Cariology update for the dental practitioner

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This continuing education course on cariology was based on a review of the current literature by the Division of Community Health at the Columbia University College of Dental Medicine. It was sponsored by Aetna Dental® Plans.
Over the past 40 years, there has been a significant reduction in the prevalence of dental decay within the U.S. population at large. The addition of fluoride to public water supplies and an increase in the commercial availability of fluoride toothpaste and rinses have contributed to this decline. Nonetheless, dental decay remains a problem in some demographics.

According to estimates, 25 percent of school-age children experience approximately 80 percent dental decay. This makes it the single most prevalent disease of children in the United States. Caries in preschoolers is increasing and now affects one in four young children.

In addition, more than 60 percent of adults between the ages of 35 to 44 years have lost at least one permanent tooth as the result of decay. In the United States, tooth retention by older adults and concomitant gingival recession expose more tooth surfaces to caries. Combining this with a potentially diminished salivary flow beckons to a growing phenomenon in dentistry: caries of root surfaces is increasing, placing the post-60 age group at substantial risk for caries.

National surveys reveal changes in the prevalence of dental decay, and in the distribution and pattern of the disease. The rates become higher with age. One in five (20 percent) children aged 6 to 11 years has tooth decay in their permanent teeth. So do half (50 percent) of children aged 12 to 15 years and two-thirds (68 percent) of adolescents aged 16 to 19 years.

A number of other factors also place a person at risk for different levels and types of tooth decay, including:

- Medical or physical condition
- Nutritional status
- Exposure to fluoride
- Oral hygiene practices
- Access to dental care

These diverse risk indicators support the idea that caries are a “chronic, infectious multifactorial disease.” Dentists should routinely assess individuals for these risk indicators (“Caries Diagnosis,” 1995).

### Caries epidemiology

In August 2005, the Centers for Disease Control and Prevention (CDC) compared the findings of two National Health and Nutrition Examination surveys (NHANES) (1988 – 1994 and 1999 – 2002). This report found the prevalence and severity of dental caries in the permanent dentition decreased by 7.4 percent. But caries increased by 15 percent in preschoolers (MMWR, 2005). Adolescents aged 16 to 19 years had the largest reduction (10.2 percent).

In addition, the report noted that the prevalence of coronal caries had also decreased (3.3 percent). The greatest reduction in coronal caries experience was among the population aged 20 to 39 years. However, this segment as well as older adults had an increased prevalence of root caries. Approximately 18 percent of dentate adults aged ≥ 20 years had root caries (including untreated and restored lesions) and that the prevalence of root caries increased with age. Within the 20 to 39 years age group, 9.4 percent had root caries, while 17.8 percent of 40 to 59 year olds and 31.6 percent of the population aged ≥ 60 years had root caries. Ten percent of the nation’s older population also had one or more untreated carious root lesions.

This uptick in root caries among adults, combined with the fact that more adults are retaining their teeth, is cause for concern. As a result, it is essential that individuals at greatest risk get comprehensive dental treatment as early as possible.

The reported findings on primary dentition are also cause for concern. The CDC reports that from 1999 through 2002, 41 percent of children aged 2 to 11 years had dental caries in their primary teeth. The presence of decay in the primary teeth is a predictor of future decay in the permanent dentition. Therefore, the upturn in caries experience in preschoolers is likely to continue into their permanent teeth. As a result, as with the older population, it is crucial that children at an increased risk of developing caries must get dental treatment at the early stages of the disease.
Paradigm shift in cariology
The caries process is a dynamic one. However, in the past it was seen as a static event. In the dynamic model, the caries process is a balance between demineralization and remineralization. The caries event is seen as potentially reversible. Therefore, the dental clinician managing the patient tries to prevent cavitation of the carious lesion via early diagnosis and treatment. The following section, comprised of five subsections, presents information for the dental clinician on the paradigm shift in cariology:

p. 3-4  1. Caries models. A description and explanation of the traditional static and the modern dynamic models of caries are presented.

p. 5-6  2. Transmission and acquisition of caries. Current concepts on the acquisition and transmission of the caries infection are described.


p. 13-14 5. Caries diagnostic aides. Available adjunctive diagnostic tests that corroborate the clinician’s traditional visual, tactile and radiographic diagnostic tools are presented.

1. Caries models
A static model is often used to portray the caries process. This model uses a Venn diagram to represent the multifactorial caries process. This process depends on the interaction of host, substrate, microbiota and salivary factors. In this model, bacteria metabolize sugars and produce acid, the pH decreases and enamel demineralizes, resulting in the initiation of the caries process.

For dental caries to develop, three essential factors must occur at the same time:

1. The chronic presence of cariogenic bacteria
2. A susceptible host
3. Available food material to support the colonization of cariogenic bacteria. The caries process can be interrupted if a factor is modified or does not exist (“Caries Diagnosis,” 1995).

The multi-factorial caries process
The modern approach to caries recognizes that risk is not evenly distributed in the general population (“Caries Diagnosis,” 1995) and moves away from the traditional static model represented by the Venn diagram model.

