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Oral Health Dialogue

A Message from Our Guest Editor …

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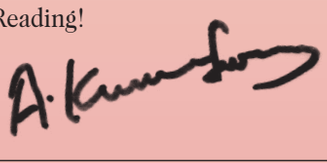
Dear Reader:

"Care" and "concern" are just two words, but when it gets generated in the oral healthcare provider's heart it assumes a much more profound form. Our patients undergo some moderately and, at times, some deep invasive interventions, but at all times need a proper algorithm for immaculate home care and recall. The dental team has the onus to counsel, consult, and ensure that all instructions would be easily conveyed for prompt usage at home.

This premiere issue of ***Oral Health Dialogue*** deals with some social concerns about halitosis, its current understanding and treatment tenets. You would also be interested in viewing some relevant evidence regarding periodontitis and cardiovascular diseases, given the alarming rise in both conditions. The clinician always needs a handy reckoner to convincingly use some menu for post-op care of restorations on teeth and implants, and Drs. Curtis and Bidra have provided a ready-to-use chart for predictable home care.

I am extremely indebted to all the authors who have very graciously contributed to this issue. And, of course, kudos to Colgate for their support of this worthy publication.

Happy Reading!



Colgate Oral Health Dialogue

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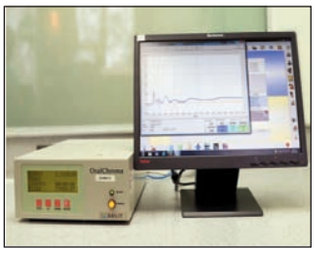
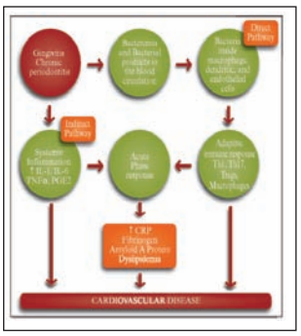
Contents



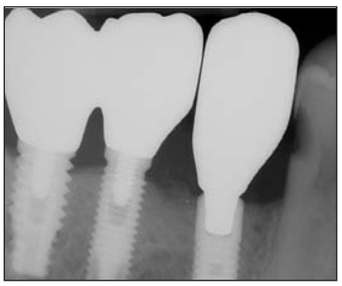
An Update on Oral Malodor
P. Mark Bartold, DDSc, PhD (Australia)

Technological advances in the diagnosis of etiological agents and the management of oral malodor allow for more predictable patient treatment outcomes and elevated oral health status.



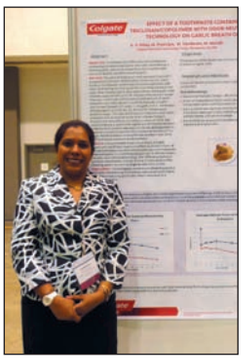
Evidence-based Linkages in Serum Biomarkers, Periodontitis, and Cardiovascular Disease in a Population Based in Cali, Colombia
Adolfo Contreras R, DDS, MSc, PhD (Colombia)

Linkages between cardiovascular disease and periodontitis continue to evolve. However, it is clear the key link between the two diseases is inflammation.



Recall and Maintenance Considerations for Patients with Fixed and/or Removable Restorations on Natural Teeth and Implants
Donald A. Curtis, DMD, FACP and Avinash S. Bidra, BDS, MS, FACP (USA)

It has been estimated that over 67,000 dental implants failed in Europe alone in 2008. Replacement costs for implant failures in the United States were estimated at over $338 million in 2007.



Colgate's Presence at AADR/CADR 2016 (USA)
Mack Morrison, PhD (USA)

Colgate supported 24 posters and one oral presentation related to gingival health, enamel health, and stain removal or whitening. Additionally, Colgate sponsored five university-based research presentations on areas related to fundamentals in oral health.

An Update on Oral Malodor

P. Mark Bartold, DDSc, PhD

Introduction

Halitosis, also referred to synonymously as "bad breath" or "oral malodor," is best described as an undesirable odor emanating from the mouth. The causes of halitosis are plentiful and include the ingestion of certain foods (such as alcohol); certain behaviors (such as poor oral hygiene, tobacco use); or some chronic medical conditions that may induce dry mouth. It is important to distinguish between oral malodor and bad breath. Oral malodor originates from within the mouth and bad breath may arise from sites other than the mouth. In this brief review, oral malodor will be the main topic of consideration. Oral healthcare professionals play a significant role in the management of oral malodor.

Prevalence of Halitosis and Oral Malodor

The incidence of chronic halitosis across global populations is difficult to determine accurately due to the lack of uniform guidelines and procedures for the measurement of halitosis, as well as poor correlation between self-reported and clinically evident halitosis.[1] Epidemiological studies have reported a variable prevalence of halitosis, ranging between 2–30% of the world's population.[2-5] For industrialized countries, the incidence of halitosis has been reported to range between 25–40% of the population.[4] It estimated that nearly 90% of halitosis cases can be determined to be oral malodor associated with poor oral hygiene, an abundance of tongue coatings, and intraoral conditions, including gingivitis, periodontitis, and dental caries.[6-8] Of the remaining 10% of cases, sinus or gastrointestinal problems account for around 5%, and other etiologies account for the remaining 5%.[8]

Classification of Halitosis

A useful classification system for halitosis has been formulated by Yaegaki and Coil.[9] This classification is based on the origin of the problem, and categorizes halitosis as temporary, intraoral, extraoral, pseudo, or halitophobia (Table 1). From this rational, treatment decisions can be made depending upon the overall diagnosis of the condition. The categories "intraoral" and "extraoral" halitosis are considered to represent the presence of "real" halitosis. The term "intraoral halitosis" is used to describe those cases where the source of the problem can be found within the oral cavity, and is most likely associated with tongue coatings, gingivitis, periodontitis, soft tissue lesions, and dental caries. "Extraoral halitosis" is usually subdivided into blood borne and non-blood borne halitosis.

The terms "pseudohalitosis" and "halitophobia" are used to describe those conditions where patients believe they have halitosis. However, following clinical assessment no such condition can be confirmed. The condition of temporary halitosis is usually associated with various types of food, drink, or tobacco use.

Pathogenesis of Intraoral Halitosis

Intraoral halitosis (also known as oral malodor) is caused principally by some of the anaerobic bacteria associated with periodontal disease through the production of acrid-smelling, volatile sulfur compounds, diamines, and phenyl compounds.[10-14] The volatile sulfur compounds have been extensively studied and are considered major contributors to oral malodor. Of these, methylmercaptan, hydrogen sulfide, and dimethyl sulphide have received the most attention. Elevated levels of methylmercaptan and hydrogen sulfide are associated with oral malodor, while the volatile sulfur compound dimethyl sulfide appears to be more commonly associated with halitosis from non-oral sources.[15]

The bacteria mostly responsible for the production of methylmercaptan and hydrogen sulfide are *Fusobacterium nucleatum, Treponema denticola, Prevotella intermedia, Porphyromonas gingivalis*, and *Bacteroides forsythus*. These bacteria reside within the subgingival plaque

Table 1. Categories of Oral Malodor

Temporary Halitosis
- Smoking
- Diet (garlic, spicy foods, dairy)

Intraoral Halitosis (Oral malodor)

Oral bacteria
- Chronic gingivitis
- Periodontitis
- Tongue coating

Acute Infections
- Abscess
- Necrotising ulcerative periodontitis
- Pericoronitis

Dry mouth
- Sjögren's disease
- Medications

Extraoral Halitosis

Nasal, paranasal, or laryngeal origins
- Including acute viral or bacterial infection, tonsillitis, deep tonsillar crypts, tonsilloliths, chronic sinusitis, postnasal drip, foreign body in nasal cavity or sinus.
- Pulmonary tract or upper gastrointestinal tract origins
- Bronchi and lungs: Including chronic bronchitis, bronchial carcinoma, bronchiectasis
- Gastrointestinal: Including regurgitation, hiatus hernia, helicobacter pylori infection, achalasia, steatorrhea, and other malabsorption conditions
- Blood borne and emitted via the lungs
- Liver cirrhosis
- Kidney insufficiency
- Systemic metabolic disorders: Including diabetes, trimethylaminuria, starvation
- Internal bleeding
- Menstrual cycle

Pseudohalitosis

Oral malodour does not exist but the patient believes they have halitosis

Halitophobia

If after treatment for genuine halitosis or pseudohalitosis the patient continues to believe they suffer from halitosis

(Adapted from Bartold, 2015[44])

associated with gingivitis and periodontitis, and are also commonly found on the dorsum of the tongue. Adults with oral malodor will have heavier tongue coating and significantly more pockets greater than 5 mm than those without oral malodor.[3]

Halitosis Assessment

When assessing for halitosis, thorough evaluations of medical and dental histories are essential starting points. The medical history should include acquiring information relating to current medications; related respiratory ailments, including nasal and sinus conditions; snoring and sleep apnea; mouth breathing; throat infections; tonsilloliths; and ingestion of foods that may contribute to bad odor. The dental history should focus on the patient's general level of dental care, including frequency of dental visits and oral hygiene practices, such as frequency of tooth brushing and use of other oral hygiene aids (*e.g.,* dental floss, interdental cleaning aids, mouthrinses, and tongue cleaners/scrapers). Focused questions relating to oral malodor must also be included to determine how long the problem has been present, whether it is worse at any particular time of day, and if anyone has commented on the problem.

Following the initial interview for medical and dental histories, both an oral evaluation and breath analysis are required.[16] The oral evaluation should include a visual assessment of the tonsils, oral debris, caries, exposed pulps, extraction wounds, interdental food impaction, and possible intraoral conditions, such as gingivitis, periodontitis, necrotizing periodontitis, peri-implantitis, pericoronitis, and recurrent oral ulcerations.

