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Prevalence of dental erosion and association with lifestyle factors in Swedish 20-year olds

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Abstract

Objective. To investigate the prevalence, distribution and severity of dental erosion and its association with lifestyle, oral and general health in young adults. ***Materials and methods.*** Four hundred and ninety-four individuals, 20-years of age, participated. Dental erosion in molars and maxillary incisors was evaluated. Caries, plaque and gingivitis were registered. Saliva samples were taken and the subjects were interviewed about behavioural and dietary habits and oral and general health. Body mass index (BMI) was calculated. The individuals were sub-divided into two groups according to the presence and absence of dental erosion: within the group with erosion was a sub-group of individuals with extensive erosion. ***Results.*** Of the individuals 25% had no erosion, 75% had erosion and 18% had extensive erosion. Erosion was found in molars in 74% of the individuals and on buccal and palatal surfaces in maxillary incisors in 4% and 7%, respectively. Cupping was seen in 65% of individuals and severe erosion in molars in 1.6%. Compared to subjects with no erosion, those with extensive erosion had a higher consumption of soft drinks ($p = 0.05$), caries prevalence ($p < 0.01$), prevalence of *mutans Streptococci* ($p < 0.01$) and BMI ($p < 0.05$). Furthermore, subjects with erosion had higher caries prevalence ($p < 0.01$) and BMI ($p < 0.01$) than those with no erosion. ***Conclusions.*** Swedish young adults have a high prevalence of dental erosion, but the level of severe erosion is low. The study disclosed a relationship between dental erosion and behavioural factors, oral health and BMI.

Key Words: *body mass index, caries, dental erosion, oral health, young adults*

Introduction

During the last few decades, there has been extensive research into the prevalence and aetiology of dental erosion [1]. The reported prevalence varies widely [2–5]. A recent study among Icelandic young adults (19–22 years old) reported dental erosion with dentine involvement in 39% of the individuals [3]. In 18-year old Norwegian adolescents, the corresponding figure was 32% [4] and in 18–19-year old Swedish adolescents it was 22% [5]. While these variations may be attributable in part to the use of different scales and scoring systems for dental erosion [6–10], the prevalence figures may also have been influenced by differences in the compositions of the cohort groups, e.g. with respect to socio-economic background, age and clinical examination procedures.

The aetiology of dental erosion is multifactorial and includes dietary factors, systemic diseases, eating disorders, salivary factors and occupational exposure [2,3,11–16]. It has also been suggested by Zero and Lussi [17] that behavioural factors play a role in modifying the extent of dental erosion. In recent decades, lifestyle has changed dramatically and an example of this is the increased intake of acidogenic products. Consumption of soft drinks in Sweden, for instance, has tripled over the last 50 years [18,19] and a clear association has been reported between dental erosion and consumption pattern [2]. The change of lifestyle might explain the increase of dental erosion

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reported in a cohort of 12-year-old children in UK, where incipient or more advanced erosive lesions were seen in 27% of the children over the 2-year observation period [20]. Furthermore, children in the Netherlands (11–12 years of age), followed for 3 years, showed a 24% increase in dental erosion on upper incisors and 27–34% on mandibular molars [21]. A German study in adolescents, based on study models, demonstrated an increase of erosion in molars of up to 17% over a 5-year period [22]. Thus, it seems that the prevalence of dental erosion is increasing and is related to modern lifestyle. In order to further elucidate the correlation between erosion and related factors, more studies are needed on well-controlled cohorts of an age at which established dental erosion could be expected.

The aim of the present study was, therefore, to investigate the prevalence, distribution and severity of dental erosion in a well-defined cohort of Swedish young adults and also to evaluate possible aetiological associations with lifestyle, oral and general health.

Materials and methods

The present study is part of the longitudinal oral health surveys of pre-school children, teenagers and young adults conducted in the Municipality of Jönköping, Sweden. All 671 individuals aged 1 year in 1988, living in four of the 13 districts affiliated with regional welfare centres, were invited to participate. The four districts included urban, suburban and rural areas and were selected as being representative of the socio-economic levels of the population in this part of Sweden. The findings on oral health and related factors in this cohort on pre-school children, teenagers and young adults have been reported previously [23–29].

The study was approved by the Regional Ethics Review Board at the University of Linköping, Sweden and the Regional Radiation Protection Board at the Municipality of Jönköping, Sweden and was carried out in accordance with the Declaration of Helsinki and Good Clinical Practice guidelines.

