Influence of Diet and Salivary Characteristics on the Prevalence of Dental Erosion among 12-year-old Schoolchildren

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ABSTRACT

Purpose: The aims of this study were to assess the prevalence of dental erosion among 12-year-old schoolchildren in Piracicaba, São Paulo, Brazil; and determine if gender, dietary habit, and salivary characteristics (salivary flow rate, buffer capacity, and pH) influence the erosion.

Methods: A cross-sectional study was carried out involving 389 children. Data on dietary habits, oral hygiene practices, and medical backgrounds were obtained by a survey. The erosion index proposed by O'Sullivan was used. Whole-fresh-saliva was collected and data was submitted to statistical analysis.

Results: The prevalence of dental erosion was 26 percent. There was no significant difference in prevalence between boys and girls (P=.19). Labial surfaces were the most affected (58 percent) and enamel loss was the most prevalent type of dental erosion (65 percent). Overall, no significant difference was found among salivary characteristics and prevalence of erosion (salivary flow rate: P=.98; buffer capacity: P=.75; pH: P=.80). Most children presented good salivary characteristics. Results indicate that the main risk factors for erosion were usage of acidic drugs, consumption of soft drinks, and temperature of acid fruits.

Conclusions: The prevalence of erosion in 12-year-old schoolchildren living in Piracicaba, SP, Brazil could be considered high. Extrinsic factors were related to erosion, while salivary characteristics seemed to have no influence on erosion.

(J Dent Child 2009;76:181-7)

Received August 20, 2008; Last Revision October 31, 2008; Revision Accepted November 3, 2008.

KEYWORDS: DENTAL EROSION, CHILDREN, SALIVA, DIET, EPIDEMIOLOGY

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Dental structure and restorations are continuously submitted to thermal, mechanical, and chemical challenges in the oral cavity. The association of these challenges is related to the longevity/stability of the restorative procedures and the preservation of the dental structure.[1]

The chemical degradation can be caused by acid challenges, including those produced by the cariogenic biofilm,[2] acidic diet (soft drinks and acidic beverages),[3,4] and salivary enzymes.[5]

Today's busy lifestyles often compel people to adopt a fast and sometimes less healthy diet, including the consumption of soft drinks, ready-made fruit juices, and fast food.[6] Consumption of soft drinks has increased dramatically in several countries, especially among children.[6-8] Brazil is the third largest consumer country of soft drinks in the world, with a rate of 16 to 18 gallons per person per year.[9]

The effects of an acidic diet on restorative materials and dental structure are surface softening[2,3,10] and roughening,[3,11,12] which can decrease the restorations' long-term durability and can be related to dental erosion.[13-15] Erosion can be strongly correlated with frequency and amount of soft drink intake.[13-16]

Erosion is defined as loss of tooth structure by chemical dissolution without bacterial involvement. The etiology of erosion can be extrinsic or intrinsic. Extrinsic etiology can be related to the environment, diet, use of medication, and lifestyle. The prevalence of dental erosion has increased, ranging from 20 percent to 57 percent, depending on the population of subjects studied for evidence of dental erosion.[13,15,17] Therefore, there is a high possibility for dental clinicians to find erosion cases in their practices.

The erosive effect of dietary acids can be influenced by several factors, such as pH, pKa, titratable acidity, temperature, concentration, buffering capacity, and chelating potential. These factors are related to the acid solution's characteristics. Frequency and method of soft drink consumption, time of contact between the liquid and tooth surface, and intrinsic dental structure properties are other factors that can influence dental erosion.[6,17-19]

Some salivary characteristics can offer protection against the acid attack.[18,20-22] Studies show that salivary pellicle can protect teeth against erosive challenge.[20,23,24] Salivary flow rate is related to the saliva's capacity to remove acids from the oral cavity (ie, the clearance). The higher the flow rate, the higher the clearance and the lower the erosive potential.[17] In addition, the higher the salivary flow rate, the higher the buffer capacity to neutralize the acidic substance and protect the dental structure against erosion.

