 24-hour period. Measurements were obtained using the patented Xu-Barnes probe.⁸

Statistical Analysis

Change in the MGMPi plaque score in a 24-hour post-treatment (no brushing) period was calculated for each subject for each treatment cell. A paired t-test, using the subject and treatment as factors, was used to detect if significant differences between products exist. A difference between treatments is considered to be significant if a 95% confidence level ($p < 0.05$) is achieved.

Results

All three studies provided results demonstrating CT provided a significant ($p \leq 0.05$) antiplaque effect compared to CPH when using the products in a randomized manner (Figure 1 and Table I).

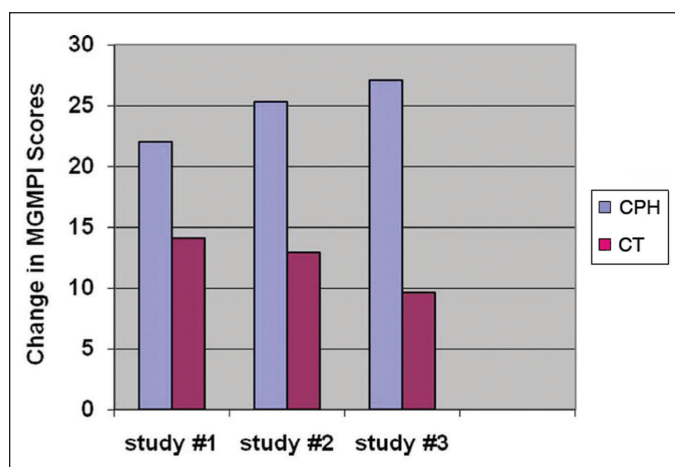


Figure 1. The average mean MGMPi scores depicted for three clinical studies demonstrating a single use of CT resulted in significantly less dental plaque formation as compared to a single use of CPH post-brushing over a 24-hour time period.

Table I

The Mean ($\pm$ SD) Difference in MGMPi Scores Between Baseline and 24 Hours After Using Either CT or CPH and the Statistical Comparison Between Products

	CT	CPH
Study # 1	14.14 $\pm$ 8.02*	22.05 $\pm$ 12.42
Study # 2	12.95 $\pm$ 7.18*	25.35 $\pm$ 10.08
Study # 3	9.65 $\pm$ 8.30*	27.09 $\pm$ 11.95

*Test products are statistically different ($p < 0.05$ at 95% confidence level).

Discussion

Many oral care products exist in the marketplace today. Consumers increasingly demonstrate their understanding of the value of high quality oral care products, and the importance of good oral hygiene. Various efficacy claims, such as antiplaque, antigingivitis, whitening, and antitartar, are often made. In an evidence-based domain, such claims need to be documented. Whenever possible, the most rigorous level of testing, the double-blind randomized clinical trial, is desirable.

Many plaque assessment methods have been published, and have been used to assess product efficacy with great success. Two commonly used methods for short-term studies are the Quigley-Hein Plaque Index (QHPI), used in the four-day plaque regrowth model,¹³ and the Modified Gingival Margin Plaque Index (MGMPi), used in the 24-hour plaque regrowth model.⁸ The two methods have been published extensively, and a 2005 paper compared the four-day methodology with the MGMPi.¹⁶ Following the review of several clinical studies, the paper found both methods predicted the long-term (six-month) antiplaque efficacy of commercial products in a similar fashion. A 2008 paper reviewed 29 clinical studies utilizing the MGMPi methodology. All studies tested two commercial products, the therapeutic dentifrice containing 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride in a silica base versus a regular fluoride dentifrice. Twenty-four of the 28 studies predicted the superiority of the therapeutic dentifrice over the regular fluoride dentifrice. The four studies, failing to show superiority, were determined to be underpowered when reviewing the sample size of each.¹⁷

The three clinical studies presented in this paper were sufficiently powered to be able to detect differences between two products, should those differences exist. Additionally, the design of a double-blind, randomized clinical trial satisfies the rigorous expectations for evidence-based documentation. The same subjects and the same examiner were recruited for all three studies, reducing unnecessary variability.

To summarize the findings, in all three trials CT significantly reduced plaque regrowth over 24 hours compared to CPH. Existing differences were determined via a two-way ANOVA. The t-test confirmed that CT was statistically significantly different from CPH.

Conclusion

Colgate Total inhibited the formation of dental plaque over 24 hours versus Crest Pro-Health in a statistically significant fashion. These *in vivo* data provide compelling results to support the antiplaque benefit of the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice. Additionally, the results

support that Colgate Total provides superior efficacy in inhibiting the formation of dental plaque compared to Crest Pro-Health.

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References

1. Fischman S. The history of oral hygiene products: How far have we come in 6000 years? *Periodontology* 2000 1997;15:7-14.
2. Scannapieco FA. Periodontal inflammation: From gingivitis to systemic disease? *Compend Contin Educ Dent* 2004;25(7 Suppl 1):16-25.
3. Myoken Y, Yamane Y, Myoken Y, Nishida T. Plaque removal with an experimental chewable toothbrush and a control manual toothbrush in a care-dependent elderly population: A pilot study. *J Clin Dent* 2005;16:83-86.
4. Mann J, Vered Y, Babayof I, Sintes J, Petrone ME, Volpe AR, Stewart B, DeVizio W, McCool JJ, Proskin HM. The comparative anticaries efficacy of a dentifrice containing 0.3% triclosan and 2.0% copolymer in a 0.243% sodium fluoride/silica base and a dentifrice containing 0.243% sodium fluoride/silica base: a two-year coronal caries clinical trial on adults in Israel. *J Clin Dent* 2001;12:71-76.
5. Panagakos FS, Volpe AR, Petrone ME, DeVizio W, Davies RM. Advanced oral antibacterial/anti-inflammatory technology: A comprehensive review of the clinical benefits of a triclosan/copolymer/fluoride dentifrice. *J Clin Dent* 2005;16:S1-S19.
6. DeVizio W. The efficacy of a new dentifrice with caries, plaque, gingivitis, calculus, tooth whitening, and malodor benefits. *J Clin Dent* 2008;19:79-80.
7. Barnes VM, Vandeven M, Richter R, Xu T. The modified gingival margin plaque index: A predictable clinical method. *J Clin Dent* 2008;19:131-133.
8. Xu T, Barnes VM. The development of a new dental probe and a new plaque index. *J Clin Dent* 2003;14:93-97.
9. Løe H, Silness J. Periodontal disease in pregnancy. Prevalence and severity. *Acta Odontol Scand* 1963;21:533-551.
10. Amornchat C, Kraivaphan P, Triratana T. Investigation of a triclosan/copolymer dentifrice on plaque viability and triclosan retention in dental plaque in a Thai population. *Mahidol Dent J* 2004;24:103-111.
11. Mariotti A. A primer on inflammation. *Compend Contin Educ Dent* 2004;25:7-15.
12. Modeer T, Bengtsson A, Rolla G. Triclosan reduces prostaglandin biosynthesis in human gingival fibroblasts challenged with interleukin-1 *in vitro*. *J Clin Periodontol* 1996;23:927-933.
13. Quigley GA, Hein JW. Comparative cleansing efficacy of manual and power brushing. *J Am Dent Assoc* 1962;65:26-29.
14. Baig A, He T. A novel dentifrice technology for advanced oral health protection: A review of technical and clinical data. *Compend Contin Educ Dent* 2005;26(9 Suppl 1):4-11.
15. Archila L, He T, Winston JL, Biesbrock AR, McClanahan SF, Bartizek RD. Antigingivitis efficacy of a stabilized stannous fluoride/sodium hexametaphosphate dentifrice in subjects previously nonresponsive to a triclosan/copolymer dentifrice. *Compend Contin Educ Dent* 2005;26(9 Suppl 1):12-18.
16. Xu T, Barnes VM. Comparison of two clinical methods for evaluating the anti-plaque efficacy of a dentifrice. *J Clin Dent* 2005;15:97-102.
17. Barnes VM, Vandeven M, Richter R, Xu T. The modified gingival margin plaque index: A predictable clinical method. *J Clin Dent* 2008;19:131-133.

A Clinical Investigation of the Efficacy of Three Commercially Available Dentifrices for Controlling Established Gingivitis and Supragingival Plaque

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Abstract

- **Objective:** To assess the efficacy of a dentifrice containing 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride for controlling established gingivitis and supragingival plaque relative to that of a dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate, and a dentifrice containing 0.243% sodium fluoride as a negative control.
- **Methods:** Following a baseline examination for gingivitis and supragingival plaque, qualifying adult male and female subjects from the Piscataway, NJ, USA area were randomized into three dentifrice groups. Subjects were instructed to brush their teeth twice daily (morning and evening) for one minute with their assigned dentifrice and a soft-bristled toothbrush. Examinations for gingivitis and supragingival plaque were repeated after six weeks of product use.
- **Results:** One-hundred and seventy-one (171) subjects complied with the protocol and completed the study. Relative to the group using the dentifrice with 0.243% sodium fluoride alone, the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride group exhibited statistically significant reductions in gingival index and supragingival plaque index scores of 25.3% and 33.0%, respectively, after six weeks of product use. Similarly, relative to the group using the 0.243% sodium fluoride dentifrice, the 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate dentifrice group exhibited statistically significant reductions in gingival index and plaque index scores of 8.1% and 14.1% after six weeks of product use. Further, relative to the 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate dentifrice group, the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice group exhibited statistically significant reductions in gingival index and plaque index scores of 18.7% and 22%, respectively.
- **Conclusion:** The overall results of this double-blind clinical study support the conclusion that a dentifrice containing 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride is efficacious for the control of established gingivitis and supragingival plaque as compared to a regular fluoride dentifrice, and that it provides a greater level of efficacy for the control of gingivitis and supragingival plaque than does a dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate.

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Introduction

It is well accepted that bacterial plaque (biofilm) is the forerunner to gingivitis,¹ and that gingivitis is widespread in the general population.¹⁻³ If left untreated, gingivitis can lead to periodontitis, a more serious form of periodontal disease. Periodontal disease, along with dental caries, is a common oral condition in adults today.⁴ Based upon survey data, it has been suggested that over 75% of today's adult population is affected by the occurrence of gingivitis.⁵ The use of fluoridated toothpastes and mouthrinses, and water fluoridation have resulted in a decline in dental caries. However, gingivitis and periodontitis have not followed a similar pattern of decline. Over 750 species

of bacteria can be found in the oral cavity, and specific groups of bacteria among these are the precursors to periodontal disease, including gingivitis and periodontitis.^{6,7}

Even with effective tooth cleaning, bacteria colonize the tooth surface, most notably around the gingival margin and interdental spaces.⁸ The developing biofilm (plaque) releases a variety of biologically active products that diffuse into the gingival epithelium to initiate the host response that eventually results in gingivitis. Left untreated, periodontal pockets may form, bone could resorb, and the tooth might be lost.

Having a disease-free oral cavity is now more important than ever. Over the last ten years, epidemiologic and clinical studies

have been conducted to understand the relationship between oral and systemic health. It is now believed that oral inflammation associated with periodontitis may contribute to systemic inflammation which has been associated with systemic diseases, most notably coronary heart disease, peripheral arterial disease, ischemic stroke, and diabetes.⁹ Therefore, it is vitally important to control the formation of plaque and gingival inflammation.

The most common method of supragingival plaque control is by tooth brushing, which is the mechanical removal of plaque.¹⁰ The American Dental Association recommends brushing twice a day and flossing once a day as a regimen for good oral hygiene.¹¹ The problem is that most people do not brush that often or brush long enough to achieve sufficient plaque removal, or do not brush properly in order to receive optimum results.