Study population

In 2007, when the individuals were 20 years of age, all 671 individuals from the original cohort were invited by letter to participate in a dental health examination and an interview. They were informed that the examination was free of charge and that any radiographs that were taken would be forwarded to their general dental practitioner. Informed consent was obtained. Of the original cohort of 671 individuals, 494 (74%), 244 males and 250 females, participated in this 19-year follow-up examination. The reasons for non-participating were relocation (n = 59), address unknown (n = 37), decline to participate (n = 38), failure to present for examination (n = 35) and death (n = 3). Five individuals were excluded; one due to a serious illness, three due to on-going orthodontic treatment with fixed appliances in one or both jaws and one for technical reasons. Three of the individuals did not wish to be weighed or measured.

Clinical examination and interview

All examinations were undertaken by one of the authors (HI). Molars and maxillary incisors were examined for dental erosion: plaque and gingivitis were registered clinically and caries was registered by clinical and radiographic examination. Saliva samples were taken and body weight and height were registered. All examinations were carried out in a dental clinic with modern equipment and optimal lightning. The teeth were carefully dried before assessment. No professional tooth cleaning was undertaken before the clinical examination. Teeth with extensive restorations were excluded from evaluation of erosion.

Dental erosion—diagnostic criteria

Molars and maxillary incisors were chosen because they are known to have a high propensity for erosion. Two scales were used for grading: a slightly modified version of the scale by Hasselkvist et al. [5] was used for erosion on molars. For maxillary incisors, a scale, slightly modified after Eccles [6] and Johansson et al. [9], was used. The incisal edge was excluded from the examination because of the difficulty of differential diagnosis of attrition and erosion on these surfaces. The severity of dental erosion was registered on a 5-point scale, see Figures 1,2,3. Cupping is understood as a shallow rounded erosion in enamel, with exposed dentin found on the occlusal surfaces of molars and fused cupping as at least two cuppings fused together on the same tooth.

Occlusal surfaces of first and second molars were registered as follows (Figure 1): *No erosion* = no cuppings/intact cusp tip, *Mild erosion* = rounded cusp tip, *Moderate erosion* = reduction of crown height. Small dentin exposure (cupping), *Severe erosion* = extensive change of tooth morphology. Major dentinal exposure (fused cuppings), *Very severe erosion* = erosion in secondary dentin. Pulp visible through the dentin.

Buccal and palatal surfaces of maxillary incisors were registered as follows (Figures 2 and 3); *No erosion* = no visible changes, developmental structures remain, macro-morphology intact. *Mild erosion* = smoothened enamel, developmental structures have partially or totally varnished. Enamel surface is shiny or matt, irregular, 'melted', macro-morphology generally intact. *Moderate erosion* = enamel surface as described in mild erosion. Macro-morphology clearly changed, facetting or concavity formation within the

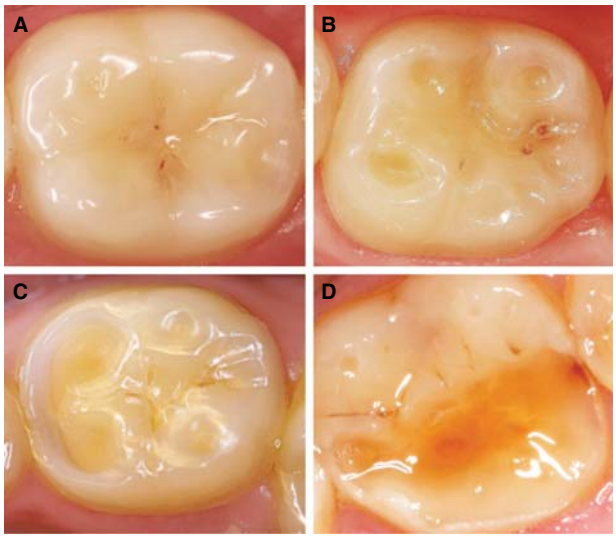

Figure 1. Grade, clinical view and criteria for dental erosion on occlusal surfaces of molars. *No erosion* = No cuppings/intact cusp tip. (A) *Mild erosion* = Rounded cusp tip. (B) *Moderate erosion* = Reduction of crown height, small dentin exposure (cupping). (C) *Severe erosion* = Extensive change of tooth morphology. Major dentinal exposure (fused cuppings). (D) *Very severe erosion* = Erosion in secondary dentin. Pulp visible through the dentin.