Many studies of erosion's prevalence have been conducted in different countries around the world, but few have been done in Brazil.

The aims of this study were to verify the prevalence and severity of dental erosion among 12-year-old children attending public schools in Piracicaba, São Paulo, Brazil and verify the association of dental erosion with diet, gender, and salivary characteristics (salivary flow rate, buffer capacity, and pH).

METHODS

A cross-sectional study was carried out in 2007 in Piracicaba. All randomly selected 12-year-old schoolchildren attended 20 different public schools. Three hundred eighty-nine children were examined in this cross-sectional survey. Children with fractured teeth, hypoplasia, or extensive restorations or who were wearing orthodontic appliances were excluded.

An informed, written consent was required from each parent or legal guardian and a letter was sent stating the study's objectives and importance and asking for their participation. Local authorities such as health and education councils were also contacted and provided necessary information and authorization. This study was only carried out after being approved by the Institutional Review Board of University of Campinas, Piracicaba Dental School, Piracicaba.

Two calibrated examiners conducted clinical examinations. A range of different levels of dental erosion was used in the calibration exercise, which was based on the diagnosis of photographic images. Reliability was assessed through the kappa test.

At first, each child individually answered a questionnaire regarding dietary and hygiene habits, as well as medical background. All children were examined at their schools under standard artificial illumination using plane mouth mirrors and sterilized gauze to remove gross debris.

The dental erosion index proposed by O'Sullivan[25] was adopted and adjusted for use in the 4 permanent maxillary incisors and permanent maxillary and mandibular first molars. Using this method, the location of the erosion was examined and, according to the severity and the affected area of the teeth, a score was attributed.

To analyze the salivary characteristics, the stimulated whole fresh saliva was collected from each child between 8 a.m. and 11 a.m. Children were asked to chew a sugarless gum, and the saliva produced during a 5-minute period was collected. The saliva produced within the first 30 seconds was discarded. The salivary flow rate was calculated by dividing the volume of collected saliva by the time (5 minutes). According to the literature, a normal salivary flow rate is approximately 1.0 to 3.0 ml/minute, while a low salivary flow rate is approximately 0.7 to 1.0 ml/minute.[26]

To calculate the salivary buffer capacity, 0.5 ml of the saliva was mixed with 1.5 ml of a 5-mM HCl solution in a plastic tube. The solution was agitated, the tube was left open for 5 minutes, and pH was then assessed. Buffering capacity was classified as low for a pH lower than 4.5, intermediate for 4.6 to 5.5, and high for greater than 5.5.[27] The saliva pH was measured using a portable pH meter (Orion 710A, Analytical Instruments, MN, USA), previously calibrated with standard pH 7.0 and 4.0 solutions.

STATISTICAL ANALYSIS

The questionnaire answers were codified, and data were submitted to statistical analysis, including (extension, and severity of erosion). Differences in the prevalence of

dental erosion according to gender, dietary habits, and salivary characteristics were tested using Pearson's chi-square and Fisher's tests, with a significant level of 5 percent. Logistic regression was also calculated to obtain the odds ratio (OR) and confidence intervals.

RESULTS

From the 389 children, 192 (49 percent) were boys and 197 (51 percent) were girls. The prevalence of erosion was 26 percent, and there was no significant difference between genders (*P*=.19; Table 1).

Of the total surfaces affected (N=295), 58 percent were on labial surfaces, 25 percent on labial and incisal/occlusal surfaces, 11 percent on incisal/occlusal surfaces, and 3 percent on palatal surfaces (Table 2). The erosion was greater in anterior teeth (93 percent) than posterior (7 percent). Regarding the severity of dental erosion, enamel loss without the loss of tooth characteristics was observed in most cases (65 percent) followed by the enamel loss with loss of tooth contour (33 percent; Table 3). In 57 percent of the affected teeth, more than half of the tooth's surface was affected (Table 4).