Dental professionals worldwide agree that self-performed plaque control is not adequate to achieve gingival health.¹² In fact, it has been reported in one study that 94% of subjects said they brushed and flossed every day, and yet all subjects had visible plaque on more than 90% of tooth surfaces.¹³

In the early 1990s, a dentifrice was introduced into the marketplace which incorporated a chemotherapeutic agent with antiplaque activity (0.3% triclosan) and a copolymer of polyvinyl-methyl ether and maleic acid (2.0% PVM/MA copolymer) into a 0.243% sodium fluoride dentifrice, which was clinically proven to reduce plaque and gingivitis in an adult population (Colgate® Total® Toothpaste, Colgate-Palmolive Co., New York, NY, USA). Triclosan is a bisphenolic antibacterial agent which has low toxicity and a broad spectrum of activity, being effective against both gram positive and gram negative bacteria.¹⁴ Colgate Total Toothpaste also contains the copolymer PVM/MA which when combined with triclosan, ensures delivery and retention of the triclosan on hard and soft tissues.^{15,16} Effective levels of triclosan are retained in the oral cavity 12 hours after brushing the teeth, allowing prolonged control of oral bacteria that cause plaque, gingivitis, tartar, and bad breath. It has been shown in long-term clinical studies to provide anticaries benefits, and has been clinically shown to reduce the recurrence of periodontal disease.^{15,16}

The combination of 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride has been clinically proven, in over seventy clinical studies, to provide oral health benefits.¹⁷ The efficacy, mode of action, and safety of a triclosan/PVM/MA copolymer/sodium fluoride toothpaste has been thoroughly researched in over 200 articles in the scientific literature.⁴ Colgate Total Toothpaste is the only toothpaste approved by the US Food and Drug Administration for the prevention of plaque and gingivitis, and is accepted by the American Dental Association for the prevention of plaque and gingivitis.¹⁸

More recently, a dentifrice was introduced into the marketplace claiming antigingivitis efficacy. The dentifrice contains 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate. Stannous fluoride, like sodium fluoride, is an active ingredient found in dentifrices to reduce caries. There have been reports in the literature which show that stannous fluoride is effective in reducing gingivitis, but it has also been shown to cause surface staining of the teeth.^{19,20} Sodium hexametaphos-

phate has been reported in the literature to reduce calculus formation, and has also been demonstrated to reduce staining.²¹

The objective of this six-week clinical study was to compare, head-to-head, the antiplaque and antigingivitis efficacy of a dentifrice containing 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride to a dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate. A dentifrice containing 0.243% sodium fluoride alone was included as a negative control. Gingivitis and plaque evaluations were conducted at baseline and after six weeks of product use.

Materials and Methods

This clinical investigation, including the consent form, was reviewed by an Institutional Review Board in accordance with Title 21 of the Code of Federal Regulations, Parts 50 and 56. This study employed a double-blind, randomized, three-treatment, parallel-group design. Adult male and female subjects from the Piscataway, NJ, USA area were enrolled into the study based upon the following criteria:

- Subjects had to be between 18 and 70 years of age, in good general health, and have signed an Informed Consent.
 - Subjects were required to be available for the six-week duration of the study.
 - Subjects had to possess at least 20 uncrowned permanent natural teeth (excluding third molars).
 - Subjects were required to present at baseline with a mean gingival index score of at least 1.0 as determined by the use of the Löe-Silness Gingival Index,^{22,23} and a mean plaque index score of at least 1.5 as determined by the use of the Turesky modification of the Quigley-Hein Plaque Index.^{24,25}
- Subjects were excluded from study participation if they:
- had partial removable dentures, orthodontic bands, or advanced periodontal disease (purulent exudate, tooth mobility, and/or extensive loss of periodontal attachment or alveolar bone).
 - had tumor(s) of the soft or hard oral tissues or five or more carious lesions requiring immediate restorative treatment.
 - had a history of allergies to personal care/consumer products or their ingredients, or they could not refrain from eating or drinking due to medical conditions for periods of up to four hours.
 - were pregnant or breast feeding women, or individuals who participated in any other clinical study or panel test within the last month of the start of the study.
 - used antibiotics at any time during the one-month period prior to entering the study, were taking any prescription medication that might interfere with the study outcome, or received a dental prophylaxis during the two weeks prior to the study baseline examination.

Prospective subjects reported to the clinical facility having refrained from any oral hygiene procedures for 12 hours, and eating, drinking, and smoking for four hours prior to the visit. Subjects signed an Informed Consent form, and were screened by the dental examiner with respect to the inclusion/exclusion criteria. Subjects who met the inclusion/exclusion criteria received a baseline gingivitis and supragingival plaque examination and an oral soft and hard tissue assessment.

Qualifying subjects were randomized into one of three treatment groups which were balanced for baseline gingivitis and supragingival plaque scores. The three dentifrices tested in this study were as follows: 1) a commercially available dentifrice containing 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride (Colgate Total Toothpaste); 2) a commercially available dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate (Crest® Pro-Health® Toothpaste, Procter & Gamble Company, Cincinnati, OH, USA); and 3) a commercially available dentifrice containing 0.243% sodium fluoride (Crest® Cavity Protection Toothpaste, Procter & Gamble Company, Cincinnati, OH, USA).

Following treatment assignment, subjects were provided with a soft-bristled toothbrush and their assigned dentifrice. All dentifrices were over-wrapped in their original package to maintain the double-blind study design. Subjects were instructed to brush their teeth with their assigned dentifrice and toothbrush twice daily (morning and evening) for one minute, and to use only the dentifrice and toothbrush provided. There were no restrictions regarding diet or smoking during the course of the study, although subjects were instructed to refrain from any oral hygiene procedures for twelve hours, and eating, drinking, and smoking for four hours prior to their six-week study examinations. Subjects returned to the clinical facility for gingivitis and supragingival plaque examinations after six weeks of product use. Additionally, at each examination subjects received an evaluation of their oral soft tissue by the examining dentist and were questioned for the occurrence of any adverse events.

Clinical Scoring Procedures

Löe-Silness Gingival Index. Gingivitis was scored according to the Löe-Silness Gingival Index. Each tooth was divided into six surfaces, three facial and three lingual, as follows: 1) mesio-facial; 2) mid-facial; 3) disto-facial; 4) mesio-lingual; 5) mid-lingual; and 6) disto-lingual. Third molars and those teeth with cervical restorations or prosthetic crowns were excluded from the scoring procedure. The gingiva adjacent to each tooth surface was scored as follows:

- 0 = Absence of inflammation.
- 1 = Mild inflammation—slight change in color and little change in texture.
- 2 = Moderate inflammation—moderate glazing, redness, edema, and hypertrophy. Bleeding on probing.
- 3 = Severe inflammation—marked redness and hypertrophy. Tendency for spontaneous bleeding.

Subject-wise scores were determined by averaging the values obtained over all scoreable surfaces in the mouth.

Quigley-Hein Plaque Index. Plaque was scored according to the Turesky modification of the Quigley-Hein Plaque Index. Each tooth was divided into six surfaces, three facial and three lingual, as follows: 1) mesio-facial; 2) mid-facial; 3) disto-facial; 4) mesio-lingual; 5) mid-lingual; and 6) disto-lingual. Third molars and those teeth with cervical restorations or prosthetic crowns were excluded from the scoring procedure. Plaque was disclosed and scored on each tooth surface according to the following criteria:

- 0 = No plaque.
- 1 = Separate flecks of plaque at the cervical margin.
- 2 = A thin, continuous band of plaque (up to 1 mm) at the cervical margin.
- 3 = A band of plaque wider than 1 mm, but covering less than 1/3 of the side of the crown of the tooth.
- 4 = Plaque covering at least 1/3, but less than 2/3 of the side of the crown of the tooth.
- 5 = Plaque covering 2/3 or more of the side of the crown of the tooth.

Subject-wise scores were determined by averaging the values obtained over all scoreable surfaces in the mouth.

Oral Soft and Hard Tissue Assessment. The dental examiner visually examined the oral cavity and peri-oral area using a dental light and dental mirror prior to each plaque and gingivitis examination. This examination included an evaluation of the soft and hard palate, gingival mucosa, buccal mucosa, mucogingival fold areas, tongue, sublingual and submandibular areas, salivary glands, and the tonsillar and pharyngeal areas.

Adverse Events. Adverse events were determined by verbal indications from the subjects or by visual examination of the dental examiner.

Statistical Methods

Statistical analyses were performed separately for the gingival index and plaque index scores. Comparisons of the treatment groups with respect to baseline gingival index and plaque index scores, as well as for age, were performed using analyses of variance (ANOVA). Within-treatment comparisons of the gingival index and plaque index scores obtained at the six-week examinations versus baseline were performed using paired t-tests. Comparisons between treatment groups with respect to gender were performed using chi-square tests. Comparisons of the treatment groups with respect to baseline-adjusted gingival index and plaque index scores at the six-week examinations were performed using analyses of covariance (ANCOVA). Post-ANCOVA pair-wise comparisons of the gingival and plaque indices scores were performed using the Tukey test for multiple comparisons. All statistical tests of hypothesis were two-sided and employed a level of significance of $\alpha = 0.05$.

Results

One-hundred seventy-one (171) subjects complied with the protocol and completed the six-week clinical study. A summary of the gender and age of the population who completed the study is presented in Table I. The treatment groups did not differ significantly with respect to either of these characteristics. Throughout the study, no adverse effects on the oral hard or soft tissues were observed by the examiner or reported by the subjects when questioned.

Baseline Data

Löe-Silness Gingival Index and Quigley-Hein Plaque Index. Table II presents a summary of the gingival and plaque index scores measured at baseline for subjects who completed the study. The mean baseline gingival index scores were 1.13 for the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium

Table I
Summary of Gender and Age for Subjects
Who Completed the Six-Week Clinical Study

Dentifrice	Number of Subjects			Age	
	Male	Female	Total	Mean	Range
0.3% triclosan/ 2.0% PVM/MA copolymer/ 0.243% sodium fluoride ¹	21	36	57	40.4	19–70
0.454% stannous fluoride/ sodium hexametaphosphate/ zinc lactate ²	27	31	58	41.4	19–70
0.243% sodium fluoride ³	20	36	56	39.6	18–76

¹Colgate Total Toothpaste.

²Crest Pro-Health Toothpaste.

³Crest Cavity Protection Toothpaste.

fluoride dentifrice group, 1.09 for the 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate dentifrice group, and 1.11 for the 0.243% sodium fluoride dentifrice group. The mean baseline plaque index scores were 2.34 for the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice group, 2.27 for the 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate dentifrice group, and 2.22 for the 0.243% sodium fluoride dentifrice group. No statistically significant differences were indicated among the dentifrice groups with respect to gingival or plaque index scores at baseline.

Six-Week Data

Löe-Silness Gingival Index. Table III presents a summary of the gingival index scores measured at the six-week examinations. The mean six-week gingival index scores were 0.74 for the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice group, 0.91 for the 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate dentifrice group, and 0.99 for the 0.243% sodium fluoride dentifrice group.

Table II
Summary of the Baseline Löe-Silness Gingival Index Scores
and Quigley-Hein Plaque Index Scores for Subjects
Who Completed the Six-Week Clinical Study

Parameter	Treatment	n	Baseline Summary (Mean ± SD) ⁴
Gingivitis	0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride ¹	57	1.13 ± 0.09
	0.454% stannous fluoride/ sodium hexametaphosphate/ zinc lactate ²	58	1.09 ± 0.09
	0.243% sodium fluoride ³	56	1.11 ± 0.12
Plaque	0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride ¹	57	2.34 ± 0.38
	0.454% stannous fluoride/ sodium hexametaphosphate/ zinc lactate ²	58	2.27 ± 0.41
	0.243% sodium fluoride ³	56	2.22 ± 0.43

¹Colgate Total Toothpaste.

²Crest Pro-Health Toothpaste.

³Crest Cavity Protection Toothpaste.

⁴No statistically significant difference was indicated among the three dentifrice groups at baseline

Comparisons vs. Baseline. The mean percent reductions from baseline were 34.5% for the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice group, 16.5% for the 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate dentifrice group, and 10.8% for the 0.243% sodium fluoride dentifrice group. All reductions were statistically significant at the 95% confidence level.