Venn diagram of dental caries etiology

Tooth
• Age
• Fluorides
• Morphology
• Nutrition
• Trace elements
• Carbonate level

Substrate
• Oral clearance
• Oral hygiene
• Salivary stimulants
• Frequency of eating carbohydrates (type, concentration)

Flora
• Streptococcus mutans (substrate)
• Oral hygiene
• Fluoride in plaque
The caries balance

It is important to recognize the caries process as a dynamic one and to use interventions targeted to the individual patient to prevent, suppress and arrest dental caries. Individualized approaches are justified given current caries distributions. An individual’s caries risk factors tend to be consistent over time, but can change based on factors such as dietary practices, the initiation of orthodontic therapy, moving to an area with non-fluoridated community water or the initiation of head and neck radiation therapy. Accurate caries risk assessment for a population or an individual is a complex process. There are models to assist the dental professional in the assessment of an individual patient’s caries risk (Bader 2005; Featherstone, et. al 2003; “Caries Diagnosis,” 1995; American Academy of Pediatric Dentistry, 2002, 2011). The patient’s caries susceptibility can then be used by the clinician and patient to reduce risk, and to determine prevention and treatment strategies (“Caries Diagnosis,” 1995).

“Demineralization,” the loss of minerals from the tooth, is started by cariogenic bacteria that produce acids which readily diffuse into the tooth and dissolve susceptible minerals. “Remineralization” is the reverse process. This occurs when the acid in the plaque is buffered by saliva, allowing the calcium and phosphate to be re-absorbed from the saliva to the partially dissolved tooth surface (Featherstone, 2003).

This newly remineralized surface is much more resistant to the acids present in plaque, especially if it is formed in the presence of fluoride. When pathological factors outweigh protective factors, the dental caries process progresses. It then follows that the reverse process will arrest and in some cases reverse caries (Featherstone, 2003). In a healthy mouth, pathological factors are balanced by protective factors.

Caries balance model

Pathological factors
- Cariogenic bacteria: mutans streptococci and lactobacillus
- Frequency of fermentable carbohydrate ingestion
- Reduced salivary function
- F Frequency of fermentable carbohydrate ingestion
- Reduced salivary function

Protective factors
- Fluoride
- Antibacterials in saliva and extrinsic: chorhexidine and xylitol
- Saliva and its components
- Dietary control
- Dental sealants
- Remineralization and caries arrest
- Demineralization and dental caries
2. Transmission and acquisition of caries

Pathogenic caries-inducing bacteria have the ability to transport fermentable sugars and carbohydrates, thereby:

- Producing organic acids (acidogenic)
- Producing extracellular and intracellular polysaccharides
- Maintaining sugar metabolism in a low pH environment (aciduric)

In addition, pathogenic bacteria can adhere tightly to surfaces in the mouth. Mutans streptococci are the main group of bacteria associated with the caries process, being important in the initiation and pathogenesis of dental caries (Tanzer et al., 2001).

Mutans streptococci can be isolated more often in higher numbers from a range of carious lesions. Advanced lesions generally yield a more diverse microflora, including acidogenic and proteolytic species working together. Lactobacilli are more common from sites in soft and necrotic dentin and have been associated with the caries process. Actinomyces (particularly A. naeslundii) are found in root surface lesions along with streptococcus mutans. The proportion of streptococcus mutans increases in advanced lesions (Schupbach et al., 1996).

Bacteria cannot maintain themselves freely in saliva. Rather, it needs to attach to a tooth surface to colonize and reproduce (Berkowitz, 2003). Therefore, since mutans streptococci cannot effectively attach to epithelial surfaces, it is unlikely that these bacteria can colonize in the mouths of infants. Actinomyces (particularly A. naeslundii) are found in root surface lesions along with streptococcus mutans. The proportion of streptococcus mutans increases in advanced lesions (Schupbach et al., 1996).

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Vertical transmission

Vertical transmission is the transfer of cariogenic bacteria from mother or primary caregiver to child via saliva. Several clinical studies have demonstrated that mothers and their babies have similar or identical bacteriocin profiles and chromosomal DNA patterns (Davey et al., 1984; Kulkasni et al., 1989). Study results have shown rates of infection in infants, with mothers having salivary levels of mutans streptococci exceeding 105 colony-forming units (CFU) per ml, up to nine times greater than in infants whose maternal salivary levels are 103 CFU per ml or less (Berkowitz et al., 1981). Suppressing maternal salivary levels of streptococcus mutans has a clear effect on delaying and, in certain cases, even preventing infant infection (Kohler et al., 1983). In general, the earlier and more intensely infected the child, the greater his or her capacity to develop cavities early and across the lifespan.

Horizontal transmission

A study conducted by Mattos-Graner and colleagues isolated the mutans streptococci bacteria in a population of nursery school children aged 12 to 30 months. Results from the analysis found that many of the children had identical genotypes of mutans streptococci strains. This implies that horizontal transmission of mutans streptococci also occurs (Mattos-Graner et al., 2001). It has also been found that children over five years of age tend to have strains of mutans streptococci similar to the mother and father, possibly implying horizontal transmission (Van Loveren et al., 2000). The implications of the horizontal transmission of mutans streptococci are important given the increased utilization of day care facilities for preschool children in the U.S. (Berkowitz, 2003).
Early childhood caries

Although officially defined simply as “one or more carious teeth before the sixth birthday,” early childhood caries (ECC) is really much more than the occasional cavity in young children (“Definition,” 2003). ECC often leads to discomfort, dysfunction and hospitalization for extensive repair (USDHHS, 2000; Edelstein, 2002). As with all other forms of caries, ECC is a diet-dependent infectious disease mediated by fluoride (DenBesten et al., 2003). However, unlike other manifestations of caries, ECC tends to progress rapidly and extensively.