enamel, no dentinal exposure. *Severe erosion* = enamel surfaces as described in mild erosion. Macro-morphology greatly changed (close to dentinal exposure of large areas) or dentin surface exposed by ≤1/3. *Very severe erosion* = enamel surface as described in grades mild, moderate and severe

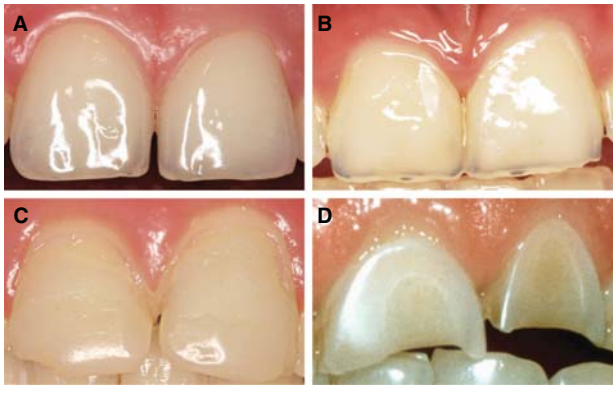

Figure 2. Grade, clinical view and criteria for dental erosion on maxillary incisors on buccal surfaces. *No erosion* = No visible changes, developmental structures remain, macro-morphology intact. (A) *Mild erosion* = Smoothened enamel, developmental structures have totally or partially varnished. Enamel surface is shiny or matt, irregular, 'melted', macro-morphology generally intact. (B) *Moderate erosion* = Enamel surface as described in mild erosion. Macro-morphology clearly changed, faceting or concavity formation within the enamel, no dentinal exposure. (C) *Severe erosion* = Enamel surfaces as described in mild erosion. Macro-morphology greatly changed (close to dentinal exposure of large areas) or dentin surface exposed by ≤1/3. (D) *Very severe erosion* = Enamel surface as described in grades mild, moderate and severe erosion with dentin surface exposed by ≥1/3 or pulp visible through dentin.

Figure 3. Grade, clinical view and criteria for dental erosion on maxillary incisors on palatal surfaces. *No erosion* = No visible changes, developmental structures remain, macro-morphology intact. (A) *Mild erosion* = Smoothened enamel, developmental structures have totally or partially varnished. Enamel surface is shiny or matt, irregular, 'melted', macro-morphology generally intact. (B) *Moderate erosion* = Enamel surface as described in mild erosion. Macro-morphology clearly changed, faceting or concavity formation within the enamel, no dentinal exposure. (C) *Severe erosion* = Enamel surfaces as described in mild erosion. Macro-morphology greatly changed (close to dentinal exposure of large areas) or dentin surface exposed by ≤1/3. (D) *Very severe erosion* = Enamel surface as described in grades mild, moderate and severe erosion with dentin surface exposed by ≥1/3 or pulp visible through dentin (courtesy by Catharina Göthberg).

erosion with dentin surface exposed by ≥1/3 or pulp visible through dentin.

In order to describe and analyse the prevalence of erosion and related factors, the total cohort was stratified into the following groups. *No erosion* = Individuals without clinical signs of dental erosion. *Erosion* = Individuals with clinically verified dental erosion. *Extensive erosion* = Individuals with one or more of the following clinical findings: (a) three or more molars with cuppings (moderate-to-very severe erosion) and/or (b) erosion on maxillary incisors (mild-to-very severe erosion). Observe that the individuals with *Extensive erosion* are also included in the *Erosion* group.

Reliability of clinical examinations of dental erosion

Eighteen individuals who had undergone clinical examination for registration on molars and maxillary incisors were re-examined within 1–2 weeks. Both simple and weighted intra-individual Cohen's kappa values were calculated. The values were 0.83 and 0.87, respectively.

Dental caries—diagnostic criteria

The criteria described by Koch [30] were applied for clinical registration of caries. Decayed and restored tooth surfaces (DFS) were recorded. Clinical caries was recorded on occlusal, buccal and lingual surfaces as follows; *initial caries* (D_i) = a lesion on the enamel

surface, with whitish areas without cavitation, *manifest caries* (D_m) = a loss of tooth substance having reached the stage of cavitation that can be diagnosed with certainty, by clinical examination with mirror and explorer after drying with air, not having a character of erosion or hypoplasia and appearing on a tooth surface not earlier restored; pits and fissures, not earlier restored, where the probe with a little pressure, sticks without doubt and requires a definite pull for removal [30].

