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Dental erosion: a widespread condition nowadays? A cross-sectional study among a group of adolescents in Norway

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Abstract

Objective. This study aimed to investigate the prevalence, distribution and severity of erosive wear in a group of 16–18-year-olds in the western part of Norway. A second aim was to describe possible associations between caries experience, socioeconomic background and origin of birth. ***Materials and methods.*** Adolescents ($n = 795$) attending recall examinations at Public Dental Service (PDS) clinics were also examined for dental erosive wear on index surfaces, using the Visual Erosion Dental Examination scoring system (VEDE). ***Results.*** In total, 795 individuals were examined. Dental erosive wear was diagnosed in 59% of the population (44% erosive wear in enamel only, 14% combination of enamel and dentine lesions, 1% erosive wear in dentine only). The palatal surfaces of upper central incisors and occlusal surfaces of first lower molars were affected the most (33% and 48% of all surfaces, respectively). Cuppings on molars were registered in 66% of the individuals with erosive wear. Erosive wear was significantly more prevalent among men (63%) than women (55%) ($p = 0.018$). ***Conclusions.*** There were no significant associations between dental erosive wear and caries experience, socioeconomic background or origin of birth.

Key Words: *dental erosive wear, prevalence, public health, severity*

Introduction

Dental erosive wear is a common clinical finding among children and adolescents. Increasing interest has been observed among the public, dental practitioners and researchers recently. The decline in caries prevalence in western countries [1,2] may have changed the focus and interest of the public on to dental erosive wear. This could explain why many dentists report that dental erosive wear is more prevalent today than 10–15 years ago [3].

Epidemiological studies on dental erosive wear are common. These have been conducted worldwide and show a wide range of prevalence [4]. In Sweden, the prevalence of dentine erosive wear has been reported to be 11.9% among 13–14 year-olds and 22.3% in 18–19 year-olds [5]. In the Netherlands, the prevalence of dentine erosive wear was 11.2% in 15 year-olds [6]. Higher values were found by Bardsley et al. [7], who reported that 53% of 14 year-old children in North West England had dental erosive wear extending into dentine. The corresponding value for 18 year-olds in Norway was 38% [8].

Prevalence studies are necessary to predict future needs for prevention, treatment and assessment of progression, as well as to stipulate resources required to handle erosive lesions in young people. Even though high prevalence of dental erosive wear has been reported in the literature [4,9,10], only a few studies have recorded the severities of the lesions or described the scoring systems used [11]. In order to identify individuals at risk for dental erosive wear and for adequate prevention and optimal treatment need to be assessed, it is valuable to consider at what age the signs of erosive wear are clearly visible. Furthermore, it is important to ascertain whether caries is a risk indicator for dental erosion. So far, there are conflicting reports on the association between caries and dental erosion [8,10,12,13]. Studies have also tried to identify patients at risk of developing dental erosions by adjusting for socioeconomic status and origin of birth. The results are inconclusive, but any tendency linking dental

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erosions and socioeconomic status or origin of birth cannot be verified [6,8,10,14,15].

The aim of the present study was, therefore, to investigate the prevalence, distribution and severity grades of dental erosive wear among 16-, 17- and 18-year old adolescents in the western part of Norway. Furthermore, we wished to describe possible associations between dental erosive wear and caries experience, socioeconomic level and origin of birth within this group.

Materials and methods

The study was conducted at five randomly selected Public Dental Service (PDS) clinics in Rogaland, a county in western Norway. All 16-, 17- and 18-year-olds scheduled for recall examinations from February to October 2012 were invited to participate.