Comparisons Among Dentifrice Groups. Relative to the 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate dentifrice group, the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice group exhibited a statistically significant 18.7% reduction in gingival index scores

Table III
Summary of the Six-Week Gingival Index Scores for Subjects Who Completed the Six-Week Clinical Study

Treatment	n	Six-Week Summary (Mean ± SD)	Within-Treatment Analysis		Between-Treatment Comparisons			
			Percent Reduction ⁴	Sig. ⁵	vs. Crest Pro-Health	vs. Negative Control		
			Percent Difference ⁶	Sig. ⁷	Percent Difference ⁸	Sig. ⁷	Percent Difference ⁸	Sig. ⁷
0.3% triclosan/2.0% PVM/MA copolymer/ 0.243% sodium fluoride ¹	57	0.74 ± 0.11	34.5%	p < 0.05	18.7%	p < 0.05	25.3%	p < 0.05
0.454% stannous fluoride/sodium hexametaphosphate/zinc lactate ²	58	0.91 ± 0.13	16.5%	p < 0.05	—	—	8.1%	p < 0.05
0.243% sodium fluoride ³	56	0.99 ± 0.15	10.8%	p < 0.05	—	—	—	—

¹Colgate Total Toothpaste.

²Crest Pro-Health Toothpaste.

³Crest Cavity Protection Toothpaste.

⁴Percent reduction exhibited by the six-week mean relative to the baseline mean. A positive value indicates a lower gingivitis score at the six-week examination.

⁵Significance of paired t-test comparing the baseline and six-week gingival index scores.

⁶Difference between six-week means expressed as a percentage of the six-week mean for Crest Pro-Health Toothpaste. A positive value indicates a lower gingivitis score for Colgate Total Toothpaste than for Crest Pro-Health Toothpaste.

⁷Significance of post-ANCOVA comparison of baseline-adjusted means.

⁸Difference between six-week means expressed as a percentage of the six-week mean for Crest Cavity Protection Toothpaste. The higher the percent difference the greater the gingivitis efficacy for the dentifrice.

after six weeks of product use ($p \leq 0.05$). Relative to the 0.243% sodium fluoride dentifrice group, the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice group exhibited a statistically significant reduction in gingival index scores of 25.3%, while the 0.454% stannous fluoride with sodium hexametaphosphate and zinc lactate dentifrice group exhibited a statistically significant 8.1% lower gingival index score, both after six weeks of product use ($p \leq 0.05$).

Quigley-Hein Plaque Index. Table IV presents a summary of the plaque index scores measured at the six-week examinations. The mean six-week plaque index scores were 1.38 for the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice group, 1.77 for the 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate dentifrice group, and 2.06 for the 0.243% sodium fluoride dentifrice group.

Comparisons vs. Baseline. The mean percent reductions from baseline were 41% for the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice group, 22% for the 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate dentifrice group, and 7.2% for the 0.243% sodium fluoride dentifrice group. All reductions were statistically significant at the 95% confidence level.

Comparisons Among Dentifrice Groups. Relative to the 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate dentifrice group, the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice group exhibited a statistically significant 22% reduction in plaque index scores after six weeks of product use ($p \leq 0.05$).

Relative to the 0.243% sodium fluoride dentifrice group, the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice group exhibited a statistically significant reduction in plaque index scores of 33%, while the 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate dentifrice group exhibited a statistically significant 14.1% lower plaque index score, both after six weeks of product use ($p \leq 0.05$).

No adverse events were observed by the examining dentist nor noted by the subjects during the study.

Discussion

There are many dentifrices on the market today that claim to provide multiple benefits to the consumer. Some dentifrices provide caries and tartar protection, other dentifrices provide caries and sensitivity protection, while others provide caries, plaque, and gingivitis protection.

Colgate Total Toothpaste was first marketed in the early 1990s. Since the inception of the original 0.3% triclosan, 2.0% PVM/MA copolymer, 0.243% sodium fluoride dentifrice, several product variants have been introduced into the marketplace. These variants all maintained the same combination of active ingredients. The efficacy, mode of action, and safety of a triclosan/PVM/MA copolymer/sodium fluoride dentifrice have been researched and confirmed in over 200 articles in the literature.⁴

Recently, a dentifrice claiming multiple benefits was introduced into the marketplace. Its active ingredient for both caries and plaque/gingivitis benefits is 0.454% stannous fluoride, with sodium hexametaphosphate and zinc lactate. There has been some ambiguity in the literature with regard to antibacterial and antimicrobial-based benefits, such as plaque and gingivitis reductions, that are ascribed to stannous fluoride. This variability may be primarily related to the inherent instability of stannous fluoride in the aqueous medium of dentifrices.²⁶ In addition, it has been widely reported that prolonged use of stannous fluoride products causes dental staining.¹⁹

This examiner-blind, three-treatment clinical study provided a comparison of the plaque and gingivitis efficacy of Colgate Total Toothpaste to Crest Pro-Health dentifrice, and Crest Cavity Protection toothpaste as a negative control. The results from the study indicated that after six weeks:

- all three dentifrice groups exhibited statistically significant reductions from baseline in gingival and plaque index scores;

Table IV

Summary of the Six-Week Plaque Index Scores for Subjects Who Completed the Six-Week Clinical Study

Treatment	n	Six-Week Summary (Mean $\pm$ SD)	Within-Treatment Analysis		Between-Treatment Comparisons			
			Percent Reduction ⁴	Sig. ⁵	vs. Crest Pro-Health		vs. Negative Control	
					Percent Difference ⁶	Sig. ⁷	Percent Difference ⁸	Sig. ⁷
0.3% triclosan/2.0% PVM/MA copolymer/ 0.243% sodium fluoride ¹	57	1.38 $\pm$ 0.38	41.0%	$p < 0.05$	22.0%	$p < 0.05$	33.0%	$p < 0.05$
0.454% stannous fluoride/sodium hexametaphosphate/zinc lactate ²	58	1.77 $\pm$ 0.46	22.0%	$p < 0.05$	—	—	14.1%	$p < 0.05$
0.243% sodium fluoride ³	56	2.06 $\pm$ 0.39	7.2%	$p < 0.05$	—	—	—	—

¹Colgate Total Toothpaste.

²Crest Pro-Health Toothpaste.

³Crest Cavity Protection Toothpaste.

⁴Percent reduction exhibited by the six-week mean relative to the baseline mean. A positive value indicates a lower plaque score at the six-week examination.

⁵Significance of paired t-test comparing the baseline and six-week plaque index scores.

⁶Difference between six-week means expressed as a percentage of the six-week mean for Crest Pro-Health Toothpaste. A positive value indicates a lower plaque score for Colgate Total Toothpaste than for Crest Pro-Health Toothpaste.

⁷Significance of post-ANCOVA comparison of baseline-adjusted means.

⁸Difference between six-week means expressed as a percentage of the six-week mean for Crest Cavity Protection Toothpaste. The higher the percent difference the greater the plaque efficacy for the dentifrice.

- both the Colgate Total Toothpaste group and the Crest Pro-Health dentifrice group exhibited a statistically significantly lower gingival index score (25.3% and 8.1%, respectively) and plaque index score (33% and 14.1%, respectively), compared to the Crest Cavity Protection toothpaste group.
- the Colgate Total Toothpaste group exhibited a statistically significantly lower gingival index score (18.7%) and statistically significantly lower plaque index score (22%) compared to the Crest Pro-Health dentifrice group.

Conclusion

The results from this study confirm the results of previous clinical studies that a dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride is efficacious in reducing gingivitis and supragingival plaque.

The results from this research, utilizing a head-to-head comparison of two commercially available dentifrices, also show that the dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride provides a greater level of antiplaque and antigingivitis efficacy than does a dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate.

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References

1. Newman MG, Takei HH, Carranza FA, eds. *Carranza's Clinical Periodontology* 9th ed. WB Saunders Company, Philadelphia, pp. 96-167, 2001.
2. Oral Health of United States Adults. The National Survey of Oral Health in US Employed Adults and Seniors. Washington, DC: Public Health Service; NIH Publication 87-2868, 1987.
3. Jeffcoat MK. Prevention of periodontal diseases in adults: strategies for the future. *Prev Med* 1994;23:704-708.
4. Blinkhorn A, Bartold PM, Cullinan MP, Madden TE, Marshall RI, Raphael SL, Seymour GJ. Is there a role for triclosan/copolymer toothpaste in the management of periodontal disease. *Br Dent J* 2009;207:117-125.
5. Albandar JM. Epidemiology and risk factors of periodontal disease. *Dent Clin North Am* 2005;49:517-532.
6. Moore WE, Holdeman LV, Cato EP, Smibert RM, Burmeister JA, Ranney RR. Bacteriology of moderate (chronic) periodontitis in mature adult humans. *Infect Immun* 1983;42:510-515.
7. Paster BJ, Boches SK, Galvin JL, Ericson RE, Lau CN, Levanos VA, Sahasrabudhe A, Dewhirst FE. Bacterial diversity in human subgingival plaque. *J Bacteriol* 2001;183:3770-3783.
8. Kolenbrander PE. Oral microbial communities: biofilms, interactions, and genetic systems. *Ann Rev Microbiol* 2000;54:413-437.
9. Taylor G. Consensus statement on oral and systemic health. *Inside Dent* 2006;2(Spec Iss):1-6.
10. Iacono VJ, Aldredge WA, Lucks H, Schwartzstein S. Modern supragingival plaque control. *Int Dent J* 1998;48(Suppl 1):290-297.
11. <http://ada.org/public/topics/cleaning.asp>, 2010.
12. O'Mullane D. New agents in the chemical control of plaque and gingivitis reaction paper. *J Dent Res* 1992;71:1455-1456.
13. Christerson LA, Grossi SG, Dunford RG, Machtei EE, Genco RJ. Dental plaque and calculus: risk indicators for their formulation. *J Dent Res* 1992;71:1425-1430.
14. Lindhe J. Triclosan/copolymer/fluoride dentifrices. A new technology for the prevention of plaque, calculus, gingivitis and caries. *Am J Dent* 1990;3(Spec Iss):S3-S4.
15. Gaffar A, Nabi N, Kashaba B, Williams M, Herles, S, Olsen S, Afflitto J. Antiplaque effects of dentifrices containing triclosan/copolymer/NaF system versus triclosan dentifrices without the copolymer. *Am J Dent* 1990;3(Spec Iss):S7-S14.
16. 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 Iss):197-206.
17. Panagakos FS, Volpe AR, Petrone ME, DeVizio W, Davies RM, Proskin HM. Advanced oral antibacterial/anti-inflammatory technology: A comprehensive review of the clinical benefits of a triclosan/copolymer/fluoride dentifrice. *J Clin Dent* 2005;16(Suppl):S1-S19.
18. Correspondence on file, Colgate-Palmolive Company, New York, NY.
19. Tinanoff N. Review of the antimicrobial action of stannous fluoride. *J Clin Dent* 1990;2:22-27.
20. Mankodi S, Lopez M, Smith I, Petrone DM, Petrone ME, Chaknis P, Proskin HM. Comparison of two dentifrices with respect to efficacy for the control of plaque and gingivitis, and with respect to extrinsic tooth staining: A six-month clinical study on adults. *J Clin Dent* 2002;13:228-233.
21. Liu H, Segreto VA, Baker RA, Vastola KA, Ramsey LL, Gerlach RW. Anticalculus efficacy and safety of a novel whitening dentifrice containing sodium hexametaphosphate: a controlled six-month clinical trial. *J Clin Dent* 2002;13:25-28.
22. Loe H, Silness J. Periodontal disease in pregnancy. I. Prevalence and severity. *Acta Odontol Scand* 1963;21:533-551.
23. Talbott K, Mandel ID, Chilton NW. Reduction of baseline gingivitis scores with repeated prophylaxis. *J Prev Dent* 1977;4:28-29.
24. Quigley GA, Hein JW. Comparative cleansing efficiency of manual and power brushing. *J Am Dent Assoc* 1962;65:26-29.
25. Turesky S, Gilmore ND, Glickman I. Reduced plaque formation by the chloromethyl analogue of vitamin C. *J Periodontol* 1970;41:41-43.
26. Tinanoff N. Progress regarding the use of stannous fluoride in clinical dentistry. *J Clin Dent* 1995;6(Spec Iss):37-40.

