CLINICAL
Feature

Pucker Up: The Effects of Sour Candy on Your Patients' Oral Health

A review of the dental erosion literature and pH values for popular candies

Although the harmful effects of acidic beverages on teeth have been well established and communicated through a variety of clinical articles and public education pieces, the Minnesota Dental Association's Public Relations Committee has determined that the new and emerging concern of the erosive effects of sour candy on the dentition should be brought to the attention of dental professionals and the public alike. Furthermore, since the serious irreversible damage caused by erosion is difficult and costly to treat, early detection and the initiation of preventive strategies are paramount to minimizing long-term consequences. The following article should serve as a review of the general topic of erosion, and should provide additional information about the increasing prevalence of erosion and the specific risks of sour candy consumption.

Robyn R. Loewen, D.D.S.,*
Robert J. Marolt, D.D.S., and**
John D. Ruby, D.M.D., Ph.D.†

Walk into any convenience or grocery store candy aisle today, and take a look at the extensive and colorful array of candy on the shelves. In addition to the traditional concoctions of chocolate, caramel, and nuts, there has been a distinct shift in preference for "extreme" or "intense" sour and fruity flavor experiences. The specific marketing of these sour fruity candies to children through packaging style and labeling, such as brightly colored plastic baby bottles filled with citric-acid-laced powder, has increased their appeal and has led to a popular new source of dietary acid, and unfortunately, a new contributing factor in the increasing prevalence of dental erosion.

Etiology of Tooth Wear

Tooth wear is caused by a complex interrelationship between erosion (dissolution of hard tissue by acidic substances), attrition (loss of tooth substance from tooth-to-tooth contact), and abrasion (wear by contact between tooth and another material). It is difficult to assess the relative influence of each of these contributing factors to tooth wear.[1,2,3] However, the location of the defects on teeth can assist in making a differential diagnosis.[4]

- Abrasion, such as that caused by overly aggressive tooth brushing, results in buccal indentations near the cervical margin or root surface of teeth, usually without any evidence of decay or decalcification.
- Attrition defects are identifiable by matching facets on occluding teeth, fractured cusps and restorations, and relatively similar wear rates of enamel and dentin.
- Erosion from industrial acid exposure typically manifests on the labial surfaces of maxillary incisors.
- Gastroesophageal reflux disease and frequent vomiting cause the loss of lingual enamel on the maxillary incisors and the lingual surfaces of the maxillary premolars and molars.
- Acidic liquids cause preferential erosion of the anterior maxillary and mandibular teeth, and are often accompanied by cervical decalcification and interproximal decay.
- Erosion from acidic solids such as candy manifests mainly on posterior teeth with smooth, glazed enamel which appears to be highly polished, "cupping" of cusp tips on posterior teeth, and the impression of "raised" restorations from a loss of the surrounding enamel (Photos 1-6 on opposite page).

Erosion

Dental erosion was described as early as 1803 by John Hunter in his text *The Natural History of the Human Teeth* as "decay of the teeth by denudation". Hunter specifically differentiated the characteristics of erosion from that of dental decay of bacterial origin.[5] Since that time erosion has been defined as the irreversible loss of dental hard tissue due to a chemical process, without any involvement by microorganisms.[6] The causative agents are usually acidic substances, whether intrinsic (gastric acid from reflux or repeated vomiting) or extrinsic (consumption

**Dr. Loewen is a pediatric dentist in private practice in Rochester, Minnesota, and Diplomate, American Board of Pediatric Dentistry and Fellow, American Academy of Pediatric Dentistry. E-mail is rloewen@charterinternet.com*

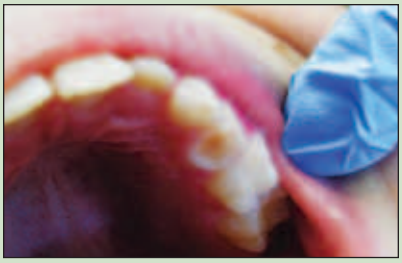
***Dr. Marolt is a general dentist in private practice in White Bear Lake, Minnesota, and member, Academy of General Dentistry. E-mail is drbobm@maroltdentistry.com*

†Dr. Ruby is associate professor, Department of Pediatric Dentistry, School of Dentistry, The University of Alabama, Birmingham, Alabama. E-mail is john–ruby@cs1dental.uab.edu

Normal primary molar and canine anatomy.