ECC starts when the child’s teeth are colonized by cariogenic bacteria (VanHoute, 1994). These bacteria are typically acquired from children’s mothers by direct salivary transmission (Berkowitz, 1979). The higher a mother’s salivary titer of these bacteria and the more frequently she “shares” her oral flora with her child, the earlier the child will acquire these bacteria and the more pathologic will be the child’s plaque. Using this knowledge, researchers have demonstrated that ECC can be prevented, delayed or minimized by suppressing a mother’s oral cariogenic flora (Thorild et al., 2003; Tenuovo et al., 1992; Köhler et al., 1983).

Early signs of ECC include plaque accumulation and/or decalcifications along the facial gingival margin of the maxillary incisors or discoloration of the lingual aspects of these teeth. While children as young as 12 months may present to the dentist with full-blown cavities, the most typical age that severely affected children present is 21 to 24 months.

Conventional treatment of ECC, particularly in severe cases, includes extractions, pulpotomies, restorations and placement of stainless steel crowns. None of these interventions, however, markedly reduces underlying caries activity. That is why young children who have had extensive dental repair so often relapse with new cavities (Berkowitz et al., 2004). Newer approaches to caries management, including suppression of cariogenic flora through use of topical fluorides and diet management, hold strong promise to slow or halt the caries process and allow for extensive recalcification of the affected teeth.

ECC is correlated to specific dietary habits. It is important for parents and caregivers of infants to understand these factors. They should:

• Not add anything to a baby’s bottle other than formula, breast milk, cow’s milk or water
• Encourage the infant to use a sippy cup as soon as possible and wean the infant from bottle feeding by one year of age
• Never allow an infant to walk around with or go to sleep with a bottle or sippy cup that contains anything other than plain water
• Not give a pacifier dipped in sugar, honey or any other sweet liquid
• Make sure that the child is exposed to adequate levels of fluoride

ECC is not only devastating in the short-term because it so often leads to pain, sleeplessness and distraction (HHS, 2000), but is worrisome in the long-term because children who experience ECC are more prone to develop cavities throughout their lives.
3. Caries risk assessment

In traditional dental practice, clinicians have approached caries from a surgical perspective using concepts promulgated by G.V. Black in the 1920s. At that pre-fluoride era, carious lesions progressed at a more rapid rate than today. However, because of the addition of fluoride to public water supplies, along with an increase in the commercial availability of fluoride toothpaste and rinses, the progression of the caries disease process is significantly slower than in the past (except in the case of early childhood caries). Because the dental carious process is often a slowly progressing one, there is movement to change the treatment paradigm in dentistry from the immediate removal of the non-cavitated carious lesion to the prevention, management and arrest of the disease process through remineralization.

Modern dental caries diagnosis and treatment recognizes the need for surgical intervention. However, it reinforces the medical model, taking into account the slowly progressing nature of the disease. Using the medical model, risk assessment of the individual patient takes on new importance. The dentist’s assignment of a patient to a risk category — low, moderate or high — is the first step in making a treatment decision. This guide provides information that will assist a dentist in assessing a patient’s caries risk, and an overview of treatment options for caries disease management.

Dental caries — the medical model and triage

Effective caries management involves triaging the patient and determining the level of caries risk. The following are important considerations for the medical model of caries:

- Caries incidence changes with dental development and root exposures (tooth surfaces susceptible to caries attack occur in childhood and in older adults with root exposure). Risk and risk indicators may vary due to changes in the host and environmental factors associated with systemic diseases.
- As dentistry moves to a more medical approach to treating pre-cavitated carious lesions (rather than a restorative orientation), accurate risk assessment is essential for dentists to develop appropriate treatment plans and approaches for individual patient caries management.

Patients can use an interactive tool to self-assess their oral health and to determine their caries risk.

Image from Child Caries Risk Assessment Tool (http://www.simplestepsdental.com).

Caries risk assessment tool for patients

A risk assessment tool for patients is available online. It is at the Aetna InteliHealth® website: www.simplestepsdental.com. This site allows patients to use an interactive tool to self-assess their oral health and to determine their caries risk (see image above). There are separate tools for parents and children.

Patients should print the results of this assessment and bring them to the dental visit. Coordination of dental office preventive and restorative treatment with oral home care can result in better oral health and a reduction in the patient’s overall caries risk.
## Patient triage tool for dental clinicians

