DENTAL EROSION IN PRIMARY DENTITION- A REVIEW

Rafi Shaik[1]

[1]*Senior Lecturer, Department of Public Health Dentistry, CKS Theja Institute of Dental Sciences and Research, Tirupati, Andhra Pradesh.*

ABSTRACT

BACKGROUND

The pattern of oral diseases has been influenced by ever changing human lifestyle. Tooth wear especially dental erosion has drawn increasing attention as risk factor for tooth damage or loss in recent years. It is a common condition in primary dentition compared to permanent dentition due to thinner and less mineralised enamel. However, it is more worrying, when this condition is being found in an alarming proportion among children. The presence of dental erosion in children is likely to be associated with a number of general health and dietary factors, but it is also aggravated by the relatively more rapid progression of erosion in the deciduous teeth. An understanding of the aetiologies and risk factors for erosion is important for early recognition of dental erosion to prevent serious irreversible damage to the dentition. This paper discusses the erosion in children with regard to its epidemiology, prevalence, clinical features, measurement and prevention.

KEYWORDS

Dental Erosion, Epidemiology, Primary Dentition, Prevention.

HOW TO CITE THIS ARTICLE: Shaik R. Dental erosion in primary dentition- A review. J. Evid. Based Med. Healthc. 2017; 4(50), 3070-3076. DOI: 10.18410/jebmh/2017/609

BACKGROUND

The pattern of oral diseases has been influenced by ever changing human lifestyle. Tooth wear, especially tooth erosion has drawn increasing attention as a risk factor for tooth damage or loss in recent years.[1] Dental erosion according to Pindborg (1970)[2] is superficial loss of dental hard tissue by a chemical process that does not involve bacteria. The term 'erosion' derived from the Latin verb erodere (to gnaw, to corrode) describes the process of gradual destruction of the surface of material usually by mechanical, electrolytic or chemical processes.[3]

Dental erosion seems to be a problem for the dental profession in this millennium. It is still doubtful if this is due to a true increase in its prevalence or the dental profession has become more aware of the condition with better diagnostic acumen. However, it is more worrying when this condition is found in an alarming proportion among children.[2] The UK Child Dental Survey in 1993 found that there were over 50% of five-year-old children with erosion in their primary incisors. If this condition is not controlled and stabilised, the child may suffer severe tooth surface loss, tooth sensitivity, over closure and poor aesthetics.[4]

Since the evolution of mankind, drastic changes have occurred in dietary patterns with much emphasis placed on consumption of healthy food and drinks.[5] The changing trend in lifestyle has replaced the commonly consumed fluids like milk and water with carbonated soft drinks and fruit juices.[6] Global sales of soft drinks have increased by 56% and is estimated that it will keep rising at about 2-3% annually per every year.[7] In developed countries, more than half of liquids consumed come from daily intake of soft drinks. According to the survey conducted in United States by Centre for Science in the Public Interest, found an average consumption of soft drinks in 2002 was approximately 16 ounces per day representating about 25% of recommended daily fluid intake of 67 ounces.[8] It was estimated that 1000 million litres of soft drinks was sold in the United Kingdom in 1950 and by 1990 this had increased.[9] Among different age groups, the largest increase in soft drinks consumption has occurred among children and adolescents. Forty per cent of preschool children drink more than 250 mL of soft drinks per day in United States.[8] There are no Indian surveys regarding soft drinks consumption per day in children.

Apart from carbonated drinks, fruit juices are also introduced into child's diet at a younger age. Recent studies have shown that children aged between 2 and 9 years consume 42% of fruit drinks.[10] Consumption of these drinks by children of all ages is popular worldwide as they are sweet. These commonly used beverages cause damage to the teeth due to their low pH and high titrable acidity leading to non-carious tooth loss also known as dental erosion.[8]

Classification of Dental Erosion

There are different classifications for dental erosion based on pathogenicity, severity and based on whether it is idiopathic, extrinsic or intrinsic in origin.