An example of early cusp tip cupping.

Significant cupping of cusp tips can be seen on the primary canine and first molar cusp tips of this 11-year-old habitual sour candy consumer.



The lingual cusp of the maxillary primary first molar is nearly obliterated in this patient who admits to chronic sour candy consumption. The lingual cusp is no longer in occlusion with the opposing molar.

Advanced destruction of entire occlusal surface extending across marginal ridge into the interproximal region.

Complete loss of occlusal surface of primary second molar and early involvement of permanent first molar cusp tip in an 11-year-old who admits to frequent consumption of sour candy and pickles.

of acidic foods or beverages, repeated exposure to chlorinated water, and industrial chemical exposure). Although identification of patients with intrinsic sources of acid erosion such as gastroesophageal reflux and those with environmental exposure are critical, this article will focus on the effects of dietary acids on the dentition, and will introduce new information on specific risks with frequent consumption of acidic candy.

The mechanism of tooth erosion has been widely described. When salivary pH levels drop to a critical level, enamel loses calcium by the formation of calcium citrate complexes, causing an etching of the enamel surface. After this superficial decalcification of enamel by acid, the remaining three to five micron layer of demineralized enamel or dentin is more susceptible to the effects of abrasion or attrition.[7] The critical pH for enamel dissolution is 5.5. However, due to the modifying effects of the oral cavity, exposure to acidic foods and beverages with pH values below 4 can result in dental erosion.[8]

There has been increasing concern over the high prevalence of tooth erosion in children, with research activity taking place in Europe, Scandinavia, Australia, and North and South America within the last decade.[9,10,11,12,13] England's 1993 National Survey of Child Dental Health included the evaluation of tooth erosion for the first time.[14]

Plaque does not typically build up on the highly polished surfaces.

Studies of dental erosion show that the prevalence rates in children seem to be increasing.[15] In epidemiologic studies prior to 2001, the prevalence of erosion in children had been estimated between 2 and 57%.[16,6] In a more recent Australian study (2007), erosion rates in primary teeth were found to be as high as 68%.[17]

Significant erosion can cause dentin sensitivity and difficulty eating, pulpal inflammation and/or pulpal exposure, progressive enamel microfracture resulting in a loss of occlusal vertical dimension, and cosmetic changes due to the exposure of dentin, making the teeth appear yellow.

Although acid erosion creates significant enamel damage, caries is not frequently seen in eroded teeth until the late stages of the condition, when the exposed dentin is unable to withstand further bacterial acid challenges. Plaque does not typically build up on the highly polished surfaces. The lack of decay in the early stages of erosion can deceive patients into a false sense of "dental health," which can make any motivation for changes to poor dietary habits difficult.

Interestingly, dental erosion is frequently seen in individuals exhibiting high levels of oral hygiene.[18] Toothbrushing immediately following an acid attack can result in increased abrasion of the soft, demineralized surface.[19] Similarly, toothbrushing immediately prior to the consumption of acidic foods

Continued on page 24

Continued from page 21

and beverages results in loss of the protective pellicle, and a greater risk of decalcification.[20,21]

Young, immature enamel is particularly prone to the erosive effects of dietary acid due to its relative porosity and lack of complete mineralization.[22,23,24] The enamel is also thinner in primary teeth than in permanent teeth, so that the erosive process may reach dentin more rapidly in primary teeth.[17] Also, it has been shown that children between three and seven years of age have larger variations and slower salivary sugar clearance rates and also lower salivary flow rates than older children and adults.[25] This suggests that, during the childhood and early adolescent years, when candy and soft drink consumption may be the greatest, both primary and permanent teeth are most susceptible to erosion.