Calibration

The clinicians attending the PDS clinics were calibrated during two sessions prior to examining the participants. The clinicians scored erosive wear according to the Visual Erosion Dental Examination (VEDE) scoring system with the following criteria: score 0: No erosion; score 1: Initial loss of enamel, no dentine exposed; score 2: Pronounced loss of enamel, no dentine exposed; score 3: Exposure of dentine, <1/3 of the surface involved; score 4: 1/3–2/3 of the dentine exposed; score 5: >2/3 of dentine exposed [16]. In addition to registration of erosive wear by surface level, cuppings on the upper and lower molars were also registered and graded following these criteria: score 1: Initial loss of enamel, no dentine exposed; score 2: Pronounced loss of enamel, no dentine exposed; score 3: Exposure of dentine. Clinicians who were uncertain about the severity of the lesions were instructed always to register the lower score. When the tooth surface showed signs of attrition, was covered by a filling or an orthodontic device or was impossible to examine, the surface was excluded from the calculations.

In the first calibration session, 74 intra-oral photographs of tooth surfaces with and without erosive lesions were used. This session was repeated after 14 days, in the same room and under identical lighting conditions. The second calibration session was performed on randomly selected adolescents aged 16-, 17- and 18 ($n = 17$). They were examined by all clinicians using the VEDE system. The examination was repeated after 14 days on 15 of the adolescents. Inter- and intra-examiner values for both sessions were calculated and expressed by weighted Cohen's kappa (κ_w).

Clinical examination

After the calibration sessions, the eight participating clinicians examined the 795 adolescents in fully equipped dental clinics using plane mouth mirrors, probes and standard lightning. Twenty surfaces on 14 teeth were selected as index surfaces. These were the occlusal surfaces of the upper and lower first and second molars and the labial and palatal surfaces of the upper incisors and canines. The teeth were dried by compressed air and cotton rolls were used to isolate the teeth.

Caries experience, measured as DMFT (decayed, missed due to caries and filled teeth) at the time of examination, was based on oral inspections and BWs, and were collected from each participant's dental record. Surfaces were defined as decayed if the carious lesions extended into dentine ($D_{3–5}MFT$).

Prior to the clinical examination, the participants answered a questionnaire. The socioeconomic status of the participants was determined by the parents' level of education: 12 years or more was defined as high education (one or both parents completed college or university education), and less than 12 years of school was defined as low level of education (both parents completed elementary or high school) [17]. National background was recorded according to the participants' country of birth and dichotomized into western origin and non-western origin. Non-western origin included Asia, Africa, South America, Central America and Eastern Europe [16].

Statistical analysis

The statistical analyses were performed using the Statistical Package for the Social Sciences (IBM SPSS Statistics, Inc. Chicago, IL, version 20). The absolute frequencies and proportions were obtained for data analysis (descriptive) and bivariate analysis (Chi-square) was used for testing possible associations between the variables. The level of significance was set at 5%. Calculation of weighted kappa (κ_w) was undertaken using a spreadsheet software (Microsoft Excel 2010). Cohen's kappa was rated as suggested by Altman [18]: <0.40; 0.41–0.60; 0.61–0.80; 0.81–1.0.

Ethical considerations

The study was approved by the local Regional Committee for Medical Research Ethics and The Norwegian Social Science Data Services (2011/1602/REK). Written, informed consent was obtained from all participants.

Results

The mean *inter-examiner* agreement value (κ_w) for the eight examiners at the surface level in the photo calibration session was 0.73 (range = 0.53–0.92) and mean *intra-examiner* agreement was 0.73 (range = 0.55–0.92), both indicating good agreement [18]. The mean *inter-examiner* agreement (κ_w) on the

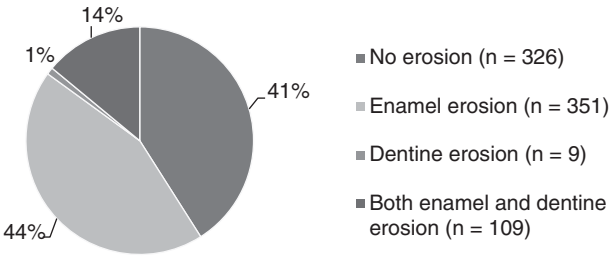

Figure 1. Percentage distribution of adolescents (n = 795): no erosion, enamel erosion only, dentine erosion only and both enamel and dentine erosion.

clinical examinations was 0.55 (range = 0.30–0.79), while the mean *intra-examiner* agreement was 0.46 (range = 0.30–0.70), both indicating moderate agreement. One of the clinicians was excluded prior to the onset of the study due to unacceptably low *inter-examiner* agreement for the clinical examinations (κ_w = 0.007).

