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Changing Perspectives on the Use of Antimicrobial Mouthrinses

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As oral health care professionals, we need to make evidence-based recommendations to our patients. Studies from which we derive our recommendations need to have been conducted with scientific rigor and need to be confirmed with other welldesigned studies. Given the numerous, long-term, peer-reviewed published studies on antimicrobial mouthrinses with consistent statistically and clinically significant outcomes, it is time to change our professional thinking and practices.

When considering the oral environment, about 20% is occupied by tooth surfaces, that is, those areas targeted for toothbrushing and flossing.[1] Dental plaque biofilm is not limited to tooth surfaces. About 80% of the remaining surfaces include the oral mucosa and specialized mucosa of the tongue.[1] Saliva, the tongue, and oral mucosa serve as reservoirs of pathogenic bacteria able to relocate and colonize on the teeth and in sulci. Using an antiseptic mouthrinse produces an antimicrobial effect throughout the entire mouth, including areas easily missed during toothbrushing and interdental cleaning. Therefore, it is not surprising that in May 2007, the American Dental Association Council on Scientific Affairs issued new advice highlighting the oral health benefits of ADA-Accepted antimicrobial mouthrinses that help prevent and reduce plaque and gingivitis.[2]

This special Supplement to the *Journal of Dental Hygiene* focuses on our changing beliefs about antimicrobial mouthrinses and their value in maintaining oral health. The papers within contain extensive information about dental plaque biofilms, the effectiveness of antimicrobial mouthrinses, and how to incorporate these agents into patients' oral self-care. Within this Supplement, dental hygienists will find *best practices* regarding antimicrobial mouthrinses so they can confidently recommend their use to patients based on the evidence. Patients look to dental hygienists for trustworthy information that can make a difference in their oral and systemic health. In this Supplement, dental hygienists have evidence-based information about antimicrobial mouthrinses from oral health experts.

Dr. Gurenlian provides a primer on dental plaque biofilm and the perpetual challenges facing its management. Drs. DePaola and Spolarich review the safety and efficacy of the major mouthrinses on the market and provide clear guidance on which products can be confidently recommended to yield predictable clinical health outcomes. New bodies of research evidence encourage the replacement of old beliefs and practices with more effective therapies; but embracing change is arduous, even with strong evidence to support the change. Joanna Asadoorian tackles the challenge of *promptly* translating evidence-based information into practice, particularly when it means change on the part of both the practitioner and the patient. From her paper, dental hygienists will better understand resistance to change, the process of change, and how to use change theory to help themselves and patients incorporate health-promoting behaviors such as twice-daily use of antimicrobial mouthrinse. Asadoorian's approach is also useful in motivating patients to adopt other beneficial oral hygiene measures.

Clinically relevant and easily applied information can be found within these pages. Through this new knowledge, dental hygienists will be equipped to better control plaque and gingivitis in patients who historically may have been excluded from antimicrobial mouthrinse recommendations. I encourage you to read this issue from cover to cover because the knowledge within will make a difference in the way you practice dental hygiene. Share the issue with your colleagues, and keep an issue in your reception area for patients to read. Patients will know that you are a valuable source for oral health care recommendations that improve and promote their health status.

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References

1. Mager DL, Ximenez-Fyvie LA, Haffajee AD, Socransky SS. Articletitle. journaltitle. year. month_if_listed;vol(issue): firstpage-lastpage.
2. American Dental Association. ADA affirms benefits of ADA-Accepted antimicrobial mouth rinses and toothpastes, fluoride mouth rinses [news release] [homepage on the Internet]. City (IL): American Dental Association; May232007. [cited 2007 Jul 27]. Available from: http://ada.org/public/media/releases/0705_release03.asp..

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The Role of Dental Plaque Biofilm in Oral Health

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Overview. Microbial biofilms are complex communities of bacteria and are common in the human body and in the environment. In recent years, dental plaque has been identified as a biofilm, and the structure, microbiology, and pathophysiology of dental biofilms have been described. The nature of the biofilm enhances the component bacteria's resistance to both the host's defense system and antimicrobials. If not removed regularly, the biofilm undergoes maturation, and the resulting pathogenic bacterial complex can lead to dental caries, gingivitis, and periodontitis. In addition, dental biofilm, especially subgingival plaque in patients with periodontitis, has been associated with various systemic diseases and disorders, including cardiovascular disease, diabetes mellitus, respiratory disease, and adverse pregnancy outcomes.

Clinical Implications.An understanding of the nature and athophysiology of the dental biofilm is important to implementing proper management strategies. Although dental biofilm cannot be eliminated, it can be reduced and controlled through daily oral care. A daily regimen of thorough mechanical oral hygiene procedures, including toothbrushing and interdental cleaning, is key to controlling biofilm accumulation. Because teeth comprise only 20% of the mouth's surfaces, for optimal oral health, the use of an antimicrobial mouthrinse helps to control biofilm not reached by brushing and flossing as well as biofilm bacteria contained in oral mucosal reservoirs.

Keywords: Antimicrobial mouthrinse, biofilm, dental plaque, oral health, periodontal disease

Introduction

In contrast to an accumulation of individual bacteria, a biofilm is a complex, communal, 3-dimensional arrangement of bacteria. Bacterial biofilms are ubiquitous and are potentially found in a variety of sites within the human body. For example, they can grow on indwelling catheters, ports, and implants; external surfaces of the eye; artificial heart valves; endotracheal tubes; and contaminated prosthetic joints. Abacterial biofilm is often the cause of persistent infections and has been associated with osteomyelitis, pneumonia in patients with cystic fibrosis, and prostatitis.[1]

In areas related to oral health care, bacterial biofilms are found in dental unit water lines, on tooth surfaces and dental prosthetic appliances, and on oral mucous membranes. Biofilm in the form of supragingival and subgingival plaque is the etiologic agent in dental caries and periodontal diseases (Figure 1).[2-5] The pathogenicity of the dental plaque biofilm is

enhanced by the fact that in biofilm form, the component bacteria have increased resistance to antibiotics and other chemotherapeutic agents and are less able to be phagocytized by host inflammatory cells. Therefore, control of the dental plaque biofilm is a major objective of dental professionals and critical to the maintenance of optimal oral health. This article reviews the characteristics of dental biofilm, its role in the etiology of periodontal diseases, and strategies for controlling the biofilm to promote health.

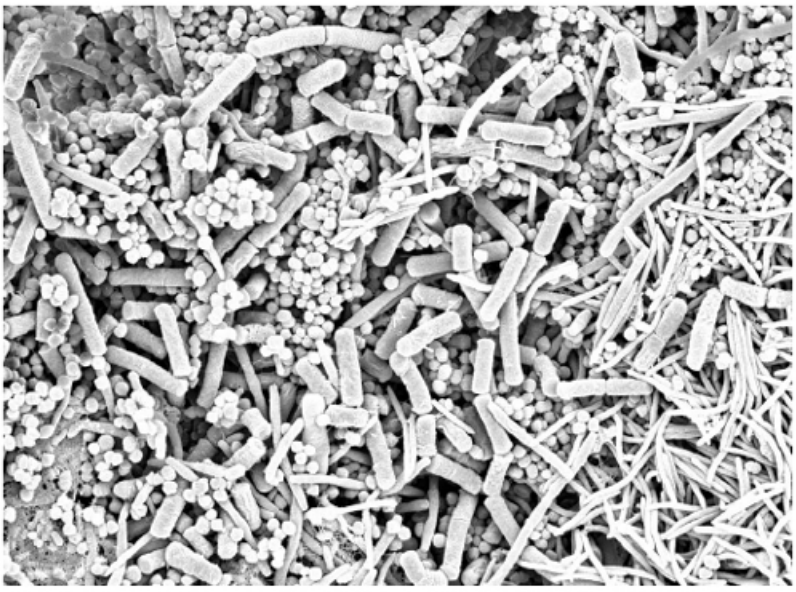

Figure 1. Scanning electron micrograph of biofilm grown from the subgingival plaque of a healthy subject for 10 days anaerobically on saliva-coated hydroxyapatite discs. (Grown by Michael Sedlacek, PhD, and Clay Walker, PhD, at the University of Florida College of Dentistry Periodontal Disease Research Center. Image taken by the University of Florida Electron Microscopy Core Facility.)

Changing Views of Dental Plaque

Over the past 50 years, the understanding and characterization of dental plaque have undergone significant evolution. Loesche[6] proposed both a nonspecific and a specific plaque hypothesis for periodontal disease initiation and progression.

The *nonspecific plaque hypothesis* proposed that the entire microbial community of plaque that accumulated on tooth surfaces and in the gingival crevice contributed to the development of periodontal disease. Plaque bacteria produced virulence factors and noxious products that initiated inflammation, challenged the host defense system, and resulted in the destruction of periodontal tissues. Under this hypothesis, the quantity of plaque was considered to be the critical factor in the development of periodontal disease. Thus, increases in the amount of plaque (quantity), as opposed to specific pathogenic microorganisms (quality) found in the plaque, were viewed as being primarily responsible for inducing disease and disease progression.[7,8]

Studies on the microbial etiology of various forms of periodontitis support the *specific plaque hypothesis*, which proposes that only certain microorganisms within the plaque complex are pathogenic. Despite the presence of hundreds of species of microorganisms in periodontal pockets, fewer than 20 are routinely found in increased proportions at periodontally diseased sites. These specific virulent bacterial species activate the host's immune and inflammatory responses that then cause bone and soft tissue destruction.[6,8,9]

Socransky and colleagues[4,10] recognized that early plaque consists predominantly of gram-positive organisms and that if the plaque is left undisturbed it undergoes a process of maturation resulting in a more complex and predominantly gram-negative flora. These investigators assigned the organisms of the subgingival microbiota into groups, or complexes, based on their association with health and various disease severities (Figure 2).[4,10] Color designations were used to denote the association of particular bacterial complexes with periodontal infections. The *blue*, *yellow*, *green*, and *purple* complexes designate early colonizers of the subgingival flora. *Orange* and *red* complexes reflect late colonizers associated with mature subgingival plaque. Certain bacterial complexes are associated with health or disease.[10,11] For example, the bacteria in the red complex are more likely to be associated with clinical indicators of periodontal disease such as periodontal pocketing and clinical attachment loss.

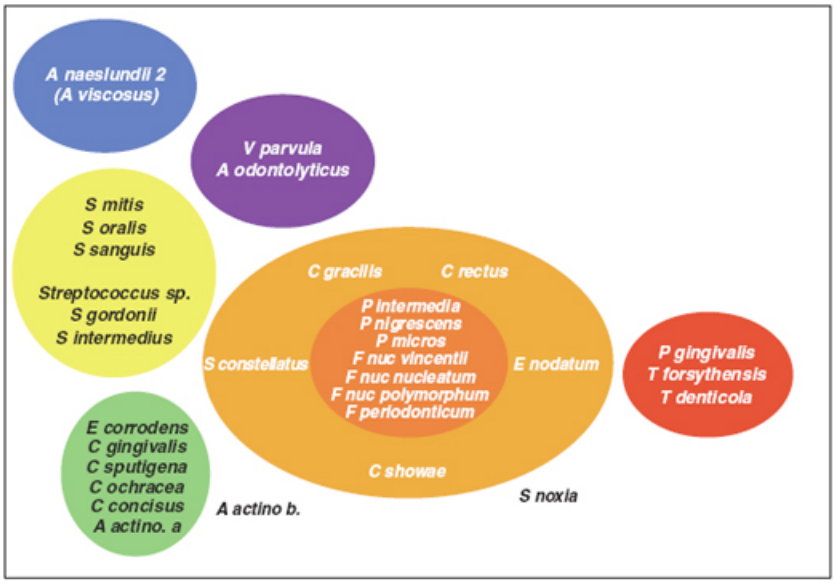

Figure 2. Microbial complexes in subgingival biofilm.[4,10] (Modified from Socransky SS, Haffajee AD, Cugini MA, et al. Microbial complexes in subgingival plaque. J Clin Periodontol 1998;25:134-144. Reprinted with permission from Blackwell Publishing.)

Plaque Recognized as a Biofilm

Research over the past decade has led to the recognition of dental plaque as a biofilm - a highly organized accumulation of microbial communities attached to an environmental surface. Biofilms are organized to maximize energy, spatial arrangements, communication, and continuity of the community of microorganisms.

Biofilms protect bacteria living within their structures and thereby provide an advantage over free-floating (planktonic) bacteria. The slimy extracellular matrix produced by biofilm bacteria encloses the microbial community and protects it from the surrounding environment, including attacks from chemotherapeutic agents. Chemotherapeutic agents have difficulty penetrating the polysaccharide matrix to reach and affect the microorganisms.[1,11-13] Thus, the matrix helps to protect bacteria deep within the biofilm from antibiotics and antiseptics, increasing the likelihood of the colonies' survival. Furthermore, the extracellular matrix keeps the bacteria banded together, so they are not flushed away by the action of saliva and gingival crevicular fluid. Mechanical methods, including toothbrushing, interdental cleaning, and professional scaling procedures, are required to regularly and effectively disrupt and remove the plaque biofilm. Antiseptics, such as mouthrinses, can help to control the biofilm but must be formulated so as to be able to penetrate the plaque matrix and gain access to the pathogenic bacteria.

Biofilms have a definite architectural structure. The bacteria are not uniformly distributed throughout the biofilm; rather, there are aggregates of microcolonies that vary in shape and size. Channels between the colonies allow for circulation of nutrients and by-products and provide a system to eliminate wastes.[14,15] Microorganisms on the outer surface of biofilms are not as strongly attached within the matrix and tend to grow faster than those bacteria deeper within the biofilm. Surface microorganisms are more susceptible to detachment, a characteristic that facilitates travel to form new biofilm colonies on nearby oral structures and tissues.

Bacteria in biofilm communicate with each other by a process called *quorum sensing*. This dynamic, sophisticated communication system enables bacteria to monitor each other's presence and to modulate their gene expression in response to the number of bacteria in a given area of the biofilm.8 In addition, as a result of quorum sensing, portions of the biofilm can become detached in order to maintain a cell density compatible with continued survival.

Stages of Biofilm Formation

The growth and development of biofilm are characterized by 4 stages: initial adherence, lag phase, rapid growth, and steady state. Biofilm formation begins with the adherence of bacteria to a tooth surface, followed by a lag phase in which changes in genetic expression (phenotypic shifts)occur. A period of rapid growth then occurs, and an exopolysaccharide matrix is produced. During the steady state, the biofilm reaches growth equilibrium. Surface detachment and sloughing occur, and new bacteria are acquired.

Initial Adherence and Lag Phase

The first phase of supragingival biofilm formation is the deposition of salivary components, known as *acquired pellicle*, on tooth surfaces. This pellicle makes the surface receptive to colonization by specific bacteria. Salivary glands produce a variety of proteins and peptides that further contribute to biofilm formation. For example, salivary mucins, such as MUC5B and MUC7, contribute to the formation of acquired pellicle,[16,17] and statherin, a salivary acidic phosphoprotein, and proline-rich proteins promote bacterial adhesion to tooth surfaces.[18] Acquired pellicle formation begins within minutes of a professional prophylaxis; within 1 hour, microorganisms attach to the pellicle. Usually, gram-positive cocci are the first microorganisms to colonize the teeth. As bacteria shift from planktonic to sessile life, a phenotypic change in the bacteria occurs requiring significant genetic up-regulation (gene signaling that promotes this shift). As genetic expression shifts, there is a lag in bacterial growth.