An assessment of tongue coating is also an essential part of the oral assessment for halitosis. The Winkel Tongue Coating Index assesses tongue coatings by dividing the dorsum of the tongue into six sections (Figure 1).[17] The presence of any tongue coating is then graded and recorded for each of the sections. An assessment of "No coating" is given a score of 0, a "light-thin coating" is given a score of 1, and a "heavy-thick coating" is given a score of 2. A score is then calculated by adding all six scores, giving a total score in the 0–12 range (Figure 1).

It is also important to assess the quantity and quality of saliva and its relationship to the presence of a dry mouth. An important consequence of reduced saliva and dry mouth is increased bacterial growth due to the absence or reduction in the antibacterial properties of saliva. With the increased bacterial load, there is an associated increase in release of volatile sulfur compounds, and thus an increase in oral malodor.

Following the oral examination, a breath odor evaluation can be carried out. There are numerous ways in which this can be completed, including organoleptic (smelling patients' exhaled breath) or the use of purpose-built instruments (*e.g.*, Halimeter® or OralChroma®).

Organoleptic Measurement of Halitosis

Organoleptic measurement of halitosis requires a trained clinician to sniff and smell the patient's expired air and score the level of odor. For this assessment, a five-point odor intensity range is used based on the clinical rating of the odor, ranging from "no odor" present (score = 0) to a "strongly offensive odor" being detected (score = 5).[18,19] The greatest problem with this form of assessment is that it is an unpleasant experience for both the patient and the assessor. Therefore, more objective and sophisticated means of measuring volatile sulphur compounds in breath have been developed for both research and clinical purposes.

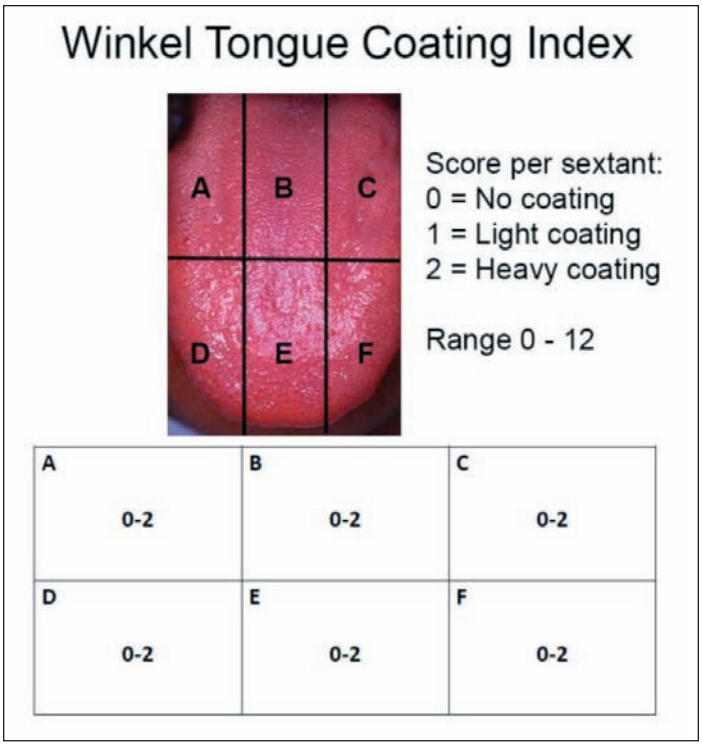


Figure 1. *Winkel Tongue Coating Score. The dorsum of the tongue is divided into sextants and the amount of tongue coating is subjectively graded for each sextant. The score is calculated by adding the scores for all sextants(0-2) for a total score within a range of 0-12.*[17]

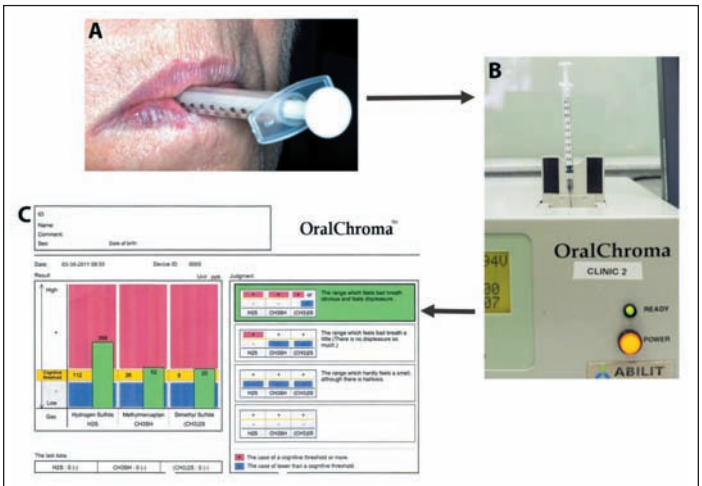
Instrumental Assessment of Halitosis

While there are many reported methods for assessing halitosis, instrumental analysis for the presence of volatile sulfur compounds is recommended because of the degree of objective assessment.[20,21]

The first of such instruments, the Halimeter®, was developed in the 1990s as a chairside instrument for measuring volatile sulphur compounds.[22] The readings from this instrument were found to not always correlate well with organoleptic scores due to the presence of other malodorous compounds, such as volatile fatty acids and cadaverine, which could be detected by organoleptic means but not by the Halimeter®. Nonetheless, the development of this instrument opened up new opportunities for research and development of clinical protocols to measure and monitor treatments for oral malodor.

More recently, another device, OralChroma®, has been developed. In contrast to measuring total volatile sulphur compounds, the OralChroma® can distinguish between and measure the three major volatile sulphur compounds associated with halitosis (*i.e.*, hydrogen sulfide, methylmercaptan, and dimethyl sulphide; Figure 2). Sample collection is simply achieved by placing a disposable syringe in the subject's mouth with their lips sealed for thirty seconds and then the contents are injected into the chromatograph. Analysis takes eight minutes. A printout is then produced depicting the levels of the three volatile sulfur compounds (Figure 3). This is particularly useful, since

Figure 2. *OralChroma® portable gas chromatograph for measuring volatile sulfur compounds (hydrogen sulfide, methyl mercaptan, and dimethyl sulfide).*



Key:

A. Sample of intraoral air is collected in a disposable syringe for 30 seconds.
B. The contents are injected into the chromatogaph.
C. Analysis takes 8 minutes after which a printout depicting the levels of the 3 volatile sulfur compounds.

Figure 3. *Sample collection and analysis for OralChroma® assessment.*

it allows for an immediate assessment of whether the source of the oral malodor is likely to be arising from the oral cavity (hydrogen sulfide and/or methylmercaptan) or elsewhere (dimethyl sulfide).

Management of Halitosis

The treatment options for halitosis (Table 2) can be divided into six categories based on the types of halitosis (Table 3).[9,16] The management of temporary, intraoral, and pseudohalitosis can be undertaken by oral healthcare professionals. However, both extraoral halitosis and halitophobia will require a multi-disciplinary approach, including the assistance of physicians, psychiatrists, and psychologists.

Management of Intraoral Halitosis

Based on gas chromatogram analyses, oral malodor is usually associated with elevated levels of hydrogen sulfide and methylmercaptan. On the other hand, elevated readings for dimethyl sulphide usually indicate an extraoral source of halitosis.[15] Upon making a diagnosis of oral malodor (as distinct from temporary halitosis, extraoral halitosis, pseudohalitosis, or halitophobia), treatment should commence. Focus is to be on the likely intraoral causes of the problem, and the approach is to be a causally related, multi-step one. In addition, all dental disease, including gingivitis, periodontitis, soft tissue lesions, and dental caries, must be diagnosed and effectively managed.

Surprisingly, although gingivitis and periodontitis are thought to be important contributory factors to oral malodor, there are few studies that have fully evaluated the effect treatment of periodontal disease has on halitosis.[23] Of the reports published to date, most confirm that periodontal treatment has a positive effect in reducing oral malodor.[24,25] However, a recent study concluded that periodontal treatment following either the full mouth periodontal disinfection or quadrant cleaning protocols reduced levels of volatile sulfur compounds, but no effect was noted for organoleptic outcomes.[26]

The most important focus in the management of intraoral halitosis must be reduction of the bacterial burden. Effective and regular oral hygiene practices (brushing and interdental cleaning) and regular (twice daily) tongue cleaning must be implemented.[27] Although some authors do not recommend tongue scraping due to the potential damage to the tongue surface, a gentle brushing with a small soft brush is an alternative recommendation.[9] Regardless of the method used (brushing or scraping), two systematic reviews evaluating the effectiveness of mechanical tongue cleaning on oral malodor have concluded that tongue cleaning results in a small but significant reduction in volatile sulphur compounds that, in order to be effective, has to be performed regularly.[28,29]

Table 2. Treatment Options (TO) for Halitosis

TO1	Explanation of halitosis, oral hygiene instruction, and tongue cleaning instructions
TO2	Address any dietary and smoking contributory factors.
TO3	Full mouth prophylaxis and management of any oral conditions likely to be contributing to oral malodor (gingivitis, periodontitis, ulcers, caries, etc.)
TO4	Referral to a medical specialist for further investigations of extraoral sources
TO5	Explanation of examination findings, reinforcement of oral hygiene practices (including tongue cleaning), education on causes of halitosis and reassurance
TO6	Referral to specialist for psychological assistance to understand and deal with condition

(Adapted from Yaegaki and Coil, 2000[9] and Bartold, 2015[44])

Table 3. Treatment Matrix for Management of Various Types of Halitosis

	Treatment Options (as defined in Table 2)					
Conditions	**TO1**	**TO2**	**TO3**	**TO4**	**TO5**	**TO6**
Temporary	X					
Intraoral	X	X	X			
Extraoral	X	X		X		
Pseudo	X	X			X	
Halitophobia	X	X				X

(Adapted from Bartold, 2015[44])

More recently, the management of oral malodor has focused on reducing the volatility of the malodorous gases. This is most commonly achieved through the use of specific ingredients in toothpastes and mouthrinses. In general, the use of clinically proven antibacterial toothpastes is recommended for the management of oral malodor.[30] Toothpastes containing antibacterial agents such as triclosan or metal ions (zinc or stannous) have been well studied and shown to have the greatest potential to influence oral malodor. Other agents such as hydrogen peroxide, essential oils, and flavors have shown limited effects in reducing oral malodor.