Mannerberg (1960)[11] Classification Based on Pathogenic Activity

1. Manifest Erosion

Actively progressing erosion is clinically diagnosed by its enamel border zones. These are thin where they meet the exposed dentin. In the Scanning Electron Microscope (SEM),

Financial or Other, Competing Interest: None.
Submission 09-06-2017, Peer Review 15-06-2017,
Acceptance 20-06-2017, Published 22-06-2017.
Corresponding Author:
Dr. Rafi Shaik,
No. 16-11-65, Haranatha Puram,
4th Lane, Nellore, Andhra Pradesh.
E-mail: drrafimdsphd@gmail.com
DOI: 10.18410/jebmh/2017/609

they show a honeycomb enamel prism pattern resembling that seen in acid etched enamel.

2. Latent or Inactive Erosions
Which through a change in the aetiologic factor are no longer subject to further decalcification have prominent thick enamel borders and do not show a honeycomb enamel prism structure in shadowed replicas observed in the SEM.

Eccles (1979)[12] Classification Based on Severity
Class I- Superficial lesion involving enamel only.
Class II- Localised lesion lesser than one third of surface involving dentin.
Class III- Generalised lesion greater than one third of surface involving dentin.

Monika Gupta, IK Pandit, Nikhil Srivastava, Neeraj Gugnani (2009)[13] classified dental erosion as following types-

1. **Idiopathic Erosion**
   Idiopathic erosion is the result of contact with acids of unknown origin where neither any tests nor the history taking are capable of providing an aetiologic explanation.

2. **Extrinsic Erosion**
   Extrinsic erosion is the result of exogenous acid that can be air borne contaminants of the work environment or acidic water in swimming pool, a side effect of gas chlorination leading to the formation of hydrochloric acid. Dietary acids, however, undoubtedly the principle causative factor for extrinsic tooth wear.

3. **Intrinsic Erosion**
   Intrinsic erosion is the result of endogenous, acids or gastric acid contacting the teeth during recurrent vomiting, regurgitation or reflux. Eating disorders of psychosomatic origin such as nervous, vomiting and anorexia nervosa are often cause of regurgitation or vomiting, which in these are self-induced.

Epidemiology of Dental Erosion-
Host factors
Genetic factors- Environmental factors have greater role than genetic factors in the formation of erosive lesions. Genetic factors have no significant influence on dental erosion.[14,15]

Saliva
There is a clear relationship between reduced salivary flow and dental erosion. Several medications of diseases reduce the salivary flow rate.[16] Saliva produced at a low flow rate has a lower pH and has a lower buffering capacity leading to erosive tooth wear.[17] In gastroesophageal reflux disease, there may be insufficient time for saliva to act before erosion occurs.[18] The unstimulated flow rate of saliva and salivary buffering capacity has been directly associated with dental erosion.[19]

Dental Anatomy and Occlusion
Deciduous enamel shows a higher degree of enamel porosity and a different mineral content compared with permanent tissue leading to dental erosion in children.[20,21] Enamel and dentine layers of primary teeth are thinner, when compared to permanent teeth and demonstrate a lower degree of remineralisation leading to dental erosion.[22] The shape and contour of teeth and their prominence in the mouth relative to drinking and swallowing patterns have been identified as factors that modify the erosion process.[13]

Physiological Soft Tissue Movements
The anatomy of teeth and soft tissue, movement of the tongue and buccal mucosa and swallowing patterns may influence the clearance rate of erosive agents.[23,24] Severe erosion was found on the palatal surface of teeth touched by the tongue with a lower pH.[17] The anatomy of oral soft tissue in relation to the teeth and physiological soft tissue movements can also influence the tooth sites that frequently come in contact with and thus influence the clearance pattern of acidic substances from the mouth.[13]

Agent Factors
Chemical Factors- Chemical factors have major influence on dental erosion. Vitamin C supplements or hydrochloric acid supplements lead to erosion via direct contact with teeth while chewing.[25,26,27] In asthma and drug-induced xerostomia reduced salivary buffering power makes patients more vulnerable to the erosive action of acids.[28] Erosion of deciduous and permanent enamel appears to emerge over time and with increasing frequency of consumption of soft drinks.[9] The most common source of intrinsic acid in children is the regurgitation of gastric contents into the mouth as occurs in gastroesophageal reflux disease.[29] Children on medications such as antihistamines and beta-2 agonist, antiasthmatic drugs such as salbutamol and terbutaline are potentially at risk for erosive tooth wear.[30] Sucking of acidic candies such as wine gum, yellow chewy fruit candy, red chewy gumball, strawberry stripes and fruit gum peach decreased the pH of whole mouth saliva to approximately 4.5, well below the pH value of 5.5 that has generally been adopted as the critical value below, which hydroxyapatite dissolve.[31]