A Comparison of the Efficacy of a Triclosan/Copolymer/Sodium Fluoride Dentifrice, a Stannous Fluoride/Sodium Hexametaphosphate/Zinc Lactate Dentifrice, and a Sodium Fluoride Dentifrice for the Control of Established Supragingival Plaque and Gingivitis: A Six-Week Clinical Study

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Abstract

- **Objective:** To compare the efficacy of a dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride in controlling established gingivitis and supragingival plaque to that of a commercially available dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate, and a commercially available dentifrice containing 0.243% sodium fluoride.
- **Methods:** Following a baseline examination for gingivitis and supragingival plaque, qualifying adult male and female subjects from the Mississauga, Ontario, Canada area were randomized into three dentifrice groups. Subjects were instructed to brush their teeth twice daily (morning and evening) for one minute with their assigned dentifrice and a soft-bristled toothbrush. Examinations for gingivitis and supragingival plaque were repeated after six weeks of product use.
- **Results:** One-hundred eighty-two (182) subjects complied with the protocol and completed the study. Relative to the 0.243% sodium fluoride dentifrice group, the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice group exhibited statistically significant reductions in gingival index and supragingival plaque index scores of 26.5% and 29.4%, respectively, after six weeks of product use. Similarly, relative to the 0.243% sodium fluoride dentifrice group, the 0.454% stannous fluoride/sodium hexametaphosphate/zinc lactate dentifrice group exhibited statistically significant reductions in gingival index and plaque index scores of 12.7% and 12.6%, respectively, after six weeks of product use. Further, relative to the 0.454% stannous fluoride/sodium hexametaphosphate/zinc lactate dentifrice group, the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice group exhibited statistically significant reductions in gingival index and plaque index scores of 15.8% and 19.2%, respectively.
- **Conclusion:** The overall results of this double-blind clinical study support the conclusion that a dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride is efficacious for the control of established gingivitis and supragingival plaque, and that it provides a greater level of efficacy for the control of gingivitis and supragingival plaque than does a dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate.

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Introduction

Fluoride dentifrices have played a significant role in reducing dental caries, and many dentifrices on the market today deliver other oral health benefits, such as improvement in periodontal health.¹⁻⁵ It is widely accepted that the control of plaque and gingivitis is the key to periodontal health. Controlling supragingival plaque starts with mechanical removal by tooth brushing.⁶ The American Dental Association defines the maintenance of good oral hygiene as tooth brushing for two minutes twice daily plus flossing once a day.⁷ However, it has been shown that self-performed tooth brushing and flossing is not always sufficient to maintain a healthy mouth.⁸ So manufacturers started looking at different chemotherapeutic agents to incorporate into dentifrice

formulations that would provide antiplaque and/or antigingivitis efficacy.

One such agent is triclosan, a phenolic antibacterial agent with low toxicity and a broad spectrum of activity, which has been shown to be effective against both gram positive and gram negative bacteria.⁹ Triclosan has been incorporated into a sodium fluoride dentifrice in combination with a polyvinylmethyl ether/maleic acid copolymer (PVM/MA copolymer) to ensure delivery and retention of the triclosan on oral hard and soft tissues. This dentifrice formulation (Colgate® Total® Toothpaste, Colgate-Palmolive Co., New York, NY, USA) has been clinically proven in numerous scientific publications to prevent and reduce plaque and reduce gingivitis in the adult population.^{10,11} It has been

shown in long-term clinical studies to provide anticaries benefits, and has been clinically proven to prevent the progression of periodontitis.¹²

Colgate Total Toothpaste is the only toothpaste approved by the US Food and Drug Administration for the prevention of plaque and gingivitis, and is accepted by the American Dental Association for the prevention of plaque and gingivitis.¹³

Stannous fluoride dentifrices have been shown to reduce caries and improve plaque control and gingivitis.^{14,15} A stabilized stannous fluoride/sodium hexametaphosphate/zinc lactate dentifrice (Crest® Pro-Health® Toothpaste, Procter & Gamble Co., Cincinnati, OH, USA) has been reported to have a significant benefit on plaque control and gingival health, and to reduce further loss of attachment in patients with periodontitis.^{16,17} Stannous fluoride, like sodium fluoride, is a common ingredient found in dentifrices to reduce caries. Sodium hexametaphosphate has been reported in the literature to reduce calculus formation.¹⁸

The objective of this six-week clinical study was to compare the antiplaque and antigingivitis efficacy of three commercially available dentifrices: a dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride (Colgate Total) to a dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate (Crest Pro-Health). A fluoride dentifrice was included as a negative control (Crest® Cavity Protection Toothpaste, Procter & Gamble Co., Cincinnati, OH, USA). Gingivitis and plaque evaluations were conducted at baseline and after six weeks of product use.

Materials and Methods

This study employed a double-blind, randomized, three-treatment, parallel-group design. Adult male and female subjects from the Mississauga, Ontario, Canada area were enrolled into the study based upon the following criteria:

- Subjects had to be between 18 and 70 years of age, in good general health, and have signed an Informed Consent document.
- Subjects were required to be available for the six-week duration of the study.
- Subjects had to possess at least 20 uncrowned permanent natural teeth (excluding third molars).
- Subjects were required to present at baseline a mean gingival index score of at least 1.0 as determined by the use of the Löe and Silness Gingival Index,^{19,20} and a mean plaque index score of at least 1.5 as determined by the use of the Turesky modification of the Quigley-Hein Plaque Index.^{21,22}

Subjects were excluded from study participation if they:

- had partial removable dentures, orthodontic bands, or advanced periodontal disease (purulent exudate, tooth mobility, and/or extensive loss of periodontal attachment or alveolar bone).
- had tumor(s) of the soft or hard oral tissues, or five or more carious lesions requiring immediate restorative treatment.
- had a history of allergies to personal care/consumer products or their ingredients, or they could not refrain from eating or drinking due to medical conditions for periods of up to four hours.

- were pregnant or breast feeding women, or individuals who participated in any other clinical study or panel test within the last month of the start of the study.
- used antibiotics at any time during the one-month period prior to entering the study, were taking any prescription medication that might interfere with the study outcome, or received a dental prophylaxis during the two weeks prior to the study's baseline examination.

Prospective subjects reported to the clinical facility having refrained from any oral hygiene procedures for twelve hours, and eating, drinking, and smoking for four hours prior to the visit. Subjects signed an Informed Consent form, and were screened by the dental examiner with respect to the inclusion/exclusion criteria. Subjects who met the inclusion/exclusion criteria received a baseline gingivitis and supragingival plaque examination and an oral soft and hard tissue assessment.

Qualifying subjects were randomized into three treatment groups which were balanced for baseline gingivitis and supragingival plaque scores. The three dentifrices tested in this study were as follows: 1) a commercially available dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride (Colgate Total Toothpaste); 2) a commercially available dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate (Crest Pro-Health Toothpaste); and 3) a commercially available dentifrice containing 0.243% sodium fluoride (Crest Cavity Protection Toothpaste).

Following treatment assignment, subjects were provided with a soft-bristled toothbrush and their assigned dentifrice. All dentifrices were over-wrapped in their original package to maintain the double-blind study design. Subjects were instructed to brush their teeth with their assigned dentifrice and toothbrush twice daily (morning and evening) for one minute, and to use only the dentifrice and toothbrush provided. Subjects were allowed to maintain routine oral hygiene procedures, such as flossing or using inter-dental stimulators. There were no restrictions regarding diet or smoking during the course of the study, although subjects were instructed to refrain from any oral hygiene procedures for twelve hours, and eating, drinking, and smoking for four hours prior to their six-week study examinations. Subjects returned to the clinical facility for gingivitis and supragingival plaque examinations after six weeks of product use. Additionally, at each examination, subjects received an evaluation of their oral soft tissue by the examining dentist, and were questioned for the occurrence of any adverse events.

Clinical Scoring Procedures

Löe-Silness Gingival Index. Gingivitis was scored according to the Löe-Silness Gingival Index. Each tooth was divided into six surfaces, three facial and three lingual, as follows: 1) mesio-facial; 2) mid-facial; 3) disto-facial; 4) mesio-lingual; 5) mid-lingual; and 6) disto-lingual. Third molars and those teeth with cervical restorations or prosthetic crowns were excluded from the scoring procedure. The gingiva adjacent to each tooth surface was scored as follows:

0 = Absence of inflammation.

1 = Mild inflammation—slight change in color and little change in texture.

2 = Moderate inflammation—moderate glazing, redness, edema, and hypertrophy.

3 = Severe inflammation—marked redness and hypertrophy. Tendency for spontaneous bleeding.

Subject-wise scores were determined by averaging the values obtained over all scoreable surfaces in the mouth.

Quigley-Hein Plaque Index. Plaque was scored according to the Turesky modification of the Quigley-Hein Plaque Index. Each tooth was divided into six surfaces, three facial and three lingual, as follows: 1) mesio-facial; 2) mid-facial; 3) disto-facial; 4) mesio-lingual; 5) mid-lingual; and 6) disto-lingual. Third molars and those teeth with cervical restorations or prosthetic crowns were excluded from the scoring procedure. Plaque was disclosed and scored on each tooth surface according to the following criteria:

0 = No plaque.

1 = Separate flecks of plaque at the cervical margin.

2 = A thin, continuous band of plaque (up to 1 mm) at the cervical margin.

3 = A band of plaque wider than 1 mm, but covering less than 1/3 of the side of the crown of the tooth.

4 = Plaque covering at least 1/3, but less than 2/3 of the side of the crown of the tooth.

5 = Plaque covering 2/3 or more of the side of the crown of the tooth.

Subject-wise scores were determined by averaging the values obtained over all scoreable surfaces in the mouth.

Oral Soft and Hard Tissue Assessment. The dental examiner visually examined the oral cavity and peri-oral area using a dental light and dental mirror prior to each plaque and gingivitis examination. This examination included an evaluation of the soft and hard palate, gingival mucosa, buccal mucosa, mucogingival fold areas, tongue, sublingual and submandibular areas, salivary glands, and the tonsillar and pharyngeal areas.

Adverse Events. Adverse events were determined by verbal indications from the subjects or by visual examination by the dental examiner.

Statistical Methods

Statistical analyses were performed separately for the gingival index and plaque index scores. Comparisons of the treatment groups with respect to baseline gingival index and plaque index scores, as well as for age, were performed using analyses of variance (ANOVA). Within-treatment comparisons of the gingival index and plaque index scores obtained at the six-week examinations versus baseline were performed using paired t-tests. Comparisons between treatment groups with respect to gender were performed using chi-square tests. Comparisons of the treatment groups with respect to baseline-adjusted gingival index and plaque index scores at the six-week examinations were performed using analyses of covariance (ANCOVA). Post-ANCOVA pair-wise comparisons of the gingival and plaque index scores were performed using the Tukey test for multiple comparisons. All statistical tests of hypotheses were two-sided, and employed a level of significance of $\alpha = 0.05$.

Results

One-hundred and eighty-two (182) subjects complied with the protocol and completed the six-week clinical study. A summary of the gender and age of the population who completed the study is presented in Table I. The treatment groups did not differ significantly with respect to either of these characteristics. Throughout the study, no adverse effects on the oral hard or soft tissues were observed by the examiner or reported by the subjects when questioned.

Table I
Summary of Gender and Age for Subjects
Who Completed the Six-Week Clinical Study

Dentifrice	Number of Subjects			Age	
	Male	Female	Total	Mean	Range
0.3% triclosan/ 2.0% PVM/MA copolymer/ 0.243% sodium fluoride ¹	22	39	61	35.59	18–65
0.454% stannous fluoride/ sodium hexametaphosphate/ zinc lactate ²	20	41	61	33.43	18–68
0.243% sodium fluoride ³	26	34	60	35.25	18–61

¹Colgate Total Toothpaste.

²Crest Pro-Health Toothpaste.