The adjunctive use of antiseptic mouthrinses is also essential to achieving a satisfactory outcome in the management of oral malodor.[31,32] Mouthrinses containing chlorhexidine are the gold standard for chemical plaque control. However, its long term use cannot be recommended due to issues with tooth staining and adverse effects on taste sensation. Alternative mouthrinse additives, such as cetylpyridinium chloride or zinc ions, have been demonstrated to be of some use in the management of oral malodor.[17,33,34] Most mouthrinses recommended for the management of oral malodor, particularly those containing zinc, are effective due to a combination of their antibacterial effect in reducing the overall bacterial load, and also through their diluting effect on the volatile sulphur compounds responsible for malodor.[35] A recent systematic review concluded that mouthrinses containing chlorhexidine plus cetylpyridinium chloride plus zinc, or those containing zinc plus cetylpyridinium chloride were most effective in the management of oral malodor.[36]

Another "interesting" mouthrinse is water. Simply by increasing saliva flow, the solubility of volatile sulfur compounds is increased and can lead to some reduction in the malodor. For these reasons, it is suggested that frequent water intake can reduce malodor for an hour.[37]

The use of probiotics as an adjunct in the management of both intraoral and extraoral halitosis has also been receiving increasing attention.[38,39] The rationale for this treatment is based on the introduction of non-odor producing, commensal bacteria to the oral cavity to regulate the re-emergence of bacteria associated with oral malodor. The results of some studies investigating the use of *Streptococcus salivarius* K12 in conjunction with mechanical subgingival debridement have shown reasonable reductions in volatile sulphur compounds.[38-41] However, other results from other studies investigating the use of probiotics as an adjunctive aid for the management of oral malodor have been equivocal, and therefore probiotics are not universally accepted as a proven method of control.[41-43]

There are many commercially available over-the-counter agents marketed for breath freshening, such as mouthrinses, sprays, lozenges, and chewing gums. However, these products simply mask the offensive smell of oral malodor for a very short time, and are generally of very limited value in the management and control of oral malodor because they do not address the driving cause(s) of the problem. While these agents do have short term effects in reducing oral malodor, they are not a treatment *per se* and may significantly delay the correct diagnosis, treatment, and management of this important clinical condition.

Management of Extraoral Halitosis

Halitosis from extraoral sources represents approximately 10% of all halitosis cases.[15] When using gas chromatography to assist in the diagnosis of halitosis, a high reading for dimethyl sulfide is considered to be consistent with halitosis associated with an extraoral source.[15] If an extraoral source of halitosis is suspected, then further assistance from an appropriate physician specializing in the management of nasal, throat (otolaryngologist), or gastrointestinal abnormalities (gastroenterologist) is advisable. In addition, consideration should also be given to the potential for kidney insufficiency, liver insufficiency/dysfunction, and other metabolic diseases to be contributing to extraoral halitosis. It is recommended that treatment options 1,2, and 4 (Table 3) be implements for such cases. While good oral hygiene (treatment option 3, Table 3) is likely to be of general benefit to the patient suffering from extraoral halitosis, it is unlikely to have any significant impact on this specific condition.

Conclusion

Oral malodor is considered to be the most common form of halitosis and is generally attributed to the production of volatile sulfur compounds, which are produced by oral bacteria and have a very unpleasant smell. For those who suffer from oral malodor, the condition causes great concern and can adversely impact their daily activities. Indeed, this is not only an important oral condition, but also an interesting sociological issue that has led to large scale marketing and consumption of breath freshening aids that represent a billion dollar industry. Surprisingly, this important and often debilitating condition continues to be poorly understood, and has tended to be overlooked by the dental profession at large. Although management of oral malodor is not perceived as a fashionable aspect of clinical dental practice, the correct diagnosis and management of this condition is very important to our patients. Oral malodor affects patients' quality of life functionally and esthetically in their activities of daily life. The field of oral malodor management is advancing rapidly. Technological advances in the diagnosis of etiological agents and the management of oral malodor allow for more predictable patient treatment outcomes and elevated oral health status.

This article is based on the publication: Bartold PM. Simple solutions for breath malodour. Dimens Dent Hyg 2015;56-61. Permission has been granted from the publisher for use of some of the graphic materials presented in this article.

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Evidence-based Linkages in Serum Biomarkers, Periodontitis, and Cardiovascular Disease in a Population Based in Cali, Colombia

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Cardiovascular disease (CVD) is the most prevalent disease epidemic worldwide. Risk factors include unhealthy habits like excess food intake and physical inactivity that lead to obesity. Genetic predisposition, smoking, and high blood lipid levels are classic risk factors for CVD.

Linkages between cardiovascular disease and periodontitis continue to evolve. Currently, the association between the two diseases is still a matter of debate, for both are multifactorial inflammatory diseases with shared confounding factors, such as smoking, subclinical infection, obesity, and diabetes. However, it is clear the key link between the two diseases is inflammation. The aim of this article is to educate dental professionals about how oral inflammation impacts cardiovascular disease.

Gingivitis and Periodontitis

Gingivitis is the reversible inflammation of the gingiva, originated by a non-specific accumulation of bacterial species – oral microbial biofilm accumulation – over the teeth and mucosal surfaces.

Periodontitis is the irreversible loss of periodontal attachment and support, and is reversible in infection and inflammation control (with proper interventions). Periodontitis is triggered by the overgrowth of 20-30 pathogenic microbial species in the periodontal crevice that permanently affect the structures supporting dentition.

Both gingivitis and periodontitis affect most humans along their life cycle. The most prevalent is gingivitis at 80%, while periodontitis affects between 20–50% of adults globally. Improving oral microbial biofilm removal by practicing regular bacterial plaque control at home is the primary prevention strategy to control both oral diseases.

Periodontitis is an infection that induces chronic inflammation. As a result, there is an increase in endothelial and systemic CVD biomarkers such as C-reactive protein (CRP), fibrinogen, and white blood cells, IL-1, IL-6, HDL, LDL, and triglycerides, ICAM I, E-selectin, MOP, and amyloid serum, among others.[1-21] These are also distinctive serum biomarkers associated with CVD.[2,12] Periodontitis and CVD are linked by similar risk factors and immunological pathways (see figure at right).

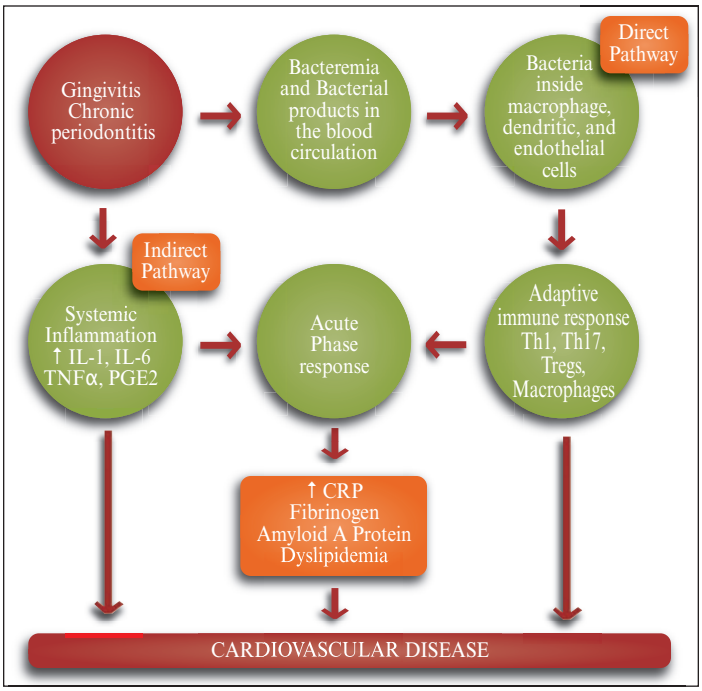
As seen in the figure, untreated gingivitis and periodontitis expose the host to continuous transient bacteremia. Bacteria and bacterial products get into macrophages, dendritic, and endothelial cells causing injury (direct pathway). This, in turn, triggers the host's inflammatory response, thereby inducing the liver into an acute-phase response, dyslipidemia, and activation of the adaptive immune system. Macrophages and plasma cells, recognizing the pathogen-associated molecular patterns of circulating bacteria, release antibodies that cross-react with the endothelium and low density lipoproteins (LDL), causing lipids to migrate into macrophages (foam cells). Antibodies and regulatory T cells (T-regulatory lymphocytes, also known as "Tregs") induce T helper cell 1 (Th1) and Th17 response, and enhance foam cell infiltration and dissemination at the blood vessels.

In the indirect pathway, bacterial toxins and/or proinflammatory cytokines disseminate in the bloodstream. Similar to the direct pathway, the circulation of these peptides triggers inflammation (IL-1, IL-6, TNF, E-Selectin, MPO, ICAM-1, PGE2). In response, the liver initiates an acute-phase response, releasing CRP, fibrinogen, and amyloid A protein into the circulation. Furthermore, there is an increase in cholesterol synthesis as a disruption in the lipid balance occurs. In addition, the chemokines target leukocytes and lymphocytes from the adaptive immune response, and initiate cell migration and activity. Both direct and indirect pathways, triggered by untreated periodontitis, could lead to CVD.

Evidence-based Linkages Between Oral Disease and CVD Biomarkers

Untreated periodontitis increases a number of important CVD biomarkers. Conversely, after treating periodontitis a significant reduction in these biomarkers is achieved (see table on next page).