Rapid Growth

During the rapid growth stage, adherent bacteria secrete large amounts of water-insoluble extracellular polysaccharides to form the biofilm matrix. The growth of microcolonies within the matrix occurs. With time, additional varieties of bacteria adhere to the early colonizers - a process known as *coaggregation* - and the bacterial complexity of the biofilm increases. These processes involve unique, selective molecular interactions leading to structural stratification within the biofilm. Coaggregation and subsequent cell division also increase the thickness of biofilm.[19-21]

Steady State/Detachment

During the steady state phase, bacteria in the interior of biofilms slow their growth or become static. Bacteria deep within the biofilm show signs of death with disrupted bacterial cells and other cells devoid of cytoplasm; bacteria near the surface remain intact. During this phase, crystals can be observed in the interbacterial matrix that may represent initial calculus mineralization.[22] As noted above, during the steady state stage, surface detachment and sloughing also occur, with some bacteria traveling to form new biofilm colonies.

Biofilm and Oral Disease

Biofilms can cover surfaces throughout the oral cavity. Microcolonies exist on oral mucosa, the tongue, biomaterials used for restorations and dental appliances, and tooth surfaces above and below the gingival margin (Figure 3). It is important for oral health professionals to communicate to their patients that both dental caries and periodontal disease are infectious diseases resulting from dental plaque biofilm accumulation. Each of these diseases requires specific strategies for prevention and treatment.

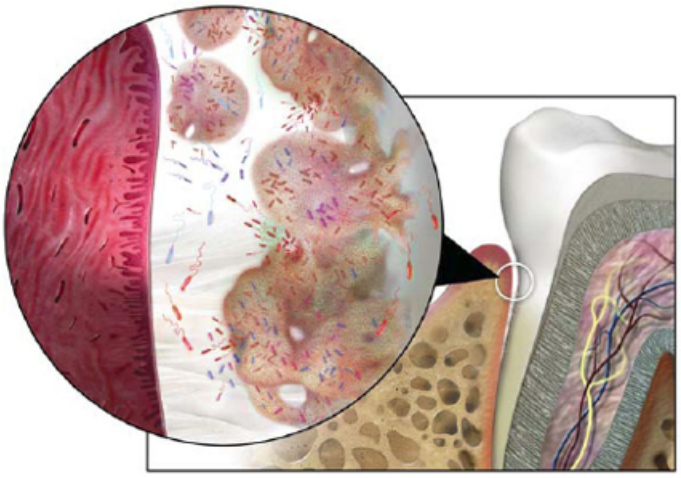

Figure 3. Biofilm lodges in the crevices around the teeth both above and below the gingival margin. Accumulation of dental plaque biofilm can result in dental caries and periodontal disease. (Figure copyright 2006 Keith Kasnot, MA, CMI, FAMI.)

With respect to periodontal disease, dental plaque biofilm demonstrates a succession of microbial colonization with changes in bacterial flora observed from health to disease. Researchers studied over 13,000 plaque samples from 185 patients with conditions ranging from oral health to periodontal disease.[4,23] As noted above, based on their findings, a number of microbial complexes were identified that were associated with various stages of disease initiation and progression. Bacterial species contained in the yellow, green, and purple complexes appear to colonize the subgingival sulcus first and predominate in gingival health. In contrast, orange complex bacteria are associated with gingivitis and gingival bleeding. Interestingly, bacteria of the orange complex may also be associated with red complex microorganisms including *Porphyromonas gingivalis*, *Tannerella forsythensis*, and *Treponema denticola*, organisms found in greater numbers in diseased sites and in more advanced periodontal disease.[10,24]

Bacterial communities living in a biofilm possess resourceful survival strategies, including a broader habitat for growth, nutrition, waste elimination, and new colonization; environmental niches for safety; barriers to thwart antimicrobial drug therapy; protection from the host's defense system including phagocytosis; and enhanced pathogenicity.[1,8] These strategies account for the ongoing challenge of successfully controlling periodontal infection and disease progression.[25]

As the biofilm matures and proliferates, soluble compounds produced by pathogenic bacteria penetrate the sulcular epithelium. These compounds stimulate host cells to produce chemical mediators associated with the inflammatory process[26] (see Figure 4).

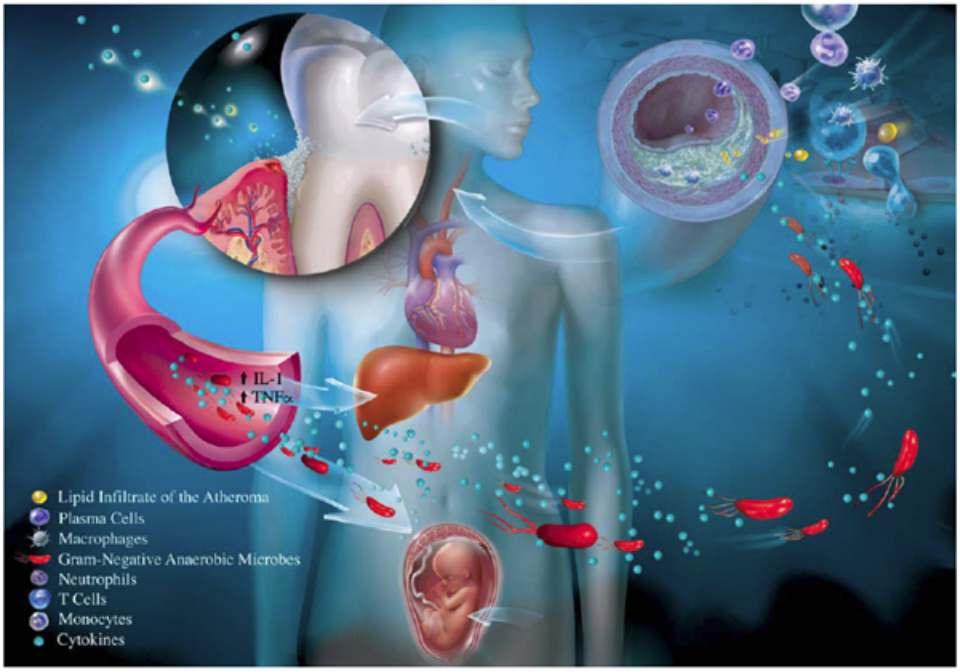

Figure 4. Subgingival plaque bacteria and/or their products may gain access to distant sites in the body through the circulatory system and may potentially contribute to systemic inflammation; in this way, a dental biofilm infection may potentially contribute to various systemic diseases and conditions. (Illustration owned by McNEIL-PPC, Inc. and provided for educational purposes only. May not be reproduced without the prior written permission of McNEIL-PPC, Inc.)

- Interleukin-1 beta (IL-1), prostaglandins, tumor necrosis factor alpha (TNF-α), and matrix metalloproteinases are mediators that recruit neutrophils to the area via chemotaxis and cause increased permeability of gingival blood vessels, permitting plasma proteins to migrate from within the blood vessels into the tissue.
- As the gingival inflammatory process continues, additional mediators are produced, and more inflammatory cell types such as neutrophils, T cells, and monocytes are recruited to the area.
- Proinflammatory cytokines are produced in the tissues as a response to the chronic inflammatory process, and these proteins may further escalate the local inflammatory response and affect the initiation and progression of systemic inflammation and disease.

The result of this chronic inflammation is a breakdown of gingival collagen and accumulation of an inflammatory infiltrate, leading to the clinical signs of gingivitis. In some individuals, the inflammatory process will also lead to the breakdown of collagen in the periodontal ligament and resorption of the supporting alveolar bone. It is at this point that the lesion progresses from gingivitis to periodontitis, continuing the same challenge from proinflammatory mediators as with chronic gingivitis. Thus, controlling dental plaque biofilm is essential to preventing and reversing gingivitis as well as preventing and managing periodontitis.

Periodontal Biofilm Infection and Systemic Health

In recent years, studies have demonstrated an association between periodontitis and various systemic diseases and conditions, including cardiovascular disease, diabetes mellitus, respiratory disease, adverse pregnancy outcomes, obesity, pancreatic cancer, and Alzheimer's disease.[27-57] While several of these associations have not been definitively established, biological mechanisms explaining some of the more extensively studied relationships are emerging.

The association between periodontal disease and some systemic diseases may relate to the ability of subgingival plaque bacteria and/or their products to gain access to the systemic circulation through the ulcerated epithelium of the periodontal

pocket. For example, environmental niches like a subgingival pocket that contains anaerobic gram-negative microorganisms can potentially seed orange and red complex bacteria and/or their products to distant sites through the circulatory system. In this way, a dental biofilm infection can potentially contribute to both oral and systemic inflammation.[25]

Research on Periodontal Microorganisms

Atheromas. Direct evidence for the role of dental biofilm infection in systemic inflammation comes from findings of periodontal microorganisms in human carotid atheromas. Studies of atheromatous lesions in carotid arteries revealed that over 40% of atheromas contain antigens from periodontal pathogens including P gingivalis, T forsythensis, and Prevotella intermedia. [28,58] In addition, P gingivalis is known to induce platelet aggregation, a component of atheroma and thrombus formation,[29] and invade endothelial cells in cell cultures.[59] While such findings suggest a possible invasion of atheromas by oral pathogens as well as possible contribution to their development, it is important to note that causality has yet to be established. Preterm Birth. Research suggests that periodontal pathogens may travel via the bloodstream from the oral cavity to the placenta initiating preterm birth. In an animal model, Han and coworkers60 found that periodontal bacteria, including *Fusobacterium nucleatum,* entered the bloodstream from ulcerated gingival sulci or periodontal pockets and negatively influenced the normal birth process.

Respiratory Disease. Likewise, biofilm in the oral cavity may serve as a reservoir of infection leading to respiratory disease. *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and enteric bacteria have been shown to colonize the teeth of patients admitted to hospitals and long-term care facilities. These bacteria may be released into saliva and aspirated into the lower airway causing respiratory infection.[46-49,61] Intubation is another vehicle by which bacteria from the oral biofilm can be directly introduced into the respiratory system. Intubation tubes support biofilm growth contributing to nosocomial infection such as pneumonia. This is one reason why oral intubation raises the risk of nosocomial infection in intensive and critical care hospital populations.

Association With Chronic Diseases and Conditions

Research has also suggested that the association between oral inflammation and systemic inflammation may be key to understanding and managing the significant, deleterious effects on the multiple organ systems involved in some chronic diseases and conditions (Figure 4).[26]

Cardiovascular Disease. Cardiovascular disease is characterized by inflammatory plaque accumulation in blood vessels that can cause thromboses and lead to myocardial infarction. Atherosclerosis represents a chronic inflammatory process that causes endothelial dysfunction and injury to the elastic and muscular arterial tissue. Early atherosclerotic lesions contain neutrophils, monocytes, and lymphocytes. These leukocytes can affect the vascular endothelial lining and cause oxidation of low-density lipoproteins. As a result, monocytes, induced to become macrophages, take up these oxidized lipoproteins and become lipid-laden foam cells. As the lesion progresses, the extracellular matrix of the vessel wall is degraded by proteolytic enzymes and becomes susceptible to rupture. Thromboses can occlude blood flow to the heart and brain and eventually lead to infarction, heart attack, or stroke.[26]

Since atherosclerosis is inflammatory by nature, identifying inflammatory markers that correlate with disease state is important. One recognized and consistent marker of systemic inflammation and poor cardiovascular prognosis is the acute-phase protein C-reactive protein (CRP), the level of which rises with systemic inflammation.[62], Animal model studies of the relationship between cardiovascular disease and periodontal disease demonstrate that clinically induced oral infection with *P gingivalis* will increase atheroma size and elevate CRP levels in the blood.[30] Conversely, some studies have shown that treatment of periodontitis decreases CRP blood levels,[64] though this has not been a consistent finding.

***Diabetes Mellitus*.** Diabetes mellitus is another chronic systemic disease associated with periodontitis. In fact, periodontitis has been identified as one of the major complications of diabetes.[65] Although diabetes increases the susceptibility to periodontal disease,[38,39,65] periodontitis may also increase the difficulty of maintaining satisfactory glycemic control in people with diabetes as compared with those with diabetes without periodontitis.[40] One biological mechanism proposed

to explain the increased incidence and severity of periodontal disease in individuals with diabetes is the finding of elevated levels of inflammatory mediators in the gingival crevicular fluid from periodontal pockets of patients with diabetes with poor glycemic control as compared with those with diabetes who are well controlled or those without diabetes. Those with poor glycemic control had considerable periodontal destruction with an equivalent bacterial challenge.[39,66] Of note, the proinflammatory cytokine TNF-α plays a significant role in this process. TNF-α has a major role in insulin resistance, the primary cause of type 2 diabetes, and is produced in large quantities by fat cells. Periodontitis also has been associated with increased levels of TNF-α. Elevated levels of TNF-α may lead to greater bone loss by killing cells that repair damaged connective tissue or bone. Elevated TNF-α levels also may exacerbate insulin resistance and worsen glycemic control.[44,66,67]

Adverse Pregnancy Outcomes. Studies also demonstrate that periodontal diseases are associated with the risk of adverse pregnancy outcomes, especially preterm low-birthweight infants.[50-52] Chronic infection, such as that found with chronic periodontitis, can stimulate the inflammatory process throughout the body. In the placenta, this may lead to elevated amniotic levels of prostaglandins, TNF-α, and IL-1 and IL-6, stimulating premature rupture of membranes, preterm labor, and the birth of lowbirth- weight infants. Intervention studies are currently under way to investigate a cause and effect relationship between advanced periodontitis and adverse pregnancy outcomes.

Strategies for Managing Dental Biofilm to Promote Health

Although dental biofilm cannot be completely eliminated, its pathogenicity can be lessened through effective oral hygiene measures. Daily toothbrushing, interdental cleaning, and the use of topical antimicrobial chemotherapeutics are patient-based strategies to reduce the bacterial biofilm and to help prevent periodontal diseases. American Dental Association (ADA)-Accepted antimicrobial mouthrinses have been shown to help prevent and reduce plaque and gingivitis when added to a daily oral hygiene regimen of mechanical plaque removal. Further, bacteria from the biofilm on mucosal and tooth surfaces are shed constantly into saliva and transferred to other areas of the mouth. Since oral mucosa, which represents about 80% of the oral cavity surface,[68] can serve as a reservoir for pathogenic bacteria that can be transferred to the tooth surface and sulcus, supplementing mechanical plaque control methods with topical antimicrobials may also play an important role in reducing reservoirs of pathogens that are unaffected by brushing and flossing directed at the tooth surface.

Using Evidence in Practice

Products recommended to patients should be those that have documented efficacy and safety. Only 2 nationally branded antiseptic mouthrinses and their generic equivalents have received the ADA Council on Scientific Affairs Seal of Acceptance for control of supragingival plaque and gingivitis: Listerine® (fixed combination of essential oils) and Peridex® (0.12% chlorhexidine gluconate). However, due to recent changes in the ADA Seal Program, Peridex® and its generic equivalents no longer carry the ADASeal because chlorhexidine gluconate is a prescription product. The fixed combination of essential oils and cetylpyridinium chloride have also been reviewed by a Food and Drug Administration (FDA) advisory committee and have received a Category I recommendation, meaning they have been found to be safe and effective for the control of supragingival plaque and gingivitis. Peridex® and its generic equivalents, which are prescription products, have been approved for marketing by the FDA via the New Drug Application route (or for generics, the Abbreviated New Drug Application process). Examples of effective antimicrobial mouthrinses currently on the market appear in Table I.