Environmental Factors
Eating Habits- Bruxism for canines, habit of holding drinks in the mouth and the habit of damaging straws during beverage consumption showed the correlation with the presence of dental erosion.[32,33] Sucking on sour, jumbo and strawberry jawbreakers induced a drop in salivary pH to values below pH 5.5 leading to dental erosion.[34]

Socioeconomic Status
Dental erosion was more prevalent in middle socioeconomic and lower socioeconomic groups.[35,36] Lower educational levels and less awareness of the dangers of acidic drinks in the lower socioeconomic groups could account for their higher predisposition to dental erosion.[37] Change of lifestyles

and maternal education were identified to be causative factor for dental erosion among preschool children.[38,39] Dental erosion was also more prevalent in middle socioeconomic and lower socioeconomic groups. The probable reason was less awareness of dangers of acidic drinks.[35,36]

Excessive Consumption of Acidic Foods and Beverages

The frequency of consumption of acidic drinks was significantly higher in patients with erosion than without.[40,41] Soft, sports and energy drinks are sources implicated in dental erosion.[42] High intake of acidic drinks and fruit drinks may constitute possible aetiological factors for severe dental erosion.[43] Frequency of fruit squash and carbonated drink consumption were associated with erosion extending to dentine or pulp.[36] In both dentitions, dental erosion was associated with the consumption of industrialised beverages, especially soft drinks.[44,45] Beverages such as fresh orange juice, strawberry yogurt drink or cola soft drink separately or in combination with acidogenic challenge cause dental erosion.[46] Erosive tooth wear was significantly associated with soft drink intake twice or 3 or more times a day.[47]

Author	Year	Country	No. of Children	Age of Subjects (Yrs.)	Prevalence of Dental Erosion
Walker et al[48]	2000	United Kingdom	1726	4-18	65% for primary dentition
Ganss et al[49]	2001	Germany	1000	8-14	70.6% for primary dentition
Al-Malik et al[50]	2002	Saudi Arabia	987	2-7	31% for primary dentition
Al-Majed et al[51]	2002	Saudi Arabia	354	5-6	34% for primary dentition
Harding et al[36]	2003	Ireland	202	5	47% for primary dentition in fluoridated area 43% for primary dentition in non-fluoridated area
Deshpande et al[35]	2004	India	100	5-6	28% in 5 years and 30.7% in 6-year-old primary dentition
Luo Y et al[38]	2005	China	1949	3-5	5.7% for primary dentition
Weigand et al[52]	2006	Germany	463	2-7	32% for primary dentition
Dooland et al[14]	2006	Australia	240	Primary and mixed dentition stages	91% for primary dentition
Chadwick et al[53]	2006	United Kingdom	10381	5-15	53% for primary dentition
Kazoullis et al[37]	2007	Australia	714	5.4-11.6	78% for primary dentition
Araujo NC et al[44]	2009	Brazil	970	5-12	Overall was 3.5% 2.5% for primary dentition
Mangueira et al[39]	2009	Brazil	983	6-12	Overall was 19.9% 12.3% for primary dentition
Gambon D.L et al[33]	2009	Netherland	421	4-7	83% for primary dentition
Sue S Taji et al[15]	2010	Australia	128	2-4	77% in monozygous twins for primary dentition 74% in dizygous twins for primary dentition 75% in singleton controls for primary dentition
Murakami C et al[47]	2011	Brazil	967	3-4	51.6% for primary dentition

Table 1. Epidemiological Studies on Prevalence of Dental Erosion in Deciduous Dentition