Dietary Acids

Numerous studies have shown the erosive potential of soft drinks, fruit juices, and sports drinks.[26,27,11,28,29,30,31,32,8,33,34,35] The degree of enamel dissolution has been shown to be directly related to the acidity of the substance and varies by type of acid.[36] Determinants of acidity include the total amount of acid available (titrable acidity), the amount of acid present in the solution (H+ ion concentration as measured by pH), and the strength of the acid (ease of dissociation as expressed by the acid dissociation constant, pKa). However, the erosive potential of a candy or beverage is a complex interaction of acidity, pH value, phosphate and fluoride levels, the type of acid, and its inherent calcium chelating properties. The *in vitro* erosive potential is further modified by salivary pH, salivary flow rates, salivary buffering capacity, calcium, phosphate and fluoride levels in saliva, duration of exposure, frequency of exposure, and time of day of exposure. For instance, exposure to acidic foods/beverages just before bedtime has been shown to be the most harmful.[37,38,30,11]

The ability of food acids to chelate calcium is considered to be a major factor in dental erosion.[39] Citric acid is the most erosive component in foods and beverages, because it chelates calcium even at higher pH levels, such as those found in buffered saliva.[30,40,41,42,43,44,45,8,34] In fact, it is twice as destructive to dental enamel as hydrochloric or nitric acid.[42] Significant dental erosion has also been shown to result from the use of vitamin C (ascorbic acid) supplements in tablet form.[7] The pH of vitamin C tablets is 1.92, well below the levels considered safe for dental enamel.

Since the destructive effects of dietary acids have been well documented, one might ask why they are used in food products at all. Some of the functions of food acidulants include flavor enhancement and modification, food preservation, pectin gelation, the inhibition of enzymatic browning, food leavening, and the complexation of cation impurities.[39] A list of common dietary acids can be seen in Figure 1.

Figure 1.
Dietary acids with potential to cause dental erosion.*

Acetic acid
Ascorbic acid
Benzoic acid (used as preservative)
Citric acid
Lactic acid
Maleic acid
Malic acid
Phosphoric acid
Proprionic acid (used as preservative)
Succinic acid
Tartaric acid
Carbonic acid

**Adapted from Milosevic 2004.*

Sour Candy

Though the destructive potential of acidic beverages and fruits has been studied extensively, there should be growing concern over the preponderance of low pH candies marketed toward children and their potential for a different pattern of occlusal enamel erosion, especially on posterior teeth. Dr. John Ruby, a pediatric dentist and associate professor at the University of Alabama at Birmingham School of Dentistry, is convinced that the combination of extremely low pH candies, immature tooth enamel, and a high frequency of ingestion is causing serious harm to children's teeth.

Dr. Ruby recently tested the pH levels of many popular candies, with startling results. One gram of each candy was dissolved in 5 ml water, then tested with Fisher Scientific pH paper accurate to within 0.1 unit. Results of his testing can be found in Figure 2. Most of the sour and fruity candies had very low pH levels. Some of the more surprising findings from his testing included Warheads Sour Spray liquid — pH 1.6, and Altoids Citrus Sours hard candies — pH 1.9. (As a familiar frame of reference, battery acid has a pH of 1.0.) More importantly, most of the sour fruity candies had lower pH levels than any of the soft drinks previously studied. Citric acid is the common "sour" flavoring agent in these products, and as mentioned previously, is the most erosive dietary acid. The low pH of these candies can also cause localized soft tissue irritation from surface damage to the mucous membranes of the inner cheek and tongue. In fact, many of these candy package labels contain a written warning about potential soft tissue irritation with frequent ingestion.

When different candy flavorings are compared, the citric-acid-related fruit flavors of lemon, cherry, and

Figure 2.
pH values for Sour Candy.*

1g candy/5mL water	pH
pH at which teeth decalcify	**4.0**
Spree®	3.0
Sweetarts®	3.0
Big Stuff Pacifier® sucker	3.0
Sour Gummi Bears®	3.0
X-treme Airheads®	3.0
Sour Punch Straws®	2.5
Shockers®	2.5
Skittles®	2.5
Baby Bottle Pop® powder	2.5
Brach's Gummi Bears®	2.5
Sqwigglies Gummi Worms®	2.5
Wonka Laffy Taffy®	2.5
Starburst®	2.4
Sweet Tarts Shock®	2.4
Lemon Heads®	2.4
Mentos® fruit chew	2.4
WarHeads® Sour Rips Roll	2.3
Lollipop Paint Shop®	2.2
Zours®	2.2
Sour Skittles®	2.2
Airheads® cherry chew	2.0
Wonka Nerds® grape	2.0
Now and Later® cherry chew	1.9
Too Tart Extra Sour Goo®	1.9
Wonka Pixy Stix® powder	1.9
Altoids Mango Sours®	1.9
Wonka Fun Dip® powder	1.8
WarHeads Sour Spray®	1.6
Battery acid	**1.0**