In 1989, Mattila, *et al.*,[10] first reported the association between poor



Biological pathways linking periodontitis and cardiovascular disease.

dental conditions and cardiac infarctions. From the inception of this seminal study, there have been more than 1,500 studies (PubMed, May 2016) that have investigated the relationship between oral disease (including periodontitis) and CVD. The bulk of the studies comprise systematic reviews and meta-analyses, descriptive studies, case control studies, cohort studies, clinical trials, *in vitro* studies, and animal model studies.[1-21] Despite inconclusive evidence demonstrating a causal relationship, biological associations remain plausible.

Recent Studies Depicting Biomarkers in Both Periodontitis and CVD

Author, Publication Year	Sample Size	Intervention	Parameters	Results
Mercanoglu *et al*., 2004	28P-CG 26NP-TG	SRP-TG NT- CG	PI, GI, PD, CAL, lipid, EDD, EID	SS > perio PRM EDD, TG Lipid- no change
Seinost, *et al.*, 2005	31-CG 30P-TG	SRP + Amox & Metro-7 days in TG	PD, CAL, lipid, HbA1c CRP, ESR, BP, FMD, BIMT	SS>FMD & CRP NSS BIMT, lipid & BP
Elter, *et al*., 2006	22P	SRP	PD, CAL, EDD, EID, CRP, IL-6, lipid	SS↓PD, IL-6, CRP; SS ↑ EDD; NSS, lipid
D'Aiuto, *et al*., 2007	55P	SRP	TNF- α, IL-β, D-dimer, E-sel, VWF	SS↑ TNF- , E-sel, D-dimer-1 days post-SRP & SS ↓ 30 days post-SRP
Tonetti, *et al*., 2007	61P-TG 59P-CG	SRP + Mino LDD-TG; NT-CG	PD, PI, BOP, lipid, BP, glucose, IL-6, E-sel, CRP, tPA, PAI-1, VWF, FMD, brachial artery diameter	SS↑ BP, CRP, IL-6, tPA, PAI-1, E-sel – 1 day; SS ↓FMD-1 days; SS ↑ FMD & SS ↓ E-sel – 60 & 180 days; SS>perio PRM-60 & 180 days
Pischon, *et al*., 2007	15 GAP	SRP; after 2 months Doxy/Amox + Metro	PD, CAL, VCAM-1, ICAM-1, E-sel, IL-6, CRP, lipid, fib	After SRP SS ↑ CRP, SS ↓-6 m; SS ↓ E-sel-6 m; SS ↓ fib-6 m; NSS IL-6, lipid
Blum, *et al*., 2007	22P-TG 10-CG	SRP + Amox & Metro	PD, CAL, BOP, FMD, FID	SS>perio PRM-6 m SS>FMD-3 months, NSS FID-3 months
Higashi, *et al*., 2008	24P-TG 24P-CG	SRP & antibiotics glucose, IL-6, FBF	PD, BOP, CAL, BP, lipid, CRP, vasodilation	SS ↓ CRP, IL-6; SS ↑ ACh induced
Piconi, *et al*., 2009	35P	SRP	PD, BOP, PI, CRP, WBC, fib, lipid, VWF, CIMT, homocysteine, PCR for Aa, Pg, Tf, Td, Fn, Pi	SS ↓ Pg, Tf, Td, Fn-1 months, NSS-3 months; SS ↓ CIMT- 6 &12 months; SS ↓ CD4+-6 months SS ↓ PD, PI, BOP-1 & 12 months NSS CRP, fib, WBC
Li, *et al*., 2011	24P-TG 23P-CG	SRP + CHX gel-TG	PI, PD, CAL, BOP, FBC CPC (CD34+) count, FC, PAT, CRP, creatinine, lipid, glucose	SS ↓ PD, BOP; SS ↓ (CD34+) count; NSS other PRM
Jaramillo, *et al*., 2013	192 advanced P, 256 moderate P 229 NP	No intervention	Socio-demographic variables, PI, PD, CAL, BOP, smoking, red complex bacteria, serum antibodies, blood lipids including cholesterol, HDL, LDL, and TG.	Tf significant association with HDL. IgG1 against Pg associated with HDL and Aa correlated with levels of HDL
Bokhari, *et al*., 2014	317 P and with coronary disease	No intervention	BOP, PD and CAL, CRP, FIB and WCC	BOP positive is related with increased serum biomarkers CRP and FIB
Ramírez, *et al*., 2014	22 P/22 NP	No intervention	Anthropometric PI, PD, CAL, BOP Endothelial function Metab. Synd. Microbiota E-selectin MPO I CAM 1	↑Red complex bacteria↑E-selectin, MPO, I CAM 1 in P versus NP
Cullinan, *et al*., 2015	193P 190NP	Triclosan Toothpaste	Total Cholesterol HDL, LDL C reactive protein WCC	↓ TC, LDL, HDL, In Test group

KEY: P: patients with periodontitis; NP: non-periodontitis patients; PD: probing depth; PI: plaque index; GI: gingival index; CAL: clinical attachment loss; SS: statistically significant; NSS: no statistically significant change; SRP: scaling and root planing; EED: endothelium-dependent dilation; FMD: flow-mediated dilation; CRP: C-reactive protein; BIMT: brachial intima-media thickness; CIMT: carotid intima-media thickness; lipid: represents total triglycerides, high-density lipoprotein and low-density lipoprotein; Perio PRM: represents clinical periodontal parameters (PD, CAL, PI); BP: blood pressure; TNF-α: tumor necrosis factor-α; IL-1β: interleukin-1β; L-6: interleukin-6; E-sel: E-selectin; Amox: amoxicillin; Metro: metronidazole; Doxy: doxycycline; Mino LDD: minocycline local drug delivery; VWF: von Willebrand factor; PCR: polymerase chain reaction; tPA: tissue plasminogen activator; WBC: white blood cell; fib: fibrinogen; PAI-1: plasminogen activator inhibitor type 1; Aa: A actinomycetemcomitans; Pg: P gingivalis; Tf: T forsythensis; Td: T denticola; Fn; F nucleatum; Pi: P intermedia; FBC; full blood count; CPC: circulating progenitor cells; CHX: chlorhexidine; ICAM-1: intercellular adhesion molecule; VCAM-1: vascular cell adhesion molecule-1; FC: flow cytometry.

Such evidence was recently confirmed by Colombian researchers based at the Group in Periodontal Medicine and the Centre for Development and Evaluation of Policies and Technologies in Public Health at the Universidad del Valle in Cali, Colombia. In this study,[16] forty-four patients were recruited. Half had chronic moderate to severe periodontitis and half had gingivitis and slight periodontitis (control). Anthropometric, clinical, biochemical parameters, endothelial function, and eight plasma biomarkers of CVD were assessed in both groups. Patients also received a full periodontal examination. Subgingival samples were collected for microbial culture and polymerase chain reaction (PCR) analysis.

Both groups were comparable in anthropometric parameters and blood pressure, and in the number of positive metabolic syndrome components. Flow-mediated dilatations (12.1 ± 10.7 versus 12.2 ± 5.5; p = 0.94) were similar in cases and controls, respectively. Clinical periodontal parameters were found to have significantly increased in patients with advanced periodontitis. Univariate analyses demonstrated significantly higher plasma levels of E-selectin (64.5 ± 30.9 versus 43.8 ± 22.2; p = 0.026) and myeloperoxidase (MPO; 103 ± 114.5 versus 49.1 ± 35.6; p = 0.032) in cases compared to controls. In addition, significantly higher levels of E-selectin, MPO, and ICAM-1 were found in periodontitis patients after adjustment by age and waist circumference. Red complex microorganisms were more frequently detected by culture and PCR analysis in those patients with severe to moderate periodontitis. Consistent with these findings, those with untreated periodontitis were found to be significantly associated with dyslipidemia[8] seen in a previous study investigated by our research team.

Global Impact of Oral-Systemic Linkages

Associations between periodontitis and CVD data comes mostly from studies of the USA, Japan, and Europe. There is a critical need for increasing scientific evidence from other global regions. Risk factors, such as genetics, nutritional habits, body complexión, and the lack of access to healthcare services, increase the susceptibility to these two epidemic diseases.

Two of our studies[8,16] confirmed that in this Latin-American population, untreated, chronic, moderate to severe periodontitis coupled with red-complex microorganisms is associated with systemic inflammation. Chronic periodontal infections and inflammation increase the risk for CVD events.

Conclusion

Strong scientific evidence shows that treatment interventions in periodontitis produce a significant lowering of both the microbial burden and systemic inflammation.[1-9,13-21] What is a matter of debate, however, is the magnitude and impact of periodontitis on the risk for CVD. Further studies to determine the causal association between periodontitis and CVD are indeed warranted. Proper oral hygiene, reduced risk factors, and early interventions are the first steps toward minimizing the inflammatory process.

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Recall and Maintenance Considerations for Patients with Fixed and/or Removable Restorations on Natural Teeth and Implants

Donald A. Curtis, DMD, FACP and Avinash S. Bidra, BDS, MS, FACP

Introduction

A structured plan for the maintenance of dental restorations is an important part of what we do as healthcare providers. A carefully organized and strategically implemented maintenance program is a strong predictor for the longevity of dental restorations, the stability of soft tissue esthetics, and, ultimately, how satisfied patients will be with provided dental services.[1-3] Even meticulously completed restorative care can fail unless the clinician and patient invest the time and energy into developing and following a structured maintenance program.

Maintenance plans for patients have historically been discussed and implemented following the completion of restorative treatment. The authors believe waiting until restorative care is complete to discuss a maintenance strategy is a mistake. A plan for the maintenance of dental restorations, especially complex dental restorations, should be discussed during the initial consultation and evaluation. If patient compliance is not expected, or if risk factors cannot be adequately controlled, the treatment plan and eventual treatment provided need to be structured accordingly.