Table I. Examples of Antiseptic Mouthrinses*

Active Ingredients	Brands	Indications	Contraindications
0.12% Chlorhexidine gluconate (available by prescription)	Peridex®† (3M ESPE, St Paul, MN) PerioGard®† (Colgate Oral Pharmaceuticals, Inc., Canton, MA) PerioRx®† (Discus Dental, Culver City, CA) Canton, MA) Various generics†	Gingivitis, supragingival plaque	Those hypersensitive to chlorhexidinegluconate or other formula ingredients. Long-term use: can cause moderate staining, increased calculus formation, and possible alteration of taste perception
Four essential oils: eucalyptol, menthol, methyl salicylate, thymol	Listerine® Antiseptic† (Johnson & Johnson Healthcare Products Division of McNEIL-PPC, Inc., Skillman, NJ) Various generics†	Supragingival plaque, gingivitis, oral malodor	Children under 12 years
Cetylpyridinium chloride	Breath Rx® (Discus Dental, Culver City, CA) Colgate Viadent® (Colgate-Palmolive, New York, NY) Crest® Pro-Health™ Rinse (Procter & Gamble, Cincinnati, OH)	Supragingival plaque, gingivitis, oral malodor	Children under 6 years

* For the mechanisms of actions of antiseptic mouthrinses, see pages 19 and 20.
† Has received the ADA Seal of Acceptance; note that as the ADA Seal program has recently phased out prescription products, chlorhexidine gluconate products no longer carry the ADA Seal.

Conclusion

Dental biofilm is a complex, organized microbial community that is the primary etiologic factor for the most frequently occurring oral diseases, dental caries and periodontal diseases. Although the dental biofilm cannot be eliminated, it can be controlled with comprehensive mechanical and chemotherapeutic oral hygiene practices. Teaching patients to use daily brushing, interdental cleaning, and antimicrobial mouthrinses that carry the ADA Seal of Acceptance increases the likelihood of periodontal disease prevention and reduction. Although additional research is needed, there is the possibility that these cost-effective, preventive strategies may minimize the effect of periodontal diseases on specific systemic conditions.

References

1. Costerton JW, Stewart PS, Greenberg EP. Bacterial biofilms: a common cause of persistent infections. Science. 1999;284: 1318-1322.
2. van Houte J. Role of micro-organisms in caries etiology. J Dent Res. 1994;73: 672-681.
3. Stenudd C, Nordlund A, Ryberg M, et al.. The association of bacterial adhesion with dental caries.. J Dent Res. 2001;80: 2005-2010.
4. Socransky SS, Haffajee AD, Cugini MA, et al.. Microbial complexes in subgingival plaque. J Clin Periodontol. 1998;25: 134-144.
5. Haffajee AD, Socransky SS. Microbial etiological agents of destructive periodontal diseases. Periodontol 2000. 1995;5: 78-11.
6. Loesche WJ. Chemotherapy of dental plaque infections.. Oral Sci Rev. 1976;9: 65-107.
7. Theilade E. The non-specific theory in microbial etiology of inflammatory periodontal disease. J Clin Periodontol. 1986;13: 905-911.
8. Thomas JG, Nakaishi LA. Managing the complexity of a dynamic biofilm. J Am Dent Assoc.. 2006;137(11 suppl): 10S-13S.
9. Loesche WJ. DNA probe and enzyme analysis in periodontal diagnostics. J Periodontol. 1992;63: 1102-1109.
10. Socransky SS, Haffajee AD. Periodontal microbial etiology. Periodontol 2000. 2005;38: 135-187.
11. Socransky SS, Haffajee AD. Dental biofilms: difficult therapeutic targets. Periodontol 2000. 2002;28: 12-34.
12. Brown MR, Gilbert P. Sensitivity of biofilms to antimicrobial agents. J Appl Bacteriol. 1993;74(suppl): 87S-97S.
13. Gilbert P, Das J, Foley I. Biofilm susceptibility to antimicrobials. Adv Dent Res. 1997;11: 160-167.
14. Costerton JW, Lewandowski Z, DeBeer D, et al.. Biofilms, the customized microniche. J Bacteriol. 1994;176: 2137-2142.
15. Wood SR, Kirkham J, Marsh PD, et al.. Architecture of intact natural human plaque biofilms studied by confocal laser scanning microscopy.. J Dent Res. 2000;79: 21-27.

16. Levine MJ, Reddy MS, Tabak LA, et al.. Structural aspects of salivary glycoproteins. J Dent Res. 1987;66: 436-441.
17. Tabak LA, Levine MJ, Mandel ID, Ellison SA. Role of salivary mucins in the protection of the oral cavity. J Oral Pathol. 1982;11: 1-17.
18. Gibbons RJ, Hay DI. Human salivary acidic proline-rich proteins and statherin promote the attachment of Actinomyces viscosus LY7 to apatitic surfaces. Infect Immun. 1988;56: 439-445.
19. Costerton JW, Cheng KJ, Geesey GG, et al.. Bacterial biofilms in nature and disease. Annu Rev Microbiol.. 1987;41: 435-464.
20. Gibbons RJ. Microbial ecology: adherent interactions which may affect microbial ecology in the mouth. J Dent Res. 1984;63: 378-385.
21. Whittaker CJ, Klier CM, Kolenbrander PE. Mechanisms of adhesion by oral bacteria. Annu Rev Microbiol. 1996;50: 513-552.
22. Wirthlin MR, Armitage GC. Dental plaque and calculus: microbial biofilms and periodontal diseases. . In: Rose LF, Mealey BL, Genco RJ, Cohen W. , editors. Periodontics: Medicine, Surgery and Implants. St. Louis, MO: Elsevier Mosby; 2004.
23. Socransky SS, Haffajee AD, Ximenez-Fyvie LA, et al.. Ecological considerations in the treatment of Actinobacillus actinomycetemcomitans and Porphyromonas gingivalis periodontal infections. Periodontol 2000. 1999;20: 341-362.
24. Kojima T, Yasui S, Ishikawa I. Distribution of Porphyromonas gingivalis in adult periodontitis patients.. J Periodontol. 1993;64: 1231-1237.
25. Grossi S, Mealey BL, Rose LF. Effects of periodontal infection on the systemic condition. . In: Rose LF, Mealey BL, Genco RJ, Cohen W. , editors. Periodontics: Medicine, Surgery and Implants. St. Louis, MO: Elsevier Mosby; 2004.
26. Gurenlian JR. Inflammation: the relationship between oral health and systemic disease.. Access. 2006;20(4)suppl: 1-9.
27. Epstein SE. The multiple mechanisms by which infection may contribute to atherosclerosis development and course.. Circ Res. 2002;90: 2-4.
28. Haraszthy VI, Zambon JJ, Trevisan M, et al.. Identification of periodontal pathogens in atheromatous plaques. J Periodontol. 2000;71: 1554-1560.
29. Herzberg MC, Meyer MW. Effects of oral flora on platelets: possible consequences in cardiovascular disease.. J Periodontol. 1996;67: 1138-1142.
30. Paquette DW. The periodontal-cardiovascular link. Compend Contin Educ Dent. 2004;25: 681-692.
31. Desvarieux M, Demmer RT, Rundek T. Periodontal microbiota and carotid intima-media thickness: the oral infections and vascular disease epidemiology study (INVEST). Circulation. 2005;111: 576-582.
32. Tiong AY, Brieger D. Inflammation and coronary artery disease. Am Heart J. 2005;150: 11-18.
33. Meurman JH, Sanz M, Janket SJ. Oral health, atherosclerosis, and cardiovascular disease. Crit Rev Oral Biol Med. 2004;15: 403-413.
34. Chun YH, Chun KR, Olguin D, Wang HL. Biological foundation for periodontitis as a potential risk factor for atherosclerosis. J Periodontal Res. 205;40: 87-95.
35. Hung HC, Willett W, Merchant A, et al.. Oral health and peripheral arterial disease. Circulation. 2003;107: 1152-1157.
36. Wu T, Trevisan M, Genco RJ, et al.. Periodontal disease and risk of cerebrovascular disease: the first national health and nutrition examination survey and its follow-up study.. Arch Intern Med.. 2000;160: 2749-2755.
37. Joshipura KJ, Hung HC, Rimm EB, et al.. Periodontal disease, tooth loss, and incidence of ischemic stroke. Stroke. 2003;34: 47-52.
38. Nishimura F, Takahashi K, Kurihara M, et al.. Periodontal disease as a complication of diabetes mellitus. Ann Periodontol. 1998;3: 20-29.
39. Ryan ME, Carnu O, Kamer A. The influence of diabetes on the periodontal tissues. Am Dent Assoc. 2003;134: 34S-40S.
40. Taylor GW, Burt BA, Becker MP, et al.. Severe periodontitis and risk for poor glycemic control in patients with non-insulindependent diabetes mellitus. J Periodontol. 1996;67(Suppl 10): 1085-1093.
41. Grossi SG, Skrepcinski FB, DeCaro T, et al.. Treatment of periodontal disease in diabetics reduces glycated hemoglobin. J Periodontol.. 1997;68: 713-719.
42. Miller LS, Manwell MA, Newbold D. The relationship between reduction in periodontal inflammation and diabetes control: a report of 9 cases. J Periodontol. 1992;63: 843-848.
43. Mealey BL, Rethman MP. Periodontal disease and diabetes mellitus: bidirectional relationship. Dent Today. 2003;22: 107-113.
44. Grossi SG, Genco RJ. Periodontal disease and diabetes mellitus: a two-way relationship. Ann Periodontol. 1998;3: 51-61.
45. Taylor GW. Bidirectional interrelationships between diabetes and periodontal diseases: an epidemiologic perspective. Ann Periodontol. 2001;6: 99-112.
46. Scannapieco FA. Role of oral bacteria in respiratory infection. J Periodontol. 1999;70 793-802.
47. Scannapieco FA, Bush RB, Paju S. Associations between periodontal disease and risk for nosocomial bacterial pneumonia and chronic obstructive pulmonary disease: a systematic review. Ann Periodontol. 2003;8: 54-69.
48. Hayes C, Sparrow D, Cohen M, et al.. The association between alveolar bone loss and pulmonary function: the VA Dental Longitudinal Study. Ann Periodontol. 1998;3: 257-261.
49. Scannapieco FA, Ho AW. Potential associations between chronic respiratory disease and periodontal disease: analysis of National Health and Nutrition Examination Survey III. J Periodontol. 2001;72: 50-56.

50. Offenbacher S, Katz V, Fertik G, et al.. Periodontal infection as a possible risk factor for preterm low birth weight. J Periodontol. 1996;67(suppl 10): 1103-1113.
51. Jeffcoat MK, Geurs NC, Reddy MS, et al.. Periodontal infection and preterm birth: results of a prospective study.. J Am Dent Assoc. 2001;132: 875-880.
52. Scannapieco FA, Bush RB, Paju S. Periodontal disease as a risk factor for adverse pregnancy outcomes: a systematic review. Ann Periodontol. 2003;8: 70-78.
53. Stein PS, Scheff S, Dawson DR. Alzheimer's disease and periodontal disease: mechanisms underlying a potential bidirectional relationship. Grand Rounds Oral-Sys Med. 2006;1: 14-24D.
54. Michaud DS, Joshipura K, Giovannucci E, Fuchs CS. A prospective study of periodontal disease and pancreatic cancer in US male health professionals. J Natl Cancer Inst. 2007;99: 171-175.
55. Stolzenberg-Solomon RZ, Dodd KW, Blaser MJ, et al.. Tooth loss, pancreatic cancer, and Helicobacter pylori. Am J Clin Nutr. 2003;78: 176-181.
56. Al-Zahrani MS, Bissada NF, Borawskit EA. Obesity and periodontal disease in young, middle-aged, and older adults. J Periodontol. 2003;74: 610-615.
57. Reeves AF, Rees JM, Schiff M, Hujoel P. Total body weight and waist circumference associated with chronic periodontitis among adolescents in the United States. Arch Pediatr Adolesc Med. 2006;160: 894-899.
58. Chiu B. Multiple infections in carotid atherosclerotic plaques. Am Heart J. 1999;138: S534-S536.
59. Dorn BR, Burks JN, Seifert KN, Progulske-Fox A. Invasion of endothelial and epithelial cells by strains of Porphyromonas gingivalis. FEMS Microbiol Lett. 2000;187: 139-144.
60. Han YW, Redline RW, Li M, et al.. Fusobacterium nucleatuminduces premature and term stillbirths in pregnant mice: implication of oral bacteria in preterm birth. Infect Immun. 2004;72: 2272-2279.
61. Scannapieco FA. Periodontal inflammation: from gingivitis to systemic disease?. Compend Contin Educ Dent. 2004;25(suppl 1): 16-25.
62. Ridker PM, Hennekens CH, Buring JE, Rifai N. C-reactive protein and other markers of inflammation in the prediction of cardiovascular disease in women. N Engl J Med. 2000;342: 836-843.
63. Liuzzo G, Biasucci LM, Gallimore JR, et al.. The prognostic value of C-reactive protein and serum amyloid A protein in severe unstable angina. N Engl J Med. 1994;331: 417-424.
64. D'Aiuto F, Parkar M, Andreou G, et al.. Periodontitis and systemic inflammation: control of the local infection is associated with a reduction in serum inflammatory markers. J Dent Res. 2004;83: 156-160.
65. Löe H. Periodontal disease: the sixth complication of diabetes mellitus. Diabetes Care. 1993;16: 329-334.
66. Salvi GE, Yalda B, Collins JD, et al.. Inflammatory mediator response as a potential risk marker for periodontal diseases in insulin-dependent diabetes mellitus patients. J Periodontol. 1997;68: 127-135.
67. Lalla E, Lamster IB, Feit M, et al.. Blockade of RAGE suppresses periodontitis-associated bone loss in diabetic mice.. J Clin Invest. 2000;105: 1117-1124.
68. Mager DL, Ximenez-Fyvie LA, Haffajee AD, Socransky SS. Distribution of selected bacterial species on intraoral surfaces. J Clin Periodontol. 2003;30: 644-654.

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Safety and Efficacy of Antimicrobial Mouthrinses in Clinical Practice

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Efficacy Overview. The use of an antimicrobial mouthrinse is an important adjunct to toothbrushing and interdental cleaning. To varying degrees, chlorhexidine gluconate (CHG), cetylpyridinium chloride (CPC), and essential oils (EO) interrupt the integrity of the bacterial cell membrane, leading to lysis and death. CHG binds to salivary mucins, tooth structure, dental plaque, and oral soft tissues and is released slowly into the mouth, where it inhibits adsorption of bacteria onto teeth. CHG is active against a wide range of gram-positive and gram-negative microorganisms. CPC binds to teeth and plaque to a lesser degree than CHG and is generally less efficacious than CHG. CHG and EO penetrate plaque biofilm and produce changes in microbial cell surface morphology that alter coaggregation, recolonization, and, thus, survival. CHG, CPC, and EO are active against a wide variety of aerobic and anaerobic bacteria. An overview of the Food and Drug Administration and American Dental Association rigorous approval processes for efficacy and safety is provided.

Safety Overview. Long-term use of CHG or EO does not adversely affect the ecology of oral microbial flora, including microbial overgrowth, opportunistic infection, or development of microbial resistance. Long-term use of CHG, CPC, or EO does not contribute to soft tissue lesions or mucosal aberrations and has no serious adverse effect on salivary flow, taste, tooth deposits, or dental restoration. There is no evidence of a causal link between alcohol-containing mouthrinses and the risk of oral and pharyngeal cancer.

Keywords: Antimicrobial mouthrinse, efficacy, gingivitis, mechanism of action, safety

Introduction

Mechanical plaque removal through toothbrushing and flossing has been the universally accepted "gold standard" for maintaining oral health since the early 1960s. However, numerous studies have shown that most patients do not effectively clean interdentally to remove dental plaque daily.[1-3] By the early 1980s, chemotherapeutic agents were marketed as adjuncts to brushing and flossing; however, no definitive guidelines for the evaluation of their safety and efficacy were available. Both the American Dental Association (ADA) and the Food and Drug Administration (FDA) have established standards for assessing the safety and efficacy of over-the-counter (OTC) and prescription mouthrinses.