**pH data generated by John Ruby, Betsy Brown, Brandon Wesley, Stephanie Momeni, and Mike Vann, Department of Pediatric Dentistry, School of Dentistry, The University of Alabama at Birmingham, Birmingham, Alabama.*

Not only are extremely sour candies prevalent and readily available at grocery and convenience stores, as well as athletic and movie concession stands, the marketing strategy of confection companies directed at very young children should be particularly disturbing to dentists and parents. For example, "Toxic Waste" is a sour hard candy presented in a colorful plastic garbage can. The label offers a challenge to hold the candy in the mouth as long as possible, with a scoring chart measured by the number of seconds tolerated. In addition, the label also refers young consumers to a "cool" website offering games and other activities, as well as advertisements for other candies made by their company. There is also a warning label on the packaging about potential soft tissue irritation with continued use.

Other youth-targeted packaging includes pacifier-shaped suckers, baby bottles filled with citric acid powder, and sour gel squeezed from a tube with a "real baby nipple". Interestingly, the label for the sour gel with the baby nipple claims the candy has "no refined sugar, less than half the calories of the original and even better tasting. Real fruit juice concentrates make contents equal to 100% juice. A portion of the proceeds is donated." (Since the manufacturer donates a portion of its proceeds to the American Diabetes Association, the logo for the American Diabetes Association can also be found on the label.) The label also has a warning: "Choking hazard – small parts, not for children under 3 years of age. Avoid getting into eyes. If this occurs, flush eyes with water immediately for 15 minutes. If irritation persists, consult your doctor. Consuming large quantities within a brief time period may cause temporary irritation to sensitive tongues." …and teeth!

grape destroy much more enamel than the near neutral aromatic flavors of cinnamon and mint.[46] Some examples of currently popular candies with the potential for erosive damage are the intensely flavored sour chewy candies, powdered candies, sour gels and sprays, and powder-coated gums. In addition to a low pH level, the consistency of a candy substance contributes to the erosive potential of a product as well. For instance, insoluble starchy "gummy" candies, thick sticky gels, and citric acid powders are particularly harmful due to their prolonged clearance times and abrasivity.[46]

Despite the current lack of *in vivo* research specifically addressing the erosion risks from sour, fruity candy, the body of knowledge regarding the erosive damage caused by other low

Continued on page 28

Continued from page 25

pH foods and beverages is significant, and the potential for erosive damage to children's teeth with frequent ingestion of these candies cannot be ignored.

Diagnosis and Intervention

Management of dental erosion consists of five essential components: diagnosis and etiology assessment, monitoring of the progression of enamel loss, dietary and oral hygiene modifications, remineralization, and restorative treatment.[16] A working understanding of the complex interaction of dental structures, oral chemistry, and dietary factors is necessary for proper recognition of erosion, interpretation of any type of assessment, and appropriate strategies for treatment.

Diagnosis

Determination of erosion as the specific cause of tooth wear and the subsequent investigation into possible sources of intrinsic or extrinsic acid are the first steps to diagnosis. A simple questionnaire can elicit adequate information to begin to differentiate between the various causes of tooth wear, including erosion, attrition, abrasion, and possibly abfraction (Figure 3). If other causes of tooth wear have been ruled out and acid erosion is suspected, a source of acid must be identified.

Intrinsic acid sources such as gastroesophageal reflux or frequent regurgitation (eating disorders, stress vomiting) require referral to an appropriate medical professional for the patient's overall health maintenance.[47] Environmental exposure to an acid source requires thoughtful education as to the long term effects of the exposure, efforts to reduce exposure, and appropriate supportive care.