Clinical Features of Erosive Lesion

Early stages of an erosive lesion results in matting appearance of enamel surface, most frequently on the labial and buccal surfaces. Initially, erosion may appear as a glazed enamel surface with loss of surface features such as perikymata. Early lesions are usually coronal and the enamel at the gingival margin remains intact.[54] Clinically, the loss of tooth substance is manifested by a shallow, broad, smooth and highly polished wedge-shaped depression on enamel surface adjacent to the cementoenamel junction.[13] On the incisal edges of the incisor teeth, thin enamel margins and peripheries are prone to chipping. Dentin is deeply scooped out and lesions are not as well defined.[55] In primary first and second incisors and canines, erosive lesions are often located incisally or affected multiple surfaces.[51] Primary posterior teeth show flattened convex surfaces or concavities, which develop in cusp tips becoming hollowed out ('cuspal cupping'). More extensive erosion of occlusal surfaces appears as flattened cuspal inclines or shallow saucer-shaped facets.[56] Wear on the palatal and labial surfaces of maxillary teeth considered to be predominantly erosive.[36] The occlusal surfaces of the molars and incisal surfaces of the incisors are the tooth surfaces showing highest degree of erosive tooth wear.[52]

Due to structural differences, primary teeth are more susceptible to the complications of erosion compared to permanent teeth. Dentine involvement as a consequence of erosion may occur more rapidly in the primary as opposed to permanent dentition due to the thinner enamel layer[43] and morphological differences.[9] Also, in immature teeth with large pulps, erosion is more likely to lead to pulpal inflammation and exposures.[57] Johansson et al reported microhardness of enamel in primary teeth to be less than in permanent teeth.[43] This is due to less mineralisation and

specifically the enamel surface not being as mature as that of the permanent teeth with a lower degree of crystallite arrangement.[43] Furthermore, primary enamel contains more water[58] and has increased permeability compared to permanent enamel.[59] This may further explain the relatively more rapid progression of erosion in the primary teeth.[43] The slower salivary sugar clearances and the lower salivary flow rates in children may contribute to increased susceptibility for erosion in children.[43] The buffering capacity of saliva is dependent on flow rates and is responsible for neutralising and clearing acids that cause dental erosion.[60,54]

Figure 1. Clinical Photograph Showing Marked Dental Erosion on the Incisal and Palatal Surfaces of the Maxillary Central and Lateral Primary Incisors. Loss of Anatomical Contour and Rounding of Enamel Edges is Evident. Thinning of Enamel has resulted in a Pink Hue being Evident Representing Pulpal Tissues Close to the Palatal Aspect

Figure 2. Clinical Photograph Showing Marked Dental Erosion on the Incisal and Palatal Surfaces of the Maxillary Central and Lateral Permanent Incisors

Measurement of Dental Erosion

Universally accepted index for the measurement of dental erosion does not exist. There are different indices given by authors.

- Eccles Index for Dental Erosion of Nonindustrial Origin (1979).
- Frida A Xhonga and Silvia Valdmanis Erosion Index (1983).[61]
- Lussi A Erosion Index (1996).[62]
- O'Sullivan Index for the Measurement of Dental Erosion (2000).[63]
- Bartlett, Ganss, Lussi A- Basic Erosive Wear Examination (BEWE) (2008).[64]

O'Sullivan (2000)[63] proposed a new index for the measurement of erosion specifically in children. The index was qualitative with a broad attempt at quantification noting whether less or more than half of the surface was affected. Every tooth was examined and assigned a three-digit score relating to the site of erosion, severity (grade 0-5) and area of surface affected.

O'Sullivan (2000)[64] Index for the Measurement of Dental Erosion.