The radiographic examination was based on four posterior bitewing radiographs; Kodak E-speed films taken with an X-ray unit at 65 kV, equipped with a long cone (focus-film interval 20 cm). Kwik-bite film holders no. 270 from Hawen (Hawe Neos Dental SA, Switzerland) were used. The films were mounted in frames and subsequently examined using a magnifying viewer [31] and light desk. If radiographs had been taken recently, they were retrieved from the subject's dentist and examined as described below. All bitewings were analysed by one of the authors (HI). The approximal surfaces, from the distal surface of the canine to the distal surface of the second molar (a total of 36 surfaces), were evaluated. Of the examined approximal surfaces, 22% were recorded as unreadable due to overlapping. Approximal caries was recorded as follows; *initial caries* (D_i) = a lesion in the enamel which has not reached the dentinoenamel junction or a lesion that reaches or penetrates the dentinoenamel junction but does not appear to extend into the dentine, *manifest caries* (D_m) = a lesion which clearly extends into the dentine. The individuals were stratified, according to caries experience at 20 years of age, into the following three sub-groups: $D_{im}FS = 0$, $D_{im}FS = 1–3$ and $D_{im}FS \geq 4$.

Plaque and gingivitis

The presence of visible plaque was recorded on four tooth surfaces on all teeth after drying with air corresponding to the criteria for Plaque Index (PI) 2 and 3 according to Silness and Löe [32]. The presence of gingival inflammation corresponding to Gingival Index (GI) 2 and 3 according to Löe and Silness [33] was recorded for four tooth surfaces on all teeth.

Saliva sampling

Paraffin-stimulated whole saliva was sampled and sent to The Department of Cariology, University of Gothenburg, Sweden for analysis. The sample was shaken on a mechanical mixer for 30 s and serially diluted in 0.05 M phosphate buffer (pH 7.3). Then, 25 µl portions were plated in duplicate onto mitis salivarius with bacitracin (MSB) agar for the growth of mutans streptococci (MS), and onto Rogosa selective lactobacilli (SL) agar for the growth of lactobacilli (LB). The MSB agar plates were incubated in candle jars at 37°C for 2 days and the Rogosa SL agar plates were incubated aerobically at 37°C for 3 days. The number of colony-forming units (CFUs) of MS was counted on the MSB agar and identified by their characteristic colony morphology. All CFUs in Rogosa SL agar were considered to be LB. The number of CFU was transformed to logarithms before the statistical analysis. The buffer capacity of saliva was estimated using the chair side Dentobuff Strip test (Orion Diagnostica, Espoo, Finland) according to the manufacturer's instructions.

Body mass index (BMI)

The body adiposity status was determined by calculating body mass index (BMI kg/m^2) and was categorized as underweight (BMI < 18.5), normal (BMI = 18.5–24.9), overweight (BMI = 25–29.9) and obese (BMI ≥ 30), according to the WHO classification [34].

Interview

All individuals were interviewed about behavioural, dietary and general health factors. The following questions were raised and stratified as follows:

- Consumption of soft drinks; 0–1 time per week, 2–3 times per week or once or several times per day;
- Consumption of fruit juice (sweetened); 0–1 time per week, 2–3 times per week or once or several times per day;
- Consumption of fruit juice; 0–1 time per week, 2–3 times per week or once or several times per day;
- Consumption of fruit; 0–1 time per week, 2–3 times per week or once or several times per day;
- Daily number of main meals; 0–2 meals or ≥3 meals;
- Use of chewing gum, daily; 1–2 pieces or ≥3 pieces;
- Tobacco habits; yes or no;
- Physical activity; ≤1 time per week, 2–3 times per week or ≥4 times per week;
- Thirst quencher when exercising; water or sport drinks/juice;
- Frequency of tooth brushing; ≥2 times daily or ≤1 time daily;
- Satisfaction with appearance of their teeth; 'satisfied, very satisfied' or 'dissatisfied, very dissatisfied';
- Self-assessed gastric reflux; yes or no;
- Perceived healthy; yes or no;
- Medication; yes or no;
- Medical checkups; yes or no.