Discovery of a dietary source of acid will require careful questioning and dietary analysis. A five-day food diary has been suggested, and should include three weekdays and two weekend days. This diary should include all medicines and vitamin supplements, as well as the frequency and method of ingestion (i.e., chewables, effervescent liquid, swish and swallow, capsules to be swallowed).[48] Review and interpretation of the diary can be performed by the dentist, with specific attention paid to the frequency and pattern of dietary acid consumption.

Figure 3.
Erosion Assessment Tool.

Dietary History Interview*

Which of these snacks do you like? How often do you eat each type of snack?

- *Oranges
- Apples
- Bananas
- *Grapes
- Nuts, like peanuts
- Potato chips, like Lays
- Tortilla chips (nacho cheese etc.), like Doritos
- Popcorn
- Chocolate candy, like Hershey's, Reese's
- Caramel candy, like Milky Way
- *Jelly beans, like Starburst
- *Gummy candy, like Gummy Bears
- *Sour gummy candy, like Sour Patch Kids
- Chewing gum, like Double Bubble bubble gum
- *Lemon flavored candies
- Licorice – red or black, like Twizzlers
- Sugarfree chewing gum, like Trident, Orbit
- *Chewy sour candy, like Skittles
- *Powdered sour candy, like Fun Dip
- *Hard sour candy, like Ice Breakers, War Heads

Asterisk designates erosive potential due to acid content.

Dental Examination

Attrition

- Wear facets present?
- History of bruxism?
- Traumatic occlusion?

Abrasion

- Buccal and/or cervical defects without decalcification?

Erosion

- Cervical decalcification or decay? (erosive beverage consumption?)
- Loss of surface texture?
- Loss of occlusal anatomy?

Cupping of cusp tips – posterior teeth?

Thinning or grooving of incisal edges – anterior teeth?

Monitoring

Ongoing assessment of enamel loss is challenging in a clinical setting. Although comparative intraoral photographs and study models will assist in evaluating long term surface changes, actual quantitative measurements of enamel loss within short term intervals are more difficult to achieve. Detailed clinical notes of any visible changes in tooth anatomy, patient sensitivity, or functional problems are essential in an ongoing assessment of the rate and progression of enamel loss.

Standardization of monitoring techniques is needed. Several indices have been proposed for measuring tooth erosion.[49,50,51,4] However, these indices are more useful for broad-based epidemiological studies of tooth wear, since they fail to localize and quantify actual enamel loss.[9] Salivary tests also need to be developed that can easily be used in clinical practice to assess salivary buffering capacity, flow rate, and composition.

Diet and Hygiene Modifications

The behavior modifications listed in Figure 4 will aid dentists in coaching patients to minimize the risk of erosion. Every attempt should be made to reduce the frequency of consumption of acidic candies, and such foods should be restricted to main meals.[48,52] For example, a change in the timing of eating sour candy between meals or at bedtime to a mealtime can reduce the severity of the acid attack due to more efficient clearance time and the buffering benefits of saliva.[37] Encourage patients to finish a meal with something neutral or alkaline — cheese, milk, or sugar-free chewable antacid tablets. Chewing sugar-free gum will stimulate saliva flow, providing a natural buffering action. Rubbing bicarbonate-containing toothpaste on the teeth with a fingertip will reduce the acid challenge on the tooth surface. Also, rinsing with water rather than brushing teeth immediately following an acid challenge can reduce demineralization by clearing the acid from the oral cavity, and will prevent inordinate damage by toothbrush abrasion of the fragile enamel surface.[48] Finally, patients should use less abrasive "sensitive" toothpastes or those with bicarbonate as an active ingredient, rather than highly abrasive whitening toothpastes.

Figure 4.
Preventive Measures to Reduce Erosion Risk from Acidic Foods.*

- Diminish frequency of consumption of acidic foods and beverages.
- Restrict acidic foods to main meals.
- Rinse with water after acid consumption.
- Chew sugar-free gum to stimulate salivary flow.
- Use only a soft toothbrush.
- Use low-abrasive fluoride and bicarbonate-containing toothpaste.
- Avoid toothbrushing immediately following an acid challenge.
- Rinse with a low-concentration, non-acidulated fluoride mouthwash two times daily.
- Apply pH neutral, highly concentrated fluoride gel or toothpaste two times weekly.
- Fluoride varnish to be professionally applied two to four times per year.
- Regular dental visits for ongoing assessment.