Code A- Labial or buccal only
Code B- Lingual or palatal only
Code C- Occlusal or incisal only
Code D- Labial and incisal/occlusal
Code E- Lingual and incisal/occlusal
Code F- Multi-surface
Table 2A. Site of Erosion on Each Tooth

Code 0- Normal enamel
Code 1- Matt appearance of the enamel surface with no loss of contour
Code 2- Loss of enamel only (loss of surface contour)
Code 3- Loss of enamel with exposure of dentine (EDJ visible)
Code 4- Loss of enamel and dentine beyond EDJ
Code 5- Loss of enamel and dentine with exposure of the pulp
Code 9- Unable to assess (e.g. tooth crowned or large restoration)
Table 2B. Grade of Severity (Worst Score for an Individual Tooth Recorded)

Code -: Less than half of surface affected
Code +: More than half of surface affected
Table 2C. Area of Surface Affected by Erosion

Prevention and Management of Dental Erosion

For appropriate preventive methods for erosion to be investigated, a confident diagnosis must be reached. The relative contribution of intrinsic and/or extrinsic sources of acid need to be identified as causative factors. Biological factors such as saliva, acquired pellicle and the tooth structure as well as behavioural factors such as eating and drinking habits, level of hydration during exercise and oral hygiene should be assessed.[1] In order to establish the risk factors involved, a comprehensive six-day diet diary should be completed by the parent or guardian and reviewed by the clinician.[65] The medical history should consider any medication that maybe acidic or maybe reducing the salivary protection of the dentition. Patients should be questioned regarding history of reflux, frequency of vomiting and any gastroesophageal reflux disease history should be further evaluated. Where intrinsic acids have been identified, it is prudent to ensure that the patient has been further evaluated by health professionals for the condition. Otherwise, referral is appropriate for further assessment and management.[66] The detailed primary, secondary and tertiary prevention for dental erosion and recommendation for patients at high risk for dental erosion has been mentioned in Table 3 and Table 4.

Primary Prevention
• Identification of aetiology.
• Use of fluoride varnish.
• Use of tooth mousse.
• Recommendations such as confining the intake of acidic foodstuffs and beverages to mealtimes and never drinking a fruit drink prior to bedtime should be given with caution.
• Acidic drinks should be drunk quickly rather than sipped.
• The use of straw to reduce the erosive potential of soft drinks.
• Laser irradiation.
Secondary and Tertiary Prevention
• The emphasis should be on early diagnosis and adequate preventive strategies.
• Restorative measures should be taken only when tooth loss caused by erosive wear reaches a certain threshold.
• The currently used glass ionomer cements and composite resins bind both to dentin and enamel and enable aesthetically acceptable restorations at all sites of the dentition.
• Adhesive restorations and cast alloy restoration for palatal and occlusal erosion.
• For labial surfaces, porcelain veneers are preferred for their strength, durability and long lasting aesthetics.
• Sandblasted nickel-chromium alloys or heat treated gold should be used where aesthetics is not important.
• Single sitting composite veneering can also be done, but it lacks the durability and aesthetics of porcelain preparations.
• In case of extensive enamel loss (>50%) or complete loss of enamel on the incisal edges porcelain fused to metal restorations offer a great range of aesthetic restorative correction and strength.
• Placement of stainless-steel crowns on deciduous molars is frequently the only satisfactory way of providing relief of symptoms, cessation of continued wear and assurance that a tooth may remain in situ until exfoliation.

Table 3. Primary, Secondary and Tertiary Prevention

1. Control of the Acid Action
• Reduce acid exposure by reducing the frequency and contact time of acids (main meals only).
• Do not hold or swish acidic drinks in your mouth. • Avoid sipping these drinks. • Drink cold drinks that are less erosive.
• Consider intake of modified food and beverages with no or reduced erosive potential.
• After an erosive challenge (vomiting, acidic diet) use a (tinand) fluoride-containing mouth rinse, a sodium bicarbonate (baking soda) solution, milk, cheese or sugar-free yogurt.
• If none of these is possible, rinse with water.
• After acid intake, stimulate saliva flow with chewing gum or lozenges.
2. Control of Dental Hygiene
• Avoid tooth brushing immediately after an erosive challenge, instead brush before.
• Use a soft toothbrush and low abrasion fluoride-containing toothpaste.
• Periodically, gently apply (tin-containing) fluoride mouth rinse. • Use concentrated topical fluoride (slightly acidic formulations are preferable as they form CaF2 at a higher rate).
3. Control of Endogenous Acid Exposure
• Suspicion of reflux- Referral to gastroenterologist.
• Anorexia-bulimia patients- Arrange for psychological or psychiatric care.
• Avoid reflux inducing foods, e.g. citrus products, vinegar, high fat foods (fried foods, high fat dairy products, high fat meats and so forth), tomato, peppermint, coffee, carbonated beverages and chocolate.
• Eat several small meals each day instead of 3 large ones. • Avoid a big meal before bedtime.
• Use chewing gum to reduce postprandial reflux after eating.
• Use acid block- Proton pump inhibitors.