Statistics

Descriptive statistics such as numbers, percentages, means and standard deviations as well as bar charts were used. To test for differences between groups on ordered categorical data, Fisher's exact test was used. For testing differences between groups on continuous data, Student's *t*-test was used; *p*-value ≤ 0.05 was considered to be statistically significant.

Results

Prevalence

Of the 494 participants, 125 (25%) individuals (67 females and 58 males) had no erosion, 369 (75%) individuals (183 females and 186 males) had erosion and 90 (18%) individuals (41 females and 49 males) had extensive erosion. Of the individuals, 367 (74%) had erosion on occlusal surfaces of the molars, 19 (3.8%) on the buccal surfaces of maxillary incisors and 36 (7.3%) on the palatal surfaces (Figure 4). There were no gender differences. Cupping (grade moderate-to-severe) in one or several molars but no erosion of maxillary incisors was seen in 286 (58%) individuals. Erosion of maxillary incisors without any erosion in molars was found in two (0.4%) individuals.

Severity of erosions

The distribution of individuals according to the grade of severity of erosion in molars is presented in Figure 5. No gender differences were found. Moderate erosion in molars was found in 320 (65%) and severe erosion in eight (1.6%) of the individuals. The percentage distribution of dental erosion in the first and second molars according to grade, is shown in Figure 6. Severe erosion (fused cuppings) was registered only in 1.6% of mandibular first molars.

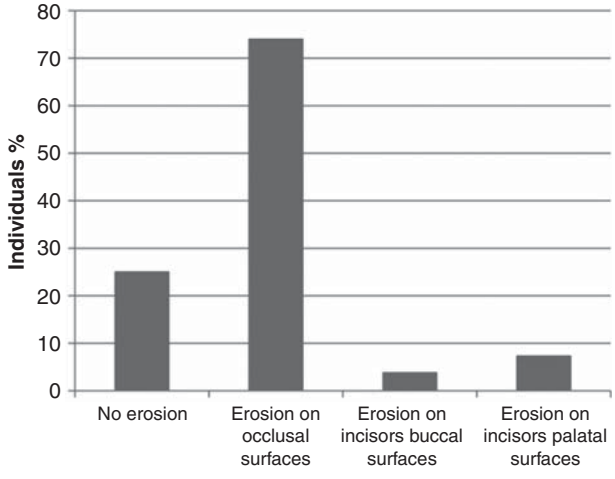

Figure 4. Percentage of individuals distributed according to dental erosion.

The distribution of individuals according to the grade of severity of dental erosion in maxillary incisors is presented in Figure 5. Erosion on the palatal surfaces was twice as common as on buccal surfaces. Severe erosion (dentine surface exposed by ≤1/3) was found on the buccal surfaces in one individual. There were no findings of very severe erosion (dentine surface exposed ≥1/3) in any individual.

Of the individuals, 35 (7%) showed both molars with moderate-to-severe erosion and maxillary incisors with mild-to-severe erosion. Severe erosion in molars and maxillary incisors was detected in one (0.02%) individual. There were no cases of very severe erosion in the material.

Erosion and behavioural factors

Consumption of soft drinks once a day or more was more prevalent in individuals with extensive erosion than in those with no erosion ($p = 0.05$), Table I. High consumption of soft drinks was twice as common among individuals with extensive erosion as among those with no erosion. There were no gender differences regarding the consumption of soft drinks. There were no statistical differences between the groups with respect to consumption of fruit juices and fruits or the number of main meals consumed per day concerning prevalence of erosion.

The frequency of chewing gums was higher in individuals with extensive erosion than in those with no erosion ($p < 0.05$). Of the individuals with extensive erosion, 28% consumed three or more pieces of chewing gum daily compared to 11% of individuals with no erosion. Physical activity more than once a week was reported by 85% of the individuals. Water was the thirst quencher for 98% of the individuals and only 1–2% consumed sports drinks. Self-assessed gastric reflux was reported by 91 individuals (18%). Of these individuals 55 reported reflux in combination with physical activity. There were no statistically significant differences between the groups with respect to physical activity or consumption of thirst quenchers concerning occurrence of dental erosion. We found no association between self-assessed gastric reflux and dental erosion. Tooth brushing twice a day was reported by 394 (81%) of all individuals. Individuals who brushed their teeth less than twice a day were more frequently found in the group with extensive erosion than those brushing their teeth twice a day ($p < 0.05$).