ADA Safety and Efficacy Guidelines for Mouthrinses

Since 1931, the ADA, through its voluntary Seal of Acceptance Program, has promoted the use of oral and dental products that are both safe and effective. Published guidelines developed by the ADAlist the acceptance criteria for each type of agent, product, or device. In order to obtain the Seal of Acceptance, a company must provide evidence establishing that a submitted agent, product, or device meets or exceeds the guidelines for that particular usage and is safe and effective. Additionally, the product must have been approved for marketing in the United States by the FDA. In 1985, the ADA recognized the potential benefits of some chemotherapeutic formulations, giving impetus to the development of guidelines for the evaluation of antiplaque and antigingivitis chemotherapeutic agents for inclusion in the Seal Program, which are still in use today.[4] In order to be awarded the Seal, an antiplaque and antigingivitis chemotherapeutic must[5]

- Be tested in populations of typical product users in a randomized, parallel-group, or crossover clinical trial in which the test product is compared with a negative control and, if appropriate, an active control
- Be supported by data from at least two 6-month studies conducted at independent sites, with assessment of gingivitis and qualitative and quantitative assessment of plaque performed at baseline, an intermediate point (usually 3 months), and 6 months
- Document a statistically significant reduction of supragingival plaque and gingivitis as compared with a negative control in each of the 2 studies and demonstrate a statistically significant reduction of gingivitis for the mouthrinse group of at least 15% for any one study and an average reduction of 20% in the 2 studies compared with the control group
- Establish product safety with respect to soft tissues, teeth, toxicology, and effects on the oral flora (eg, adverse shifts in microbial populations, the development of microbial resistance, and the emergence of opportunistic organisms)

Data from the studies are then presented to and reviewed by the ADA Council on Scientific Affairs. If the product meets the established standards, it is awarded the ADA Seal of Acceptance.[4,5]

For the professional and consumer, the ADASeal for antimicrobial mouthrinses indicates that

- Product data have successfully undergone an intensive, nonbiased safety and efficacy review
- Evidence supports the manufacturer's claim for effectiveness against supragingival dental plaque and gingivitis
- The product is safe when used as directed

FDA Regulation

The FDA regulates prescription drugs as well as any OTC products that make therapeutic claims, such as the reduction of gingivitis. The FDA has accepted key elements for gingivitis assessment used by the ADA Seal Program as appropriate for its review. However, in contrast to the ADA, which evaluates products, the FDA evaluates active ingredients while recognizing that the way in which an ingredient is formulated may affect its clinical activity. In 2003, the recommendations of the FDA's Dental Plaque Subcommittee of the Nonprescription Drugs Advisory Committee were published, and they included the conditions under which OTC products for the reduction or prevention of dental plaque and gingivitis would

be recognized as safe, effective, and not misbranded.[6,7] In addition to data supporting effectiveness, the following criteria are examined by the FDA[6]:

- Incidence and risk of adverse reactions and significant side effects when used according to adequate directions
- Margin of safety with normal use
- Potential for harm from abuse or misuse
- Potential for inducing adverse side effects (such as irritation, ulceration, inflammation, erosion, damage to teeth/restorations)
- Benefit-risk ratio

After assessing an OTC ingredient, the FDA assigns the ingredient to a category of I, II, or III [6,7]:

- Category I: The ingredient is both safe and effective and is not misbranded.
- Category II: The ingredient is not generally recognized as safe and effective or is misbranded.
- Category III: There are insufficient data to evaluate safety and/or effectiveness.

The FDA may also approve products, both prescription and OTC, through the New Drug Application (NDA) process. The NDA process is a more lengthy one that also requires documentation of both the safety and efficacy of the product.

Mouthrinses That Meet ADA and/or FDA Guidelines

Two antiseptic mouthrinses (and their generic equivalents) have been awarded the ADA Seal for chemotherapeutic control of supragingival plaque and gingivitis: 0.12% chlorhexidine gluconate (CHG) mouthrinse (Peridex®) and essential oils (EO) mouthrinse (Listerine®). Because of a recent change in the ADA Seal Program, Peridex® and its generic equivalents as prescription products no longer carry the ADASeal. However, no CPC formulation has yet to obtain the ADA Seal. (See also page 32 for more information on the ADA Seal Program.)

The FDA's Dental Plaque Subcommittee of the Nonprescription Drugs Advisory Committee has classified 2 OTC mouthrinse ingredients as both safe and effective and not misbranded (Category I): cetylpyridinium chloride (CPC; examples of products include Colgate Viadent® and Crest® Pro-Health™ Rinse) and EO.[6,7] CHG was reviewed and found to be safe and effective by the FDA by means of an NDA and is available in the United States only by prescription.

Although many commercial mouthrinse manufacturers claim antiplaque and antigingivitis properties, most lack the efficacy data required to earn the ADA Seal. Stannous fluoride has received Category I recommendation by the FDA's advisory committee, and triclosan has received NDA approval by the FDA. However, these agents are not found in mouthrinse formulations in the United States. This article discusses the safety and efficacy data of mouthrinses that have been approved by the FDA, recommended as Category I by the advisory committee, or awarded the ADA Seal.

KEY POINT: The ADA and FDA have rigorous approval processes

The ADA grants its Seal of Acceptance to mouthrinses that have documented safety and efficacy through at least 2 longitudinal, controlled clinical trials. The FDA evaluates OTC ingredients making therapeutic claims. It has adopted key elements for gingivitis assessment from the ADA Seal of Acceptance criteria and assigns categories (I, II, or III) based on level of safety and efficacy. For certain prescription mouthrinses, the FDA evaluates safety and efficacy via the New Drug Application (NDA) process.

Antimicrobial Mouthrinse Safety

Two essential criteria for any product are *safety* and *efficacy*. The most effective product would be useless if it were not safe; conversely, the safest product would be inconsequential if it did not work. Issues related to safety in mouthrinses include the following:

- Are there any adverse effects on the oral microbial flora?
- Are there any oral soft tissue aberrations?
- Does routine use adversely affect dental restorative materials?
- Are there any contraindications for the use of these products?

Each of these concerns merits careful consideration.

Do Mouthrinses Have Adverse Effects on Oral Microbiota?

Some dental professionals may fear that antiseptic mouthrinses pose a risk in killing or inhibiting normal flora with subsequent repopulation with opportunistic and/or more pathogenic or resistant organisms. The microbial shift would manifest as an overgrowth of opportunistic organisms, such as *Candida*. Fortunately, studies document no adverse effects on supragingival dental plaque microflora after 6 months of continued use with either CHG or EO.[8-12] Table I describes the findings of several studies of the impact of EO and CHG on normal oral flora. Evidence confirms that daily, long-term use (6 months or longer) of CHG or EO does not adversely affect oral microbial flora, including no microbial overgrowth, opportunistic infection, or development of microbial resistance.

Table I. Effect of CHG and EO on Normal Oral Flora

Mouthrinse	Study Description	Outcome	References
0.12% Chlorhexidine gluconate (CGH) and essential oils (EO)	Several studies of 6 months' duration or longer; dental plaque harvested at baseline, midpoint, and end. Minimum inhibitory concentration microbial samples taken	Routine use of CHG and EO did not cause adverse shifts in plaque ecology, emergence of opportunistic pathogens, or development of resistant microbial strains	8, 9,12
0.12% CHG and EO	*Candida* species (*C albicans, C dubliniensis, C krusei, C glabrata, C tropicalis*) grown in vitro and treated with 0.12% CHG or EO	Both agents effective against test fungal species at commercially available concentrations with comparable inhibition between CHG and EO	13
EO	Randomized, crossover study with 29 adults to determine whether regular antimicrobial rinse use had the potential for a selective increase of *Streptococcus mutans* or an overgrowth of fungal species. Participants rinsed with EO or placebo for 14 days	Reduction in *S mutans*: Recoverable *S mutans* counts from the participants' interproximal spaces reduced by 75.4% with EO compared with control. Total streptococci in interproximal plaque declined by 69.9%. EO activity 37.1% greater against *S mutans* than against other streptococci. No increase in risk of caries	14
EO	In vivo investigations in persons with denture stomatitis caused by an overgrowth of *C albicans* and other fungal species in maxillary prostheses	Rinsing with EO twice daily was as effective as nystatin oral suspension in reducing clinical palatal inflammation and candidiasis	15,16

Do Mouthrinses Cause Oral Mucosal or Other Soft Tissue Aberrations?

Concerns about potential adverse effects on oral mucosa and other soft tissue include the following:

- Does alcohol cause adverse effects such as an increased risk of oral and pharyngeal cancer (OPC)?
- Are the active ingredients found in CHG, CPC, and EO safe for long-term use on the oral mucosa?
- Do mouthrinses affect salivary flow?
- Are there adverse effects on taste or tooth deposits?

Several studies have addressed these issues and are discussed below.

Does alcohol cause adverse effects such as an increased risk of OPC? Many mouthrinses contain pharmaceutical-grade alcohol to solubilize active ingredients, make them biologically active, or dissolve flavoring agents. Typical alcohol levels in mouthrinses include the following:

- CHG: generally 12.6% alcohol
- CPC: 6% to 18% alcohol (traditional) and alcohol free, with high-bioavailability CPC, 0.07%17
- EO: 26.9% alcohol (original "gold" product) and 21.6% alcohol (flavored products)

Oral care professionals may be reluctant to recommend an alcohol-containing mouthrinse (ACM) because of perceived risk for developing OPC. It is well known that tobacco usage and excessive alcoholic beverage consumption cause a substantial portion of the OPC.[18-20] Since most mouthrinses contain alcohol, do ACMs increase cancer risk as well? A number of studies have examined a cause-effect relationship between ACMs and OPC with varying results.[19,21-27] A critical review of investigations that suggested a causeeffect relationship revealed a number of deficiencies and study design flaws that necessitate rethinking the ACM-cancer link[28,29]:

- Lack of a dose-response based on frequency and/or duration of mouthwash use
- Inconsistent findings among studies
- Lack of a scientific or biological basis to explain inconsistent findings between males and females
- Absence of correction for alcoholic beverage ingestion and tobacco use
- Inclusion of pharyngeal cancer, an improper classification as mouthrinses only contact the oral cavity
- Inclusion of other head and neck carcinomas, lymphomas, and sarcomas as oral cancer, an improper classification as mouthrinses only contact the oral cavity

KEY POINT: No link between ACMs and OPC

According to the FDA, National Cancer Institute, and ADA, there is no evidence of a causal relationship between ACMs and OPC.[6,28] Most mouthrinses accepted by the ADA as safe and effective contain alcohol. The ADA Seal documents a product's safety and efficacy, and the ADA recommends that patients continue to use antiseptic mouthrinses as advised by their dental hygienist and dentist.[28,34]

A widely referenced study by the National Cancer Institute erroneously concluded that OPC risks were elevated 60% among female and 40% among male users of mouthwash (with >25% alcohol).[27] This epidemiologic retrospective investigation consisted of interviews with 866 patients with OPC, diagnosed January 1984 through March 1985, and 1249 controls from the general population without OPC sampled from 4 areas of the United States. Reanalysis of this report by independent reviewers concluded that many patients in the OPC group (6.6% of men and 12.6% of women) had tumors of nonmucosal histology that could not have been contacted by an ACM. Reanalysis of the data showed no relationship between ACMs and OPC.[6,30,31] Additional investigators continue to report that there is no evidence that ACM use increases OPC risk.[28,32,33]

Data comparisons of topical alcohol exposure of the oral mucosa from ACMs and alcoholic beverage consumption may be invalid. Two or even 3 topical administrations of a 25% ACM, each lasting 30 seconds, seem unlikely to produce the same effect as long-term, habitual alcoholic beverage consumption. Pharmaceutical alcohol is not a carcinogen.[6,28] However, chemicals and additives found in alcoholic beverages can cause cancer; for example, urethane, a known carcinogen, is commonly found in alcoholic beverages.[6,19,28] Commercial mouthrinses contain pharmaceuticalgrade denatured alcohol (pure ethanol), which is free from contaminating carcinogens.

Taking the following precautions should limit any potential problems with ACMs:

- Advise patients to consult with their abuse sponsor (counselor) before using an ACM.
- EO is indicated for use in individuals over the age of 12 years. The effectiveness and safety of CHG have not been established in individuals under 18 years.35,36
- Use of an ACM in persons taking disulfiram (Antabuse®) and metronidazole (Flagyl®) is contraindicated, because in combination they may induce nausea, vomiting, and other unpleasant side effects.37,38

Do the active ingredients of CHG, CPC, and EO adversely affect the oral mucosa? Evidence supports that long-term use of CHG, CPC, or EO does not contribute to soft tissue lesions or mucosal aberrations. Longterm clinical trials (at least 6 months' duration) produced substantial evidence documenting the safety of the active ingredients of CHG, CPC, and EO mouthrinses on the oral mucosa and periodontium.[39-52] Complete oral soft tissue examinations were performed at each data collection period (baseline, 3 months, and 6 months) in these studies. Findings revealed no differences in the incidence or severity of adverse events between the CHG, CPC, or EO groups and control/placebo groups. With EO, users report an initial tingling/burning sensation that lessens rapidly with time and is considerably reduced by the addition of flavoring such as citrus.[29,42] A burning sensation and occasional mild desquamation have also been reported with CPC use.[53]

Do mouthrinses affect salivary flow? Xerostomia is a common side effect of many systemic diseases, radiation/chemotherapy, and numerous OTC and prescription medications. Amisconception is that the use of an ACM desiccates the oral mucosa, leading to xerostomia. However, studies have shown that rinsing with an EO mouthrinse does not induce mucosal drying or aberration.[54,55] Table II summarizes these study findings.

Table II. Effects of EO on Salivary Flow

Study Description	Outcome	References
Effect of EO versus placebo on the salivary flow rate and oral mucosa of 19 volunteers with documented xerostomia who used 3 rinses daily for 14 days followed by a cross-over after a 7-day washout period. Pre- and postrinse salivary flow rates were measured and oral soft tissues examined for evidence of irritation and inflammation	Under exaggerated conditions (3 rinses/day instead of the recommended 2), no lesions attributable to EO observed in the majority of patients. No statistically significant differences detected between pre- and postrinse salivary flow rates for either the EO or control group	54
Effect on salivary flow or symptoms of dry mouth of an EO mouthrinse and a non–alcohol-containing mouthrinse	No significant effect on salivary flow or dry mouth between the 2 groups	55

Are there adverse effects on taste and tooth deposits? Some patients may experience a bitter taste with EO use.[56] Taste alteration, as well as increased supragingival calculus formation and brown staining of the teeth and tongue, is associated with use of CHG and CPC.[42,46,56-60] CHG stains teeth, esthetic restorations, and implant abutments, and this staining can be problematic in a society that desires cosmetic dentistry and whiter and brighter teeth.[36,56]

Does Routine Use of Mouthrinses Adversely Affect Dental Restorative Materials?

A number of studies have addressed the concern raised about the effect of antimicrobial mouthrinses on dental materials. Other than the potential for staining with CHG and CPC, there are no documented adverse effects on dental materials. Table III summarizes the findings of these studies.