### Risk category

<table>
<thead>
<tr>
<th>Age classification</th>
<th>Child/adolescent</th>
<th>Adult</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Low</strong></td>
<td>1. No carious lesions in past year</td>
<td>1. No carious lesions in past year</td>
</tr>
<tr>
<td></td>
<td>2. No or few restorations</td>
<td>2. No or few restorations</td>
</tr>
<tr>
<td></td>
<td>3. Coalesced or sealed pits and fissures</td>
<td>3. Adequately restored surfaces</td>
</tr>
<tr>
<td></td>
<td>4. Mutans streptococci count &lt; 100,000 CFU/ml†</td>
<td>4. Mutans streptococci count &lt; 100,000 CFU/ml†</td>
</tr>
<tr>
<td></td>
<td>5. Good oral hygiene</td>
<td>5. Good oral hygiene</td>
</tr>
<tr>
<td></td>
<td>6. Appropriate fluoride use</td>
<td>6. Regular dental visits</td>
</tr>
<tr>
<td></td>
<td>7. Regular dental visits</td>
<td></td>
</tr>
<tr>
<td><strong>Moderate</strong></td>
<td>1. One carious lesion in past year</td>
<td>1. One carious lesion in past year</td>
</tr>
<tr>
<td></td>
<td>2. Mutans streptococci count between 100,000 CFU/ml and 1,000,000 CFU/ml†</td>
<td>2. Mutans streptococci count between 100,000 CFU/ml and 1,000,000 CFU/ml†</td>
</tr>
<tr>
<td></td>
<td>3. Deep pits and fissures</td>
<td>3. Exposed roots</td>
</tr>
<tr>
<td></td>
<td>4. Fair oral hygiene</td>
<td>4. Fair oral hygiene</td>
</tr>
<tr>
<td></td>
<td>5. Inadequate fluoride</td>
<td>5. White spots and/or interproximal radiolucentes</td>
</tr>
<tr>
<td></td>
<td>6. White spots and/or interproximal radiolucenties</td>
<td>6. Irregular dental visits</td>
</tr>
<tr>
<td></td>
<td>7. Irregular dental visits</td>
<td>7. Orthodontic treatment</td>
</tr>
<tr>
<td><strong>High</strong></td>
<td>1. Two or more carious lesions in past year</td>
<td>1. Two or more carious lesions in past year</td>
</tr>
<tr>
<td></td>
<td>2. Significant caries in siblings</td>
<td>2. Past root caries or large number of exposed roots</td>
</tr>
<tr>
<td></td>
<td>4. Mutans streptococci count &gt; 1,000,000 CFU/ml†</td>
<td>4. Mutans streptococci count &gt; 1,000,000 CFU/ml†</td>
</tr>
<tr>
<td></td>
<td>5. Deep pits and fissures</td>
<td>5. Deep pits and fissures</td>
</tr>
<tr>
<td></td>
<td>6. No/little systemic and topical fluoride exposure</td>
<td>6. Inadequate use of topical fluoride</td>
</tr>
<tr>
<td></td>
<td>7. Poor oral hygiene</td>
<td>7. Poor oral hygiene</td>
</tr>
<tr>
<td></td>
<td>8. Poor manual dexterity</td>
<td>8. Poor manual dexterity</td>
</tr>
<tr>
<td></td>
<td>9. Frequent sugar intake</td>
<td>9. Frequent sugar intake</td>
</tr>
<tr>
<td></td>
<td>10. Irregular dental visits</td>
<td>10. Irregular dental visits</td>
</tr>
<tr>
<td></td>
<td>11. Inadequate saliva flow</td>
<td>11. Inadequate saliva flow</td>
</tr>
<tr>
<td></td>
<td>12. Inadequate feeding or nursing (infants)</td>
<td></td>
</tr>
</tbody>
</table>

The Patient Triage Tool for Dental Clinicians is available on [www.aetnadental.com](http://www.aetnadental.com).

†Colony-forming units/ml

4. Protective interventions

Fluoride products

Dentists often use topical and systemic fluorides to prevent and manage dental caries. The use of fluorides in drinking water, toothpaste and in other products has resulted in a decline or possible delay in the prevalence of dental caries in the permanent dentition of children in the U.S. (Bratthall et al., 1996). Fluoride is delivered either systemically or topically. Systemic fluorides include fluoridated water and dietary supplements. Topical fluorides include dentifrices, mouth rinses, gels and other professionally applied treatments, such as varnishes. Patients ingest systemic fluorides, incorporating them into tooth structures through a pre-eruption effect. Topical fluorides strengthen teeth already present in the mouth, making them decay-resistant.

In 1962 the U.S. Public Health Service recommended the amount of fluoride in drinking water range from 0.7 to 1.2 milligrams per liter to prevent dental decay. However in the fall of 2010, the Department of Health and Human Services (HHS) convened an expert panel of scientists to review new information related to fluoride intake and to develop new recommendations for community water fluoridation. This led HHS to propose changing the recommended level for community water systems to 0.7 milligrams per liter (CDC, 2013). In the United States 66 percent of the population has access to community water fluoridation (MMWR, 2002). For patients without regular exposure to optimal levels of fluoride, there are other sources of systemic fluoride available.

Dietary fluoride supplements are available as chewable tablets, liquids and drops by prescription for children 6 months to 16 years, living in areas with less than optimally fluoridated water, either at home or where the “primary” water is fluoride deficient (“Caries Diagnosis,” 1995; MMWR, 2001).

For supplements to be effective, long-term daily compliance is necessary. But supplements should be provided only when the level of fluoride exposure is known for certain. Patient exposure to multiple water sources can make this determination complex. Excess exposure to fluoride can lead to fluorosis in developing teeth (“Caries Diagnosis,” 1995). With increased concern about mild fluorosis, dentists are encouraged to use their clinical judgment regarding a child’s risk of caries development and adjust dosages appropriately.

Dietary fluoride supplement schedule for children at high caries risk

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Fluoride concentration in drinking water (ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;0.3</td>
</tr>
<tr>
<td>Birth to 6 months</td>
<td>None</td>
</tr>
<tr>
<td>6 months to 3 years</td>
<td>0.25 mg/day</td>
</tr>
<tr>
<td>3 to 6 years</td>
<td>0.50 mg/day</td>
</tr>
<tr>
<td>6 to 16 years</td>
<td>1.0 mg/day</td>
</tr>
</tbody>
</table>

* 1.0 ppm = mg/liter

Adapted from Fluoride Supplements: Evidence-based Clinical Recommendations. JADA, 2010; 141; 1480-1489

Practitioners are encouraged to evaluate all potential fluoride sources and conduct a caries risk assessment before prescribing fluoride supplements.

For children at low caries risk, dietary fluoride supplements are not recommended and other sources of fluoride should be considered as a caries preventive intervention.

For children at high caries risk, dietary fluoride supplements are recommended according to the schedule presented in the table above.