³Crest Cavity Protection Toothpaste.

Baseline Data

Löe-Silness Gingival Index and Quigley-Hein Plaque Index.

Table II presents a summary of the gingival and plaque index scores measured at baseline for subjects who completed the study. The mean baseline gingival index scores were 1.81 for the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice group, 1.82 for the 0.454% stannous fluoride/sodium hexametaphosphate/zinc lactate dentifrice group, and

Table II
Summary of the Baseline Löe-Silness Gingival Index Scores
and Quigley-Hein Plaque Index Scores for Subjects
Who Completed the Six-Week Clinical Study

Parameter	Treatment	n	Baseline Summary (Mean $\pm$ SD) ⁴
Gingivitis	0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride ¹	61	1.81 $\pm$ 0.22
	0.454% stannous fluoride/ sodium hexametaphosphate/ zinc lactate ²	61	1.82 $\pm$ 0.21
	0.243% sodium fluoride ³	60	1.88 $\pm$ 0.26
Plaque	0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride ¹	61	2.73 $\pm$ 0.27
	0.454% stannous fluoride/ sodium hexametaphosphate/ zinc lactate ²	61	2.70 $\pm$ 0.24
	0.243% sodium fluoride ³	60	2.71 $\pm$ 0.32

¹Colgate Total Toothpaste.

²Crest Pro-Health Toothpaste.

³Crest Cavity Protection Toothpaste.

⁴No statistically significant difference was indicated among the three dentifrice groups at baseline.

1.88 for the 0.243% sodium fluoride dentifrice group. The mean baseline plaque index scores were 2.73 for the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice group, 2.70 for the 0.454% stannous fluoride/sodium hexametaphosphate/zinc lactate dentifrice group, and 2.71 for the 0.243% sodium fluoride dentifrice group. No statistically significant differences were indicated among the dentifrice groups with respect to gingival or plaque index scores at baseline.

Six-Week Data

Löe-Silness Gingival Index. Table III presents a summary of the gingival index scores measured at the six-week examinations. The mean six-week gingival index scores were 1.33 for the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice group, 1.58 for the 0.454% stannous fluoride/sodium hexametaphosphate/zinc lactate dentifrice group, and 1.81 for the 0.243% sodium fluoride dentifrice group.

Comparisons vs. Baseline. The mean percent reductions from baseline were 26.5% for the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice group, 13.2% for the 0.454% stannous fluoride/sodium hexametaphosphate/zinc lactate dentifrice group, and 3.7% for the 0.243% sodium fluoride dentifrice group. All reductions were statistically significant at the 95% confidence level.

Comparisons Among Dentifrice Groups. Relative to the 0.454% stannous fluoride/sodium hexametaphosphate/zinc lactate dentifrice group, the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice group exhibited a statistically significant 15.8% reduction in gingival index scores after six weeks of product use ($p \leq 0.05$).

Relative to the 0.243% sodium fluoride dentifrice group, the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice group exhibited a statistically significant reduction in gingival index scores of 26.5%, while the 0.454% stannous fluoride/sodium hexametaphosphate/zinc lactate dentifrice group exhibited a statistically significant 12.7% lower

gingival index score, both after six weeks of product use ($p \leq 0.05$).

Quigley-Hein Plaque Index. Table IV presents a summary of the plaque index scores measured at the six-week examinations. The mean six-week plaque index scores were 1.85 for the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice group, 2.29 for the 0.454% stannous fluoride/sodium hexametaphosphate/zinc lactate dentifrice group, and 2.62 for the sodium fluoride dentifrice group.

Comparisons vs. Baseline. The mean percent reductions from baseline were 32.2% for the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice group, 15.2% for the 0.454% stannous fluoride/sodium hexametaphosphate/zinc lactate dentifrice group, and 3.3% for the 0.243% sodium fluoride dentifrice group. All reductions were statistically significant at the 95% confidence level.

Relative to 0.454% stannous fluoride/sodium hexametaphosphate/zinc lactate dentifrice group, the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice group exhibited a statistically significant 19.2% reduction in plaque index scores after six weeks of product use ($p \leq 0.05$).

Comparisons Among Dentifrice Groups. Relative to the 0.243% sodium fluoride dentifrice group, the 0.3% triclosan/2.0% PVM/MA copolymer/0.243% sodium fluoride dentifrice group exhibited a statistically significant reduction in plaque index scores of 29.4%, while the 0.454% stannous fluoride/sodium hexametaphosphate/zinc lactate dentifrice group exhibited a statistically significant 12.6% lower gingival index score, both after six weeks of product use ($p \leq 0.05$).

No adverse events were observed by the examining dentist nor noted by the subjects during the study.

Discussion

The maintenance of an effective level of plaque control is the cornerstone of any attempt to prevent and control periodontal disease, but most people fail to achieve a level of oral hygiene

Table III
Summary of the Six-Week Gingival Index Scores for Subjects Who Completed the Six-Week Clinical Study

Treatment	n	Six-Week Summary (Mean $\pm$ SD)	Within-Treatment Analysis		Between-Treatment Comparisons			
			Percent Reduction ⁴	Sig. ⁵	vs. Crest Pro-Health Percent Difference ⁶	Sig. ⁷	vs. Crest Cavity Protection Percent Difference ⁸	Sig. ⁷
0.3% triclosan/2.0% PVM/MA copolymer/ 0.243% sodium fluoride ¹	61	1.33 $\pm$ 0.20	26.5%	$p < 0.05$	15.8%	$p < 0.05$	26.5%	$p < 0.05$
0.454% stannous fluoride/sodium hexametaphosphate/zinc lactate ²	61	1.58 $\pm$ 0.22	13.2%	$p < 0.05$	—	—	12.7%	$p < 0.05$
0.243% sodium fluoride ³	60	1.81 $\pm$ 0.33	3.7%	$p < 0.05$	—	—	—	—

¹Colgate Total Toothpaste.

²Crest Pro-Health Toothpaste.

³Crest Cavity Protection Toothpaste.

⁴Percent reduction exhibited by the six-week mean relative to the baseline mean. A positive value indicates a lower gingivitis score at the six-week examination.

⁵Significance of paired t-test comparing the baseline and six-week gingival index scores.

⁶Difference between six-week means expressed as a percentage of the six-week mean for Crest Pro-Health Toothpaste. A positive value indicates a lower gingivitis score for Colgate Total Toothpaste than for Crest Pro-Health Toothpaste.

⁷Significance of post-ANCOVA comparison of baseline-adjusted means.

⁸Difference between six-week means expressed as a percentage of the six-week mean for Crest Cavity Protection Toothpaste. The higher the percent difference the greater the gingivitis efficacy for the dentifrice.

Table IV
Summary of the Six-Week Plaque Index Scores for Subjects Who Completed the Six-Week Clinical Study

Treatment	n	Six-Week Summary (Mean $\pm$ SD)	Within-Treatment Analysis		Between-Treatment Comparisons			
			Percent Reduction ⁴	Sig. ⁵	vs. Crest Pro-Health Percent Difference ⁶	Sig. ⁷	vs. Crest Cavity Protection Percent Difference ⁸	Sig. ⁷
0.3% triclosan/2.0% PVM/MA copolymer/ 0.243% sodium fluoride ¹	61	1.85 $\pm$ 0.38	32.2%	p < 0.05	19.2%	p < 0.05	29.4%	p < 0.05
0.454% stannous fluoride/sodium hexametaphosphate/zinc lactate ²	61	2.29 $\pm$ 0.46	15.2%	p < 0.05	—	—	12.6%	p < 0.05
0.243% sodium fluoride ³	60	2.62 $\pm$ 0.33	3.3%	p < 0.05	—	—	—	—

¹Colgate Total Toothpaste.

²Crest Pro-Health Toothpaste.

³Crest Cavity Protection Toothpaste.

⁴Percent reduction exhibited by the six-week mean relative to the baseline mean. A positive value indicates a lower plaque score at the six-week examination.

⁵Significance of paired t-test comparing the baseline and six-week plaque index scores.

⁶Difference between six-week means expressed as a percentage of the six-week mean for Crest Pro-Health Toothpaste. A positive value indicates a lower plaque score for Colgate Total Toothpaste than for Crest Pro-Health Toothpaste.

⁷Significance of post-ANCOVA comparison of baseline-adjusted means.

⁸Difference between six-week means expressed as a percentage of the six-week mean for Crest Cavity Protection Toothpaste. The higher the percent difference the greater the plaque efficacy for the dentifrice.

commensurate with periodontal health.^{23,24} Periodontal diseases are initiated by plaque bacteria and, consequently, much research has focused on the possibility of enhancing oral hygiene by incorporating chemotherapeutic agents into dentifrice formulations.²⁵ The effectiveness of a dentifrice formulation containing 0.3% triclosan and 2.0% copolymer in delivering a more effective level of plaque control and periodontal health has been demonstrated in numerous clinical trials and documented in narrative and systematic reviews.^{3-5,26,27} Dentifrices containing stabilized stannous fluoride have also been shown to improve plaque control and gingivitis in studies of six months' duration.²⁸⁻³¹

This double-blind, parallel, three-treatment clinical study provided a comparison of the plaque and gingivitis efficacy of a clinically documented, commercially available dentifrice formulation containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride (Colgate Total Toothpaste) to a commercially available dentifrice formulation containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate (Crest Pro-Health Toothpaste). The third dentifrice in the study was a commercially available dentifrice containing 0.243% sodium fluoride, used as a negative control (Crest Cavity Protection Toothpaste).

The results from the study indicated that after six weeks' use of the dentifrices:

- All three dentifrice groups exhibited statistically significant reductions from baseline in gingival and plaque index scores.
- Both the Colgate Total dentifrice group and the Crest Pro-Health dentifrice group exhibited a statistically significantly lower gingival index score (26.5% and 12.7%, respectively) and plaque index score (29.4% and 12.6%, respectively) compared to the Crest Cavity Protection dentifrice group.
- The Colgate Total dentifrice group exhibited a statistically significant lower gingival index score (15.8%) and plaque index score (19.2%) compared to the Crest Pro-Health dentifrice group.

Conclusion

The results from this study confirm the results of many previous clinical studies that a dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride is efficacious in reducing gingivitis and supragingival plaque.

The results from this research also show that a dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride provides a greater level of efficacy than does a dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate.