Table III. Effects of Antimicrobial Mouthrinses on Dental Materials

Mouthrinse	Study Description	Outcome	References
Seven mouthrinses (5 alcohol-containing mouthrinses [ACMs], 1 alcohol free, and 1 plain water)	In vitro study of resin specimens placed in 1 of 7 mouthrinses and vibrated for 30 seconds or 1 minute twice daily (to simulate actual use exposure times) for 180 days	No statistical difference among the tested solutions. ACMs caused no increased reduction in composite resin hardness	61
Essential oils (EO)	In vitro study measured effect of EO on resin bond strength on human teeth embedded in dental stone. Tooth surfaces etched and rinsed for 30 seconds with distilled water or various EO dilutions. Each tooth was then dried, a film of adhesive resin applied followed by composite resin, and shear bond strength (SBS) recorded	No differences in SBS found between the EO and control groups at all dilutions. EO had no effect on resin bond strength	62
EO	Direct effect of EO use on dental materials. Specimens of amalgam, glass ionomer, and composite subjected to EO or distilled water for a continuous 10-day period. For each material, compressive strength and water fluid absorption were compared; surface porosity was evaluated with scanning electron micrographs (SEM). Also, 10 subjects wore appliances with implanted study materials and rinsed twice daily for 30 seconds with EO or placebo. After 10 days, dental materials examined by SEM	No significant differences between the EO and control groups detected in vitro or in vivo. EO use had no adverse effect on restorative materials tested	63

KEY POINT: CHG, CPC, and EO cause no serious adverse effects in a generally healthy population when used according to directions

This includes effects on salivary flow, taste, tooth deposits, and dental restorations. Some users may experience minor taste alteration, staining, and supragingival calculus formation with some CHG and CPC formulations.

Efficacy of Mouthrinses

How Antimicrobial Mouthrinses Work

Antiseptics are chemical agents used to eliminate oral microorganisms in a variety of ways:

- By producing cell death
- By inhibiting microbial reproduction
- By inhibiting cellular metabolism

Most antiseptic agents are bactericidal, although some are bacteriostatic. The effectiveness of these agents varies widely and is dependent upon product formulation, concentration of the active agent, dose, substantivity, compliance, and interactions with other chemicals present in the oral cavity at the time of use. Different antimicrobial mouthrinses have demonstrated efficacy against bacteria, fungi, viruses, and spores. Some products produce a wide spectrum of activity, while others are effective against selected microorganisms only.[56] Notably, most studies, including longitudinal trials, testing the efficacy of CHG used the commercial product Peridex®, and Listerine® was the EO commercial product used

for all studies cited in this paper. CPC commercial preparations used in research studies vary by product concentration and brand.

Mechanism of action of CHG. CHG (0.12%) is a bactericidal bisbiguanide antiseptic, with demonstrated efficacy against the following organisms:

- A wide range of gram-positive and gram-negative organisms64
- Aerobes and anaerobes, many of which are associated with plaque and gingivitis, including Fusobacterium and Prevotella intermedia65
- Herpes simplex virus 1 and 2, human immunodeficiency virus 1, cytomegalovirus, influenza A, parainfluenza, and hepatitis B.12,66,67 CHG is not approved for the prevention and treatment of viral infections
- Seven species of Candida and other yeasts13,68,69 (often used alone or in combination with other antifungal medications to reduce opportunistic infections in at-risk populations, such as those undergoing treatment for leukemia or bone marrow transplantation70,71)

Exposure to CHG causes rupturing of the bacterial cell membrane, which allows for leakage of the cytoplasmic contents, resulting in cell death.[72,73] CHG binds to salivary mucins, reducing pellicle formation and inhibiting colonization of plaque bacteria.[64,74] It also binds to bacteria, which inhibits their adsorption onto the teeth.[64] CHG has been shown to penetrate the dental plaque biofilm, which enables CHG to access and kill pathogens embedded within the biofilm.[72]

CHG binds tightly to tooth structure, dental plaque, and oral soft tissues. It is released slowly into the mouth, which allows antimicrobial effects to be sustained for up to 12 hours, thus its high degree of substantivity.[64,75] A 30-minute interval is optimal between toothbrushing and rinsing with CHG to avoid an interaction between the positively charged detergents found in dentifrices (eg, sodium lauryl sulfate) and the cationic CHG rinse. This interaction, and possible inactivation of CHG, can also occur with the anionic fluoride ion found in stannous fluoride and in some toothpastes and mouthrinses.[73,76]

Mechanism of action of CPC. CPC, a quaternary ammonium compound, demonstrates bactericidal activity. Its mechanism of action is similar to CHG in that it ruptures the bacterial cell wall membrane, resulting in leakage of the intracellular contents and eventual cell death. CPC is also thought to alter bacterial metabolism and inhibit cell growth.[73, 77]

CPC binds to tooth structure and dental plaque biofilm; however, the degree of binding is not as strong as with CHG. Further, CPC is rapidly released from binding sites, which explains why it is generally less efficacious than CHG.[73] Like CHG, this cationic rinse may adversely interact with other charged ions found in dentifrices and mouthrinses, possibly limiting its biological activity.

Published data regarding the efficacy of CPC-containing mouthrinses are limited. In the United States, CPC is available in 2 concentrations: 0.05% found in cosmetic mouthrinses (Cepacol® and Scope®) and 0.07% found in therapeutic mouthrinses (BreathRx® and Crest® Pro- Health™ Rinse). It has been suggested that the unique vehicle found in Crest® Pro-Health™ Rinse is purported to increase the product's oral bioavailability when compared with other CPC-containing mouthrinses.[78]

In vitro studies have documented that CPC can be effective against the following organisms:

- Actinomyces viscosus, Porphyromonas gingivalis, Campylobacter rectus, Streptococcus sanguis, Eikenella corrodens, Salmonella typhimurium, Fusobacterium nucleatum, Haemophilus ctinomycetemcomitans, Lactobacillus casei, and P intermedia78
- Several species of Candida68,69,79-81

CPC, like CHG, has been suggested as a possible agent for the prevention and treatment of fungal infections. However, CPC mouthrinses may adversely affect systemic azole drug treatment of oropharyngeal candidiasis in immunocompromised persons. This negative outcome may be attributed to either a cross-resistance to the azole drugs against CPC-resistant

organisms or drug antagonism between CPC and azole antifungal medications when they are used in combination.[82] Two of 5 fluconazole-resistant C albicans strains have also exhibited reduced susceptibility to CPC.[82]

Mechanism of action of EO. EO antiseptic mouthrinse is a bactericidal combination of phenolic essential oils, including eucalyptol, menthol, methyl salicylate, and thymol. Phenolic compounds exert their antimicrobial effects by the following mechanisms[77, 83-87]:

- Cause protein denaturation
- Alter the cell membrane, resulting in leakage of the intracellular contents and eventual cell death
- Alter bacterial enzyme activity
- Exhibit anti-inflammatory properties by inhibiting prostaglandin synthetase, an enzyme involved in the formation of prostaglandins, which are primary inflammatory mediators. Note that the anti-inflammatory effect of phenolic compounds occurs at concentrations lower than those needed for antibacterial activity
- Cause perforation of the cell membrane and rapid efflux of intracellular contents (especially thymol)
- Alter neutrophil function by suppressing the formation of and scavenging existing free radicals generated in neutrophils and by altering neutrophil chemotaxis (especially thymol)

A 30-second exposure time to EO produces morphologic cell surface alterations in a variety of oral pathogens that suggest the loss of cell membrane integrity.[88] Cell surface changes may also alter bacterial coaggregation and recolonization that could potentially affect the growth and metabolism of these organisms. Microscopic evidence of cell surface roughening was obtained for the following microorganisms:

- C albicans
- F nucleatum
- A viscosus
- A viscosus
- S sanguis

Cell surface changes that result from a short exposure time to EO may adversely affect bacterial and fungal survival.[88] Exposure to levels of EO sublethal to microorganisms also reduces bacterial coaggregation with gram-positive pioneer species, an essential step in plaque maturation and the development of the complex pathogenic flora found in gingival disease. Decreased bacterial coaggregation reduces the rate of plaque maturation, which in turn may result in a decreased plaque mass, as is observed clinically with EO use.[89] EO also has been shown to extract endotoxins from gramnegative bacteria.[90] Endotoxins play an important role in pathogenesis; thus, reduction in endotoxin level should manifest as a decrease in gingival inflammation.

Unlike other OTC mouthrinses, EO has been shown to penetrate the dental plaque biofilm and is active against bacteria embedded within the biofilm.[72,91-93] EO kills a wide variety of aerobic and anaerobic bacteria\ associated with plaque biofilm and gingivitis, including the following[94]

- A actinomycetemcomitans
- A viscosus
- S mutans
- S sanguis
- Bacteroides species

Efficacy against gram-positive and gram-negative organisms occurs even at concentrations that are less than full strength.[94,95] A single 30-second rinse reaches and exerts an antibacterial effect interproximally, an important consideration given that gingival disease starts between the teeth and that individuals often cannot access interproximal areas with mechanical plaque removal techniques such as toothbrushing and flossing. Total recovered bacteria from proximal tooth surfaces was 43.8% lower following a single 30-second rinse of EO compared with a control (P=.001).[96] Rinsing twice daily with EO as an adjunct to brushing for 11 days reduced total recoverable streptococci in interproximal plaque by 69.9% (P<.001), with EO producing a 37.1% greater activity against *S mutans* than other streptococci. A significant reduction of 75.4% in total recoverable *S mutans* count was observed (P<.001).14 Studies also have demonstrated significant suppression of the oral flora for several hours after rinsing, documenting that the antimicrobial activity of EO extends beyond the rinsing period.[97-99]

In vitro studies have shown that EO is also active against viruses, including herpes simplex virus 1 and 2, hepatitis B, human immunodeficiency virus 1, and influenza Avirus, as well as against 7 species of *Candida*.[13,67,100] Like CHG, EO is not approved for the prevention and treatment of viral infections.

Unlike CHG and CPC, EO has a neutral electrical charge and does not interact negatively with other charged ions found in dentifrices and mouthrinses.[73] Moreover, its action is not inhibited by proteins in blood serum that inactivate many antimicrobial agents, including CHG.[94,95]

Efficacy of Mouthrinses on Plaque Biofilm and Gingivitis

The primary indication for antimicrobial mouthrinse use is the reduction of supragingival plaque biofilm and gingivitis in patients. A recent meta-analysis of 6-month clinical trials to evaluate the efficacy of a variety of antiplaque and antigingivitis products revealed that the largest body of studies supported the efficacy of EO.[101]A smaller body of studies supported the antiplaque and antigingivitis efficacy of 0.12% CHG. Results regarding the efficacy of CPC varied and were dependent upon product formulation.[101] Efficacy studies of CHG, CPC, and EO are summarized in Tables IV, V, and VI, respectively.

Table IV. Effects of CHG on Supragingival Plaque and Gingivitis

Investigator	Trial Length (months)	No. of Subjects	Concentration of CHG (%)	Plaque Decrease (%)	Gingivitis Decrease (%)
Löe et al, 1976[49]	24	120	0.20	45	27
Lang et al, 1982[50]	6	158	0.10 0.20	16.2 19.4	66.6 80.4
Segreto et al, 1986[102]	3	600	0.12 0.20	36 28	37 28
Grossman et al, 1986[48]	6	430	0.12	61	39
Grossman et al, 1989[47]	6	481	0.12	49	31
Brightman et al, 1991[103]	3	34	0.12	64.9	60.0
Overholser et al, 1990[42]	6	124	0.12	50.3	30.5
Eaton et al, 1997[104]	3	121	0.12	28	25
Charles et al, 2004[46]	6	108	0.12	21.6	18.2

Table V. Effects of CPC on Supragingival Plaque and Gingivitis

Investigator	Trial Length (months)	No. of Subjects	Concentration of CHG (%)	Plaque Decrease (%)	Gingivitis Decrease (%)
Allen et al, 1998[105]	6	111	0.05	28.2	24.0
Mankodi et al, 2005[51]	6	139	0.07	15.8	15.4
Stookey et al, 2005[52]*	6	366	0.075	17	23
			0.10	19	20

* The mouthrinse formulations in this study were experimental.

Table VI. Effects of EO (Listerine®) on Supragingival Plaque and Gingivitis

Investigator	Trial Length (months)	No. of Subjects	Rinsing Supervision	Plaque Decrease (%)	Gingivitis Decrease (%)
Lamster et al, 1983[40]	6	145	Supervised	22	28
Gordon et al, 1985[39]	9	85	Supervised	19.5	23.9
DePaola et al, 1989[41]	6	107	Supervised	34	34
Overholser et al, 1990[42]	6	124	Supervised	36.1	35.9
Charles et al, 2001[43]	6	316	Unsupervised	56.1	22.9
Bauroth et al, 2003[44]	6	326	Unsupervised	21	12
Sharma et al, 2004[45]	6	237	Unsupervised	51.9	21.0
Charles et al, 2004[46]	6	108	Unsupervised	18.8	14.0

The following observations can be made from these study results:

- CHG generally reduces more plaque than either CPC or EO, a predictable outcome given its greater substantivity; the longer an antimicrobial agent stays in contact with plaque bacteria, the greater its effect.
- CHG and EO are comparable in reducing gingivitis.39-41,43-45,48-50,102-104
- In head-to-head comparison studies that evaluated both CHG and EO in the same participants, antiplaque effects were greater for CHG, but antigingivitis effects were similar for both agents.42,46,47
- Both CHG and EO demonstrate greater reductions in supragingival plaque and gingivitis as compared with CPC (see Tables IV, VI).

Perhaps one EO study best summarizes the effectiveness of mouthrinses as an aid to reducing supragingival plaque and controlling gingivitis. In a large, randomized, controlled clinical trial involving 237 participants, those who added twice-daily rinsing with EO to their homecare routine of regular brushing and flossing demonstrated a 51.9% greater reduction in plaque and a 21.0% greater reduction in gingivitis, as compared with those who brushed and flossed only.[45] This study demonstrates the benefit of adding an EO mouthrinse to regular mechanical plaque removal and shows that mouthrinses are able to reach bacteria in areas that are difficult to access and where mechanical methods often leave residual plaque behind.

Approved Mouthrinses Are Efficacious Throughout the Entire Mouth

Using an antiseptic mouthrinse produces an antimicrobial effect throughout the entire mouth, including areas easily missed during toothbrushing and interdental cleaning. Studies have demonstrated that antiseptics kill bacteria in saliva and on the soft tissues of the mouth, including the tongue and oral mucosa, which are reservoirs of pathogenic bacteria that are able to transfer and colonize onto the teeth.[98,105-108] These collective research findings, with consideration given to the respective

adverse events profiles of antiseptic agents, reinforce the value of using CHG, CPC, and EO in addition to mechanical plaque control for longterm maintenance of gingival health.

Conclusion

Antimicrobial mouthrinses that are approved by the FDA and carry the ADA Seal of Acceptance are safe and effective for the reduction of supragingival plaque and gingivitis. Products that have not been evaluated in longterm clinical trials have no scientific evidence documenting safety or efficacy and should be used with caution. Antimicrobial mouthrinses with established safety and efficacy are an important and effective addition to mechanical plaque control methods to establish a healthy mouth. Most patients will benefit by adding an ADA-Accepted antimicrobial mouthrinse to their self-care daily regimen of brushing and interdental cleaning.