When fluoride supplements are prescribed, they should be taken daily to maximize the caries prevention benefit.
Fluoride is available in over-the-counter rinses and gels for consumers. Prescription rinses and gels are best for high-risk patients. Fluoride foams, gels and rinses are helpful when professionally applied for patients with moderate to high caries risk due to smooth surface caries activity. Other patients who may be at risk, including orthodontic patients, those undergoing head and neck radiation, and people with decreased salivary flow should also receive professionally applied fluoride products.

Fluoride varnishes have been used to prevent dental caries for many years outside the U.S. They are available in the United States. However, to date manufacturers have sought federal authority for labeling only as a desensitizing agent and cavity varnish, although they do have the potential for caries prevention. Studies show fluoride varnishes have equal or superior caries-prevention benefits compared to standard professionally applied topical fluoride used in the United States (Seppa et al., 1995; Tewari et al., 1990). They are easy to apply. Application requires smaller fluoride exposure than gel or foam applications. About 0.3 to 0.6 ml of varnish is enough to cover the dentition (Donly, 2003). Fluoride varnishes are painted directly onto the teeth and remain on the surface for an extended period of time.

**Some available fluoride varnishes**

**Duraphat**
Colgate Oral Pharmaceuticals, Inc., Canton, MA

5 percent NaF available in 10 ml tubes

**Duraflor**
Pharmascience, Montreal, CA

5 percent NaF available in 10 ml tubes

**Fluor Protector**
Ivoclar/Viavdent, Amherst, NY

1 percent Difluorosilane available in 1 ml ampules and 0.4 ml single-dose units

**Cavity Shield**
OMNII Oral Pharmaceuticals, West Palm Beach, FL

5 percent NaF in unit-dose packages with application brush

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**Pit and fissure sealants**

Sealant placement is an important part of preventing caries. This non-invasive prevention treatment has a high long-term retention rate. Molars, because of their deeper fissures, are more likely to have pit and fissure caries than premolars, which have shallower fissures. Therefore, they are prime candidates for preventive sealants. However, sealants are indicated wherever tooth anatomy suggests pit and fissure caries risk. Apply sealants when teeth first erupt into the oral cavity. However, they can be applied at any time after a tooth has fully erupted, as caries risk varies during a person’s lifetime and can depend upon many factors such as diet and changes in lifestyle. Check sealants during routine visits and reapply as necessary.

A major concern with dental sealants is the sealing of unrecognized caries. A number of studies have shown that intact sealants arrest dental caries progression (Handelman et al., 1987; Mertz-Fairhurst et al., 1986).

The American Dental Association Policy on Dental Sealants ("Dental Sealants," 1997) recommends sealants for teeth at highest risk for dental caries (first and second molars). In patients at high risk, dentists may also want to seal primary molars if the pit and fissure anatomy is particularly deep. The American Dental Association Council on Dental Education and the Council on Dental Practice support the provision of dental sealants for preventive oral health care. Auxiliary personnel who participate in the provision of dental care must have appropriate education and training and meet any additional criteria needed to ensure competence. Dental sealants have proven highly effective in the prevention of pit and fissure caries.
### Antimicrobials (chlorhexidine gluconate 0.12 percent)

Some studies have found that a reduction in the mother’s cariogenic bacteria level using antimicrobial treatment is associated with reduced transmission of cariogenic bacteria and caries development in children (Caufield et al., 2001). The use of antimicrobial mouth rinses helps to reduce the levels of cariogenic bacteria, and thereby inhibits acid production and glucan synthesis. They are for use in high-risk individuals with a high cariogenic bacteria count or recent caries experience, or both. Antimicrobial mouth rinses are recommended for use as an adjunctive therapy. They should not be used as caries treatment alone. Rather, they are best used in a multi-stage treatment process, which includes restoration of frank carious lesions, pit and fissure sealant application, and the sealing and repair of fractured, non-carious margins of amalgam restorations.

Treatment requires regular monitoring for increases in bacterial counts and any side effects, such as teeth discoloration. If necessary, repeat treatments to reduce cariogenic bacteria count (“Caries Diagnosis,” 1995). A recent publication on non-fluoride caries preventive agents found no reduction in dental caries with chlorhexidine use in children or adults (Rethman et al., 2011).

It is important to note that antimicrobial treatments may have some limitations. Several studies suggest these treatments may be less effective because of the inability of antimicrobials to penetrate subclinical lesions, margins of restorations or pits and fissures (Caufield et al., 2001).

The dental professional has used chlorhexidine, an antibacterial agent, for over two decades to prevent and/or treat periodontal disease and dental caries. Its oral use and antimicrobial effects have been examined and evaluated over the years. The data suggests that it is effective in reducing the number of caries pathogens and subsequently reduces the incidence of dental caries (Anderson, 2003).

However, the majority of the studies looked at the effectiveness of chlorhexidine involved gels, varnishes and other materials not available in the United States. As a result, the findings cannot be generalized to the 0.12 percent rinses currently available, via prescription, in the U.S. Despite this, the use of chlorhexidine mouth rinses for the prevention and treatment of dental caries should not be dismissed. It is suggested that chlorhexidine mouth rinses are suitable to use when treating high-risk adult patients who demonstrate that they will comply with the treatment regime.

The use of chlorhexidine on children has not been studied. As a result, there is currently no specific information available on the benefits of using chlorhexidine on children.

### Xylitol

Xylitol is a naturally occurring sugar substitute with anticariogenic properties (Lynch and Milgrom, 2003). It is a sugar alcohol with sweetness equal to table sugar. Xylitol may inhibit caries in the oral cavity. Unlike table sugar, it is not readily metabolized by microorganisms and, therefore, consumption of xylitol has little effect on plaque pH.