**Adapted from Imfeld 1996 and Gandara.*

Remineralization

Treatment for erosive defects should begin with stabilization of the structural integrity of the tooth surface and the promotion of remineralization. Topical fluoride found in over-the-counter rinses and toothpastes, prescription-strength toothpastes, professionally applied fluoride treatments, and fluoride varnishes will provide reduced enamel solubility and control the symptoms of tooth sensitivity.[53] Oral hygiene products containing amorphous calcium phosphate can enhance fluoride uptake for more efficient remineralization and an increased resistance to further demineralization.

> Restoration requires choosing the least invasive procedure.

Restoration

The goal of restorative treatment should be to maintain adequate function and esthetics of primary and permanent teeth. Erosion from the chewing or sucking of acidic candy primarily affects the occlusal surfaces of the posterior teeth. Eroded primary teeth should be restored to maintain vertical dimension and mesial-distal width, reduce symptomatic sensitivity, and provide pulpal protection for the maintenance of vitality until exfoliation. Frequently, full-coverage stainless steel crowns are the most appropriate restorative choice for severely eroded posterior primary teeth.

The restoration of eroded permanent teeth requires choosing the least invasive procedure while providing maximum protection from

Continued on page 32

Continued from page29

the further loss of tooth structure. Occlusal sealants and resin-bonded restorations in "cupped" cusp tip lesions will provide mechanical protection for the affected surfaces, reduce dentin hypersensitivity, and improve the appearance of severely eroded posterior teeth.[16] Many of these teeth will eventually require full-coverage cast or ceramic restorations to preserve remaining tooth structure and provide adequate esthetics and function. Since full-coverage restorations are costly and involve significant additional loss of tooth structure, it is essential that appropriate early counseling and behavior modification should occur to prevent the need for such invasive treatment.

Summary

Children's increasing preference for "extreme" sour candy and the industry's response in the variety of sour candies marketed to children has created a new twist on the dental erosion front. Additional research is needed to test the actual erosive potential of sour candies *in vivo* and the modifying effects of factors such as salivary buffering capacity. Streamlined measurement tools and standardization of assessments are needed to enable population-based epidemiological studies of the effects of all types of tooth wear. New remineralizing products are reaching the market, but long term efficacy studies on their ability to actually provide protection from erosive demineralization are needed. Lastly, a practical clinical method to measure salivary flow rate, salivary pH, and buffering capacity needs to be developed, so that individual susceptibility factors can be assessed. However, a simple awareness of the potential for increased erosion from extrinsic food sources and an understanding of the mechanism of demineralization are essential to early detection, intervention, and the prevention of invasive restorative procedures. ■

Author's Note

This author knows from personal experience as a parent how much these products appeal to children. Dentists and parents need to realize the possible harm to their children's teeth with repeated exposure to these "treats". As advocates for our patients and their families, Minnesota dentists need to spread the word about this emerging trend and its potentially devastating effects.