Of all adolescents invited to participate in the study (n = 846), 795 (94%) accepted and 52% (n = 411) were women. Erosive lesions were found in 59% (n = 469) of the adolescents (Figure 1). There was no significant difference in the prevalence of dental erosion in the three age groups (Figure 2). Of those with dental erosive wear, 10% had only one affected surface. The distribution of erosive lesions among the adolescents is shown in Figure 3 and Table 1. Molars had more frequent dentine lesions (23%, n = 108) than anterior teeth (0.4%, n = 2). When calculating at the surface level, dental erosive wear was most frequently observed on the palatal surfaces of upper central incisors (33%) and on the occlusal surfaces of lower first molars (50% on the lower left molar, 45% on the right). Of the 2015 surfaces affected with enamel lesions only (cuppings not included), 70% were registered as score 1 and 30% as score 2.

At the individual level, 32% (n = 253) of the palatal surfaces of the upper central incisors were affected and 52% (n = 415) had erosive lesions on the occlusal surface of the first lower molar.

Cuppings on molars were found in 66% (n = 308) of the 469 individuals with erosive wear. Of these, 24% (n = 112) had at least one cupping extending into dentine. Dentine cuppings only were found in 12% (n = 54) of cases. The total number of occlusal surfaces on first molars in the material was 3106. Of these, 19% (n = 602) were registered with cuppings. The lower left molar was most frequently affected (46%, n = 276), followed by the lower right molar (39%, n = 233).

The prevalence of dental erosive wear was significantly lower in women than in men (55% vs 63%, p = 0.018). Erosive wear extending into dentine was also significantly more prevalent among male participants (19% vs 11%, p = 0.012). Cuppings on molars were found in 70% (n = 169) of the men and in 62% (n = 139) of the women (p = 0.067). Men had significantly more cuppings extending into dentine (28% vs 19%, p = 0.044).

Mean DMFT for 16-, 17- and 18-year-olds was 2.93, 4.03 and 4.10, respectively (p = 0.025). No caries experience (DMFT = 0) was registered in 22%. Nine per cent (n = 73) had neither dental erosive wear nor caries experience. The combination of erosion and caries in the dentition was found in 46% (n = 366) of cases and was not significantly different in male compared with female participants (49% vs 43%).

The prevalence of erosive wear was 59%, in adolescents both with and without caries experience. Considering dentine lesions, the distribution was similar: 15% (n = 94) of those with caries experience and 14% (n = 24) of those without had erosive lesions extended into dentine (p = 0.610). Low socioeconomic status was found in 30% of the population and 6% were of non-western origin. When considering socioeconomic status in relation to distribution