Erosion and oral health

The mean caries prevalence at 20 years of age was D_{im} FS = 5.8. Caries prevalence was higher in individuals with erosion ($p < 0.01$) and extensive erosion

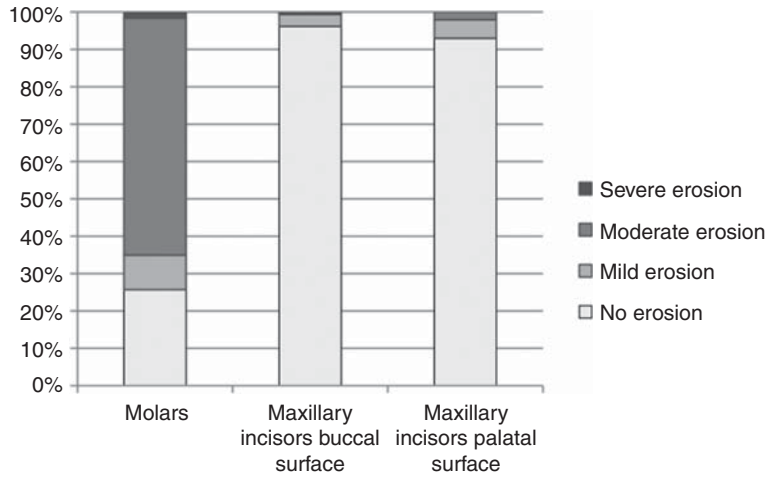

Figure 5. Percentage distribution of individuals according to grade of severity of dental erosion in molars and maxillary incisors on buccal and palatal surfaces.

($p < 0.01$) compared to individuals with no erosion (Table II). In the group of individuals with extensive erosion, 58% had ≥4 $D_{im}FS$ compared to 34% among those with no erosion. There were no significant inter-group differences with respect to plaque or gingivitis. The number of MS was more prevalent in individuals with extensive erosion ($p < 0.01$) than in those with no erosion. No inter-group differences were found for buffer capacity or LB counts.

Erosion and general health

There were no differences between individuals with or without erosion with respect to self-perceived health, medical treatment or regular medication. BMI was calculated for 491 individuals; 340 (69%) were of normal weight, 91 (18%) were overweight and 33 (7%) were obese. Twenty-seven (6%) were underweight. There were higher frequencies of overweight and obese individuals with erosion ($p < 0.001$) and extensive erosion ($p < 0.05$) compared to those with no erosion (Table III). Of individuals with erosion 31 (9%) were obese compared to two (2%) individuals with no erosion.

Discussion

The most striking findings in the present study were the high prevalence of dental erosion and also the low level of severe erosion. The study also disclosed a relationship between dental erosion on one hand and behavioural factors, oral health and BMI on the other hand.

In the present study, 75% of the individuals showed signs of dental erosion. This is in agreement with the study by Fares et al. [35] in which the proportion of 21-year-olds with at least one surface with exposed dentine was ~77%. In their study and in some other studies [5,36], males had significantly more wear in dentine than females. Jensdottir et al. [3] reported a

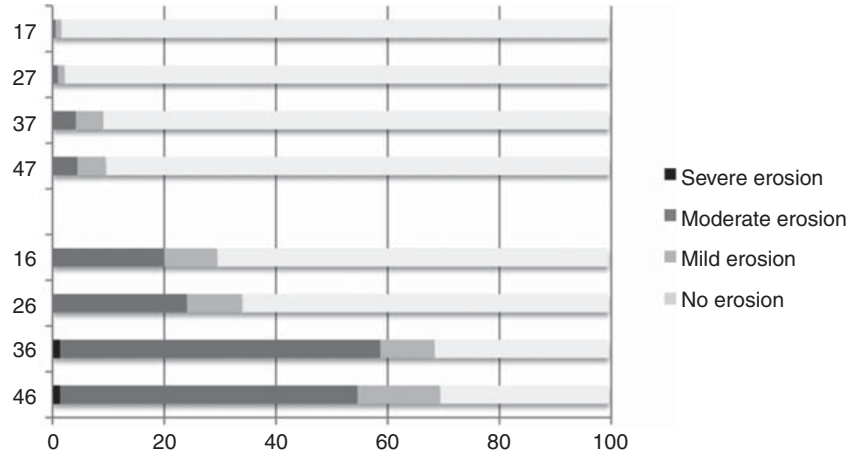

Figure 6. Percentage distribution of dental erosion in first and second molars according to grade.