References

1. Beals D, Ngo T, Feng T, et al.. Development and laboratory evaluation of a new toothbrush with a novel brush head design. Am J Dent. 2000;13: 5A-14A.
2. Bader HI. Floss or die: implications for dental professionals. Dent Today. 1998;17: 76-82.
3. Oliver RC, Brown LJ, Löe H. Periodontal diseases in the United States population. J Periodontol. 1998;69: 269-278.
4. Council on Dental Therapeutics. Guidelines for acceptance of chemotherapeutic products for the control of supragingival dental plaque and gingivitis. J Am Dent Assoc. year. month_if_listed;vol(issue): firstpage-lastpage.
5. American Dental Association Council on Scientific Affairs. Acceptance Program Guidelines: Chemotherapeutic Products for Control of Gingivitis [homepage on the Internet]. Chicago (IL): ADA; c1997. [cited 2007 May 5]. Available from: http://www.ada.org/ada/seal/standards/guide_chemo_ging.pdf.
6. Food and Drug Administration Oral health care drug products for over-the-counter human use; antigingivitis/ antiplaque drug products; establishment of a monograph; proposed rules.. Fed Regist. May292003;68:32232-32287.
7. Wu CD, Savitt ED. Evaluation of the safety and efficacy of over-the-counter oral hygiene products for the control of plaque and gingivitis. Periodontol 2000. 2002;28: 91-105.
8. Minah GE, DePaola LG, Overholser CD, et al.. Effects of 6 months use of an antiseptic mouthrinse on supragingival dental plaque microflora. J Clin Periodontol. 1989;16: 347-352.
9. Walker C, Clark W, Tyler K, et al.. Evaluation of microbial shifts following long-term use of an oral antiseptic mouthrinse [abstract]. J Dent Res. 1989;68: 412.
10. Emilson CG, Fornell J. Effect of toothbrushing with chlorhexidine gel on salivary microflora, oral hygiene, and caries. Scand J Dent Res. 1976;84: 308-319.
11. Schiott CR, Briner WW, Loe H. Two year oral use of chlorhexidine in man. II. The effect on the salivary bacterial flora. J Periodontal Res. 1976;11: 145-152.
12. Briner WW, Grossman E, Buckner RY, et al.. Effect of chlorhexidine gluconate mouthrinse on plaque bacteria.. J Periodontal Res. 1986;21(suppl): 44-52.
13. Meiller TF, Kelley JI, Jabra-Rizk MA, et al.. In vitro studies of the efficacy of antimicrobials against fungi.. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2001;91: 663-670.
14. Fine DL, Furgang D, Barnett ML, et al.. Effect of an essential oil-containing antiseptic mouthrinse on plaque and salivary Streptococcus mutans levels. J Clin Periodontol. 2000;27: 151-161.
15. DePaola LG, Minah GE, Elias SA, et al.. Clinical and microbial evaluation of treatment regimens to reduce denture stomatitis. Int J Prosthodont. 1990;3: 369-374.
16. DePaola LG, Minah GE, Leupold RL, et al.. The effect of antiseptic mouthrinses on oral microbial flora and denture stomatitis. Clin Prev Dent. 1986;8: 3-8.
17. White DJ. An alcohol-free therapeutic mouthrinse with cetylpyridinium chloride (CPC) - the latest advance in preventive care: Crest Pro-Health Rinse.. Am J Dent. 2005;18: 3A-8A.
18. Parkin DM, Pisani P, Lopez AD, Masuyer E. At least one in seven cases of cancer is caused by smoking: global estimates for 1985. Int J Cancer. 1994;59: 494-504.
19. Blot WJ, McLaughlin JK, Winn DM, et al.. Smoking and drinking in relation to oral and pharyngeal cancer.. Cancer Res. 1988;48: 3282-3287.
20. Negri E, La Vecchia C, Franceschi S, Tavani A. Attributable risk for oral cancer in northern Italy. Cancer Epidemiol Biomarkers Prev. 1993;2: 189-193.
21. Garro AJ, Leiber CS. Alcohol and cancer. Annu Rev Pharmacol Toxicol. 1990;30: 219-249.

22. Weaver A, Fleming SM, Smith DB. Mouthwash use and oral cancer: carcinogen or coincidence?. J Oral Surg. 1979;37: 250-253.
23. Mashberg A, Barsa P, Grossman ML. A study of the relationship between mouthwash use and oral and pharyngeal cancer. J Am Dent Assoc. 1985;110: 731-734.
24. Kabat GC, Herbert JR, Wynder EL. Risk factors for oral cancer in women. Cancer Res. 1989;49: 2803-2806.
25. Young TB, Ford CN, Brandenburg JH. An epidemiologic study of oral cancer in a statewide network. Am J Otolaryngol. 1986;7: 200-208.
26. Wynder EL, Kabat G, Rosenberg S, Levenstein M. Oral cancer and mouthwash use. J Natl Cancer Inst. 1983;70: 255-260.
27. Winn DM, Blot WJ, McLaughlin JK, et al.. Mouthwash and oral conditions in the risk of oral and pharyngeal cancer.. Cancer Res. 1991;51: 3044-3047.
28. Ciancio SG. Alcohol in mouthrinse: lack of association with cancer. Biol Ther Dent. 1993;9: 1-2.
29. Silverman S, Wilder R. Antimicrobial mouthrinse as part of a comprehensive oral care regimen: safety and compliance factors. J Am Dent Assoc. 2006;137: 22S-26S.
30. Cole P, et al.. Alcohol-containing mouthwash and oropharyngeal cancer: an epidemiologic prospective.. Unpublished study in OTC. 2001;Vol 210476.
31. FDC Reports.. Alcohol-containing mouthwash concern "alleviated" by existing data.. The Tan Sheet. 1996. June10;4(24): 1-5.
32. Cole P, Rodu B, Mathisen A. Alcohol-containing mouthwash and oropharyngeal cancer: a review of the epidemiology. J Am Dent Assoc.. 2003;134: 1079-1087.
33. Elmore JG, Horwitz RI. Oral cancer and mouthwash use: evaluation of the epidemiologic evidence.. Otolaryngol Head Neck Surg. 1995;113: 253-261.
34. American Dental Association Council on Dental Therapeutics. Mouthrinse use and the risk of oral and pharyngeal cancer (position statement). Chicago (IL): American Dental Association; 1991. Sept29.
35. Listerine® Antiseptic [package insert]. Skillman (NJ): Johnson & Johnson Healthcare Products Division of McNEILPPC, Inc; 2007.
36. Peridex® (chlorhexidine gluconate 0.12%) Oral Rinse [package insert]. West Palm Beach (FL): 3M ESPE; 2007.
37. Antabuse® (disulfiram) [package insert]. East Hanover, (NJ): Odyssey Pharmaceuticals, Inc.; 2001.
38. Gage TW, Pickett FA. Mosby's Dental Drug Reference. (6thed). St. Louis (MO): Mosby/Elsevier; 2003.
39. Gordon JM, Lamster IB, Seiger MC. Efficacy of Listerine antiseptic in inhibiting the development of plaque and gingivitis.. J Clin Periodontol. 1985;12: 697-704.
40. Lamster IB, Alfano MC, Seiger MC, et al.. The effect of Listerine antiseptic on the reduction of existing plaque and gingivitis. Clin Prev Dent. 1983;5: 12-16.
41. DePaola LG, Overholser CD, Meiller TF, et al.. Chemotherapeutic inhibition of supragingival dental plaque and gingivitis development.. J Clin Periodontol. 1989;16: 311-315.
42. Overholser CD, Meiller TF, DePaola LG, et al.. Comparative effects of 2 chemotherapeutic mouthrinses on the development of supragingival dental plaque and gingivitis. J Clin Periodontol. 1990;17: 575-579.
43. Charles CH, Sharma NC, Galustians HJ, et al.. Comparative efficacy of an antiseptic mouthrinse and an antiplaque/antigingivitis dentifrice: a six-month clinical trial.. J Am Dent Assoc. 2001;132: 670-675.
44. Bauroth K, Charles CH, Mankodi SM, et al.. The efficacy of an essential oil antiseptic mouthrinse vs. dental floss in controlling interproximal gingivitis: a comparative study.. J Am Dent Assoc. 2003;vol(134): 359-365.
45. Sharma N, Charles CD, Lynch MC, et al.. Adjunctive benefit of an essential oil-containing mouthrinse in reducing plaque and gingivitis in patients who brush and floss regularly: a six-month study. J Am Dent Assoc. 2004;135(issue): 496-504.
46. Charles CH, Mostler KM, Bartels LL, Mankodi SM. Comparative antiplaque and antigingivitis effectiveness of a chlorhexidine and an essential oil mouthrinse: 6-month clinical trial.. J Clin Periodontol. 2004;31: 878-884.
47. Grossman E, Meckel AH, Issacs RL, et al.. A clinical comparison of antibacterial mouthrinses: effects of chlorhexidine, phenolics and sanguinarine on dental plaque and gingivitis. J Periodontol. 1989;60: 435-440.
48. Grossman E, Reiter G, Sturzenberger OP, et al.. Six-month study of the effects of a chlorhexidine mouthrinse on gingivitis in adults. J Periodontal Res. 1986;21(Suppl 16): 33-43.
49. Löe H, Schiött CR, Glavind L, Karring G. Two years oral use of chlorhexidine in man. I. General design and clinical effects.. J Periodontal Res. 1976. >;11: 135-144.
50. Lang NP, Hotz P, Graf H, et al.. Effects of supervised chlorhexidine mouthrinses in children. A longitudinal clinical trial. J Periodontal Res. 1982;17: 101-111.
51. Mankodi S, Bauroth K, Witt JJ, et al.. A 6-month clinical trial to study the effects of a cetylpyridinium chloride mouthrinse on gingivitis and plaque. Am J Dent. 2005;18: 9A-14A.
52. Stookey GK, Beiswanger B, Mau M, et al.. A 6-month clinical study assessing the safety and efficacy of two cetylpyridinium chloride mouthrinses. Am J Dent. 2005;18: 24A-28A.
53. Ashley FP, Skinner A, Jackson P, et al.. The effect of a 0.1% cetylpyridinium chloride mouthrinse on plaque and gingivitis in adult subjects.. Br Dent J. 1984;157: 191-196.

54. Fischman SL, Aguirre A, Charles CH. Use of essential oilcontaining mouthrinses by xerostomic individuals: determination of potential for oral mucosal irritation. Am J Dent. 2004;17: 23-26.
55. Kerr AR, Katz RW, Ship JA. A comparison of the effects of two commercially available non-prescription mouthrinses on salivary flow rates and xerostomia: a pilot study. Quintessence Int. 2007;38: 440-447.
56. Ciancio SG. Antiseptics and antibiotics as chemotherapeutic agents for periodontitis management.. Compend Contin Educ Dent. 2000;21: 59-78.
57. Mandel ID. Chemotherapeutic agents for controlling plaque and gingivitis. J Clin Periodontol. 1988;15: 488-498.
58. Kerr AR, Ship JA. Tooth discoloration [Internet]. Available from: http://www.medtext.com/hdcn.htm.
59. Sheen S, Addy M. An in vitro evaluation of the availability of cetylpyridinium chloride and chlorhexidine in some commercially available mouthrinse products. Br Dent J. 2003;194: 207-210.
60. Bascones A, Morante S, Mateos L, et al.. Influence of additional active ingredients on the effectiveness of non-alcoholic chlorhexidine mouthwashes: a randomized controlled trial. J Periodontol. 2005;76: 1469-1475.
61. Norman R. Surface hardness effects of various mouthrinses on a composite resin [abstract].. J Dent Res. 1997;76: 325-Abstract 2490.
62. Von Fraunhofer JA, Kelley JJ, DePaola LG, Meiller TF. The effect of a dental unit waterline treatment solution on composite-dentin shear bond strengths.. J Clin Dent. 2004;15: 28-32.
63. Von Fraunhofer J, Kelley JI, DePaola LG, Meiller TF. The effect of a mouthrinse containing essential oils on dental restorative materials. Gen Dent. 2006;54): 403-407.
64. Wolff LF. Chemotherapeutic agents in the prevention and treatment of periodontal disease. Northwest D. 1985;64: 15-24.
65. De Boever EH, Loesche WJ. Assessing the contribution of anaerobic microflora of the tongue to oral malodor.. J Am Dent Assoc. 1995;126: 1384-1393.
66. Bernstein D, Schiff G, Echler G, et al.. In vitro virucidal effectiveness of a 0.12% chlorhexidine gluconate mouthrinse. J Dent Res. 1990;69: 874-876.
67. Baqui AA, Kelley JI, Jabra-Rizk MA, et al.. In vitro effect of oral antiseptics on human immunodeficiency virus-1 and herpes simplex virus type 1. J Clin Periodontol. 2001;28: 610-616.
68. Giuliana G, Pizzo G, Milici ME, et al.. In vitro antifungal properties of mouthrinses containing antimicrobial agents.. J Periodontol. 1997;68: 729-733.
69. Giuliana G, Pizzo G, Milici ME, Giangreco R. In vitro activities of antimicrobial agents against Candida species. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1999;87: 44-49.
70. Sharon A, Berdicevsky I, Ben-Aryeh H, Gutman D. The effect of chlorhexidine mouth rinses on oral Candida in a group of leukemic patients. Oral Surg Oral Med Oral Pathol. 1977;44: 201-205.
71. Epstein JB, Vickars L, Spinelli J, Reece D. Efficacy of chlorhexidine and nystatin rinses in prevention of oral complications in leukemia and bone marrow transplantation. Oral Surg Oral Med Oral Pathol. 1992;73: 682-689.
72. Foster JS, Pan PC, Kolenbrander PE. Effects of antimicrobial agents on oral biofilms in a saliva-conditioned flowcell. Biofilms. 2004;1: 5-12.
73. Ciancio SG. Chemical agents: plaque control, calculus reduction and treatment of dentinal hypersensitivity.. Periodontol 2000. 19995;8: 75-86.
74. Fine DH. Mouthrinses as adjuncts for plaque and gingivitis management: a status report for the American Journal of Dentistry.. Am J Dent. 1988;1: 259-263.
75. Weeks C, Briner W, Rebitski G, et al.. Immediate and prolonged effect of 0.12% chlorhexidine on salivary bacteria [abstract]. J Dent Res. 1988;67: 326.Abstract 1711.
76. Barkvoll P, Rølla G, Svendsen AK. Interaction between chlorhexidine digluconate and sodium lauryl sulfate in vivo. J Clin Periodontol. 1989;16: 593-595.
77. Scheie AA. Modes of action of currently known chemical antiplaque agents other than chlorhexidine.. J Dent Res. 1989;68: 1609-1616.
78. Witt J, Ramji N, Gibb R. Antibacterial and antiplaque effects of a novel, alcohol-free oral rinse with cetylpyridinium chloride. J Contemp Dent Pract. 2005;6: 1-9.
79. Meier S, Collier C, Scaletta MG, et al.. An in vitro investigation of the efficacy of CPC for use in toothbrush decontamination. J Dent Hyg. 1996;70: 161-165.
80. Nakamoto K, Tamamoto M, Hamada T. In vitro effectiveness of mouthrinses against Candida albicans. Int J Prosthodont. 1995;8: 486-489.
81. Phillips BJ, Kaplan W. Effect of cetylpyridinium chloride on pathogenic fungi and Nocardia asteroides in sputum. J Clin Microbiol. 1976;3: 272-276.
82. Edlind MP, Smith WL, Edlind TD. Effects of cetylpyridinium chloride resistance and treatment on fluconazole activity versus Candida albicans. Antimicrob Agents Chemother. 2005;49: 843-845.
83. Goodson JM. Response. . In: Loe H, Kleinman DV. , editors. Dental Plaque Control Measures and Oral Hygiene Practices. Oxford, England: IRL Press; 1986. 143- 146.