During the initial consultation and evaluation, a careful review of patient history, medical status, medications, age, dexterity, adherence, planned treatment, and anticipated functional use are considered. The goal is to match the numerous variables that influence treatment with the anticipated requirements to maintain the planned restorations. An understanding of potential biologic complications, such as caries or periodontal disease, as well as mechanical complications from bruxism and material limitations, can form the basis of a discussion with the patient that results in improved patient involvement and understanding. It is from this dialogue that a maintenance strategy is developed and matched to treatment needs and anticipated compliance. Developing a maintenance plan may include the need for additional diagnostic testing and/or the use of specific interventions to address patient-specific risk factors.

The maintenance plan will include recommendations for patient recall intervals, at-home maintenance regimen completed by the patient on a daily basis, and a professional maintenance regimen that the dental team completes in the office. The elements of the maintenance program should be complementary, patient-specific, and address potential factors that could compromise restorative treatment.

This article presents an outline of recommendations for patient recall visits, at-home maintenance, and professional maintenance regimens for patients with tooth-borne and/or implant-borne restorations. Recent systematic reviews on the maintenance of tooth-borne and implant-borne restorations by Bidra, *et al.*[4,5] and clinical practice guidelines[6] (CPGs) form the basis of this article. These systematic reviews and CPGs were sponsored by the American College of Prosthodontists (ACP), and included a scientific panel of experts appointed by the ACP, American Dental Association (ADA), Academy of General Dentistry (AGD), and American Dental Hygienists Association (ADHA), who critically evaluated and debated findings from two recent systematic reviews[4,5] to develop clinical practice on the maintenance of tooth-borne and implant-borne restorations.[6] In addition, we provide a summary of related research on the topic of maintenance of tooth-borne and implant-borne restorations.[1-48] Our objective is to outline important findings from these systematic reviews, CPGs, and related literature, with the goal to improve patient outcomes and decrease the need for retreatment, defined here as the early replacement of restorations for preventable reasons.

Maintenance for Patients with Tooth-borne Restorations

General Considerations

Consideration of maintenance plans for dental restorations has more relevance now than ever before; patients are getting older as our society ages, and more patients are receiving complex dental restorations. With age-associated loss of tooth structure and an oral environment often altered from a high carbohydrate diet and medication-induced xerostomia, avoiding biologic and mechanical complications is challenging. The economic liability of dental treatment, both to the individual and to society, makes the need for maintenance programs even more compelling.

Preventive strategies have been successful with younger patient cohorts, yet prevention efforts and the development of comprehensive maintenance protocols for patients with complex tooth-borne removable and/or fixed restorations have been comparatively underemphasized. In this article we outline general maintenance guidelines with the understanding that the eventual maintenance program will need to be adapted to the specific needs, risk factors, and expected compliance of the individual patient.

Patient Recall Intervals

Why do we use six-month recalls in dentistry? Unfortunately, there is limited evidence describing what the most appropriate recall regimens should be. In patients with complex tooth-borne removable and fixed restorations, there is even less evidence as to the most appropriate recall schedule. The six-month patient recall interval was initially advocated in 1879 by the American Academy of Dental Science. Later, the American Dental Association (ADA) also advocated the six-month recall time period. In the 1930s, the six-month interval for dental visits was popularized by a promotional advertisement in a popular dentifrice commercial (Ipana; Bristol-Meyers Company, New York, NY), resulting in the wide acceptance of the six-month interval for dental visits as a standard in the dental insurance industry. Despite the lack of scientific evidence, the six-month interval for recalls is still widely accepted by clinicians and patients alike.[7,8]

In a systematic review of dental recall intervals and incidence of dental caries, it was determined that a six-month recall protocol for caries prevention was not supported by the literature, and that existing evidence for current recall protocols is weak.[7,8] The authors concluded that clinicians should consider assigning recall intervals to patients on the basis of patients' risk of developing caries. Traditionally, both patients at low and high risk for dental disease have been placed on six-month recalls, with the logic of early detection of disease, prevention of disease, and oral cancer screening. An additional consideration for continued practice of a six-month recall is to allow the dentist to identify health issues, such as sleep disorders, diabetes, or hypertension, and appropriately refer the patient to a physician. Although all of these may be valid reasons to consider six-month recalls, there are many reasons for tailoring a recall plan specific to the patient needs. It is important to explain to the patient that the recall schedule is a discussion point and is based on many factors, some of which can be modified to decrease the risk of complications.

Recall programs based on risk assessment of potential complications, such as caries or periodontal disease, have become increasingly accepted in dentistry. For example, rather than just assessing existing caries, it is important to consider the risk for future caries. This is important because the removal of caries, although an important therapeutic goal, does not decrease the risk of future caries.[9,10] Similarly, the use of risk assessment models has been applied to the management of periodontal disease, since equivalent levels of plaque may result in different levels of inflammation in different individuals, and require different recall intervals.[11,12] More accurate risk assessment models are expected to result in improved outcomes at a lower cost.[11] In creating a maintenance plan for a patient with complex dental restorations, both patient-specific factors and the restorative care can potentially add risk.

At-home Maintenance

The exact at-home maintenance program for each patient will depend on many factors, including the patient's history, adherence, medications, systemic health, age, dexterity, type of restorative procedure, and anticipated use. Current evidence indicates that the type of prosthesis fabricated can have an impact on aftercare needs, and should be accounted for in the maintenance program. Additionally, the use of specific oral topical agents, like chlorhexidine, fluoride, and triclosan, can aid in reducing risk for gingival inflammation, dental caries, and candidiasis. Therefore, both the type of restorations considered and the patient risk factors need to be considered before the decision is made on how to guide the patient toward an at-home maintenance program.

A carefully considered maintenance program is especially important for patients receiving complex tooth-borne dental restorations and who are at an increased risk for aftercare. For example, in evaluating caries risk of an abutment for the more complex fixed dental prosthesis (FDP; formerly known as fixed partial denture or bridge) compared to the less complex single crown, FDP abutments had a 27% increased risk for caries.[13] Additionally, when complex tooth-borne restorations, such as FDPs, were placed and patients did not adhere to a maintenance program, plaque levels and loss of teeth due to periodontal disease were significantly higher than when patients did comply with a maintenance program.[13] In patients wearing a partial denture, maintenance programs accompanied by an illustrated manual resulted in a decrease in denture plaque accumulation.[14] In addition, regular supervision resulted in a good standard of oral and denture hygiene in removable dental prosthesis (RDP) wearers over a prolonged period of time.[14] Overnight use of RDP, denture age, and storage conditions have also been shown to potentially increase the incidence of oral mucosal lesions in patients who wear an RDP[15] (Figure 1).

Figure 1. *Occlusal image of the maxillary arch showing severe palatal soft tissue damage and periodontal disease around remaining teeth, caused by continual wearing of an interim partial denture for several years. This resulted in loss of all teeth and a complete denture. This situation could have been prevented by regular patient recall and patient education about removal of the prosthesis during sleep and at-home maintenance of the restoration.*

A fixed prosthesis has been shown to be more difficult to maintain than single crowns, and the need for a structured maintenance program is therefore even more critical in order to avoid complications of treatment (Figure 2). For example, Ortolan, *et al*. reported on 93 patients that those with single crowns showed better oral hygiene levels than patients with FDPs during professional recall and maintenance.[16] Similarly, Ikai, *et al*. showed that patients with FDPs who did not participate in a professional maintenance program, had a high mean plaque index (43.2%), and the failure rate of the FDPs was also high (33%) over a follow-up period greater than 16 years.[13] It is also interesting that patients treated with removable partial dentures needed more "extensive" and "moderate" maintenance than patients with fixed restorations.[17] The authors suggested that this difference should also be considered during treatment planning.[17]

Figure 2. *Frontal image showing a bruxism patient with long-span fixed dental prosthesis with multiple porcelain fractures and previous attempts at chair-side repair. This is a major mechanical complication of fixed dental prostheses and requires sectioning of the entire prosthesis and remake. Such complications can be prevented by fabrication of an occlusal device to protect the restorations.*

There is evidence that judicious use of fluoride, triclosan, and chlorhexidine can, in selected application, provide benefit for patients with dental restorations and for individuals with risk factors for failure of restorations. Ekstrand, *et al*. compared toothpastes with 5,000 ppm or 1,450 ppm fluoride in a randomized control trial (RCT) on 125 patients, and determined that toothpaste with 5,000 ppm fluoride was significantly more effective for controlling root caries lesion progression and promoting remineralization.[18] Patients involved in this study were from elder care facilities in Denmark, and had some remaining teeth and either a partial RDP or FDP. Thus, the use of high fluoride-containing toothpastes in patients with high-risk treatment, such as a partial RDP or FDP, should be considered.

The use of chlorhexidine has been shown to help maintain the health of tissues around teeth restored with composite resin, and can be an adjunct in decreasing *Candida albicans*.[19,20] In a study completed on 20 patients with diabetes mellitus, the periodontal tissues of teeth restored with class V composite resin were improved with 0.12% chlorhexidine rinse compared to no chlorhexidine.[19] In a double-blind RCT, López-Jornet, *et al*. showed that twice-daily use of 10 ml of 0.2% alcohol-free chlorhexidine rinse for 60 seconds significantly decreased colony forming units of *Candida albicans*, and improved gingival health in elderly patients with partial removable denture prostheses.[20] The use of chlorhexidine on a daily basis can decrease taste sensation, stain teeth and/or a prosthesis, and may leave an unpleasant taste. It is, therefore, important to only use chlorhexidine when necessary.

The use of a 0.3% triclosan-containing fluoride dentifrice should be considered in patients at high risk for root caries, those with numerous single crowns, and in those with higher-risk prosthetic procedures, such as a fixed dental prosthesis (bridge).[21] In a large-scale RCT on 1,357 patients, fluoride-containing toothpastes were compared with or without a 0.3% triclosan dentifrice to evaluate primary caries on root surfaces and recurrent caries around crowns over a three-year period.[21] A 0.3% triclosan dentifrice significantly decreased root caries by six times over a three-year period.[21] The crown failure was three-times higher when using a dentifrice without triclosan. A triclosan-containing dentifrice should be considered for patients at high risk for root caries (Figure 3).