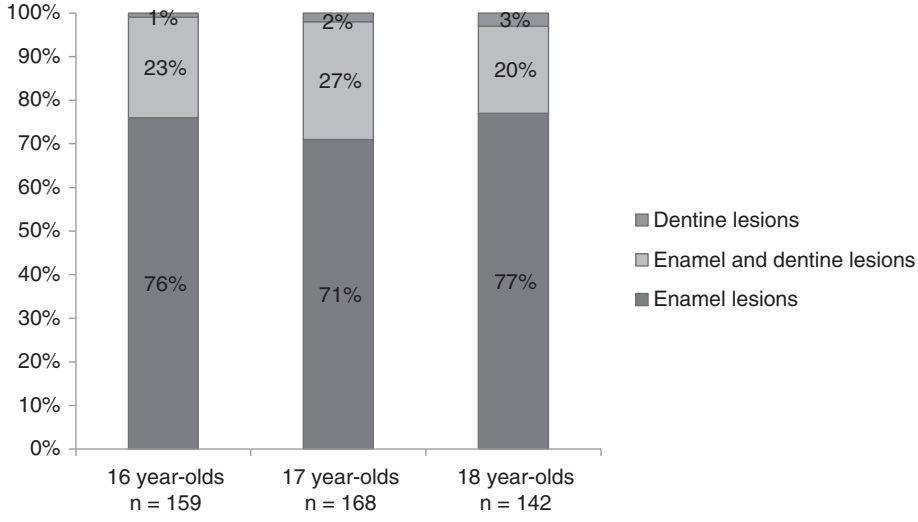

Figure 2. The distribution of the adolescents with erosion according to year of birth (n = 469).

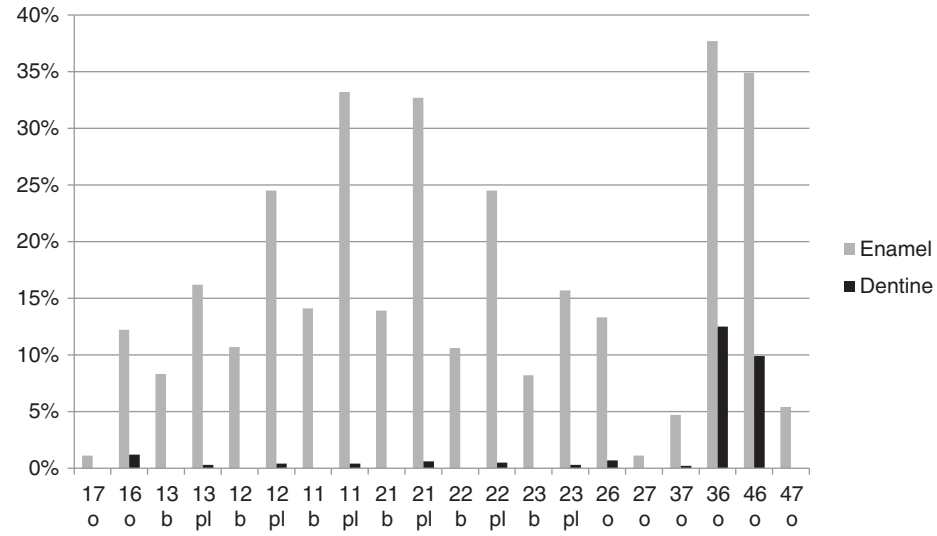

Figure 3. Percentage of affected index surfaces with enamel and dentine lesions (o, occlusal surface; b, buccal surface; pl, palatal surface).

of dental erosive wear on tooth-level, no statistical significance was detected (incisors; $p = 0.945$, molars; $p = 0.846$). No significant association was found between dental erosive wear in general and socioeconomic status or origin of birth.

Discussion

The prevalence of dental erosive wear in the present study was high compared with values reported from Nordic countries [8,19,20]. The prevalence of dentine lesions was lower than results from a similar study from Norway [8] and Sweden [5], but higher than reported from Iceland (5.5%) among 15 year-olds [20] and among 12–17 year-olds from Denmark (0.2%) [19]. Studies from other countries have found the prevalence of dentine lesions in young adults range from 8.7–53% [7,14,21,22].

Clinicians seem to feel that erosive lesions are more frequent today [3]. A lifestyle involving high consumption of acidic soft drinks is considered a risk for development of dental erosions. The expenditure of acidic drinks per household in Norway has increased by 37% from 1992 to 2009 when adjusted for consumer price index [23,24]. Data from Denmark, Norway and the Netherlands indicate that adolescents tend to increase their consumption of acidic soft drinks with increasing age [25]. The different prevalence found in the present study compared with the study from the eastern part of Norway [8], which used the same calibration method and scoring system, may indicate variations in different parts of the country, as is the case of dental caries prevalence. Bartlett et al. [26] identified residence in rural areas as an important risk factor for tooth wear: a higher presence of dental erosive wear was found in the present study conducted in a rural area compared to the study reported from the capital of Norway [8]. Another important factor is the time span between the studies: the prevalence study among 18 year-olds was conducted in 2008 [8], 4 years before the data collection of the present study.