84. Walker CB. Microbiological effects of mouthrinses containing antimicrobials. Clin Periodontol. 1998;15: 499-505.
85. Shapiro S, Meier A, Guggenheim B. The antimicrobial activity of essential oils and essential oil components towards oral bacteria. Oral Microbiol Immunol. 1994;9: 202-208.
86. Kuehl FA, Humes JL, Egar RW, et al.. Role of prostaglandin endoperoxide PGG2 in inflammatory processes. Nature. 1977;265: 170-172.
87. Azuma Y, Ozaza N, Ueda Y, Takagi N. Pharmacological studies on the anti-inflammatory action of phenolic compounds. J Dent Res. 1986;65: 53-56.
88. Kubert D, Rubin M, Barnett ML, Vincent JW. Antiseptic mouthrinse-induced microbial cell surface alterations.. Am J Dent. 1993;6: 277-279.
89. Fine DH, Furgang D, Lieb R, et al.. Effects of sublethal exposure to an antiseptic mouthrinse on representative plaque bacteria. J Clin Periodontol. 1996;23: 444-451.
90. Fine DH, Letizia J, Mandel ID. The effect of rinsing with Listerine antiseptic on the properties of developing dental plaque. J Clin Periodontol. 1985;12: 660-666.
91. Pan P, Barnett ML, Coelho J, et al.. Determination of the in situ bactericidal activity of an essential oil mouthrinse using a vital stain method. J Clin Periodontol. 2002;27256: 256-261.
92. Fine DH, Furgang D, Barnett ML. Comparative antimicrobial activities of antiseptic mouthrinses against isogenic planktonic and biofilm forms of Actinobacillus actinomycetemcomitans. J Clin Periodontol. 2001;28: 697-700.
93. Ouhayoun JP. Penetrating the plaque biofilm: impact of essential oil mouthrinse. J Clin Periodontol. 2003;30(suppl 5): 10-12.
94. Ross NM, Charles CH, Dills SS. Long-term effects of Listerine antiseptic on dental plaque and gingivitis.. J Clin Dent. 1989;1: 92-95.
95. Whitaker EJ, Pham K, Feik D, et al.. Effect of an essential oil-containing antiseptic mouthrinse on induction of platelet aggregation by oral bacteria in vitro. J Clin Periodontol. 2000;27: 370-373.
96. Charles CH, Pan PC, Sturdivant L, Vincent JW. In vivo antimicrobial activity of an essential oil-containing mouthrinse on interproximal plaque bacteria.. J Clin Dent. 2000;11: 94-97.
97. Pitts G, Brogdon C, Hu L, et al.. Mechanism of action of an antiseptic, anti-odor mouthwash. J Dent Res. 1983;62: 738-742.
98. DePaola LG, Minah GE, Overholser CD. Effect of an antiseptic mouthrinse on salivary microbiotia. Am J Dent. 1996;9: 93-95.
99. Furgang K, Sinatra K, Schreiner H, et al.. In vitro antimicrobial activity of an essential oil mouthrinse.. J Dent Res. 2002;81(special issue A): Abstract 2854.
100. Dennison DK, Meredith GM, Shillitoe EJ, Caffesse RG. The antiviral spectrum of Listerine antiseptic. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1995;79: 442-448.
101. Gunsolley JC. A meta-analysis of six-month studies of antiplaque and antigingivitis agents.. J Am Dent Assoc. 2006;137: 1649-1657.
102. Segreto VA, Collins EM, Beiswanger BB, et al.. A comparison of mouthrinses containing two concentrations of chlorhexidine. J Periodontal Res. 1986;21(suppl): 23-32.
103. Brightman LJ, Terezhalmy GT, Greenwell H, et al.. Theeffects of a 0.12% chlorhexidine gluconate mouthrinse on orthodontic patients aged 11 through 17 with established gingivitis. Am J Orthod Dentofacial Orthop. 1991;100: 324-329.
104. Eaton KA, Rimini FM, Zak E, et al.. The effects of a 0.12% chlorhexidine-digluconate-containing mouthrinse versus a placebo on plaque and gingival inflammation over a 3-month period. A multicentre study carried out in general dental practices. J Clin Periodontol. 1997;24: 189-197astpage.
105. Allen DR, Davies R, Bradshaw B, et al.. Efficacy of a mouthrinse containing 0.05% cetylpyridinium chloride for the control of plaque and gingivitis: a 6-month clinical study in adults. Compend Contin Educ Dent. 1992;19(2 suppl): 20-26.
106. Dahlen G. Effect of antimicrobial mouthrinses on salivary microflora in healthy subjects.. Scand J Dent Res. 1984;92: 38-42.
107. Jenkins S, Addy M, Wade W, Newcombe RG. The magnitude and duration of the effects of some mouthrinse products on salivary bacterial counts. J Clin Periodontol. 1994;21: 397-401.
108. Pitts G, Pianotti R, Feary TW, et al.. The in vivo effects of an antiseptic mouthwash on odor-producing microorganisms. J Dent Res. 1981;60: 1891-1896.
109. Fine DH, Furgang D, Sinatra K, et al.. In vivo antimicrobial effectiveness of an essential oil-containing mouth rinse 12 h after a single use and 14 days' use.. J Clin Periodontol. 2005;32: 335-340.

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Strategies for Incorporating Antimicrobial Mouthrinses into Daily Oral Care

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Overview. A cost-effective way of improving patient outcomes is adopting preventive practices known to be effective. As "front-line" providers of dental health services and information, dental hygienists are an important catalyst for the implementation of evidence-based preventive practices - such as the twice-daily use of antimicrobial mouthrinses - in the self-care routines of patients. However, encouraging patients to adopt new behaviors can present a challenge: providers may be uncomfortable with recommending new behaviors and patients may be resistant to learning new skills. As expert clinicians, educators, and counselors, dental hygienists are in an excellent position to help patients make changes and learn new behaviors.

Clinical Implications. This article discusses practical methods for promoting change. Targeting interventions to individual patient values, stage of readiness to change, and skill set encourages patient incorporation of new behaviors. Time should be allotted for supervised practice of new skills, and patients should be supported in planning for effective and lasting behavior change. Through effective communication, skills teaching, and use of follow-up, dental hygienists can help patients adopt healthy behaviors.

Keywords: Antimicrobial mouthrinse, compliance, dental hygiene,, oral health, patient education

Introduction

The merits of oral hygiene to health have long been valued by oral health care providers. However, public awareness of the importance of oral health and the links between oral and systemic health and disease has increased in recent years, particularly since the publication of *Oral Health in America: A Report of the Surgeon General* in 2000 and the subsequent release and implementation of the *National Call to Action to Promote Oral Health*, a public-private partnership under the leadership of the Office of the Surgeon General.[1,2] Dental hygienists now have an important window of opportunity to counsel patients on behaviors that promote oral health. Health care providers, including dental hygienists, can act as catalysts for change by teaching patients about oral health, modeling health behaviors, and helping patients adopt healthy behaviors.[3]

It has been noted that "the most cost-effective opportunity to improve patient outcomes over the next quarter century will likely come not from discovering new therapies but from discovering how to deliver therapies that are known to be

effective."[4] The aim of this article is to enable dental hygienists to put evidence-based information about antimicrobial mouthrinses into practice by effectively communicating research findings with patients and promoting incorporation of healthy behaviors into their self-care regimens. This review will focus on practical methods for promoting positive change and suggest ways to involve patients in optimizing their oral health. By promoting optimal oral care, dental hygienists can make a significant difference in the health and well-being of their patients.

Initiating Behavioral Change

While encouraging patients to adopt new, healthful behaviors is something dental hygienists frequently do, they may find it difficult to recommend new behaviors, such as use of antimicrobial mouthrinses. Barriers to change are varied and include:

- Habit: Dental hygienists may recommend traditional oral hygiene methods most often (such as brushing and flossing), despite research demonstrating the effectiveness of other oral hygiene aids and techniques.5
- Lack of confidence6: Dental hygienists may lack the confidence to use motivational interviewing techniques (please see Practical Strategies for Change)
- Lowered expectations: Hygienists may feel that patients are unlikely to change their behaviors despite counseling. Patients that dental hygienists have the lowest expectation of - those with high plaque levels - may receive less genuine verbal interaction and not receive the more intensive instruction they need.7 These more challenging patients may be ideal candidates for dental hygienists to begin targeting for incorporating antimicrobial oral rinsing into daily home care.
- Not enough time: Lack of interest and resistance from the patient and poor financial incentives for oral hygiene instruction may contribute to limiting the time spent on education.8,9

For all of these reasons, dental hygienists may tend to continue to recommend the traditional therapies of brushing and flossing alone. However, compliance with daily flossing has been reported to be generally low, ranging from only 10% to 30%,[5] so patients may benefit from information about new and adjunctive methods for thorough plaque removal.

But changing dental hygienist behavior is difficult due to the complexity of the process, and different barriers likely respond to different approaches to change.[10,11] Simple exposure to new knowledge may be insufficient to overcome most barriers to change practices,[11,12] but dissemination of information can be more effective in changing behavior when combined with other methods such as interactive educational activities, enabling tools, and reminders.[13] In addition, comparing one's current practice behaviors to sources of evidence, such as guidelines and external feedback, has been shown to motivate change.[12,14] Reading journal articles that summarize the evidence base in a subject area, like the ones published in this journal supplement, and comparing the findings to one's current practice may stimulate a need that encourages practitioners to change their professional behaviors.

Recently, two professional dental organizations have officially acknowledged evidence about the adjunctive use of daily antimicrobial rinsing. The American Dental Association (ADA) released a statement in support of the use of ADA-Accepted antimicrobial mouthrinses in addition to traditional brushing and interdental cleaning.[15] The Canadian Dental Hygienists' Association (CDHA) published a position statement supporting the incorporation of antimicrobial rinsing in patient home care routines.[16] Both of these documents provide support for the dental hygienist as he or she recommends that patients incorporate oral rinsing into their daily routine.

Practical Strategies for Change

The patient is the center of any successful change effort. Promoting change starts with listening to the patient and providing suggestions and skills teaching that are aligned with the patient's values. Dental hygienists need to be comfortable with actively questioning and interviewing patients to elicit the patient's beliefs and values about oral hygiene, health, and disease and be prepared for responses that do not conform with ideals.[28] Effective questioning minimizes patient

defensiveness, allowing patients to consider change. The following are strategies that can promote effective dialogue and support adoption of healthy behaviors.

- Ask patient about current oral health practices Begin with determining the patient's current level of selfcare. Example: "What do you do each day to take care of your teeth and gums?" You may want to ask the patient questions that elicit felt needs, such as, "If you could change anything about your oral health, what would you change?" Avoid a confrontational approach, and be sure to support healthy activities the patient is already performing.
- Assess patient readiness to change Determine the patient's readiness to incorporate new self-care behaviors.23 The initial question may be "Would you be willing to try using an antimicrobial mouthrinse twice daily?" If the patient responds positively, move to practical support. If the patient responds with disinterest, determine any obstacles to change. "Have you tried them in the past? Did you find one you liked? Why not? Why don't you think it would be helpful?" Be sure to maintain a nonconfrontational attitude. It may help to write down patient objections, and continue to listen to objections until the patient is finished. Active listening may diffuse patient resistance. If the patient is unwilling to consider change, providing interventions over multiple visits can encourage the patient to rethink his or her decision. Always work within the patient's stage of readiness to change.
- Supervise new skills/behaviors If the patient is ready to attempt new behaviors, supervised practice will enhance patient self-efficacy.3 Encourage the patient to practice using mouthrinse, and show the patient what to look for on the label. This will increase the patient's comfort level and success with the new behavior. Remind the patient that if a product was shown via research to be effective with twice daily use, using the product once daily may not yield the desired outcomes.
- Structure a plan for successful adoption of the new behavior If the patient is ready to change, it is also important to help with the plan for success. Unlike other negative behaviors such as overeating or smoking, patients do not derive positive satisfaction when neglecting oral self-care. The primary obstacle is apathy. Work with the patient to develop a brief change plan that incorporates environmental support. Encourage the patient to be specific. These planning steps maximize the likelihood of successful change. Example: "I'm glad you're ready to make a positive change. I've seen many patients significantly improve the health of their gums by adding an antimicrobial mouthrinse to their daily routine. Do you have an antimicrobial mouthrinse? Do you know where to look to find out if your rinse is ADA-Accepted? When do you plan to use your rinse? Will your use of the rinse match the manufacturer's recommendations for daily care?"
- Anticipate obstacles Stressful life experiences can disrupt the formation of positive habits.18 Encourage the patient to incorporate external memory triggers (eg, notes to self) to allow him or her to maintain or resume positive oral health practices during disruptive or stressful periods. If the patient does not discuss obstacles, you may want to engage in self-disclosure or share examples from your experience with other patients. Example: "It can be hard sometimes to remember new healthy habits when we're busy, sick, traveling, or stressed out. I'm a dental hygienist, and some days I'm so busy I barely have time to brush my teeth. What are some ways that help you remember to do things when life is stressful? What are some obstacles that may keep you from using an antimicrobial mouthrinse twice daily?"
- Follow up with the patient Ask the patient about whether he or she has successfully incorporated the behavior and any obstacles that were encountered: "Were you able to find a product you really liked? Could you easily access the product? Was it hard to be consistent? What was your biggest challenge?" Praise any progress toward the desired behavior, and revise the patient's action plan accordingly: "Even though you weren't able to use the rinse every day twice daily, I'm glad that you were able to use it before bed most nights. You have made a great start! Do you think you can use it more often? When do you think you can incorporate a second rinse into your day?" Specific follow-up demonstrates care for the patient and is appreciated. Follow-up is also central to maintaining change.26,27

While it takes time to change behaviors, the above interventions are brief and can be incorporated into a preventive, therapeutic, or periodontal maintenance visit. Through use of effective questioning and encouraging patients to share their health values and behaviors, dental hygienists can offer targeted advice and be perceived as caring and supportive while fulfilling their responsibility to educate patients. Nonconfrontational questioning minimizes patient defensiveness and ensures they will be as receptive as possible to receiving information on their oral health. Repeated interventions can assist patients as they adopt positive behaviors that will improve oral health and quality of life.

Encouraging Compliance / Adherence

Once a dental hygienist decides to assist patients in improving their oral health status through the implementation of an evidence-based product, (eg, an antimicrobial mouthrinse), the dental hygienist must motivate the patient to change his or her daily oral care routine. Research confirms what dental hygienists know intuitively, that patients are reluctant to change their home care routines and, overall, may not display interest in oral hygiene instruction.[9,17]

Despite the value people place on oral health, patients are increasingly strained with meeting the demands of daily life.[18] Stressful life events have also been shown to interfere with selfcare.[18] In a study examining the impact of oral hygiene education, patients with poor oral hygiene subsequent to instructions and education reported having difficulty taking care of their teeth and had more factors that interfered with self-care than the more successful study participants.[19] Moreover, because incorporating complex behaviors - such as traditional oral self-care behaviors - may be met with less compliance than simpler strategies,[19] oral rinsing interventions may produce improved adherence (see Adherence versus Compliance).

Adherence versus Compliance

Compliance is a common term used in oral health care literature to describe a patient's willingness to follow a practitioner's instructions.[20,28] The term has been criticized because it implies that the patient assumes a passive role and acquiesces to professional recommendations he or she may not understand or agree with.[17,20,28] Some authors use the term adherence instead of compliance, as it implies that the patient takes a more active role in decision making and thereby improves behavior change.[20]

Further complicating the issue of compliance, research evidence demonstrates that even persons with high plaque levels believe they are doing a good job with their oral home care.[19] The fact that patients have an inability to evaluate their oral hygiene effectiveness and monitor their oral health status has been raised as a weakness undermining dental hygiene instruction.[8] Finally, compliance in behaviors preventing conditions perceived to be non-life threatening, such as periodontal disease and dental caries, may have a lower priority for patients.[18,20]

Dental hygienists can encourage patients to adopt healthy behaviors, such as the twice-daily use of an ADA-Accepted antimicrobial mouthrinse, by a variety of methods. Dental hygienists can listen to patient feelings and values and emphasize the value and relevance of oral hygiene care before providing oral hygiene education.[21] This allows patients to link improved health behaviors to these values, enhancing their readiness to make positive changes.[21]

In addition, change efforts should be tailored to the patient's expressed readiness to change. According to the Transtheoretical Model of Change, patients are in one of several stages of readiness to incorporate new behaviors,[20,22]- and interventions should be targeted accordingly. Table I shows stages of change and appropriate interventions based on the patient's stages of readiness.