Table 4. Recommendations for Patients at High Risk for Dental Erosion

CONCLUSION

Dental erosion or chemical wearing away of the tooth structure is a dental health problem of the modern world, and if not detected early, may result in serious irreversible damage to the dentition. Many factors can lead to dental erosion in children. The high prevalence of dental erosion reported in children calls for further research into its prevention such as the use of protective additives to alleviate the erosive effects of acidic foods and beverages. Knowledge of the risk factors and protecting factors is a prerequisite for prevention of dental erosion. Therefore, the parents and children should receive comprehensive information about the risks of the intake of acid food and drinks as well as recommendations about tooth friendly eating and drinking habits. Change of dietary habits maybe difficult, but still remains the best way of prevention of dental erosion.

REFERENCES

[1] Lussi A, Jaeggi T. Erosion--diagnosis and risk factors. Clin Oral Investig 2008;12 Suppl 1:S5-S13.
[2] Pindborg JJ. Pathology of dental hard tissues. Copenhagen: Munksgaard 1970.

[3] Ten Cate JM, Imfeld T. Dental erosion, Summary. Eur J Oral Sci 1996;104(2):241-244.
[4] O'Brein M. Children's dental health in the United Kingdom 1993. OPCS, London: HMSO 1994.
[5] Banan LK, Hegde AM. Plaque and salivary changes after consumption of fresh fruit juices. J Clin Paediatr Dent 2005;30(1):9-13.
[6] Hunter ML, Patel R, Loyn T, et al. The effect of dilution on the in vitro erosive potential of a range of dilutable fruit drinks. Int J Paediatr Dent 2008;18(4):251-255.
[7] Tahmassebi JF, Duggal MS, Malik-Kotru G, et al. Soft drinks and dental health: a review of the current literature. J Dent 2006;34(1):2-11.
[8] Kitchens M, Owens BM. Effect of carbonated beverages, coffee, sports and high energy drinks and bottled water on the in vitro erosion characteristics of dental enamel. J Clin Pediatr Dent 2007;31(3):153-159.
[9] Hunter ML, West NX, Hughes JA, et al. Erosion of deciduous and permanent dental hard tissue in the oral environment. J Dent 2000;28(4):257-263.
[10] Hunter L, Patel S, Rees J. The in vitro erosive potential of a range of baby drinks. Int J Paediatr Dent 2009;19(5):325-329.
[11] Mannerberg F. Appearance of tooth surfaces as observed in shadowed replicas, in various age groups: in long-term studies, after tooth-brushing, in cases of erosion and after exposure to citrus fruit juice. Odout Revv 1960;11 Suppl 6:1-116.
[12] Eccles JD. Dental erosion of nonindustrial origin. A clinical survey and classification. J Prosthe Dent 1979;42(6):649-653.
[13] Gupta M, Pandit IK, Srivastava N, et al. Dental erosion in children. J Oral Health Comm Dent 2009;3(3):56-61.
[14] Dooland KV, Townsend GC, Kaidonis JA. Prevalence and side preference for tooth grinding in twins. Aust Dent J 2006;51(3):219-224.
[15] Taji SS, Seow WK, Townsend GC. A controlled study of dental erosion in 2 to 4 year old twins. Int J Paediatr Dent 2010;20(6):400-409.
[16] McCay CM, Will L. Erosion of molar teeth by acid beverages. J Nutrition 1949;39(3):313-324.