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References

1. Marinho VC, Higgins JP, Sheiham A, Logan S. Fluoride toothpastes for preventing dental caries in children and adolescents. *Cochrane Database Syst Rev* 2003;1:CD002278.
2. Twetman S, Axelsson S, Dahlgren H, Holm AK, Källestål C, Lagerlöf F, Lingström P, Mejäre I, Nordenram G, Norlund A, Petersson LG, Söder B. Caries-preventive effect of fluoride toothpaste: A systematic review. *Acta Odontol Scand* 2003;61:347-355.
3. Davies RM, Ellwood RP, Davies GM. The effectiveness of a toothpaste containing triclosan and polyvinyl-methyl ether maleic acid copolymer in improving plaque control and gingival health. A systematic review. *J Clin Periodontol* 2004;31:1029-1033.
4. Hioe KP, van der Weijden GA. The effectiveness of self-performed mechanical plaque control with triclosan containing dentifrices. *Int J Dent Hyg* 2005;3:192-204.
5. Gunsolley JC. A meta-analysis of six-month studies of antiplaque and anti-gingivitis agents. *J Am Dent Assoc* 2006;137:1649-1657.
6. <http://ada.org/public/topics/cleaning.asp>, 2010.
7. Axelsson P, Lindhe J, Nyström B. On the prevention of caries and periodontal disease. Results of a 15-year longitudinal study in adults. *J Clin Periodontol* 1991;18:182-189.
8. O'Mullane D. New agents in the chemical control of plaque and gingivitis: reaction paper. *J Dent Res* 1992;71:1455-1456.
9. Lindhe J. Triclosan/copolymer/fluoride dentifrices. A new technology for the prevention of plaque, calculus, gingivitis and caries. *Am J Dent* 1990;3(Spec

- Iss):S3-S4.
10. Gaffar A, Nabi N, Kashaba B, Williams M, Herles S, Olsen S, Afflitto J. Antiplaque effects of dentifrices containing triclosan/copolymer/NaF system versus triclosan dentifrices without the copolymer. *Am J Dent* 1990;3(Spec Iss):S7-S14.
 11. 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 Iss):197-206.
 12. Panagakos FS, Volpe AR, Petrone ME, DeVizio W, Davies RM, Proskin HM. Advance oral antibacterial/anti-inflammatory technology: A comprehensive review of the clinical benefits of a triclosan/copolymer/fluoride dentifrice. *J Clin Dent* 2005;16(Suppl):S1-S19.
 13. Correspondence on file, Colgate-Palmolive Company, New York, NY.
 14. Faller RV, Best JM, Featherstone JD, Barrett-Vespone NA. Anticaries efficacy of an improved stannous fluoride toothpaste. *J Clin Dent* 1995;6(Spec Iss):89-96.
 15. Paraskevas S, van der Weijden GA. A review of the effects of stannous fluoride on gingivitis. *J Clin Periodontol* 2006;33:1-13.
 16. Mankodi S, Bartizek RD, Winston JL, Biesbrock AR, McClanahan SF, He T. Anti-gingivitis efficacy of a stabilized 0.454% stannous fluoride/sodium hexametaphosphate dentifrice. *J Clin Periodontol* 2005;32:75-80.
 17. Papas A, He T, Martuscelli G, Singh M, Bartizek RD, Biesbrock AR. Comparative efficacy of stabilized stannous fluoride/sodium hexametaphosphate dentifrice and sodium fluoride/triclosan/copolymer dentifrice for the prevention of periodontitis in xerostomic patients: A 2-year randomized clinical trial. *J Periodontol* 2007;78:1505-1514.
 18. Liu H, Segreto VA, Baker RA, Vastola KA, Ramsey LL, Gerlach RW. Anticalculus efficacy and safety of a novel whitening dentifrice containing sodium hexametaphosphate: A controlled six-month clinical trial. *J Clin Dent* 2002;13:25-28.
 19. Loe H, Silness J. Periodontal disease in pregnancy. I. Prevalence and severity. *Acta Odontol Scand* 1963;21:533-551.
 20. Talbott K, Mandel ID, Chilton NW. Reduction of baseline gingivitis scores with repeated prophylaxis. *J Prev Dent* 1977;4:28-29.
 21. Quigley GA, Hein JW. Comparative cleansing efficiency of manual and power brushing. *J Am Dent Assoc* 1962;65:26-29.
 22. Turesky S, Gilmore ND, Glickman I. Reduced plaque formation by the chloromethyl analogue of vitamin C. *J Periodontol* 1970;41:41-43.
 23. Claydon NC. Current concepts in toothbrushing and interdental cleaning. *Periodontol 2000* 2008;48:10-22.
 24. Loe H. Oral hygiene in the prevention of caries and periodontal disease. *Int Dent J* 2000;50:129-139.
 25. Paraskevas S. Randomized controlled clinical trials on agents used for chemical plaque control. *Int J Dent Hyg* 2005;3:162-178.
 26. Volpe AR, Petrone ME, DeVizio W, Davies RM, Proskin HM. A review of the plaque, gingivitis, calculus and caries clinical efficacy studies with a fluoride dentifrice containing triclosan and PVM/MA copolymer. *J Clin Dent* 1996;7(Suppl):S1-S14.
 27. Blinkhorn A, Bartold PM, Cullinan MP, Madden TE, Marshall RI, Raphael SL, Seymour GJ. Is there a role for triclosan/copolymer toothpaste in the management of periodontal disease? *Br Dent J* 2009;207:117-125.
 28. Mankodi S, Petrone DM, Battista G, Petrone ME, Chaknis P, DeVizio W, Volpe AR, Proskin HM. Clinical efficacy of an optimized stannous fluoride dentifrice, Part 2: A 6-month plaque/gingivitis clinical study, northeast USA. *Compend Contin Educ Dent* 1997;18(Spec Iss):10-15.
 29. Williams C, McBride S, Bolden TE, Mostler K, Petrone DM, Petrone ME, Chaknis P, DeVizio W, Volpe AR, Proskin HM. Clinical efficacy of an optimized stannous fluoride dentifrice, Part 3: A 6-month plaque/gingivitis study, southeast USA. *Compend Contin Educ Dent* 1997;18(Spec Iss):16-20.
 30. Beiswanger BB, Doyle PM, Jackson RD, Mallatt ME, Mau M, Bollmer BW, Crisanti MM, Guay CB, Lanzalaco AC, Lukacovic MF, Majeti S, McClanahan SF. The clinical effect of dentifrices containing stabilized stannous fluoride on plaque formation and gingivitis. A six-month study with *ad libitum* brushing. *J Clin Dent* 1995;6(Spec Iss):46-53.
 31. Perlich MA, Bacca LA, Bollmer BW, Lanzalaco AC, McClanahan SF, Sewak LK, Beiswanger BB, Eichold WA, Hull JR, Jackson RD, Mau MS. The clinical effect of a stabilized stannous fluoride dentifrice on plaque formation, gingivitis and gingival bleeding: a six-month study. *J Clin Dent* 1995;6(Spec Iss):54-58.

Comparative Investigation of the Efficacy of Triclosan/Copolymer/Sodium Fluoride and Stannous Fluoride/Sodium Hexametaphosphate/Zinc Lactate Dentifrices for the Control of Established Supragingival Plaque and Gingivitis in a Six-Month Clinical Study

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Abstract

- **Objective:** This double-blind clinical study, conducted at the University of Puerto Rico, San Juan, Puerto Rico, was designed to compare the efficacy of two commercially available dentifrices for the control of supragingival plaque and gingivitis.
- **Methods:** Qualifying adult male and female subjects from the San Juan, Puerto Rico area were randomly assigned to one of two treatment groups: 1) a commercially available dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride (Colgate® Total®); and 2) a commercially available dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate (Crest® Pro-Health®). All subjects received an oral soft and hard tissue examination, and were dispensed their assigned dentifrice product, along with a soft-bristled adult toothbrush for home use. Subjects were instructed to brush their teeth for one minute, twice daily (morning and evening), using only the dentifrice provided. Examinations for supragingival plaque and gingivitis, and oral soft and hard tissue assessments were repeated after six weeks, three months, and six months of product use.
- **Results:** One-hundred and nine (109) subjects complied with the protocol and completed the six-month examinations. At the six-month examination, both treatment groups exhibited statistically significant reductions from baseline with respect to supragingival plaque and gingivitis scores. Relative to the Crest Pro-Health Toothpaste group, the Colgate Total Toothpaste group exhibited statistically significant reductions in supragingival plaque index scores of 18.5%, 20.7%, and 25.8% after six weeks, three months, and six months of product use, respectively. For gingival index scores, statistically significant reductions of 20.5%, 18.9%, and 17.1% were exhibited after six weeks, three months, and six months of product use, respectively.
- **Conclusion:** The results of this double-blind clinical study support the conclusion that a dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride provides a significant reduction in established supragingival plaque and gingivitis, as compared to a dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate when used over a period of six months.

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Introduction

Dental plaque-induced gingivitis is inflammation of the gingival tissues characterized by a change in color, texture, and a tendency to bleed upon probing.^{1,2} Unlike periodontitis, there is no tissue attachment loss to the tooth structure in gingivitis. However, if unattended, gingivitis can lead to periodontitis and, eventually, to tooth loss.³

Epidemiological studies have reported a high prevalence of gingivitis in adult populations in the US, with variations observed in different ethnic groups and gender. According to the US National Survey of Employed Adults conducted in 1985, 47% of men and 39% of women presented bleeding on probing in at least

one site.⁴ An apparent improvement in gingival health in adults has been reported since the First National Survey in Adults conducted in 1960–1962. The prevalence reported in that first study was 85% in men, 79% in women, while years later a prevalence of 50% in adults was reported in the NHANES III (1988–1994). More recently, Dye, *et al.* concluded that data from NHANES III and NHANES 1999–2004 indicates that periodontitis has declined across nearly all major groups in the US.^{5,6} Findings from the NHANES⁷ revealed that Hispanics in the US had a higher prevalence of gingivitis than Caucasian adults in the US.

The scientific literature supports that the accumulation of dental plaque, or what is commonly referred to now as the oral

biofilm, in susceptible hosts is associated with gingivitis and periodontitis,⁸ considering it a cause and effect relationship.⁴

Plaque or biofilm formation is a process that consists of a formation of the acquired pellicle on the tooth surface. There is then the initial adhesion and attachment of gram positive bacteria, followed by microbial colonization by gram negative anaerobic bacteria. This leads to an organized and structured biofilm. Bacterial plaque is the primary cause of gingivitis in conjunction with other predisposing factors, such as tobacco, calculus, and orthodontic therapy, among others.⁹

Therefore, therapy for gingivitis should be directed primarily at the reduction of oral bacteria and calcified and non-calcified deposits.¹⁰ Optimal oral hygiene, brushing twice daily, and flossing as recommended by the ADA, all contribute to good oral health.¹¹ However, a large percentage of the population is unable to adequately clean their teeth. In a clinical study, more than 66% of subjects who stated that they brushed their teeth twice a day presented with dental plaque.⁸ Several factors, such as the brushing technique, duration of brushing, and failure to remove plaque from interproximal areas of posterior teeth and lingual areas, affect and impede mechanical plaque removal.¹²

The high prevalence of gingivitis reported in the US and other parts of the world⁴ and its possible development into periodontitis, combined with the evidence from clinical studies showing the difficulties encountered in adequately removing dental plaque,^{8,12} and the recent evidence relating periodontal disease and atherosclerotic disease,¹³ all support the use of chemotherapeutic agents in dental products for plaque control.

Chemotherapeutic agents with antibacterial properties, such as triclosan, have been added to fluoride-containing toothpastes to reduce plaque and gingivitis. Triclosan is a nonionic, bisphenolic germicidal agent. It has low toxicity, a broad spectrum of activity, and is effective against both gram positive and gram negative bacteria.¹⁴ Colgate® Total® Toothpaste (Colgate-Palmolive Co., New York, NY, USA) also contains the copolymer, PVM/MA (polyvinylmethyl ether/maleic acid), which, when combined with the triclosan, ensures the delivery and retention of triclosan to hard and soft tissues.^{15,16} The combination of 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride, Colgate Total Toothpaste, has been tested in clinical studies and shown to significantly reduce plaque and gingivitis.^{17,18}

The objective of this six-month randomized clinical trial was to compare the efficacy of a dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride to a dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate for the control of established supragingival plaque and gingivitis.

Materials and Methods

This clinical study, conducted at the School of Dental Medicine of the University of Puerto Rico in San Juan, Puerto Rico, employed a double-blind, randomized, two-treatment, parallel-group design. Adult male and female subjects from the San Juan area were enrolled into the study based upon the following criteria:

- Subjects had to be between the ages of 21 and 70, in generally good health, and possess a minimum of 20 uncrowned permanent natural teeth (excluding third molars).

- Subjects needed to be available for the duration of the study, and to sign an Informed Consent form.
- Subjects were required to present, at baseline, a mean Löe-Silness Gingival Index^{1,2} score of at least 1.0, and a mean plaque index score of 1.5 or greater, as determined by the Turesky modification of the Quigley-Hein Plaque Index.^{19,20}
- Subjects were excluded from the study if they had orthodontic bands, presence of partial dentures, tumors of the soft or hard tissues of the oral cavity, advanced periodontal disease (purulent exudates, tooth mobility, and/or extensive loss of periodontal attachment or alveolar bone), five or more carious lesions requiring immediate restorative treatment, or a history of allergies to oral care/personal care consumer products or their ingredients. Additionally, pregnant or lactating women, individuals with a history of alcohol or drug abuse, or individuals who had participated in any other clinical study or who had used antibiotics any time within one month preceding the study were excluded from participation.
- Subjects who received a dental prophylaxis within two weeks prior to the baseline examination, or subjects with existing medical conditions or conditions which precluded them from not eating and drinking for periods up to four hours, or who were taking any medications that might interfere with the study outcome were also excluded from the study.