Another important issue is the number of examiners involved in the study. In a population with a higher frequency of initial enamel lesions than more severe lesions, as is the case in the present study, greater variation between clinicians is expected, thereby increasing uncertainties about the recordings. Clinicians find it more difficult to record the initial lesions. This impression is supported by studies that have shown lower examiner agreement for initial lesions [27]. Larsen et al. [28] also pointed out that the clinicians had difficulties registering the junction between intact enamel and enamel lesions.

In most of the studies on prevalence of dental erosions only one examiner was used [5,8,20]. The examiners in these studies were calibrated, but the calibrations system was usually not described [5,20]. A pre-requisite for including many examiners in an epidemiological study is that they are calibrated prior

Table I. Number of affected surfaces in those with enamel lesions only, dentine lesions only and those with enamel and dentine lesions ($n = 469$).

	1 or 2 surfaces affected	3 or 4 surfaces affected	5 or more surfaces affected	Total ($n = 469$)
Only enamel erosion	153 (44%)	61 (17%)	137 (39%)	351 (100%)
Only dentine erosion	9 (100%)	0	0	9 (100%)
Enamel and dentine erosion	12 (11%)	20 (18%)	77 (71%)	109 (100%)

to commencing data collection. This is important, not only to reduce variations between the examiners, but also so they are familiar with the grading system in use.

In this study, the calibrations were performed on pictures of tooth surfaces with and without erosive lesions, in addition to clinical examination of the adolescents. The mean kappa values for the involved clinicians indicated moderate agreement [18]. One of the clinicians had kappa values significantly lower than the other eight clinicians and was therefore excluded. In addition to the thorough calibration of the examiners, other measures were taken to limit bias and over-registration. The clinicians were encouraged to register only on selected index teeth, as well as to use the lower erosion score when in doubt. A 'full mouth recording' is time-consuming and may decrease the accuracy of a grading system as well as the diagnosis of dental erosive wear [29]. Therefore, in the present study, index teeth and surfaces were selected based on earlier 'full mouth recording' studies among adolescents [15,22,28,30]. The studies demonstrated the highest prevalence of dental erosion on the occlusal surfaces of molars and the labial and palatal surfaces of maxillary anterior teeth.

It was considered important to distinguish between erosive wear and wear assumed to be purely attrition/abrasion and, therefore, only palatal, labial and occlusal surfaces were assessed. Incisal surfaces of front-teeth, supposed to be influenced by attrition/abrasion, were thus excluded.

There were several reasons for the choice of study group. At the age of 16, 17 and 18 years, the selected index teeth have been present and exposed to erosive challenges for several years. In young people, there is a higher probability of finding surfaces exposed to erosive challenge only, as attrition and abrasion are less compared with older individuals [31]. Furthermore, in Norway young people are offered free of charge examination at the PDS clinics, which facilitates participation: of 924 individuals scheduled for recall examination, 847 attended the examination at the PDHS clinics. Due to the high response rate (94%), the likelihood of non-response bias is low [18] and, therefore, the material is considered to be representative.

Several reports have documented men to have a higher prevalence of dental erosive wear than women [7,8,10,14,15,20–22] and several reasons for this difference can be imagined. Women are known to have thicker enamel [32]. According to Bardsley et al. [7], other factors such as greater muscle mass and biting force could contribute to increased risk of dental erosive wear among men [7]. A previous study has also shown that the consumption of soft drinks is higher and more frequent in young men than in young women [5]. On the other hand, it has been shown that girls tend to consume more fruit and juices [33].