In addition, xylitol inhibits the growth of streptococcus mutans by accumulating intracellularly (Lynch and Milgrom, 2003). Studies confirm that short-term consumption of xylitol is associated with decreased streptococcus mutans levels in saliva and plaque. Long-term consumption seems to have a streptococcus mutans selective effect for populations of bacteria less likely to adhere to tooth surfaces (Trahan, 1995).

Xylitol is a convenient way of introducing prevention in children at risk for dental caries (Lynch and Milgrom, 2003). Studies on populations of school children show that chewing gum containing xylitol reduces and arrests dental decay (Makinen et al., 1995). There was also a dose–response relationship observed; those given the highest dose of xylitol gum experienced the greatest effect (Makinen et al., 1995).

A study by Soderling and colleagues compared the effect of chlorhexidine varnish, fluoride varnish and 100 percent xylitol gum (65 percent by weight, chewed at least two times per day) in mothers. They found that children of mothers treated with xylitol had the lowest levels of mutans streptococci during intervention (until the child was two years) and at a six year follow-up (Soderling et al., 2001).

But chewing gum is not considered safe for small children and is discouraged in schools (Lynch and Milgrom, 2003).

However, other xylitol-containing products are as effective as gum in caries prevention (Alanen et al., 2000). The results of a recent blinded randomized control trial found that xylitol lozenges did not produce a clinical reduction in caries in adults (Bader et al., 2013).

The side effects of xylitol are similar to those of all sugar alcohols. Because it is absorbed slowly in the gastrointestinal tract, excessive amounts can result in osmotic diarrhea. This usually occurs when xylitol is consumed at levels four to five times higher than is needed for dental caries prevention (Lynch and Milgrom, 2003). The Food and Drug Administration approved xylitol for use as a food sweetener in the 1960s (Roberts et al., 2002). It is safe for use in children, pregnant women and nursing mothers (Akerblom et al., 1982; Brambilla et al., 1998).
There are many products with xylitol – diet bars, candies, chewing gums, oral health care products and vitamins. A few of these products are:

- Epic™ gum, mints and other products
- Nabisco®-Carefree Koolerz Gum
- Tic Tac® Silvers
- Adams® Trident Advantage
- Crest® Multicare Toothpaste
- Rembrandt® Dazzling Breathdrops
- Bayer Flintstone™ Vitamins

(Lynch and Milgrom, 2003)

**Combination therapy**

Combination treatment of caries includes fluorides, sealants, antimicrobials and xylitol (NIH Consensus Statement, 2001).

Rinsing twice daily with 0.12 percent chlorhexidine gluconate, and chewing four to five sticks of xylitol gum per day for five minutes each time, for two weeks, can lead to a substantial reduction in streptococcus mutans levels (Lynch and Milgrom, 2003). In expectant mothers, this benefits the child by inhibiting the vertical transmission of cariogenic bacteria (Lynch and Milgrom, 2003).

The combined use of stannous fluoride toothpaste and acidulated phosphate fluoride (APF) topical solution is more effective than using them individually. A large study of children in London and the Isle of Wight examined the anticariogenic effects of combined and separate home-use of a monofluorophosphate (MFP) toothpaste and an APF gel applied twice yearly (Mainwaring and Naylor, 1978). The study found that the combined use of MFP toothpaste and APF gel resulted in significantly lower three-year caries increments (Mainwaring and Naylor, 1978). Other studies have reported the anticariogenic effect of combining stannous fluoride solutions, toothpastes and prophylactic pastes (Gish and Muhler, 1965).

A study conducted among children living in a heavily fluoridated community in Michigan examined the effect of combined sealant and fluoride treatment. All participants received dietary counseling and oral hygiene education. The children in the treatment group had sealants applied to the occlusal surfaces of their teeth and APF gel applications for four minutes every six months. Children in the treatment group experienced substantially less caries over the duration of the study (Bagramian et al., 1979). Other studies in the United States and Finland have drawn similar conclusions (Ripa et al., 1987; Rantala, 1979).

A Swedish study measured the effectiveness of a 1 percent chlorohexidine and 0.2 percent sodium fluoride gel applied three times daily on two consecutive days, on levels and subsequent colonization of streptococcus mutans in the saliva of mothers of one-year-olds (Tenovuo et al., 1992). Results showed that the application of the chlorohexidine-sodium fluoride gel twice a year resulted in lower streptococcus mutans levels in the mothers, which slowed colonization, and consequently resulted in a decline in child’s caries incidence (Tenovuo et al., 1992).

**Dietary counseling for the prevention and/or control of dental caries**

Providing dietary counseling is an important component of overall dental care. This six-step model of dietary counseling uses evidence-based guidelines (Wan and McGlone, 2003).

1. **Identify high-risk patients**

During every dental visit, remind patients:

- What they eat and drink has a direct impact on their oral health
- To maintain a balanced and nutritious diet

Patients with a history of caries and who are at an increased risk of future caries need more detailed dietary advice.

2. **Take a dietary history**

A dietary history will help identify any eating practices that may contribute to caries development. The primary purpose of this assessment is to identify the pattern of sugar consumption and exposure in patients at risk for future caries.