Table I. Number of individuals in percentages with no erosion, erosion and extensive erosion according to behavioural factors. *p*-Values for the comparisons between no erosion/erosion and no erosion/extensive erosion, respectively.

	No erosion		Erosion			No erosion		Extensive erosion		
Behavioural factors	*n*	%	*n*	%	*p*	*n*	%	*n*	%	*p*
Soft drink consumption										
0–1 times per week	40	32	86	23		40	32	20	22	
2–3 times per week	70	56	222	60	0.11	70	56	50	56	0.05
Once or several times per day	14	11	60	16		14	11	20	22	
Chewing gum; How many pieces of gum are you chewing daily?										
1–2 pieces	68	88	190	79		68	88	46	72	
≥3 pieces	9	12	52	21	0.07	9	12	18	28	0.02
Tooth brushing frequency?										
≤1 daily	13	10	54	15		13	10	19	21	
≥2 daily	111	90	311	85	0.29	111	90	71	79	0.03

trend towards higher erosion scores in molars in males, but this male predominance was not statistically significant. In the present study no gender difference could be verified.

In several of the earlier studies, the reported prevalence of dental erosion is lower than in the present study [3–5]. This might be due to differences in definitions of dental erosion and/or the scoring systems used. In the present study, severe erosion is defined as extensive change of tooth morphology and major dentinal exposure (fused cuppings) on occlusal surfaces of molars. Other authors have described severe erosion as cupping >1 mm on the occlusal surface of molars [5] or as rounded cups and grooves on occlusal aspects with dentin involvement [8]. Accordingly, the definitions of severe erosion vary in the extension of dentin exposure, which in turn may affect which individuals will be regarded as suffering from severe erosions.

In the present study, ~35% of the individuals showed no erosion or only mild erosion in molars, 63% had moderate erosion, i.e. one or more cuppings, and only 2% had severe erosions. This is in agreement with results reported by Hasselkvist et al. [5] and Mulic et al. [4]. The minor differences between the studies can be explained by different tooth groups studied and/or scoring systems used. In this context, it is questionable whether an individual with only one or a few cuppings in molars should be regarded as 'diseased' or if this condition might be considered to be a normal variation in a healthy population.

Several studies have reported an association between dental erosion and consumption of soft drinks among young adults [3,12,13,37]. Soft drink consumption in the US increased during 1977–1996 with almost 300% [38]. In a study in Icelandic young adults (19–22 years old) significantly higher erosion scores were found on molars of subjects drinking more than 1 litre of carbonated drinks per week than those who did not [3]. This is confirmed in the present study, where frequent consumption of soft drinks was significantly more prevalent in the group with extensive erosion.

Use of chewing gum was more common in the group with extensive erosion, which indicates that there might be an abrasive effect from chewing gums on already softened enamel. This finding has not been reported earlier. Considerations should, therefore, be made regarding the use of fluoride chewing gum as a preventive measure in individuals diagnosed with both erosion and caries.

In the present study, there is a statistically significant association between caries and dental erosion. This is in agreement with a study by Mulic et al. [4]. Furthermore, O'Sullivan and Curzon [39] showed that individuals with erosion have salivary characteristics that more closely match those of caries-active

Table II. Number of individuals in percentages with no erosion, erosion and extensive erosion according to caries. *p*-Values for the comparisons between no erosion/erosion and no erosion/extensive erosion, respectively.

	No erosion		Erosion			No erosion		Extensive erosion		
$D_{im}FS$	*n*	%	*n*	%	*p*	*n*	%	*n*	%	*p*
0	45	36	83	22		45	36	18	20	
1–3	37	30	106	29	0.005	37	30	20	22	0.003
≥4	44	34	180	49		43	34	52	58	

Table III. Number of individuals in percentages with no erosion, erosion and extensive erosion according to body mass index. *p*-Values for the comparisons between no erosion/erosion and no erosion/extensive erosion, respectively.