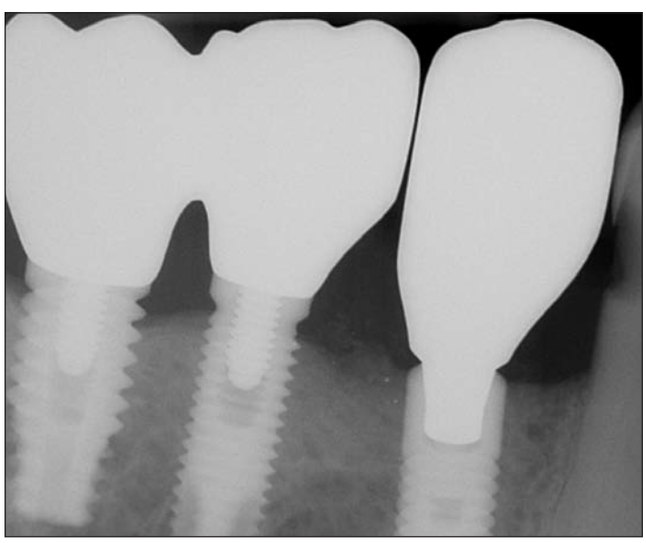

Figure 3. *Peri-apical radiograph showing distal proximal caries on the natural tooth adjacent to implant restorations. There is an increased potential for caries on teeth adjacent to implant restorations as these teeth may often have recession and are susceptible to root caries. A high fluoride level toothpaste for at-home maintenance and fluoride varnish for in-office recall appointments should be considered.*

Professional Maintenance Regimen

Professional maintenance, or what the dental team does during office visits, can have a significant effect on oral health outcomes. Zenthöfer, *et al*. and Morino, *et al*. independently conducted studies in nursing homes on partially edentulous patients with both natural teeth and partial RDPs, and concluded that professional oral health intervention (including professional teeth and denture cleaning and manual brushing by hygienists) significantly improved oral health conditions in the elderly.[22,23] Partially edentulous patients also benefit from an oral hygiene instruction program, which was shown to be more effective than a non-supervised program in improving oral health conditions in the elderly.[22,23] De Visschere, *et al*. also noted that additional individual factors, such as the unique characteristics of the individual nursing home, might also have an impact on the outcome improvement.[24]Along similar lines, Ribeiro, *et al*., in an RCT in Brazil, concluded that the group with oral hygiene instruction had improved gingival indexes compared to the control group with no oral hygiene instruction.[14] The authors also noted that reinforcement of these professional instructions was necessary to maintain compliance.

Maintenance for Patients with Implant-borne Restorations

General Considerations

The fabrication of implant restorations represents a considerable investment of time and resources, with the anticipation of an enduring result by patients and clinicians. Current guidelines for the maintenance of implant restorations are often based on traditional protocols for patients with natural dentition rather than what is most suitable for maintenance of implant supporting tissues. Implants are not teeth, and implant-borne restorations are diverse and present with unique biological and mechanical complications, all of which warrant a patient-specific and risk-based recall regimen (Figures 4 and 5).

Figure 4. *Frontal image of a maxillary full arch fixed implant-supported prosthesis showing severe fracture of the denture teeth with the titanium bar intact. This is the most common complication seen in full arch fixed implant-supported prosthesis with this type of biomaterial.*

Figure 5. *Image showing the intaglio surface of a denture where the soft liner material used after implant surgery has degraded and become a severe plaque trap as a result of poor patient compliance with recall and poor at-home maintenance regimen. This situation may have been avoided by regular patient recall, patient education, and at-home maintenance of the restoration.*

Five-year success rates of dental implants now exceed 95%,[25] and this has allowed dentists to predictably improve function and comfort for many patients. In 2007, replacement costs for implant failures in the United States were estimated at over $338 million.[26] Our goals are no longer just osseointegration, but also for an enduring functional, stable, and esthetic restorative result. This requires a realization that implants differ from teeth and require unique considerations for a maintenance program. Patients often do not realize the value of maintenance programs, and may feel the expensive new implant-supported treatment is resistant to breakdown. However, the recent literature reinforces that clinicians use forethought in planning a patient-specific maintenance program based on patient characteristics and needs, prosthesis design and material, patient compliance, and how the patient does with the provisional restoration.

Implant-supported single crowns and implant-supported FDPs have favorable survival rates, but considerable mechanical and biologic complications in the long term. Ten-year survival rates for implants supporting single crowns were reported as approximately 95%.[25] In addition, implant-supported FDPs were reported as 93%.[27] Notably, 33.6% of patients had a mechanical and/or biologic complication in the first five years, prompting the authors to recommend that patients be placed in a well-structured maintenance program. [27]

Mechanical complications of implant-supported FDPs include veneering material fractures (13.5%), screw loosening (5.3%), loss of retention of cemented FDPs (4.7%), and screw fracture (1.3%) over a five-year period. [27,28]

The importance of maintenance programs for patients with dental implants is well illustrated in a study by Costa, *et al*., in which 80 partially edentulous patients, restored with implants and diagnosed with peri-implant mucositis, were monitored to determine how often they progressed to peri-implantitis over a five-year period.[2] Patients active in a maintenance program progressed to peri-implantitis much less frequently (18%) compared to those not active in a maintenance program (43.9%).[2]

Another recent article showed that the incidence of dental implant failure was 90% less in patients who were enrolled in a maintenance program, as opposed to patients who were not enrolled.[1] Numerous recent articles have emphasized the importance of patient-specific maintenance programs.[1-3] Risk factors, such as lack of manual dexterity, motivation, or compliance need to be identified early so both the treatment plan and maintenance plan can reflect anticipated patterns of use, recall, and compliance.

Patient Recall Intervals

Few comparative studies about maintaining soft tissue surrounding dental implants currently exist. Clearly, additional comparative studies are needed to understand the impact of patient recall intervals on maintenance of soft tissue health. By default, clinicians are using existing recall and maintenance protocols established for patients with natural dentition. Although the use of six-month recall intervals is an adequate starting point, the recall interval needs to reflect the patient's needs and influencing factors, such as prosthetic design, biologic and mechanical issues, and conditions of the supporting tissues.

At-home Maintenance

At-home use of chlorhexidine and triclosan have shown promise in helping to maintain the health of soft tissues supporting dental implant restorations.

In a very interesting use of chlorhexidine, Paolantonio, *et al*. evaluated microbial penetration in the peri-implant tissue in 30 subjects over an eight-month period.[29] When a 1% chlorhexidine gel was applied to the internal part of the fixture prior to abutment placement, a decrease in internal bacterial colonization was observed when compared to when no gel was applied.[29] The application of chlorhexidine into the internal part of the fixture is recommended for patients with a high risk of developing peri-implant disease.

The at-home use of a triclosan-containing dentifrice has resulted in improvement of soft tissue measures in patients with both implants and teeth. At-home use of triclosan was also efficacious in an edentulous population, restored with implants and diagnosed with peri-implant mucositis.[30,31] In a six-month study of the effects of a 0.3% triclosan/copolymer toothpaste on oral biofilms and gingival inflammation, Sreenivasan, *et al*. evaluated 120 subjects in a double-blind study evaluating plaque, gingival inflammation, bleeding on probing, and microbiological analysis.[30] After three and six months, the triclosan/copolymer toothpaste group had significantly lower levels of dental plaque, gingivitis, and bleeding-on-probing compared to those not using the triclosan.[30]

In a separate study of 120 edentulous patients restored with at least two implants and diagnosed with mucositis, the impact of triclosan on soft tissue and plaque measures was evaluated at baseline, three, and six months.[31] Patients using a triclosan-containing dentifrice had reduced bleeding-on-probing scores, from 53.8% to 29.1%, while the control group had a slight increase in percentage of bleeding-on-probing. The authors recommend using a triclosan-containing dentifrice for patients at high risk for peri-implant disease.

Professional Maintenance Regimen

Substantial evidence exists that shows the importance of professional and at-home care of implant-borne restorations. Katsoulis, *et al*., in a prospective study on 41 patients with maxillary removable or fixed rehabilitations, showed that cast bar overdentures, CAD/CAM milled bar overdentures, and fixed prostheses all required professional maintenance during the two-year study period, with the probability of a complication occurring in the first year being 60–70%.[32] Fewer maintenance issues were seen in patients with implant-supported fixed restorations than in patients with a bar overdenture over a two-year period. Fischer and Stenberg, in a prospective cohort study based on a larger RCT, collected data over a ten-year period on outcomes and maintenance of screw-retained, implant-supported, complete-arch, cast titanium-acrylic resin prostheses in the edentulous maxilla of 24 patients.[33] They evaluated the number of prosthetic teeth re-cemented or replaced, screw loosening, and the number of remakes of fixed

prostheses, as well as cantilever length as a potential risk for fracture at baseline and one-, three-, five- and ten-year professional recall visits. They concluded that the most frequent complication was related to fractured denture teeth (Figures 4 and 6). The status of the opposing dentition and length of cantilever did not add risk.[33]

Professional recommendations of oral hygiene aids for patient at-home use were found in independent studies. Swierkot, *et al*.,[34] Rasperini, *et al*.,[35] and Vandekerckhove, *et al*.[36] all showed that the use of electric toothbrushes

Figure 6. *Image showing the tissue surface of an immediate loaded mandibular full arch fixed implant-supported prosthesis completely covered with calculus at the time of removal during a follow-up appointment. This situation may have been avoided by regular patient recall, patient education, and at-home maintenance of the restoration.*

was a safe and efficient method for plaque removal around implant-borne restorations, and that electric toothbrushes had no adverse effects on peri-implant health. However, the electric toothbrushes were not shown to be superior to conventional brushing in removing plaque.