Dental erosive wear appeared most frequently on the palatal surfaces of the upper central incisors and the occlusal surfaces of the lower first molars. This is supported by the findings from other epidemiological studies [15,21] and is probably due to the pattern of eruption. These teeth are the first permanent teeth to erupt and are, therefore, exposed to erosive challenges for longer [6]. The high prevalence of erosive lesions on mandibular first molars has also been found in other studies [8,20,21]. In addition to being the first permanent teeth to erupt, this may be partly explained by the thinner enamel in the lower molars than in the upper ones. The enamel is also thinner in the first molar compared with the second and third molars [32]. Friction with the tongue on the palatal surfaces of the upper central incisors has also been suggested to play an important role [34], as well as the presence of a thinner pellicle [35]. The reason why the maxillary central incisors are more often affected than the lateral incisors might be the later eruption of the laterals.

The assumption that the first signs of dental erosive wear appear on the lower first molar is supported by the fact that two thirds of the adolescents had erosive lesions on the molars only. A similar conclusion was drawn in a cross-sectional and longitudinal investigation on study models, where the authors concluded that the lower first molars may be the site of the initial onset of dental erosion [30]. As has been described earlier, the enamel cap area in the first molars has thin enamel [32]. Our study showed a prevalence of cuppings of over 60%, which is in accordance with findings in a similar study [8].

No differences in prevalence of dental erosions between age groups were revealed in the present study. This is in accordance with the findings of Larsen et al. [28], who studied the same age groups, but is in contrast with the results from two other studies [5,36]. Nunn et al. [36] found that 42% and 56% of palatal surfaces on upper central incisors had dental erosions in 11–14 year-olds and 15–18 year-olds, respectively. Hasselkvist et al. [5] found a higher prevalence of severe erosion extending into dentine in a group of 18–19 year-olds (22.3%) compared with 13–14 year-olds (11.9%). In the first study the difference was not very obvious and in both studies the age span was greater than in the present investigation and that of Larsen et al. [28], which could explain the differences in the results.

Progression of dental erosive wear of 12% and 26% was demonstrated in adolescents from 12 years to 14 years and from 12 years to 15 years, respectively [6,14]. Rodriguez et al. [37] concluded that tooth wear progression in 63 examined participants with a mean age of 39.1 years was relatively slow, 78% of the participants showed median wear <15 μm over a 6-month period. Even though longitudinal data remain sparse, the available studies suggest that, with increasing age, lesion progression increases.

Dental erosive wear and caries experience were registered in approximately half of the population studied. It has been shown that frequent consumption of sugary soft drinks is a habit often related to high caries experience [38] and is assumed to have erosive potential. No association between dental erosion and caries experience was found in the present study. Previous studies have presented conflicting results. Dugmore and Rock et al. [10] found a significant association between dental erosions and caries experience in 12 year-olds in the UK. Mulic et al. [8] also showed this association in 18 year-old adolescents in Norway. Although the intake of sugary soft drinks might be a pre-disposing factor for both, dental erosive wear and caries have different sites of predilection and the mechanisms of development are different [39].

The present study neither showed any significant relations between dental erosive wear and socioeconomic background nor associations with birth origin, which is in accordance with other studies [1,8,20]. There are studies that demonstrate a higher prevalence of dental erosive wear in groups with lower socioeconomic status [14,22] and also in groups with higher socioeconomic status [15] and there are studies which show associations with origin of birth [10,14]. Van Rijkom et al. [15] and Truin et al. [1] have speculated that high prevalence of dental erosions in groups with higher socioeconomic status may be due to more frequent tooth brushing, hence less dental plaque, making tooth surfaces more susceptible to acidic attack. Bardolia et al. [21] confirmed frequent tooth brushing to be a positive predictor for development of dental erosive wear. However, a recent study revealed that adolescents with dental erosive wear tend to brush their teeth less often and for a shorter period of time than adolescents without erosion [40].

The prevalence of dental erosive wear was found to be high among the 16–18 year-olds included in this study. The majority of the lesions were confined to enamel, illustrating that these were initial stage lesions. Although recording small lesions entails uncertainty, it is still important to record them to initiate preventive measures and to predict future treatment need.

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