	No erosion		Erosion			No erosion		Extensive erosion		
BMI	*n*	%	*n*	%	*p*	*n*	%	*n*	%	*p*
Normal weight	84	67	256	70		84	67	65	72	
Overweight	24	19	67	18	0.0002	24	19	15	17	0.02
Obese	2	2	31	9		2	2	7	8	
Underweight	15	12	12	3		15	12	3	3	

individuals. This is supported by the findings in the present study where MS were significantly more prevalent in individuals with extensive erosion. Furthermore, Barkeling et al. [40] showed that MS count was correlated with both BMI and a higher intake of sweet foods. This may be attributed to lifestyle factors, e.g. high intake of sweet products such as soft drinks, a correlated risk factor for both caries and erosions. Therefore, individuals with a high frequency of caries lesions should be thoroughly looked upon for evidence of dental erosion.

Plaque has been found to inhibit dental erosion of enamel *in vitro* and *in vivo* [41,42]. However, in the present study there were no associations between prevalence of plaque and erosion. This is in line with data reported by El Aidi et al. [43]. Furthermore, there was no association with erosion concerning gingivitis. Low buffering capacity has been reported to be the most significant salivary factor in the development of erosion in individuals of 3–16 years of age [39]. In the present study, however, there was no association between stimulated salivary buffer capacity and erosion. The reason may be that the study population was healthy and that most individuals had a normal salivary secretion rate, which increases the bicarbonate concentration in saliva. There are also other studies which show no association between dental erosion and salivary buffer capacity [44].

The few individuals with severe erosion in molars (n = 8; 1.6%) in the present study restricted the possibility to perform deeper analyses of reported gastric reflux and severe erosion. Gastric reflux has been found to be a significant factor in the development of dental erosion [14,45]. Gastric reflux and consumption of soft drinks during exercise has been suggested to be part of the aetiology of dental erosion in young males who were exposed to physical activity [46]. In our study we analysed if self-assessed gastric reflux or frequency of physical activity was related to dental erosion, but found no such association.

A higher proportion of individuals with extensive erosion reported tooth brushing once a day or less compared to individuals with no erosion. This is in line with data reported by Mulic et al. [47], who reported associations between the presence of erosion and brushing teeth once per day or less. It had been suggested that prolonged and frequent tooth brushing might increase the risk of tooth wear [2]. However, Ganss et al. [28,41] showed that neither brushing frequency nor tooth brushing force increased substance loss of eroded dentin.

In the present study, young adults with high BMI had higher frequencies of erosions. This is in agreement with McGuire et al. [48], who reported that obese children have an increased risk of having erosive tooth wear compared to normal-weight children. Childhood obesity/overweight has been associated with number of daily servings of soft drinks [49]. Furthermore, in adolescents and young adults, obesity/overweight has been associated with higher caries prevalence [24]. In addition, abdominal obesity could be associated with oesophageal dysfunction such as increased acid exposure and reflux symptoms which in turn may lead to a higher risk for dental erosion [50]. Furthermore, in adolescents and young adults obesity/overweight has been associated with higher caries prevalence [24]. The above findings are supported by the present study which shows an association between dental erosion and obesity as well as caries.

There are some limitations in the present cross-sectional study, as in most prevalence studies of dental erosion. Diagnosis of early signs and symptoms of wear, particularly that of an erosive nature, has proved difficult to detect and classify [51–53]. To overcome this problem, a simplified scoring system was developed for the present study. This scoring system has in many aspects similarities with those proposed by Hasselkvist et al. [5], Eccles [6] and Johansson et al. [9]. In most scoring system for erosions used, the grading on occlusal surfaces of molars is based on dentin involvement or not [8]. A new scoring system, the so called BEWE, Basic Erosive Wear Examination index [54], has recently been presented to make clinical research on dental erosion more comparable. Unfortunately, this scoring system was not presented when the present study was initiated.

The scoring system in the present study, where the levels moderate (cuppings) and severe (fused cuppings) erosion have been used, makes it possible to compare the prevalence of erosions with most other

studies and scoring systems. Furthermore, only teeth and tooth surfaces with previously known susceptibility for erosion were studied [2]. Thus, in our study the examination was restricted to occlusal surfaces in molars and buccal/palatal surfaces of maxillary incisors. The intra-individual kappa-value was 0.83 from double examinations, which indicates a good level of reliability. In cross-sectional studies of young adults the observed tooth wear can have occurred at a younger age. This makes it difficult to associate the erosion with the information taken from the actual questionnaire.

To conclude, the present study shows a high prevalence of dental erosion; however, of rather low severity. Only a few individuals had severe erosion. There was a relationship between erosion and behavioural factors, oral health and BMI.

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