References

1. Pindborg J. Pathology of dental hard tissues. Copenhagen, Denmark: Munksgaard. 1970.
2. Bell EJ, Kaidonis J, Townsend G, Richards L. Comparison of exposed dentinal surfaces resulting from abrasion and erosion. Aust Dent J 43:362-366, 1998.
3. Smith B. Tooth wear: aetiology and diagnosis. Dent Update 16:204-212, 1989.
4. Eccles JD. Dental erosion and diet. J Dent 2:153-159, 1974.
5. Asa R. Special report: erosion. AGD Impact 35(4):54, 2007. 27Jan2008.
6. Lussi A, Jaeggi T. Dental erosion: from diagnosis to therapy. Monogr Oral Sci 20:140-151, 2006.
7. Giunta JL. Dental erosion resulting from chewable vitamin C tablets. JADA 107:253-256, 1983.
8. Rytömaa I, Meurman JH, Koskinen J, Laakso T, Gharazi L, Turunen R. In vitro erosion of bovine enamel caused by acidic drinks and other foodstuffs. Scand J Dent Res 96:324-333, 1988.
9. Gandara BK, Truelove EL. Diagnosis and management of dental erosion. J Contemp Dent Pract 1(1):16-23, 1999.
10. Deery C, Wagner ML, Longbottom C, Simon R, Nugent ZJ. The prevalence of dental erosion in a United States and United Kingdom sample of adolescents. Ped Dent 22:505-510, 2000.
11. Milosevic A. Dietary acids – a risk to dental health? British Food Journal. 106(6):457-464, 2004.
12. Maupomé G, Ray JM. Structured review of enamel erosion literature (1980-1998): a critical appraisal of experimental, clinical and review publications. Oral Diseases 6:197-207, 2000.
13. Imfeld T. Dental erosion. Definition, classification and links. Eur J Oral Sci 104:151-155, 1996.
14. O'Brien M. Children's dental health in the United Kingdom 1993. Office of Population Censuses and Surveys. Her Majesty's Stationary Office, London, 1994.
15. Sheiham A. Dietary effects on dental diseases. Pub Health Nut 4:569-591, 2001.
16. Linnett V, Kim Seow W. Dental erosion in children: a literature review. Ped Dent 23:37-43, 2001.
17. Kazoullis S, Seow WK, Holcombe T, Newman B, Ford D. Common dental conditions associated with dental erosion in schoolchildren in Australia. Ped Dent 29:33-39, 2007.
18. Shaw L, Smith AJ. Dental erosion – the problem and some practical solutions. Brit Dent J 186(3):115-118, 1998.
19. Zero D. Etiology of dental erosion – extrinsic factors. Eur J Oral Sci 104:162-177, 1996.
20. Kuroiwa M, Dodaka T, Kuroiwa M, Abe M. Brushing induced effects with and without a non-fluoride abrasive dentrifice on remineralization of enamel surfaces etched with phosphoric acid. Caries Res 28:309-314, 1994.
21. Amaechi B, Higham S, Edgar W, Milosevic A. Thickness of acquired salivary pellicle as a determinant of the sites of dental erosion. J Dent Res 78:1821-1828, 1999.
22. Massler M. Teen-age cariology.Dent Clin No Am 13:405-423, 1969.
23. Wilson PR, Beynon AD. Mineralization differences between human deciduous and permanent enamel measure by quantitative microradiography. Arch Oral Biol 34:85-88, 1989
24. Johansson AK, Sorvari R, Birkhed D, Meurman JH. Dental erosion in deciduous teeth — an *in vitro* and *in vivo* study. J Dent 29(5):333-340, 2001.
25. Crossner CG, Hase JC, Birkhed D. Oral sugar clearance in children compared with adults. Caries Res 25:201-206, 1991.
26. Erickson PR, Alevizos DL, Rindelaub DJ. Soft drinks: hard on teeth. Northwest Dentistry 2:15-19, 2001.
27. Toumba J, Duggal MS. Fruit drinks, caries and erosion in children. Dental Health 38(4):5-8, 1999.
28. Lussi A, Jaeggi T, Jaeggi-Schärer S. Prediction of the erosive potential of some beverages. Caries Res 29(5):349-354, 1995.
29. Edwards M, Creanor SL, Fore RH, Gilmour WH. Buffering capacities of soft drinks: the potential influence on dental erosion. Journal of Oral Rehab 26(12):923-927, 1999.
30. Jarvinen VK, Rytömaa I, Heinonen OP. Risk factors in dental erosion. J Dent Res 70(6):942-947, 1991.
31. Meurman JH, Rytömaa I, Kari K, Laakso T, Murtomaa h. Salivary pH and glucose after consuming various beverages including sugar-containing drinks. Caries Res 21:353-359, 1987.
32. Sorvari R, Kiviranta I, Luoma H. Erosive effect of a sport drink mixture with and without addition of fluoride and magnesium on the molar teeth of rats. Scand J Dent Res 96:226-231, 1988.
33. Larsen MJ, Nyvad B. Enamel erosion by some soft drinks and orange juices relative to their pH, buffering effect and content of calcium phosphate. CariesRes 33:81-87, 1999.