Regarding salivary flow rate, buffer capacity, and pH, most children demonstrated good salivary aspects. Of the 389 children, 16 (4 percent) had a high salivary flow rate (>3.0 ml/minute), 263 (68 percent) had a normal salivary flow rate (1.0-3.0 ml/minute), and 110 (28 percent) had a low salivary flow rate (0.7-0.9 ml/minute). The results for buffer capacity were as follows: 246 children (63 percent) presented with a good buffer capacity (pH >5.0); 80 children (21 percent) presented with an intermediate buffer capacity (pH=4.5-5.5); and 63 (16 percent) presented with a low buffer capacity (pH <4.5). The pH results showed 375 children (96 percent) a normal or basic pH (>7.0). There was no significant association between any salivary characteristic and dental erosion (salivary flow rate: *P*=.98; buffer capacity: *P*=.75; pH: *P*=.80).

There was no significant association between dental erosion and ingestion of acidic beverages (*P*=.42), frequency (*P*=.13), or mode of ingestion (*P*=.20). Evaluating the odds ratio (OR) values, however, it could be observed that children who consume soft drinks had twice the chance of developing dental erosion (OR=2.09 [0.24-17.65]). The chances of developing dental erosion were also high among children who had a high frequency of soft drink intake (OR=1.35 [0.83-2.19]) and among those drinking beverages at room temperature (OR=1.98 [0.74-5.29]), ready-made fruit juices (OR=1.12 [0.69-1.80]), and sport drinks (OR=1.54 [0.83-2.86]).

There was no significant association between dental erosion and frequency of ingestion of acidic fruits and candies (*P*=.70). There was a significant association, however, between dental erosion and temperature of ingestion of the fruits (*P*=.030); the higher the fruit's temperature, the higher the erosion prevalence.

There was no significant association between dental erosion and some habits (hygiene and parafunctional) or

Table 1. Prevalence of Dental Erosion Among 12-year-old Schoolchildren in Piracicaba in 2007 (Chi-square Test)

Gender	Dental erosion			
	Yes	No	Total	*P*-value
	N (percent)	N (percent)	N (percent)	
Female	45 (12)	152 (39)	197 (51)	
Male	55 (14)	137 (35)	192 (49)	
Total	100 (26)	289 (74)	389 (100)	.1904

Table 2. Number (percent) of Tooth Surface Affected by Dental Erosion in 12-year-old Schoolchildren in Piracicaba in 2007

Affected surfaces	No.	Percent
Labial only	171	58
Palatal/lingual only	10	3
Incisal/occlusal only	32	11
Labial and incisal/occlusal	74	25
Palatal/lingual and incisal/occlusal	02	1
Multisurface	06	2
Total	295	100

Table 3. Severity of Dental Erosion in 12-year-old Schoolchildren in Piracicaba in 2007

Severity of dental erosion	No.	Percent
Enamel loss with no loss of tooth contour	192	65
Enamel loss only (loss of tooth contour)	97	33
Loss of enamel with exposure of dentin	6	2
Total	295	100

Table 4. Area of the Surface Affected by Dental Erosion in 12-year-old Schoolchildren in Piracicaba in 2007

Area affected	No.	Percent
< half of the surface affected	128	43
> half of the surface affected	167	57
Total	295	100

between dental erosion and general health of the children (P=.11), except for the significant association observed between dental erosion and ingestion of acidic drugs (ie, aspirin; P=.020).

DISCUSSION

In this study, 389 12-year-old schoolchildren were examined. According to previous statistical calculations, the estimated population can be considered representative of the number of children at this age enrolled in Piracicaba public schools. To assess the prevalence of dental erosion and compare with other epidemiological studies, the index proposed by O'Sullivan[25] was used. The same index was used by Peres et al,[15] however, these authors evaluated only the 4 permanent maxillary incisors. In this study the permanent first molars were also evaluated. The assessment of these teeth in 12-year-old children is appropriate because, at this age, these teeth have been exposed in the mouth for a considerable period of time compared to other permanent teeth.