Table I. Transtheoretical Stages of Change and Suggested Interventions[20, 22-23]

Stage	Characteristics	Suggested Intervention
Precontemplation	Patient is unaware of the need for behavior change or resistant to change *"I won't change"*	Verify patient's state of readiness Raise patient awareness *"Are you aware of the health benefits of using an antimicrobial mouthrinse twice daily?"*
Contemplation	Patient has considered changing behavior but is not currently taking action *"I might change"*	Verify patient's state of readiness Compliment patient on thinking about making a change *"Sounds like you've been thinking about making changes in your oral self-care. That's great! What would you say is holding you back from taking that step?"*
Preparation	Patient is ready to take positive action *"I will change"*	Verify patient's state of readiness Provide actionable information *I'm glad you're ready to make a healthy change. If you wanted to use mouthrinse tonight, what steps would you need to take?* (eg, suggest purchasing a mouthrinse known to reduce plaque and gingivitis)
Action	Patient is making initial steps toward behavior change *"I am making a change"*	Verify patient's state of readiness Support change *"I'm glad you decided to give mouthrinse a try. Have you thought about ways to make it easier to continue your new habit?"* (eg, suggest placing it on the counters in all the bathrooms, placing a reminder note on the bathroom mirror, or including it in an oral care kit at work)
Maintenance	Patient has incorporated behavior change successfully, although some relapse may have occurred *"I have been making changes"*	Verify patient's state of readiness Support behavior maintenance, explore potential obstacles, make contingency plans *"That's wonderful to hear you're using mouthrinse! I can see the improvement in your plaque and gingival bleeding scores. It takes time to change lifetime habits. We will keep monitoring your oral health status at each dental hygiene visit. Let me show you how to monitor yourself at home."*

In addition to matching educational interventions to patient readiness for change, it is important to tailor information to each individual patient. Through the skillful use of listening, questioning, imparting knowledge, and teaching skills, the dental hygienist can influence the key dimensions of patient behavior including acquiring knowledge, changing attitudes, heightening perceived needs, and improving motivation.[19,24] While the actual interventions recommended may be the same across a variety of patients - for example, twice daily use of an antimicrobial rinse - the individual tailoring of educational sessions to these behavioral dimensions are critical for motivating change.[19,25] As new products are introduced to the market, the dental hygienists' role becomes crucial in helping patients understand the personal health care implications of the research literature.[25]

The provision of information about safe and effective antimicrobial mouthrinses is important, but information alone will not change patient behavior.[8,9] The teaching of new skills is a necessary component of an effective intervention. Skills acquisition is facilitated by introducing skills one at a time, allowing time for supervised practice. This approach increases the chance for successful transfer of knowledge from the office to the home setting.[7] Using quantitative hygiene assessment tools such as plaque and gingivitis scores can help patients see the relevance of instruction to their oral health.[7]

Table II summarizes important features of successful dental hygiene interventions designed to motivate patients into changing their home care behaviors. These factors combined with the patient's belief that he or she has control over his or her oral hygiene and health will increase the likelihood for positive behavior change.[3]

Table II. Dental Hygienist Actions for Supporting Patient Behavior Change

General for All Patients	Individualized to Specific Patient
Target high-risk patients	Provide sufficient contact time
Clarify patient values	Ensure mastery of one skill at a time
Determine the patient's state of readiness for change	Provide meaningful praise
Inquire about current behaviors	Include intraoral demonstrations
Tailor approach—ensure relevance	Include supervised practice
Convince patient of effectiveness of intervention	Encourage a partnership incorporating two-way communication
Highlight the pleasurable sensations and social benefits of oral hygiene and health	Ensure patient can self-monitor improvements (eg, decreased redness, swelling, and bleeding)
Maintain a positive environment	Provide patient specific written educational materials to supplement interventions
Display warmth and genuineness	Assist patient in managing when home care will occur, incorporating contingency plans
Provide ongoing reminders	
Be prepared for relapse	

The fact that research-supported, oral health-promoting behaviors (such as the twice-daily use of a safe and effective antimicrobial mouthrinse) need to be carried out over one's lifetime contributes to the challenge.[17] Studies consistently show that modest gains achieved initially in changing patient behavior diminish with time and minimize initial gains.[19] Key elements to maximize that patients maintain their new behaviors include the use of positive feedback, patient reminders (such as phone calls and postcards), and adapting dental hygiene instructions to the needs of the patient.[20] In a series of 3 studies evaluating the maintenance of self-care behavior programs, adherence was improved when reminders were used, seemingly for as long as the reminders were provided.[26] Therefore, maintenance of behavioral change is an ongoing and deliberate process.[27]

Conclusions

As preventive oral health experts, dental hygienists must continually evaluate methods of enhancing oral health and recommend those techniques and products with evidence-based effectiveness to their patients. This article has examined strategies for promoting behavioral change in the context of adoption of twice-daily use of antimicrobial mouthrinses, which have been shown to effectively reduce plaque and promote oral health when used as part of a daily self-care regimen. These principles can also be applied when teaching patients about other health care products and behaviors.

References

1. US Department of Health and Human Services. Oral Health in America: A Report of the Surgeon General [homepage on the Internet]. Rockville (MD): US Department of Health and Human Services, National Institute of Dental and Craniofacial Research, National Institutes of Health; 2000. Available from: http://www2.nidcr. nih.gov/sgr/sgrohweb/welcome.htm.
2. US Department of Health and Human Services. National Call to Action to Promote Oral Health. NIH Publication No. 03-5303 [homepage on the Internet]. Rockville (MD): US Department of Health and Human Services, National Institute of Dental and Craniofacial Research, National Institutes of Health; 2003. Available from: http://www.surgeongeneral.gov/topics/oralhealth/nationalcalltoaction.htm.
3. Koelen MA, Lindstrom B. Making healthy choices easy choices: the role of empowerment. Eur J Clin Nutr. 2005;59(suppl 1): S10-S16.
4. Berenholz S, Pronovost PJ. Barriers to translating evidence into practice. Curr Opin Crit Care. 2003;9: 321-325.
5. Asadoorian J. Flossing: Canadian Dental Hygienists Association Position Statement: CDHA Position Paper.. CJDH. 2006;40: 112-144.
6. Cabana MD, Rand CS, Powe NR, et al.. Why don't physicians follow clinical practice guidelines? A framework for improvement. JAMA. 1999;282: 1458-1465.
7. Milgrom P, Weinstein P, Melnick S. Oral hygiene Instruction and health risk assessment in dental practice.. J Public Health Dent. 1989;49: 24-31.

8. McConaughy FL, Lukken KM, Toevs SE. Health promotion behaviors of private practice dental hygienists. J Dent Hyg. 1991;54: 222-230.
9. Basson WJ. Oral health education provided by oral hygienists in private practice.. SADJ. 1999;54: 53-57.
10. Bosse G, Breuer JP, Spies C. The resistance to changing guidelines - what are the challenges and how to meet them.. Best Pract Res Clin Anaesthesiol. 2006;20: 379-395.
11. Bain KT. Barriers and strategies to influencing physician behavior. Am J Med Qual. 2007;22: 5-7.
12. Bloom BS. Effects of continuing medical education on improving physician clinical care and patient health: A review of systematic reviews.. Int J Technol Assess Health Care.. 2005;21: 380-385.
13. Gray J. Changing physician prescribing behaviour. Can J Clin Pharmacol. 2006;13: e81-e84.
14. Mead P. Clinical guidelines: promoting clinical effectiveness or a professional minefield?. J Adv Nurs. 2000;31: 110-116.
15. ADA affirms benefits of ADA-Accepted antimicrobial mouth rinses and toothpastes, fluoride mouth rinses [news release][homepage on the Internet]. Chicago (IL): American Dental Association; c2007. [cited 2007 Jul 27]. Available from: http://ada.org/public/media/releases/0705_release03.asp.
16. Asadoorian J. Oral rinsing: Canadian Dental Hygienists Association Position Statement. CDHA position paper on commercially available over-the-counter oral rinsing products. CJDH. 2006;40: 168-183.
17. Blinkhorn AS. Factors affecting the compliance of patients with preventive dental regimens.. Int Dent J. 1993;43: 294-298.
18. Ower P. The role of self-administered plaque control in the management of periodontal diseases: 2. Motivation, techniques and assessment. Dent Update. 2003;30: 110-116.
19. Weinstein P, Milgrom secondauthorgivenname, Melnick S, et al.. How effective is oral hygiene instruction? Results after 6 and 24 weeks.. J Public Health Dent. 1989;49: 32-38.
20. Silverman S, Wilder R. Antimicrobial mouthrinse as part of a comprehensive oral care regimen: safety and compliance factors. J Am Dental Assoc. 2006;137(11 suppl): 22S-26S.
21. Horowitz LG, Dillenberg J, Rattray J. Self-care motivation: a model for primary preventive oral health behavior change.. J Sch Health. 1987;57: 114-118.
22. Prochaska JO, Norcross JC, DiClemente CC. Changing for Good: The Revolutionary Program That Explains the Six Stages of Change and Teaches You How to Free Yourself From Bad Habits. New York (NY): William Morrow; 1994.
23. Astroth DB, Cross-Poline GN, Stach DJ, et al.. The transtheoretical model: an approach to behavioral change. J Dent Hyg. 2002;76: 286-295.
24. Uitenbroek DG, Schaub RMH, Tromp JA, Kant JH. Dental hygienists' influence on the patients' knowledge, motivation, self-care, and perception of change. Community Dent Oral Epidemiol. 1989;17: 87-90.
25. Gluch-Scranton J. Motivational strategies in dental hygiene care. Semin Dent Hyg. 1991;3: 1-4-6-8.
26. McCaul KD, Glasgow RE, O'Neill HK. The problem of creating habits: establishing health-protective dental behaviors.. Health Psychol. 1992;11: 101-110.
27. Cifuentes M, Fernald DH, Green LA, et al.. Prescription for health: changing primary care practice to foster healthy behaviors. Ann Fam Med. 2005;3: S4-S12.
28. Chu R, Craig B. Understanding the determinants of preventive oral health behaviours.. Probe. 1996;30: 12-18.

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Antimicrobial Mouthrinses in Contemporary Dental Hygiene Practice: The Take Home Message

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Introduction

The primary indication for antimicrobial mouthrinse use is to achieve a reduction in supragingival plaque and gingivitis. Evidence shows that an American Dental Association (ADA)-Accepted antimicrobial mouthrinse can result in a greater reduction in plaque and gingivitis than brushing and flossing alone.[1] Therefore, even the most diligent brusher and flosser can benefit from the addition of an ADA-Accepted antimicrobial mouthrinse to the daily homecare regimen.

Antimicrobial mouthrinses reduce the bacterial count and inhibit the pathogenic bacterial activity in dental biofilm that can cause gingivitis, a precursor to periodontitis. Brushing and flossing alone may not always be enough to control the pathogenicity of dental biofilm. Untreated, gingivitis can advance to periodontitis and tooth loss and may be associated with other chronic diseases and conditions such as diabetes mellitus, cardiovascular disease, obesity, and pre-term birth. Most patients will improve their oral health by adding an ADA-Accepted antimicrobial mouthrinse to their self-care daily regimen of brushing and interdental cleaning. Therefore, the incorporation of an ADA-Accepted mouthrinse into the daily regimen of brushing and cleaning interdentally is important to achieve optimal oral health outcomes.

The ADA Seal of Acceptance Program

More than 100 companies voluntarily participate in the ADA Seal of Acceptance Program and more than 400 oral care products marketed directly to consumers carry the ADA Seal (Figure 1).[2] Oral health care professionals and consumers can visit http://www.ada.org/ada/seal/adaseal_consumer_shopping.pdf to identify products that have earned the ADA Seal of Acceptance to guide their recommendations and purchases of overthe- counter (OTC) products. Given the importance of oral and systemic health, and product safety and efficacy, this list is likely to expand and should be reviewed regularly.

Figure 1. The American Dental Association Seal of Acceptance. (Courtesy of the American Dental Association.)

The safety and efficacy data for the twice-daily use of an antiplaque and antigingivitis antimicrobial mouthrinse is unequivocal. Products that have been found effective against plaque and gingivitis and that have earned the ADA Seal are those that contain 0.12% chlorhexidine gluconate (CHG) or a fixed combination of essential oils (EO). Listerine® - a fixed combination of EO - and its generic equivalents carry the ADA Seal; however, because of recent changes in the ADA Seal program, prescription products such as Peridex® (0.12% CHG), even if they have previously earned the ADA Seal, are no longer included in the ADASeal program, as the granting of the ADA Seal for prescription product has been phased out.

Evidence-Based Literature

In addition to the ADA Seal, well prepared, published systematic reviews and meta-analyses that synthesize a large number of rigorous studies on a focused topic and that arrive at clear conclusions can be extremely valuable in guiding clinical decisions regarding products, devices, treatments, and interventions. Many such studies and reviews in addition to original research papers are cited throughout this supplement, and these references can provide further background and information on the benefits of using an antimicrobial mouthrinse as part of a daily regimen.

One good example cited within these pages is a recent meta-analysis of 6-month studies of antiplaque and antigingivitis agents.[3] Moreover, systematic reviews on a variety of dental subject areas are also available from the Cochrane Library including the Cochrane Database of Systematic Reviews at www.cochrane.org. This site is an essential resource for busy dental hygienists who strive to maintain an evidence-based practice.

In general, possessing a basic knowledge of what constitutes appropriate research methods and the ability to read the professional literature increases the dental hygienist's competence as a critical consumer of research, enabling the dental hygienist to translate important research findings into practice in a timely manner.

Conclusions

In conclusion, most patients will improve their oral health by adding an ADA-Accepted antimicrobial mouthrinse to their self-care daily regimen of toothbrushing and interdental cleaning. Within the context of clinical practice and current research evidence, dental hygienists should recommend that patients practice a three-step daily oral hygiene regimen of brushing, interdental cleaning, and rinsing with an ADA-Accepted antimicrobial mouthrinse to help prevent and reduce plaque and gingivitis and speak with their dental hygienist or dentist for additional guidance. Understanding the process of change and matching professional oral care recommendations to patient's specific needs, goals, values, and levels of readiness to change may lead to patient adherence and attainment of desired clinical outcomes over the long term. Regardless of the level of adherence to professional recommendations, patients need regular instruction and encouragement from a dental hygienist they trust.

References

1. Sharma N, Charles CH, Lynch MC, et al.. Adjunctive benefit of an essential oil-containing mouthrinse in reducing plaque and gingivitis in patients who brush and floss regularly: a six-month study. J Am Dent Assoc. 2004;135: 496-504.
2. About the ADA Seal of Acceptance [homepage on the Internet]. Chicago (IL): American Dental Association; [cited 2007 Jul 30]. Available from: http://www.ada.org/ada/seal/ index.asp.
3. Gunsolley JC. A meta-analysis of sixmonth studies of antiplaque and antigingivitis agents.. J Am Dent Assoc. 2006;137: 1649-1657.