The key information required is:

- The number of times food was consumed per day and how many times snacks were eaten
- The type of food consumed (liquid, solid or sticky and/or long-lasting)
- Whether the food stimulates saliva production
- The sequence of food intake (i.e., is the consumption of cariogenic food followed by anticariogenic food)

3. **Set patient goals**

It is important that the goals that are set are realistic and achievable. Advise patients to:

- Eliminate high-sugar snacks and drinks
- Restrict high-sugar content foods to meal times when other foods that are a part of the meal may have anticariogenic properties
• Recommend consumption of nutritious foods such as hard cheeses and nuts as between-meal snacks
• Chew sugar-free gum after eating to help neutralize the acidogenic effects of the food consumed
• Make sure that water is readily available for frequent sipping
• Follow the United States Department of Agriculture’s (USDA) Food Guide Pyramid and eat a nutritionally balanced diet that contains foods from the five major food groups: grains, fruits, vegetables, meats and beans and milk

4. Develop an action plan

To increase patient compliance with suggested dietary changes, it is important to tailor the advice to the individual. Reviewing the patient’s eating patterns, and subsequently identifying “problem” foods, beverages and consumption practices, may provide useful information when deciding on a plan of action. For example, if a person is an “emotional eater,” that is, will eat when feeling happy, sad or stressed, discussing alternative methods of dealing with these emotions may help the patient to reduce sugar intake frequency.

5. Monitor and review

As with any behavioral modification, patients who change their dietary habits will find it difficult making adjustments to their new eating practices. They will need ongoing monitoring, feedback, encouragement and support. Therefore, within a few weeks of implementing the plan, it is important to have a follow-up visit to assess patient progress.

6. Refer

Conducting a patient dietary assessment may help identify an individual who needs expert dietary guidance. Refer patients who have special or complex dietary problems, a medical condition or an eating disorder to their physician or to a registered dietitian for help.

5. Caries diagnostic aides

Caries risk assessment tests

CRT® Bacteria and CRT® Buffer
(Ivoclar Vivadent)

http://www.ivoclarvivadent.us/

The CRT Bacteria test determines mutans streptococci and lactobacilli counts in saliva. It is highly selectivity and produces results after two days.

The CRT Buffer test helps determine the buffering capacity of saliva. This test provides results in five minutes. Blue indicates high buffering capacity. Yellow indicates low buffering capacity (Ivoclar Vivadent web page).

Saliva-check mutans

Saliva-check mutans is a chair-side test for streptococcus mutans. It measures the number of colony forming mutans streptococci units in the patient’s saliva. If the number of colony forming units is greater than 500,000, the test is positive. It uses a monoclonal antibody system. It is rapid with the tests results obtained in 15 minutes.

Saliva-CheckBUFFER® (GC America)

http://www.gcamerica.com/products/preventive/Saliva_Check_BUFFER/

Saliva-Check is a combination of six tests:

1. Hydration testing measures salivary production.
2. Salivary Consistency testing visually assesses the viscosity of unstimulated saliva.
3. Resting Saliva pH testing measures the pH of unstimulated saliva.
4. Stimulated Saliva Flow testing measures the quantity of saliva produced in five minutes while chewing an unflavored piece of wax.
5. Stimulated Saliva pH testing measures the pH of saliva produced under masticatory stimulus.
6. Saliva Buffering Capacity testing measures the ability of saliva to minimize an acid challenge.

The tests take about 10 minutes total per patient (GC America webpage).
Adjunctive diagnostic aides

Several new diagnostic aides are commercially available. They provide adjunctive information to the visual and radiographic examination in determining the caries diagnosis. To make an accurate diagnosis and subsequently provide appropriate treatment, it is important to understand the diagnostic procedure. Knowing the reliability and validity of the instrument, as well as the sensitivity and specificity of the procedure are important to determining how much weight to give the results (Pretty and Maupomé, 2004).

Four types of diagnostic aides are available to dental practitioners in the U.S. These systems use the following technologies:

- Laser fluorescence
- Electrical impedence
- Light-induced fluorescence
- Light-emitting diodes

Laser fluorescence

DIAGNOdent® (laser caries detection aid) is one example of a laser fluorescence unit. It uses laser fluorescence to measure and quantify bacterial presence in carious lesions (Ross, 1999). It emits a laser beam into the tooth that is absorbed and re-emitted as fluorescence (Pretty and Maupomé, 2004 [2]).

The DIAGNOdent has been found to perform effectively, though not significantly better than visual examination (Pretty and Maupomé, 2004 [2]). In comparison to the visual method, the DIAGNOdent was more sensitive and less specific for identifying dentinal caries on occlusal surfaces of both in-vitro primary and permanent teeth (Bader and Shugars, 2004). However, the fact that the DIAGNOdent quantifies demineralization makes it more useful than visual examination in the long-term monitoring of the patient’s teeth (Pretty and Maupomé, 2004 [2]). Because the DIAGNOdent provides no images, but rather a numeric indicator that can be recorded and monitored, it is more useful combined with a visual exam where it has been shown to improve the clinician’s ability to detect demineralization (Pretty and Maupomé, 2004 [2]).

Some limitations of diagnostic tools that utilize laser fluorescence technology:

- Laser fluorescence only determines demineralization and not decay or other changes in the anatomy of the tooth (Yang and Dutra, 2005)
- It is sensitive to the presence of stains, plaque and calculus; thus is at risk of returning false-positive results (Yang and Dutra, 2005)

DIAGNOdent also is available as a pen-style device.

Electrical impedence

An example of a unit that uses electrical impedence is the CarieScan Pro. It uses electrical impedence to measure demineralized tooth structure. Demineralized tooth structure exhibits a higher impedence than healthy tooth surfaces or structures.