The lesions caused by erosion are difficult to diagnose and, in most cases, are not noticed by clinicians during the clinical inspection.[28] This can be explained by the lack of knowledge about this disease and the difficulty of linking its clinical aspects and possible etiological factors. Moreover, other forms of tooth wear, abrasion, and/or attrition wear may be occurring at the same time, making the diagnosis of erosion imprecise. Therefore, it was essential for this study to distinguish between different types of tooth wear, considering the possibility that they were acting simultaneously.[13,29]

By using a questionnaire, it was possible to identify and distinguish the presence of wear associated with the presence of parafunctional habits (bruxism), oral hygiene habits (frequency of tooth-brushing and excessive force during brushing), gastric problems (gastroesophageal reflux disease [GERD]), etc. When more than 1 type of wear was identified, the predominant etiological factor was assessed and the other factors were considered aggravating. In this study, all conflicting cases were excluded.

The erosion prevalence in this study was 26 percent (95 percent confidence interval). This agrees with Al-Majed et al.'s findings,[30] but was higher or lower than the results of other studies.[14,15,31] This difference may be explained by several factors, such as differences in the criteria and classifications adopted for assessment of dental erosion, length of exposure to risk factors, and size, age, gender, and geographic location of the studied population.[32,33] The standardization of these indices and the teeth examined facilitate such comparisons.

In this study, there was no significant difference between dental erosion and gender (Table 1). This agrees with the data reported by other studies.[13,15,34]

The clinical features commonly observed in this population were smooth and shiny enamel surfaces, with loss of apparent shininess when the surface was dry. In some cases, loss of enamel contour and increase of incisal translucence was observed. Most cases showed erosion only on enamel (Table 3) involving more than half of the affected area (57 percent; Table 4), corroborating with other studies.[6,13,15,31,35] These findings could be related to the intensity and exposure of the dental structure to the etiologic risk factors.[13]

The predominance of erosion on the labial surface found in this study (Table 2) agrees with the data reported by Peres et al,[15] Williams et al,[36] Al-Majed et al,[30] Al-Dlaigan et al,[34] and Dugmore and Rock.[37] The labial surface is generally in the path of liquids during the intake. According to Bashir et al,[38] the maxillary incisors' labial surfaces accumulates more acid and has a minor salivary clearance. Moreover, these authors reported that this region is far from the major salivary glands and the action of the tongue. Another explanation could be related to the mode of consumption of the liquids, swallowing, sucking, or seeping slowly or rapidly.[39] In this study, there was no association between dental erosion and the mode of drink consumption.

This study also intended to evaluate the possible associations between dental erosion and dietary habits, especially ingestion of acidic beverages. Although some studies[7,13,17,29] demonstrated significant association between frequency of ingestion of soft drinks or fruit juices and dental erosion, in this study no significant association could be observed.

A high frequency of soft drink consumption was observed—63 percent of the children consumed soft drinks more than 3 times a week, especially cola-based carbonated beverages (57 percent). Fushida and Cury[16] demonstrated that a daily consumption of cola provokes significant loss of enamel and dentin structure proportionally to the frequency of ingestion. In this study, children who drank soft drinks had twice the chance of developing dental erosion (OR=2.09 [0.24-17.65]) compared to those who do not drink any soft drink.

There was no significant difference between consumption of diet/light or normal soft drinks and dental erosion prevalence. Other authors[40] verified that normal soft drinks provoke higher erosion than diet soft drinks due to the thermodynamic adhesion difference between them (ie, diet drinks are easily removed from the enamel surface by saliva).

Regarding the ingestion of fruit juices (natural or artificial), there was no significant association with dental erosion. The chance of developing erosion in children who drink artificial acidic fruit juices, however, was 1.12 times higher than for those who do not drink fruit juices (OR=1.12 [0.69-1.80]).

Studies demonstrated that the velocity of enamel dissolution depends on the beverage's temperature during ingestion,[18,41] since beverages at room temperature can produce more erosion compared to colder drinks. The present study's results, however, do not show significant

difference between dental erosion and beverage temperature. There was a significant association only between dental erosion and the temperature of the acidic fruits (P=.030). The higher the room temperature, the higher the dental erosion. One possible explanation for this is that children probably take longer to eat a fruit than to drink a beverage, increasing the time of contact between the acidic fruit and the dental structure.