The use of curettes as hand instrumentation has been compared to a glycine powder air polishing system. Mussano, *et al*. evaluated the use of polytetrafluoroethylene (PTFE; Teflon) curettes as hand instrumentation or a glycine powder air polishing system.[37] Periodontal probing depth, bleeding on probing, and bacterial infiltration within the gingival sulcus were evaluated at baseline, one week, and four weeks. The authors concluded that glycine powder air polishing was more effective than PTFE curettes for the maintenance of peri-implant soft tissues.[37]

The Call for Clinical Practice Guidelines Imperative to Maintaining Tooth- and Implant-borne Restorations

As the name indicates, clinical practice guidelines or CPGs are intended to provide clinicians with guidance in diagnosis, treatment planning, and clinical decision-making.[38] CPGs have been shown to improve clinical outcomes and patient care processes.[39-41] CPGs are often followed in medicine, and they have been shown to improve clinical outcomes.[41]

It is important to note that recommendations made in CPGs are not always supported by scientific evidence. This is because many empirical procedures and treatments that yield favorable outcomes do not necessarily have scientific evidence.[42] Many prevalent dental CPGs are not necessarily based at the highest level of scientific evidence. Rather, they are based on a combination of scientific evidence, empiricism, and the analysis of risk versus benefit ratio to patients. Such examples include antibiotic prophylaxis before dental procedures to prevent endocarditis in certain cardiac patients,[43] the use of prophylactic antibiotics prior to dental procedures in patients with prosthetic joints,[44] antibiotic prophylaxis for dental patients at risk for infection,[45] oral health care for the pregnant adolescent,[46] guidelines for the care and maintenance of complete dentures,[47] and management of patients with medication-related osteonecrosis of the jaws (MRONJ).[48]

An appropriate professional maintenance regimen, an at-home maintenance regimen, and a suitable recall regimen are vital for long-term success, especially for those patients with complex dental needs.[15,16] There is limited scientific evidence, and it is clear that current guidelines for maintenance and recall are poorly defined, for those with complex tooth-borne and implant-borne restorations. Therefore, the call for clinical practice guidelines is needed to provide direction for dental healthcare providers, with the aim of prosthetic restoration sustainability and longevity.

With this goal, the American College of Prosthodontists (with collaborations lead by a scientific panel appointed by the ACP, ADA, AGD, and ADHA, and based on two rigorous systematic reviews) has developed and approved the following CPGs (seen in Tables 1 and 2 on the pages that follow) that serve as a baseline, and will evolve to reflect up-to-date scientific evidence and best clinical practices. These applied guidelines will improve clinical outcomes and, ultimately, improve the oral health of the patients we serve.

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Table 1. Clinical Practice Guidelines for Recall and Maintenance of Patients with Tooth-borne Dental Restorations

Number	Topic	Guideline	Strength of Recommendation as Described by Shekelle, *et al.*[38]*
1.	Patient recall	Patients with tooth-borne restorations (fixed or removable) should be advised to obtain a dental professional examination at least every 6 months as a lifelong regimen.	D
		Patients categorized by the dentist as higher risk based on age, ability to perform oral self-care, biological or mechanical complications of natural teeth or tooth-borne restorations should be advised to obtain a dental professional examination more often than every 6 months, depending upon the clinical situation.	D
2A.	Professional maintenance: Tooth-borne removable resorations (partial removable dental prostheses)	Professional maintenance for patients with tooth-borne removable restorations should include an extraoral and intraoral health and dental examination, oral hygiene instructions for existing natural teeth and any restorations, oral hygiene intervention (cleaning of natural teeth and restorations), and use of oral topical agents, as deemed clinically necessary.	A, C, D
		Professional maintenance of the partial removable dental prostheses should include hygiene instructions, detailed examination of the prosthesis, prosthetic components, and patient education about any foreseeable problems that could impair optimal function with the restoration. The partial removable dental prosthesis should be professionally cleaned extraorally using professionally accepted mechanical and chemical methods.	D
		Professionals should recommend and/or prescribe appropriate oral topical agents and oral hygiene aids suitable for the patient's at-home maintenance needs.	D
2B.	Professional maintenance: Tooth-borne fixed restorations (intracoronal restorations, extracoronal restorations, veneers, single crowns, and partial fixed dental prostheses)	Professional maintenance for patients with tooth-borne fixed restorations should include an extraoral and intraoral health and dental examination, oral hygiene instruction for natural teeth and the fixed restorations, oral hygiene intervention (cleaning of natural teeth and restorations), and use of oral topical agents, as deemed clinically necessary.	A, C, D
		Professionals should recommend and/or prescribe appropriate oral topical agents and oral hygiene aids suitable for the patient's at-home maintenance needs.	D
		When clinical signs indicate the need for an occlusal device, professionals should educate the patient and fabricate an occlusal device to protect the tooth-borne fixed restorations.	D
		Professional maintenance of the occlusal device should include hygiene instructions, detailed examination of the occlusal device, and patient education about any foreseeable problems that could impair optimal function with the occlusal device. The occlusal device should be professionally cleaned extraorally, using professionally accepted mechanical and chemical methods.	D
3A.	At-home maintenance: Tooth-borne removable restorations (partial removable dental prostheses)	Patients with tooth-borne removable restorations should be educated about brushing existing natural teeth and restorations twice daily, and the use of oral hygiene aids, such as dental floss, water flossers, air flossers, interdental cleaners, and electric toothbrushes.	C, D
		Patients with tooth-borne removable restorations should be educated about cleaning their prosthesis at least twice daily, using a soft brush and the professional-recommended denture-cleaning agent.	D
		Patients with multiple and complex restorations on existing teeth, supporting or surrounding the removable restoration, should be advised to use oral topical agents such as a dentifrice containing 5,000 ppm fluoride or a dentifrice with 0.3% triclosan, and to add supplemental short-term use of chlorhexidine gluconate, when indicated.	A, C, D
		Patients with tooth-borne removable restorations should be advised to remove the restoration from the mouth during sleep. The removed prosthesis should be stored in a prescribed cleaning solution.	D
3B.	At-home maintenance: Tooth-borne fixed restorations (intracoronal restorations, extracoronal restorations, veneers, single crowns, and partial fixed dental prostheses)	Patients with tooth-borne fixed restorations should be educated about brushing twice daily and the use of oral hygiene aids, such as dental floss, water flossers, air flossers, interdental cleaners, and electric toothbrushes.	A, D
		Patients with multiple and complex restorations on existing teeth should be advised to use oral topical agents, such as a dentifrice containing 5,000 ppm fluoride or a dentifrice with 0.3% triclosan, and to add supplemental short-term use of chlorhexidine gluconate, when indicated.	A, C, D
		Patients prescribed with occlusal devices should be advised to wear the occlusal device during sleep.	D
		Patients prescribed with occlusal devices should be educated about cleaning their occlusal device before and after use, with a soft brush and the prescribed cleaning agent. Patients should also be educated about proper methods for storage of the occlusal device when not in use.	D

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Table 2. Clinical Practice Guidelines for Recall and Maintenance of Patients with Implant-borne Dental Restorations