[17] Jarvinen VK, Rytömaa II, Heinonen OP. Risk factors for dental erosion. J Dent Res 1991;70(6):942-947.
[18] Hara AT, Lussi A, Zero DT. Biological factors. In: Lussi A, ed. Dental erosion: from diagnosis to therapy. Monographs in oral science. Basel (Switzerland): Karger 2006:88-99.
[19] Dawes C. Salivary flow patterns and the health of hard and soft oral tissues. Journal of American Dental Association 2008;139 Suppl 2:18-24.
[20] Cutress TW. The inorganic composition and solubility of dental enamel from several specified population groups. Arch Oral Biol 1972;17(1):93-109.
[21] Fejerskov O, Stephen KW, Richards A. Combined effect of systemic and topical fluoride treatments on human deciduous teeth--case studies. Caries Res 1987;21(5):452-459.
[22] Wilson PR, Beynon AD. Mineralization differences between human deciduous and permanent enamel measured by quantitative microradiography. Arch Oral Biol 1989;34(2):85-88.
[23] Holst JJ, Lange F. Perimylolysis: a contribution towards the genesis of tooth wasting from non-mechanical causes. Acta Odontol Scand 1939;1(1):36-48.
[24] Stephan RM. Effects of different types of human foods on dental health in experimental animals. J Dent Res 1966;45(5):1551-1561.
[25] Giunta JL. Dental erosion resulting from chewable vitamin C tablets. J Am Dent Assoc 1983;107(2):253-256.
[26] Hays GL, Bullock Q, Lazzari EP, et al. Salivary pH while dissolving vitamin C-containing tablets. Am J Dent 1992;5(5):269-271.
[27] Maron FS. Enamel erosion resulting from hydrochloric acid tablets. JADA 1996;127(6):781-784.
[28] Kargul B, Tanboga I, Ergeneli S, et al. Inhaler medicament effects on saliva and plaque pH in asthmatic children. J Clini Pediatr Dent 1998;22(2):137-410.
[29] Linnett V, Seow WK. Dental erosion in children: a literature review. Pediatr Dent 2001;23(1):37-43.
[30] Dugmore CR, Rock WP. Asthma and tooth erosion. Int J Paediatr Dent 2003;13(6):417-424.
[31] Jensdottir T, Nauntofte B, Buchwald C, et al. Effects of sucking acidic candy on the whole-mouth saliva composition. Caries Res 2005;39(6):468-474.
[32] Rios D, Magalhaes A, Honorio H, et al. The prevalence of deciduous tooth wear in six-year-old children and its relationship with potential explanatory factors. Oral Health Prev Dent 2007;5(3):167-171.
[33] Gambon DL, Brand HS, Nieuw Amerongen AV. The erosive potential of candy sprays. Br Dent J 2009;206(10):E20.
[34] Brand HS, Gambon DL, Van Dop LF, et al. The erosive potential of jawbreakers, a type of hard candy. Int J Dental Hygiene 2010;8(4):308-312.
[35] Deshpande SD, Hugar SM. Dental erosion in children: an increasing clinical problem. J Indian Soc Pedod Prev Dent 2004;22(3):118-127.
[36] Harding MA, Whelton H, O'Mullane DM, et al. Dental erosion in 5 year-old Irish school children and associated factors. Community Dental Health 2003;20(3):165-170.
[37] Kazoullis S, Seow WK, Holcombe T, et al. Common dental conditions associated with dental erosion in schoolchildren in Australia. Pediatr Dent 2007;29(1):33-39.
[38] Luo Y, Zeng XJ, Du MQ, et al. The prevalence of dental erosion in preschool children in china. J Dent 2005;33:115-121.
[39] Mangueira DF, Sampaio FC, Oliveira AF. Association between socioeconomic factors and dental erosion in