The protein derivate from milk (casein) can help minimize the enamel loss during erosive challenges, making the dental structure less soluble to acid attack.[18,41] In the present study, children showed a high frequency of consumption of this type of drink (79 percent of children drink milk at least 2 times a day). Consumption, frequency, and temperature of milk, however, had no influence on dental erosion prevalence. Evaluating the OR values for frequency of milk ingestion (OR=0.67 [0.38-1.19]) and temperature (OR=0.83 [0.50-1.37]), a possible protective effect of milk against erosion was observed: the higher the frequency of ingestion and the lower the temperature, the lower the chance of developing dental erosion.

The stress of modern life has increased the number of patients with gastritis and GERD. These diseases turn the salivary pH acidic or induce the contact of gastric acids with dental surfaces, resulting in dental erosion.[7,42] In this study, contrary to the findings of other studies,[6,7,42] no significant association between dental erosion and gastric problems was observed. Only 3 children reported gastric problem (reflux disease), but with no clinical signs of the disease. A significant association was observed, however, between dental erosion prevalence and ingestion of acidic medicaments (acid acetylsalicylate aspirin and vitamin C tablets). In this study, children reported ingesting these drugs in the form of effervescent tablets, which could increase their erosive effects.

Amaechi and Higham[17] and Shaw and Smith[7] found higher erosive wear on patients who maintained high oral hygiene patterns, including a high frequency of tooth-brushing and mouth-rinsing. Regarding the habits (oral hygiene and parafunctional habits), this study found no association with dental erosion.

The lack of association between dental erosion prevalence and etiological factors could be related to the size of the examined population, relatively short period of exposure time to the acidic diet, and possible protective effects of the saliva or basic drinks. Caglar et al[43] and Deery et al,[13] did not find any association between dental erosion and possible etiological factors (beverages, fruits, regurgitation, vomit, gastric problems, and bruxism), which agrees with this study's results.

The risk of developing dental erosion is not only associated with dietary habits. Saliva's protective effects (flow rate, volume in the mouth, buffer capacity, and clearance) play a role in the development of dental erosion.[23,24] The acquired pellicle is capable of protecting teeth against erosion.[44] This protective effect, however, depends on the acid concentration, duration of the erosive challenge, and maturation of biofilm. Nevertheless, in this study saliva's protective effects could not be assessed, since there was no significant association between dental erosion and salivary characteristics. Most children showed good salivary characteristics (high salivary flow rate and buffer capacity, and neutral or basic pH).

Making patients aware of the effects of an erosive diet is essential to prevent dental erosion. Personalized preventive strategies should be established to educate children and their parents regarding indiscriminate consumption of acidic substances.[18]

Due to the lack of knowledge about this disease and its multifactorial etiology, a detailed dietary history, oral hygiene habits, and thorough medical background are important to obtain an earlier diagnosis, recommendations, preventive measurements, and treatment of dental erosion.[17,29]

Another relevant aspect of dental erosion prevention is the inclusion of information on the label about an acidic product's erosive potential during frequent and prolonged consumption.

CONCLUSIONS

Based on this study's results, the following conclusions can be made:

1. The prevalence of dental erosion in 12-year-old children attending public schools in Piracicaba, Brazil, can be considered high, affecting mainly the labial surfaces of maxillary incisors.
2. Dietary habits were not associated with dental erosion. Children who drink soft drinks, however, have twice the chance of developing dental erosion.
3. Salivary characteristics had no influence on prevalence of dental erosion.

ACKNOWLEDGMENTS

The authors wish to thank Fundação de Apoio à Pesquisa do Estado de São Paulo (FAPESP) for financial support of this research (process no. 07/54087-9), as well as Waldomiro Vieira Filho and Marcelo Correa Maistro, the technicians of Biochemistry and Pediatric Dentistry Laboratories of FOP/UNICAMP, respectively, for their help with the saliva analysis.

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