Prospective study subjects reported to the clinical facility having refrained from all oral hygiene procedures for 12 hours, and having refrained from eating, drinking, or smoking for four hours prior to their examination. All prospective subjects who met the inclusion/exclusion criteria received a baseline plaque and gingivitis examination, along with an oral soft and hard tissue assessment.

Qualifying subjects were randomly assigned to one of the two study treatments:

1. A commercially available dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride (Colgate Total Toothpaste).
2. A commercially available dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate (Crest® Pro-Health® Toothpaste, Procter & Gamble Co., Cincinnati, OH, USA).

Following their assignment to a study group, all subjects were provided with their assigned dentifrice and an adult soft-bristled toothbrush for home use. All dentifrice products were supplied in their original packaging and overwrapped with a white label to mask the product's identity. Subjects were instructed to brush their teeth for one minute, twice daily (morning and evening), using only the dentifrice and toothbrush provided, and to refrain from any other oral hygiene procedures throughout the duration of the study. There were no restrictions regarding diet or smoking habits during the course of the study.

Subjects returned to the clinical facility for plaque and gingivitis examinations and oral soft and hard tissue assessments after six weeks, three months, and six months of product use. All examinations were performed by the same dental examiner using the same procedures as employed at baseline. Training and standardization sessions were conducted before the beginning of

the study's data collection visits at the University of Puerto Rico School of Dental Medicine. The dental examiner and a back-up examiner were trained and standardized on the plaque and gingivitis indices employed in the study by a periodontist who served as the reference examiner. At the six-week, three-month, and six-month examinations, in addition to visual examinations by the dental examiner, subjects were also interviewed to determine if they experienced any adverse events during the study period.

Clinical Scoring Procedures

Plaque Assessment. Plaque was scored according to the Turesky modification of the Quigley-Hein Plaque Index. Each tooth was divided into six surfaces, three facial and three lingual, as follows: 1) mesio-facial; 2) mid-facial; 3) disto-facial; 4) mesio-lingual; 5) mid-lingual; and 6) disto-lingual. Third molars and those teeth with cervical restorations or prosthetic crowns were excluded from the scoring procedure. Plaque was disclosed and scored on each tooth surface according to the following criteria:

0 = No plaque.

1 = Separate flecks of plaque at the cervical margin of the tooth.

2 = A thin, continuous band of plaque (up to 1 mm) at the cervical margin of the tooth.

3 = A band of plaque wider than 1 mm, but covering less than 1/3 of the crown of the tooth.

4 = Plaque covering at least 1/3, but less than 2/3 of the crown of the tooth.

5 = Plaque covering 2/3 or more of the crown of the tooth.

Whole-mouth mean scores were obtained by averaging the values obtained over all scoreable surfaces in the mouth.

Gingivitis Assessment. Gingivitis was scored according to the Löe-Silness Gingival Index. Each tooth was divided into six surfaces, three facial and three lingual, as follows: 1) mesio-facial; 2) mid-facial; 3) disto-facial; 4) mesio-lingual; 5) mid-lingual; and 6) disto-lingual. Third molars and those teeth with cervical restorations or prosthetic crowns were excluded from the scoring procedure. The gingiva adjacent to each tooth surface was scored as follows:

0 = Absence of inflammation.

1 = Mild inflammation: slight change in color and little change in texture.

2 = Moderate inflammation: moderate glazing, redness, edema, hypertrophy. Tendency to bleed upon probing.

3 = Severe inflammation: marked redness and hypertrophy. Tendency to spontaneous bleeding.

Whole-mouth mean scores were obtained by averaging the values obtained over all scoreable surfaces in the mouth.

Oral Soft and Hard Tissue Assessments. The dental examiner visually examined the oral cavity and peri-oral area using a dental light and dental mirror. This examination included an assessment of the soft and hard palate, gingival mucosa, buccal mucosa, mucogingival fold areas, tongue, sublingual and submandibular areas, salivary glands, and the tonsillar and pharyngeal areas of the mouth.

Adverse Events. Adverse events were obtained from an interview with the subject and a dental examination by the investigator.

Statistical Methods

Statistical analyses were performed separately for the gingival index and plaque index. Comparisons of the treatment groups with respect to baseline plaque and gingivitis scores, as well as for age, were performed using analyses of variance (ANOVA). Comparisons between the treatment groups with respect to gender were performed using chi-square tests. Within-treatment comparisons of the plaque and gingivitis scores obtained at the six-week, three-month, and six-month examinations versus baseline were performed using paired t-tests. Comparisons of the treatment groups with respect to baseline-adjusted plaque and gingivitis scores at the six-week, three-month, and six-month examinations were performed using analyses of covariance (ANCOVA). All statistical tests of hypothesis were two sided, and employed a level of significance of $\alpha = 0.05$.

Results

Of the one-hundred and twenty-one (121) subjects who entered the study, 109 subjects (90.1%) complied with the protocol and completed the six-month examination. The subjects who did not complete the study were discontinued for reasons unrelated to the use of the study treatments. A summary of the age and gender of the study population who completed the six-month examination is presented in Table I. The treatment groups did not differ significantly with respect to either of these characteristics. Throughout the study, no adverse effects on the soft or hard tissues of the oral cavity were observed by the examiner or reported by the participants when questioned.

Table I
Summary of Age, Gender, and Smoking Status
for Subjects Who Completed the Clinical Study

Treatment	Number of Subjects			Age	
	Male	Female	Total	Mean	Range
Colgate Total Toothpaste ¹	18	36	54	40	21–63
Crest Pro-Health Toothpaste ²	14	41	55	39	21–68

¹A commercially available dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride.

²A commercially available dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate.

Baseline Data

Table II presents a summary of the plaque index and gingival index scores measured at the baseline examination for those subjects who completed the six-month examinations. For plaque index, the mean baseline scores were 3.16 for the Colgate Total Toothpaste group, and 3.19 for the Crest Pro-Health Toothpaste group. For gingival index, the mean baseline scores were 2.17 for the Colgate Total Toothpaste group, and 2.18 for the Crest Pro-Health Toothpaste group. No statistically significant difference was indicated between the treatment groups with respect to plaque or gingival index scores at baseline.

Six-Week Data

Plaque Index. Table III presents a summary of the plaque index scores measured after six weeks of product use.

The mean six-week plaque index scores were 2.12 for the Colgate Total Toothpaste group, and 2.60 for the Crest Pro-Health

Table II

Summary of the Baseline Löe-Silness Gingival Index Scores and Quigley-Hein Plaque Index Scores for Subjects Who Completed the Six-Month Clinical Study

Parameter	Treatment	n	Baseline Summary (Mean $\pm$ SD) ³
Plaque Index	Colgate Total Toothpaste ¹	54	3.16 $\pm$ 0.64
	Crest Pro-Health Toothpaste ²	55	3.19 $\pm$ 0.56
Gingival Index	Colgate Total Toothpaste ¹	54	2.17 $\pm$ 0.36
	Crest Pro-Health Toothpaste ²	55	2.18 $\pm$ 0.40

¹A commercially available dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride.

²A commercially available dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate.

³No statistically significant difference was indicated between the two treatment groups at baseline with respect to either the Plaque Index or Gingival Index.

Toothpaste group. The mean percent reductions from baseline were 32.9% for the Colgate Total Toothpaste group, and 18.5% for the Crest Pro-Health Toothpaste group, both of which were statistically significant.

Relative to the Crest Pro-Health Toothpaste group, the Colgate Total Toothpaste group exhibited a statistically significant 18.5% reduction in plaque index scores after six weeks of product use.

Gingival Index. Table IV presents a summary of the gingival index scores measured after six weeks of product use.

The mean six-week gingival index scores were 1.40 for the Colgate Total Toothpaste group, and 1.76 for the Crest Pro-Health Toothpaste group. The mean percent reductions from baseline

were 35.5% for the Colgate Total Toothpaste group, and 19.3% for the Crest Pro-Health Toothpaste group, both of which were statistically significant.

Relative to the Crest Pro-Health Toothpaste group, the Colgate Total Toothpaste group exhibited a statistically significant 20.5% reduction in gingival index scores after six weeks of product use.

Three-Month Data

Plaque Index. Table V presents a summary of the plaque index scores measured after three months of product use.

The mean three-month plaque index scores were 1.95 for the Colgate Total Toothpaste group, and 2.46 for the Crest Pro-Health Toothpaste group. The mean percent reductions from baseline were 38.3% for the Colgate Total Toothpaste group, and 22.9% for the Crest Pro-Health Toothpaste group, both of which were statistically significant.

Relative to the Crest Pro-Health Toothpaste group, the Colgate Total Toothpaste group exhibited a statistically significant 20.7% reduction in plaque index scores after three months of product use.

Gingival Index. Table VI presents a summary of the gingival index scores measured after three months of product use.

The mean three-month gingival index scores were 1.20 for the Colgate Total Toothpaste group, and 1.48 for the Crest Pro-Health Toothpaste group. The mean percent reductions from baseline were 44.7% for the Colgate Total Toothpaste group, and 32.1% for the Crest Pro-Health Toothpaste group, both of which were statistically significant.

Table III

Summary of the Six-Week Plaque Index Scores for Subjects Who Completed the Six-Month Clinical Study

Treatment	n	Six-Week Summary (Mean $\pm$ SD)	Within-Treatment Analysis		Between-Treatment Analysis	
			Percent Reduction ³	Sig. ⁴	Percent Difference ⁵	Sig. ⁶
Colgate Total Toothpaste ¹	54	2.12 $\pm$ 0.51	32.9%	p < 0.05	18.5%	p < 0.05
Crest Pro-Health Toothpaste ²	55	2.60 $\pm$ 0.57	18.5%	p < 0.05		

¹A commercially available dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride.

²A commercially available dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate.

³Percent reduction exhibited by the six-week mean relative to the baseline mean. A positive value indicates a lower plaque score at the six-week examination.

⁴Significance of paired t-test comparing the baseline and six-week examinations.

⁵Difference between six-week means expressed as a percentage of the six-week mean for Crest Pro-Health Toothpaste. A positive value indicates a lower plaque score for Colgate Total Toothpaste than for Crest Pro-Health Toothpaste.

⁶Significance of post-ANCOVA comparison of baseline-adjusted means.

Table IV

Summary of the Six-Week Gingival Index Scores for Subjects Who Completed the Six-Month Clinical Study

Treatment	n	Six-Week Summary (Mean $\pm$ SD)	Within-Treatment Analysis		Between-Treatment Analysis	
			Percent Reduction ³	Sig. ⁴	Percent Difference ⁵	Sig. ⁶
Colgate Total Toothpaste ¹	54	1.40 $\pm$ 0.24	35.5%	p < 0.05	20.5%	p < 0.05
Crest Pro-Health Toothpaste ²	55	1.76 $\pm$ 0.24	19.3%	p < 0.05		

¹A commercially available dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride.

²A commercially available dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate.

³Percent reduction exhibited by the six-week mean relative to the baseline mean. A positive value indicates a lower gingivitis score at the six-week examination.

⁴Significance of paired t-test comparing the baseline and six-week examinations.

⁵Difference between six-week means expressed as a percentage of the six-week mean for Crest Pro-Health Toothpaste. A positive value indicates a lower gingivitis score for Colgate Total Toothpaste than for Crest Pro-Health Toothpaste.

⁶Significance of post-ANCOVA comparison of baseline-adjusted means.

Table V
Summary of the Three-Month Plaque Index Scores for Subjects Who Completed the Six-Month Clinical Study

Treatment	n	Three-Month Summary (Mean $\pm$ SD)	Within-Treatment Analysis		Between-Treatment Analysis	
			Percent Reduction ³	Sig. ⁴	Percent Difference ⁵	Sig. ⁶
Colgate Total Toothpaste ¹	54	1.95 $\pm$ 0.61	38.3%	p < 0.05	20.7%	p < 0.05
Crest Pro-Health Toothpaste ²	55	2.46 $\pm$ 0.51	22.9%	p < 0.05		

¹A commercially available dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride.