Brazilian schoolchildren. J Public Health Dent 2009;69(4):254-259.
[40] Asher F, Read MJ. Early enamel erosion in children associated with excessive consumption of citric acid. Br Dent J 1987;162(10):384-387.
[41] Millward A, Shaw L, Smith AJ. The distribution and severity of tooth wear and the relationship between erosion and dietary constituents in a group of children. Int J Paediatr Dent 1994;4(3):151-157.
[42] Milosevic A. Sports drinks hazard to teeth. Br J Sports Medicine 1997;31(1):28-30.
[43] Johansson AK, Sorvari R, Birkhed D, et al. Dental erosion in deciduous teeth--an in vivo and in vitro study. J Dent 2001;29(5):333-340.
[44] Araujo NC, Andreza CLT, Massoni CR, et al. Dental erosion and consumption of industrialized beverages in a group of children in Recife/Pernambuco, Brazil. Rev. Odonto 2009;24(2):120-123.
[45] Tarsitsa Gatou. Eleni Mamai-Homata. Tooth wear in the deciduous dentition of 5-7 year old children: risk factors. Clin Oral Investig 2012;16(3):923-933.
[46] Tedesco TK, Gomes NG, Soares FZM, et al. Erosive effects of beverages in the presence or absence of caries stimulation by acidogenic challenge on human primary enamel: an in vitro study. Eur Arch Paediatr Dent 2012;13(1):36-40.
[47] Murakami C, Oliveira LB, Sheiham A, et al. Risk indicators for erosive tooth wear in Brazilian preschool children. Caries Res 2011;45(2):121-129.
[48] Walker A, Gregory JR, Bradnock G, et al. National diet and nutritional survey: young people aged 4 to 18 years. London: HMSO 2000.
[49] Ganss C, Klimek J. Dental erosion in children and adolescents--a cross-sectional and longitudinal investigation using study models. Community Dent Oral Epidemiol 2001;29(4):261-274.
[50] Al-Malik MI, Holt RD, Bedi R. Erosive caries and rampant caries in preschool children in Jeddah, Saudi Arabia; Community Dent oral Epidemiol 2002;30(1):16-23.
[51] Al-majid, Maguire A, Murray JJ. Risk factor for dental erosion in 5-6 years old and 12-14 year old boys in Saudi Arabia. Community dental oral health 2002;30(1):38-46.
[52] Wiegand A, Muller J, Werner C, et al. Prevalence of erosive tooth wear and associated risk factor in 2-7-year-old German kindergarten children. Oral Dis 2006;12(2):117-124.
[53] Chadwick BL, White DA, Morris AJ, et al. Non-carious tooth conditions in children in the UK, 2003. Br Dent J 2006;200(7):379-384.
[54] Young WG, Khan F. Sites of dental erosion are saliva-dependent. J Oral Rehab 2002;29(1):35-43.
[55] Khan F, Young WG, Law V. Cupped lesions of early onset dental erosion in young southeast Queensland adults. Aust Dent J 2001;46(2):100-107.
[56] Khan F, Young WG, Daley TJ. Dental erosion and bruxism. A tooth wear analysis from South East Queensland. Aust Dent J 1998;43(2):117-127.
[57] Harley K. Tooth wear in the child and the youth. Br Dent J 1999;186(10):492-496.
[58] Bonte E, Deschamps N, Goldberg M, et al. Quantification of free water in human dental enamel. J Dent Res 1988;67(5):880-882.
[59] Linden LA, Bjorkman S, Hattab F. The diffusion in vitro of fluoride and chlorhexidine in the enamel of human deciduous and permanent teeth. Arch Oral Biol 1986;31(1):33-37.
[60] Crossner CG, Hase JC, Birkhed D. Oral sugar clearance in children compared with adults. Caries Res 1991;25(3):201-206.
[61] Xhonga FA, Valdmanis S. Geographic comparisons of the incidence of dental erosion: a two centre study. J Oral Rehabil 1983;10(3):269-277.
[62] Lussi A. Dental erosion clinical diagnosis and case history taking. Eur J Oral Sci 1996;104(2):191-198.
[63] O'Sullivan EA. A new index for the measurement of erosion in children. Eur J Paediatr Dent 2000;1(2):69-74.
[64] Bartlett D, Ganss C, Lussi A. Basic Erosive Wear Examination (BEWE): a new scoring system for scientific and clinical needs. Clin Oral Investig 2008;12(Suppl 1):S65-S68.
[65] Young WG. Tooth wear: diet analysis and advice. Int Dent J 2005;55(2):68-72.
[66] Aine L, Baer M, Maki M. Dental erosion caused by gastroesophageal reflux disease in children. ASDC J Dent Child 1993;60(3):210-214.