Number	Topic	Guideline	Strength of Recommendation as Described by Shekelle, *et al.*[38]
1.	Patient recall	Patients with implant-borne restorations (fixed or removable) should be advised to obtain a dental professional examination visit at least every 6 months as a lifelong regimen.	D
		Patients categorized by the dentist as higher risk based on age, ability to perform oral self-care, biological, or mechanical complications of remaining natural teeth, tooth-borne restorations, or implant-borne restorations should be advised to obtain a dental professional examination more often than every 6 months, depending upon the clinical situation.	D
2A.	Professional maintenance (Biological): Implant-borne removable restorations (implant-supported partial removable dental prostheses and implant-supported overdenture prostheses)	Professional biological maintenance for patients with implant-borne removable restorations should include an extraoral and intraoral health and dental examination, oral hygiene instruction, hygiene instruction for the prostheses, and oral hygiene intervention (cleaning of any natural teeth, tooth-borne restorations, implant-borne restorations, or implant abutments).	A, C, D
		Professionals should use chlorhexidine gluconate as the oral topical agent of choice when antimicrobial effect is needed clinically.	A, C
		Professionals should use cleaning instruments compatible with the type and material of the implants, abutments, and restorations, and powered instruments, such as the glycine powder air polishing system.	A, C, D
		Implant-supported partial removable dental prostheses and implant-supported overdenture prostheses should be professionally cleaned extraorally using professionally accepted mechanical and chemical cleaning methods..	D
		Professionals should recommend and/or prescribe appropriate oral topical agents and oral hygiene aids suitable for the patient's at-home maintenance needs.	A, C, D
2B.	Professional maintenance (Mechanical): Implant-borne removable restorations (implant-supported partial removable dental prostheses and implant-supported overdenture prostheses)	Professional mechanical maintenance for patients with implant-borne removable restorations should include a detailed examination of the prosthesis, intra- and extraoral prosthetic components, and patient education of foreseeable problems that could impair optimal function of the restoration.	C, D
		Professionals should recommend and perform adjustment, repair, replacement, or remake of any or all parts of the prosthesis and prosthetic components that could compromise function.	C, D
2C.	Professional maintenance (Biological): Implant-borne fixed restorations (implant-supported single crowns, partial fixed dental prostheses and implant-supported complete arch fixed prostheses)	Professional biological maintenance for patients with implant-borne fixed restorations should include an extraoral and intraoral health and dental examination, oral hygiene instruction, and oral hygiene intervention (cleaning of any natural teeth, tooth-borne restorations, implant-borne restorations, or implant abutments).	A, C, D
		Professionals should use chlorhexidine gluconate as the oral topical agent of choice when antimicrobial effect is needed clinically.	A, C
		Professionals should use cleaning instruments compatible with the type and material of the implants, abutments, and restorations, and powered instruments, such as the glycine powder air polishing system.	A, C, D
		In patients with implant-supported fixed prostheses, the decision to remove the prosthesis for biological maintenance should be based on the patient's demonstrated inability to perform adequate oral hygiene. The prosthesis contours should be reassessed to facilitate at-home maintenance.	D
		Professionals should consider using new prosthetic screws when an implant-borne restoration is removed and replaced for professional biological maintenance.	D
2D.	Professional maintenance (Mechanical): Implant-borne fixed restorations (implant-supported single crowns, partial fixed dental prostheses, and implant-supported complete arch fixed prostheses)	Professional mechanical maintenance for patients with implant-borne fixed restorations should include a detailed examination of the prosthesis, prosthetic components, and patient education about any foreseeable problems that could compromise function.	C, D
		Professionals should recommend and perform adjustment, repair, replacement, or remake of any or all parts of the prosthesis and prosthetic components that could impair patient's optimal function.	C, D
		Professionals should consider using new prosthetic screws when an implant-borne restoration is removed and replaced for professional mechanical maintenance.	D
		When clinical signs indicate the need for an occlusal device, professionals should educate the patient and fabricate an occlusal device to protect implant-borne fixed restorations.	D
		Professional maintenance of the occlusal device should include hygiene instructions, detailed examination of the occlusal device, and patient education about any foreseeable problems that could impair optimal function with the occlusal device. The occlusal device should be professionally cleaned extraorally using professionally accepted mechanical and chemical methods.	D
		Patients with multiple and complex restorations on existing teeth should be advised to use oral topical agents, such as a dentifrice containing 5,000 ppm fluoride or a dentifrice with 0.3% triclosan, and to add supplemental short-term use of chlorhexidine gluconate, when indicated.	A, C, D
		Patients prescribed with occlusal devices should be educated to wear the occlusal device during sleep.	D
3A.	At-home maintenance: Implant-borne removable restorations (implant-supported partial removable dental prostheses, and implant-supported overdenture prostheses)	Patients with implant-supported partial removable dental prostheses should be educated about brushing existing natural teeth and restorations twice daily, and the use of oral hygiene aids, such as dental floss, water flossers, air flossers, interdental cleaners, and electric toothbrushes.	C, D
		Patients with implant-borne removable restorations should be advised to clean their intraoral implant components at least twice daily, using a soft brush and the professional-recommended oral topical agent.	D
		Patients with implant-borne removable restorations should be advised to clean their prosthesis at least twice daily using a soft brush with a professional-recommended denture-cleaning agent.	D
		Patients with implant-borne partial or complete removable restorations should be advised to remove the restoration while sleeping. The removed prosthesis should be stored in a prescribed cleaning solution.	D
3B.	At-home maintenance: Implant-borne fixed restorations (implant-supported single crowns, partial fixed dental prostheses and implant-supported complete arch fixed prostheses)	Patients with implant-borne fixed restorations should be educated about brushing twice daily, and the use of oral hygiene aids, such as dental floss, water flossers, air flossers, interdental cleaners, and electric toothbrushes.	C, D
		Patients with multiple and complex implant-borne fixed restorations should be advised to use oral topical agents, such as a dentifrice containing 0.3% triclosan, and to add supplemental short-term use of chlorhexidine gluconate, when indicated.	A, C, D
		Patients prescribed with occlusal devices should be advised to wear the occlusal device during sleep.	D
		Patients prescribed with occlusal devices should be educated about cleaning their occlusal device before and after use with a soft brush and the prescribed cleaning agent. Patients should also be educated about proper methods for storage of the occlusal device when not in use.	D

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Colgate's Presence at AADR/CADR 2016

Mack Morrison, PhD

The Annual Meeting of the American Association for Dental Research (AADR) and Canadian Association for Dental Research (CADR) was held at the Los Angeles Convention Center from March 16–19, 2016. Colgate-Palmolive had a strong presence at the meeting, including a booth in the exhibit hall, symposium sponsorship, and scientific presentations. Scientific presentations included both clinical and *in vitro* studies. Colgate sponsored an AADR Study Research Fellowship, and provided an educational grant to help support the efforts of the American College of Prosthodontists in developing an Industry-Sponsored Symposium titled, "Clinical Practice Guidelines for Recall and Maintenance of Patients with Tooth-Borne and Implant-Borne Dental Restorations" (see related article by Curtis and Bidra in this issue). Colgate had the largest booth at the meeting, which was twice as large as the one from Procter & Gamble. This allowed us to leverage our brand strength with dental professionals by distributing large amounts of toothpaste and toothbrushes to the attendees (see Figure 1). The toothpastes presented were Colgate® Total®, Colgate® Enamel Health™, and Colgate® Sensitive. In addition, a variety of toothbrushes were distributed.

Figure 1. *Leadership in toothbrushes and toothpastes.*

Supported Research

In addition to sponsoring the symposium, Colgate supported (authored or sponsored) 24 posters and one oral presentation. Areas of focus included nine presentations related to gingival health, seven presentations related to enamel health, and four presentations relating to stain removal or whitening. Colgate sponsored five university-based research presentations on areas related to fundamentals in oral health.

Gingival Health Research

Colgate supported *in vivo* research studies in key dental indication areas, including gingival health, enamel health, and whitening. In the area of gingival health research, presenters demonstrated that Colgate® Total® Pro Breath Health toothpaste is highly effective in reducing garlic food odor (see Figure 2). In addition, significant reductions in dental plaque – anaerobic and malodor organisms – were observed twelve hours after brushing with Colgate® Total® toothpaste compared to brushing with a fluoride toothpaste. Finally, brushing with Colgate® Total® toothpaste demonstrated significant reductions in bloodstream bacteria as compared to brushing with a fluoride toothpaste.

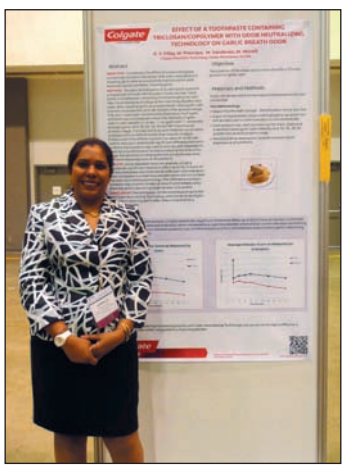

Figure 2. *Dr. Premie Pillay*

Mouthwash

Several presentations supported Colgate® Total® mouthwash in the United States, and demonstrated that using Colgate® Total® mouthwash provided an immediate antibacterial effect of greater than 99% reduction as compared to using an antibacterial mouthwash. Another presentation demonstrated that both Colgate® Total® mouthwash, as well as a Colgate® chlorhexidine mouthwash, demonstrated broad spectrum antimicrobial activity against laboratory strains. Significant effects from these study products were found on bacteria in oral samples from human subjects, as compared to those using a Listerine mouthwash and those using a non-antibacterial mouthwash.

Toothbrushes

In toothbrushes, a study on the Slimsoft™ toothbrush demonstrated that when compared to a manual, flat-trim toothbrush, Slimsoft with tapered bristles (17x slimmer than ordinary end-rounded bristle tips) provided significant reductions in plaque after a single brushing. There were also reductions in both plaque and gingivitis after 12 weeks compared to a manual, flat-trim toothbrush.

Enamel Health

In enamel health, there were several Colgate-authored presentations. First, A. Kakar (see Figure 3) demonstrated that delivering an 8% arginine-based gel (Pro-Argin™) from a sensitivity relief pen built into the Colgate® Sensitive toothbrush, results in an immediate, statistically significant, reduction in dentin hypersensitivity as compared to a placebo gel. This statistically significant reduction is maintained throughout seven days of follow-up use. In another Colgate-authored presentation, evidence from a high-foaming, potassium nitrate-based toothpaste demonstrated superior reductions in dentin hypersensitivity as compared to a control toothpaste after four and eight weeks of use. These reductions were equivalent to the reductions observed for a regular-foaming, potassium nitrate-based toothpaste.

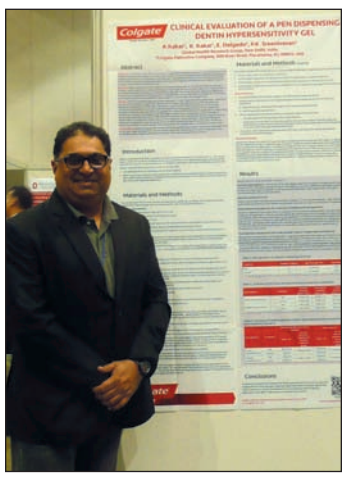

Figure 3. *Dr. Ashish Kakar*

Colgate also sponsored university-based research programs in areas related to fundamentals in oral health research. In caries research, low levels of arginine in a weakly buffered *S. mutans* UA159 medium containing sucrose, resulted in a higher pH when compared to the same medium lacking arginine. Furthermore, there was no evidence of ammonium ion production. A second university-based research program demonstrated that treatment of biofilms with arginine may protect the oral cavity against sucrose-induced acid generation through re-engineering of the oral microbial community. Also in caries research, Colgate sponsored a study that reviewed the effectiveness of silver diamine fluoride (SDF), and found it is a cost effective preventative treatment. More research is needed on this prospective anticaries agent.

Whitening Studies

In *in vitro*, whitening studies, three presentations supported Colgate® Optic White® Express White toothpaste. In particular, a new wine stain model was able to differentiate between whitening toothpastes with distinctive modes of action. Colgate® Optic White® Express White had significantly more wine stain removal as compared to Crest® 3D White Luxe, Glamorous White, an abrasive toothpaste. In research using an *in vitro* brushing model, Colgate® Optic White® Express White toothpaste delivered significantly better whitening performance when compared to an abrasive whitening toothpaste, Crest® 3D White Glamorous White, and a basic silica toothpaste, Crest® Cavity Protection. Using this same *in vitro* brushing method, a final presentation demonstrated that Colgate® Optic White® Express White also delivered significantly more *in vitro* whitening performance when compared to the Crest® Pro-Health™ HD™, a 2-step whitening system containing a fluoride toothpaste and a peroxide whitening gel.

Overall, Colgate-Palmolive had a strong presence at the meeting, including a sizable footprint in the exhibit hall, symposium sponsorship, and significant numbers of scientific presentations.

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