²A commercially available dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate.

³Percent reduction exhibited by the three-month mean relative to the baseline mean. A positive value indicates a lower plaque score at the three-month examination.

⁴Significance of paired t-test comparing the baseline and three-month examinations.

⁵Difference between three-month means expressed as a percentage of the three-month mean for Crest Pro-Health Toothpaste. A positive value indicates a lower plaque score for Colgate Total Toothpaste than for Crest Pro-Health Toothpaste.

⁶Significance of post-ANCOVA comparison of baseline-adjusted means.

Table VI
Summary of the Three-Month Gingival Index Scores for Subjects Who Completed the Six-Month Clinical Study

Treatment	n	Three-Month Summary (Mean $\pm$ SD)	Within-Treatment Analysis		Between-Treatment Analysis	
			Percent Reduction ³	Sig. ⁴	Percent Difference ⁵	Sig. ⁶
Colgate Total Toothpaste ¹	54	1.20 $\pm$ 0.27	44.7%	p < 0.05	18.9%	p < 0.05
Crest Pro-Health Toothpaste ²	55	1.48 $\pm$ 0.25	32.1%	p < 0.05		

¹A commercially available dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride.

²A commercially available dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate.

³Percent reduction exhibited by the three-month mean relative to the baseline mean. A positive value indicates a lower gingivitis score at the three-month examination.

⁴Significance of paired t-test comparing the baseline and three-month examinations.

⁵Difference between three-month means expressed as a percentage of the three-month mean for Crest Pro-Health Toothpaste. A positive value indicates a lower gingivitis score for Colgate Total Toothpaste than for Crest Pro-Health Toothpaste.

⁶Significance of post-ANCOVA comparison of baseline-adjusted means.

Table VII
Summary of the Six-Month Plaque Index Scores for Subjects Who Completed the Six-Month Clinical Study

Treatment	n	Six-Month Summary (Mean $\pm$ SD)	Within-Treatment Analysis		Between-Treatment Analysis	
			Percent Reduction ³	Sig. ⁴	Percent Difference ⁵	Sig. ⁶
Colgate Total Toothpaste ¹	54	1.75 $\pm$ 0.65	44.6%	p < 0.05	25.8%	p < 0.05
Crest Pro-Health Toothpaste ²	55	2.36 $\pm$ 0.55	26.0%	p < 0.05		

¹A commercially available dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride.

²A commercially available dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate.

³Percent reduction exhibited by the six-month mean relative to the baseline mean. A positive value indicates a lower plaque score at the six-month examination.

⁴Significance of paired t-test comparing the baseline and six-month examinations.

⁵Difference between six-month means expressed as a percentage of the six-month mean for Crest Pro-Health Toothpaste. A positive value indicates a lower plaque score for Colgate Total Toothpaste than for Crest Pro-Health Toothpaste.

⁶Significance of post-ANCOVA comparison of baseline-adjusted means.

Relative to the Crest Pro-Health Toothpaste group, the Colgate Total Toothpaste group exhibited a statistically significant 18.9% reduction in gingival index scores after three months of product use.

Six-Month Data

Plaque Index. Table VII presents a summary of the plaque index scores measured after six months of product use.

The mean six-month plaque index scores were 1.75 for the Colgate Total Toothpaste group, and 2.36 for the Crest Pro-Health Toothpaste group. The mean percent reductions from baseline were 44.6% for the Colgate Total Toothpaste group, and 26.0% for the Crest Pro-Health Toothpaste group, both of which were statistically significant.

Relative to the Crest Pro-Health Toothpaste group, the Colgate

Total Toothpaste group exhibited a statistically significant 25.8% reduction in plaque index scores after six months of product use.

Gingival Index. Table VIII presents a summary of the gingival index scores measured after six months of product use.

The mean six-month gingival index scores were 1.16 for the Colgate Total Toothpaste group, and 1.40 for the Crest Pro-Health Toothpaste group. The mean percent reductions from baseline were 46.5% for the Colgate Total Toothpaste group, and 35.8% for the Crest Pro-Health Toothpaste group, both of which were statistically significant.

Relative to the Crest Pro-Health Toothpaste group, the Colgate Total Toothpaste group exhibited a statistically significant 17.1% reduction in gingival index scores after six months of product use.

No significant adverse events were reported or observed during this study.

Table VIII
Summary of the Six-Month Gingival Index Scores for Subjects Who Completed the Six-Month Clinical Study

Treatment	n	Six-Month Summary (Mean $\pm$ SD)	Within-Treatment Analysis		Between-Treatment Analysis	
			Percent Reduction ³	Sig. ⁴	Percent Difference ⁵	Sig. ⁶
Colgate Total Toothpaste ¹	54	1.16 $\pm$ 0.29	46.5%	p < 0.05	17.1%	p < 0.05
Crest Pro-Health Toothpaste ²	55	1.40 $\pm$ 0.28	35.8%	p < 0.05		

¹A commercially available dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride.

²A commercially available dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate.

³Percent reduction exhibited by the six-month mean relative to the baseline mean. A positive value indicates a lower gingivitis score at the six-month examination.

⁴Significance of paired t-test comparing the baseline and six-month examinations.

⁵Difference between six-month means expressed as a percentage of the six-month mean for Crest Pro-Health Toothpaste. A positive value indicates a lower gingivitis score for Colgate Total Toothpaste than for Crest Pro-Health Toothpaste.

⁶Significance of post-ANCOVA comparison of baseline-adjusted means.

Discussion and Conclusion

The present randomized clinical trial compared the efficacy of two commercially available dentifrices in the control of established supragingival plaque and gingivitis. This study provided a six-week, three-month, and six-month whole-mouth evaluation of the plaque and gingivitis efficacy of a dentifrice containing 0.3% triclosan, 2.0% PVM/MA copolymer, and 0.243% sodium fluoride (Colgate Total Toothpaste), and a dentifrice containing 0.454% stannous fluoride, sodium hexametaphosphate, and zinc lactate (Crest Pro-Health Toothpaste) when used for one minute, twice daily.

Toothpastes containing the combination of 0.3% triclosan/2.0% copolymer/0.243% sodium fluoride, have been clinically proven in numerous studies to significantly reduce plaque and gingivitis.^{17,21} In addition, antimicrobial tests²² have also been employed to evaluate the effects of oral hygiene products. Haraszthy, *et al.*⁸ assessed the antimicrobial efficacy of commercial dentifrices containing fluoride, stannous fluoride, and triclosan/copolymer/fluoride on the microorganisms frequently present in the oral cavity, and demonstrated that the dentifrice containing the triclosan/copolymer/fluoride (Colgate Total) resulted in a significantly higher inhibition of bacterial growth as compared to both the stannous fluoride (Crest Pro-Health) and the sodium fluoride dentifrices (p < 0.00005). According to Haraszthy, *et al.*⁸ "Colgate Total had a substantially greater effect on gram negative pathogens (including *Aggregatibacter actinomycetemcomitans*, *E. corrodens*, and *F. Nucleatum*), gram positive organisms, such as streptococci, oral yeast, such as *Candida albicans*, and non-oral bacteria, including staphylococci and bacillus spp."

In the present study, subjects assigned to both the Colgate Total Toothpaste group and the Crest Pro-Health Toothpaste group exhibited statistically significant reductions from baseline with respect to supragingival plaque and gingivitis scores at the six-week, three-month, and six-month examinations.

Relative to the Crest Pro-Health Toothpaste group, the Colgate Total Toothpaste group exhibited statistically significant reductions in supragingival plaque index scores of 18.5%, 20.7%, and 25.8% after six weeks, three months, and six months of product use, respectively. For gingival index scores, statistically significant reductions of 20.5%, 18.9%, and 17.1% were exhibited after the same time intervals, respectively.

The results of this double-blind clinical study support the conclusion that a dentifrice containing 0.3% triclosan, 2.0%

PVM/MA copolymer, and 0.243% sodium fluoride provides a significant reduction in established supragingival plaque and gingivitis when used over a period of six months.

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References

- Löe H, Silness J. Periodontal disease in pregnancy. I. Prevalence and severity. *Acta Odontol Scand* 1963;21:533-551.
- Talbott K, Mandel ID, Chilton NW. Reduction of baseline gingivitis scores with repeated prophylaxes. *J Prev Dent* 1977;4:28-29.
- Jeffcoat MK. Prevention of periodontal diseases in adults: strategies for the future. *Prev Med* 1994;23:704-708.
- Position Paper: Epidemiology of Periodontal Diseases. Academy Report. *J Periodontol* 2005;76:1406-1419.
- Dye BA, Tan S, Smith V, Lewis BG, Barker LK, Thornton-Evans G, Eke PI, Beltran-Aguilar ED, Horowitz AD, Li CH. Trends in oral health status: United States, 1988-1994 and 1999-2004. *Vital Health Stat* 2007;11:1-92.
- Stamm JW. Epidemiology of gingivitis. *J Clin Periodontol* 1986;13:360-370.
- Ismail AI, Szpunar SM. The prevalence of total tooth loss, dental caries, and periodontal disease among Mexican Americans, Cuban Americans, and Puerto Ricans: findings from HHANES 1982-1984. *Am J Public Health* 1990;80:66-70.
- Haraszthy V, Zambon JJ, Sreenivasan PK. The antimicrobial efficacy of commercial dentifrices. *Gen Dent* 2010;58:50-55.
- Newman MG, Takei HH, Carranza FA. *Carranza's Clinical Periodontology* 10th ed. WB Saunders Co., Philadelphia, pp. 179-172, 141-147, 2006.
- Research, Science and Therapy Committee of the American Academy of Periodontology. Treatment of plaque-induced gingivitis, chronic periodontitis, and other clinical conditions. Academy report. *J Clin Periodontol* 2001;72:1790-1800.
- <http://ada.org/3072.aspx?currentTab=1>
- Davies RM, Davies GM, Ellwood RP. Prevention. Part 4: Toothbrushing: What advice should be given to patients. *Br Dent J* 2003;3:135-141.
- Joshi K, Zavallos JC, Ritchie CS. Strength of evidence relating periodontal disease and atherosclerotic disease. *Compend Contin Educ Dent* 2009;30:430-439.
- Lindhe J. Triclosan/copolymer/fluoride dentifrices. A new technology for the prevention of plaque, calculus, gingivitis and caries. *Am J Dent* 1990;3(Spec Iss):S3-S4.
- Gaffar A, Nabi N, Kashuba B, Williams M, Herles S, Olsen S, Afflitto J. Anti-plaque effects of dentifrices containing triclosan/copolymer/NaF system versus triclosan dentifrices without the copolymer. *Am J Dent* 1990;3(Spec Iss):S7-S14.
- 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 Iss):197-206.
- Panagakos FS, Volpe AR, Petrone ME, DeVizio W, Davies RM, Proskin

- HM. Advanced oral antibacterial/anti-inflammatory technology: A comprehensive review of the clinical benefits of a triclosan/copolymer/fluoride dentifrice. *J Clin Dent* 2005;16(Suppl):S1-S19.
18. Ciancio SG. Improving our patients' oral health: The role of a triclosan/copolymer/fluoride dentifrice. *Compend Contin Educ Dent* 2007;28:178-183.
19. Quigley GA, Hein JW. Comparative cleansing efficacy of manual and power brushing. *J Am Dent Assoc* 1962;65:26-29.
20. Turesky S, Gilmore ND, Glickman I. Reduced plaque formation by the chloromethyl analogue of vitamin C. *J Periodontol* 1970;41:41-43.
21. Mateu FA, Boneta AE, DeVizio W, Stewart B, Proskin HM. A clinical investigation of the efficacy of two dentifrices for controlling established supragingival plaque and gingivitis. *J Clin Dent* 2008;19:85-94.
22. Fine DH. Chemical agents to prevent and regulate plaque development. *Periodontol 2000* 1995;8:87-107.

Notes

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