Light-induced fluorescence

The Spectra Caries Detection Aid is one unit that uses light-induced fluorescence. It uses light-induced fluorescence (blue ultraviolet light) to detect sound tooth surfaces and bacterial pigments. Researchers tested this new technology in an in-vitro study on 41 extracted molars. This study found that the Spectra has a good ability to detect caries in enamel and dentin (Graye et al., 2012). The system stores the images on a computer to allow for lesion comparison at recall visits. The Spectra is available as a pen-style device.

Light-emitting diodes

The Midwest Caries I.D. is an example of the final type of unit. It uses light-emitting diodes (LED) to detect dental caries. The pen-style device lets off a tone when it detects a caries lesion. A recent study found these types of devices are less accurate than laser fluorescence devices in detecting occlusal dental caries (Aktan, 2012).
References


Edelstein BL. Dental care considerations for young children. Spec Care Dentist 2002; 22 (3 Suppl):115 – 25S.


Clinical practice continuing education questions:

Cariology clinical practice update

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1. Caries risk assessment tests that are available for office use include all of the following except:
   A. Lactobacilli count
   B. Streptococci count
   C. Buffer capacity test
   D. DNA probes

2. Before prescribing systemic fluorides (fluoride supplementation) to a patient, you should:
   A. Apply topical fluorides to the primary dentition
   B. Assess the caries risk and fluoride status of the drinking water
   C. Restore all carious teeth and seal teeth that are at risk
   D. Apply fluoride varnish to cervical margins of at-risk teeth

3. What amount of supplemental fluoride would you prescribe for a high-risk five-year-old living in a city with less than 0.3 ppm fluoride in the community water supply?
   A. None
   B. 0.25 mg/day
   C. 0.50 mg/day
   D. 1.0 mg/day

4. Mutans streptococci are most commonly transmitted in which of the following ways?
   A. Through the saliva from mother to child (vertical transmission)
   B. Through the saliva from father to child
   C. Through the saliva from sibling to sibling

5. Early childhood caries (ECC) is defined as:
   A. Caries on the anterior primary teeth only
   B. Caries on the permanent dentition after age six
   C. One or more carious teeth before the 6th birthday

6. Combination therapy or the use of multiple protective interventions, such as chlorhexidine and sodium fluoride, is more effective than individual use.
   A. True
   B. False

7. Xylitol sweetened products inhibit the growth of streptococcus mutans. It is included in which of the following products:
   A. Gums
   B. Toothpaste
   C. Vitamins
   D. All of the above

8. Eliminating high-sugar snacks and drinks and recommending consumption of nutritious foods is part of which step in the dietary counseling model presented in this monograph?
   A. Identify high-risk patients
   B. Take a dietary history
   C. Set patient goals
   D. Develop an action plan
   E. Monitor and review
   F. Refer

9. Diagnostic tests, such as DIAGNOdent, can provide adjunctive information to the visual and radiographic examination in determining the caries diagnosis.
   A. True
   B. False

10. An adult patient with two or more carious lesions in the past year, previous root caries and a mutans streptococci count of greater than 1 X 106 is considered to be at risk for caries:
    A. Low
    B. Moderate
    C. High

Correct answers for 1-10
The responses to #11-20 are optional and will only be reported in the aggregate. Results will not be reviewed at the individual level.

11. In your office, do you currently assess your patient's caries risk using a microbiological test?
   - A. Yes
   - B. No

12. Do you currently use caries assessment aids such as Laser Caries Detection Aid (DIAGNOdent)?
   - A. Yes
   - B. No

13. Do you use antimicrobial treatment (chlorhexidine) to reduce the caries risk for high-risk patients?
   - A. Yes
   - B. No

14. Do you use fluoride varnishes in your practice?
   - A. Yes
   - B. No

15. Do you routinely place dental sealants in your office?
   - A. Yes
   - B. No

16. Do you routinely prescribe systemic fluorides for high-risk children in your practice?
   - A. Yes
   - B. No

17. After reading this monograph, I will assess caries risk in my practice for each patient, using low, moderate and high categories for risk.
   - A. Strongly agree
   - B. Agree
   - C. Neither agree nor disagree
   - D. Disagree
   - E. Strongly disagree

18. After reading this cariology update, I am confident that I can conduct caries risk assessment in my practice.
   - A. Strongly agree
   - B. Agree
   - C. Neither agree nor disagree
   - D. Disagree
   - E. Strongly disagree

19. Overall, this cariology update enhanced my ability to develop a caries risk assessment and triage system.
   - A. Strongly agree
   - B. Agree
   - C. Neither agree nor disagree
   - D. Disagree
   - E. Strongly disagree

20. Please rate the relevance of this cariology update to your clinical practice.
    1  2  3  4  5
    Irrelevant  Relevant
All patient care and related decisions are your sole responsibility, and this information does not dictate or control your clinical judgment regarding the appropriate treatment of any individual patient. Please be aware that not all dental plans cover all of the treatments or tests described in this document. This clinical practice update is based on a review of the current literature and was prepared by David A. Albert, D.D.S., M.P.H.; Joseph McManus, DMD, MS, MHA, MBA, MS; Panos N. Papapanou, D.D.S., Ph.D.; and Angela Ward, R.D.H., M.A., of the Columbia University College of Dental Medicine, and sponsored by Aetna Dental. We would like to acknowledge the assistance of Sharifa Z. Barracks-Williams, a graduate Doctoral student in the Columbia University Mailman School of Public Health. Continuing education credit is available from Aetna Dental upon completion of the examination questions. This course is also located online at www.aetnadental.com. For those offices without Internet access, a copy of the CE course can be obtained by calling the National Dentist Line at 1-800-451-7715.

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