34. Asher F, Read MJF. Early enamel erosion in children associated with excessive consumption of citric acid. Br Dent J 167:384-387, 1987.
35. Jain P, Nihill P, Sobkowski J, Agustin MZ. Commercial soft drinks: pH and *in vitro* dissolution of enamel. Gen Dent 55(2):150-154, 2007.
36. McDonald JL Jr, Stookey GK. Influence of different carboxylic acids on enamel dissolution in the presence and absence of sucrose. J Dent Res 54(4):187, 1975.
37. Millward A, Shaw L, Smith AJ, Rippin JW, Harrington E. The distribution and severity of tooth wear and the relationship between erosion and dietary constituents in a group of children. Int J Ped Dent 4:151-157, 1994.
38. Lussi A, Jaeggi T, Schärer S. The influence of different factors on *in vitro* enamel erosion. Caries Res 27:387-393, 1993.
39. Kleber CJ, Putt MS, Muhler JC. Enamel dissolution by various food acidulants in a sorbitol candy. J Dent Res 57:447-451, 1978.
40. West NX, Hughes JA, Addy M. Erosion of dentin and enamel *in vitro* by dietary acids: the effect of temperature, acid character, concentration and exposure time. J Oral Rehab 27:875-880, 2000.
41. McClure FT, Ruzicka SJ. The destructive effect of citrate vs lactate ions on rats' molar tooth surfaces, in vivo. J Dent Res 25:1-12, 1946.
42. Elsbury WB. Hydrogen-ion concentration and acid erosion of the teeth. Br Dent J 93:177-179, 1952.
43. Miller CD. Enamel erosive properties of fruits and various beverages. J Am Diet Assoc 28(4):319-324, 1952.
44. Davis WB, Winter PJ. Dietary erosion of adult dentine and enamel. Br Dent J 143:116-119, 1977.
45. Linkosalo E, Markkanen S, Alakuijala A, Seppa L. Effects of some commercial health beverages, effervescet vitamin C preparations and berries on human dental enamel. Proc Finn Dent Soc. 84:31-38, 1988.
46. Bibby BG, Mundorff SA. Enamel demineralization by snack foods. J Dent Res 54:461-470, 1975.
47. Shaw L, Smith A. Erosion in children: an increasing clinical problem? Dent Update 21:103-106, 1994.
48. Imfeld T. Prevention of progression of dental erosion by professional and individual prophylactic measures. Eur J Oral Sci 104:215-220, 1996.
49. Smith B, Knight J. An index for measuring the wear of teeth. Brit Dent J 156:435-438, 1984.
50. Aine L, Baer M, Maki M. Dental erosions caused by gastroesophageal reflux disease in children. J Dent Child 60:210-214, 1993.
51. O'Sullivan E, Curzon M, Roberts G, Milla P. Gastroesophageal reflux in children and its relationship to erosion of primary and permanent teeth. Eur J Oral Sci 106:765-769, 1998.
52. Moynihan PJ. Dietary advice in dental practice. Brit Dent J 193(10):563-568, 2002.
53. Featherstone JDB. The science and practice of caries prevention. JADA 131:887-899, 2000.

Introducing a new public health campaign from the MDA

First soda pop. Now sour candy. The danger of these popular acidic drinks and candies is taking a toll on patients' teeth, through devastating erosion of tooth enamel. A prevalent new trend by young people, sucking and chewing on sour candies for long periods of time, is of particular concern.

The MDA's *Sip All Day, Get Decay* campaign led the nation in educating the public about the damaging effects of continued sipping of soda pop. Now with our NEW campaign, ***The Power of Sour on Your Teeth***, we are leading the profession once again, this time urging dentists to educate patients about the serious effects of these seemingly harmless sour candy treats.

If you want to stop this rising trend of dental erosion caused by sour candies, order these educational brochures and posters for your office today. To obtain an order form, call the MDA office at 612-767-8400 or 800-950-3368.