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Dental erosion: Prevalence and severity among 16-year-old adolescents in Troms, Norway

ABSTRACT

Aim To study the prevalence, distribution and severity of dental erosion among 16-year-old adolescents in the Troms region of Norway.

Materials and methods Study design: The participants were recruited through the Tromsø-study ("Fit Futures"), and 392 16-year-olds were examined for dental erosion using clinical intraoral photographs. Three calibrated clinicians used the Visual Erosion Dental Examination (VEDE) system to register and grade the dental erosive wear.

Results More than one third (38%) of the participants showed dental erosion on at least one tooth surface, 18% were limited to the enamel, while 20% of the adolescents showed erosive wear extending into the dentine. The occlusal surfaces of the lower first molars, and the palatal surfaces of the maxillary incisors were the most often and most severely affected. Of the participants showing dental erosion, 93% exhibited "cuppings" on the molars, with 48% limited to the enamel and 52% extending into the dentine. The highest prevalence of "cuppings" (73%) was found on the first lower molars, especially the mesiobuccal cusp of the teeth. The prevalence and severity of dental erosion was found to be higher in male than in female participants ($p < 0.0001$).

Conclusions The results from this study indicate a high prevalence and severity of dental erosion among adolescents in Troms and stress the importance of information, early and effective diagnostics and implementation of prevention strategies.

Keywords Adolescents; Dental erosion; Prevalence.

Introduction

In the recent years, the areas of interest in dental healthcare have changed significantly. Whilst the incidence of caries has decreased in the Western world, the focus has shifted to the apparent increase in prevalence of dental erosive wear [Marthaler, 2004]. Many researchers and clinicians have found dental erosive wear to be a growing problem among children, adolescents and adults, and has been assumed that the prevalence of this condition is higher today compared to 10-15 years ago [Mulic et al., 2012a]. One of the reasons suggested is that the consumption of acidic drinks—thought to be one of the most important factors leading to dental erosive wear—has increased greatly over the past decades [Lussi et al., 2004]. Despite the fact that the reported prevalence of dental erosive wear vary due to wide methodological variations [Kreulen et al., 2010] and cannot be directly compared, there are indications that it is relatively common among children and adolescents [Arnadottir et al., 2010; Hasselkvist et al., 2010; Margaritis et al., 2011]. In children (2-7 years old) the prevalence has been reported to range from 0 to 34% in primary teeth, in adolescents (11-20 years old) the values range from 2 to 53%, and in adults (>22 years old) from 11 to 77% [Arnadottir et al., 2010; Daly et al., 2011; Isaksson et al., 2014; Hasselkvist et al., 2010; Lussi et al., 1991; Margaritis et al., 2011; Mulic et al., 2012b; Søvik et al., 20014]. Recently, several studies investigating the prevalence of dental erosion in the Nordic countries have been reported. In a study on Icelandic adolescents, the prevalence of dental erosion was found to be 16% and 30% in 12 year-olds and 15 year-olds, respectively [Arnadottir et al., 2010]. A study carried out in Oslo, reported that 38% of the 1456 investigated 18-year-olds exhibited dental erosive wear [Mulic et al., 2012b]. This study was recently repeated in Rogaland, where 59% of the investigated 16-18-year-olds suffered from erosive wear [Søvik et al., 2014]. Data collected from Swedish adolescents further indicated that the prevalence of erosive damage is significant. Hasselkvist and co-workers reported a prevalence of 22% in 18- and 19-year-olds [Hasselkvist et al., 2010], while Isaksson and co-workers estimated that 75% of the 494 20-year-old adolescents studied showed dental erosion [Isaksson et al., 2014]. Erosive damage on permanent teeth in children and adolescents may compromise the dentition for the rest of their lives and may require repetitive and complex restorations. As a result, it is important to detect erosive wear at an early stage so that necessary preventative measures can be implemented. It is also important to investigate the prevalence and severity of dental erosion in the population in order to raise awareness among clinicians and other healthcare professionals to increase the focus on this condition.

No prevalence studies regarding dental erosion have been carried out in Northern Norway, and hence the aim

of this study was to identify the prevalence, distribution and severity of erosive damage among 16-year-old adolescents in Troms. This study will provide important knowledge regarding the prevalence of this condition in adolescents.

Materials and methods

Data collection

The data used in this study was collected from a section of the Tromsø study, a comprehensive study concerning chronic diseases and population health in Northern Norway. In 2010-2011, all first-year upper-secondary school students in the two neighboring municipalities in Northern Norway, Tromsø and Balsfjord, were invited to join the cross-sectional health survey Fit Futures [Winther et al., 2014]. Fit Futures details the health of adolescents and included a dental examination for the first time in 2011, consisting of a standard clinical examination and bitewings. In addition, intraoral photographs were taken. An experienced dentist carried out the examinations and the collected clinical variables were: caries, quality of the filling material, periodontal health, disruptions in the mineralisation of the enamel, trauma to the dentition and dental erosive wear. As a part of the clinical examination, eight photographs (Canon EOS 60D; Canon 105 mm; Sigma EM-140 DG) were taken by one dental assistant in the following order: the buccal surfaces of the teeth in the first and fourth quadrant (#1), the corresponding surfaces in the second and third quadrant, the buccal surfaces of the upper and lower anterior teeth (#3), the occlusal surfaces of the upper teeth (#4 & 5) and lower teeth (#6 & 7), and the palatal surfaces of the upper anterior teeth (#8). All the pictures were coded to ensure the anonymity of the participants.

Study sample size and method

Of the 1137 individuals invited to participate in the Fit Futures, 1010 accepted (response rate: 92.9%). Only adolescents aged 16 years at the time of examination were included in the present study ($n = 868$) and 45% of the individuals ($n = 392$) were randomly selected for scoring of dental erosive wear. High quality intraoral photographs, 8 for each participant, were used to score the erosive lesions. The clinical photographs of the 392 adolescents were shown on a flat screen in a room with indirect, standardised lighting and examined independently by three experienced dentists. Buccal and palatal surfaces on all upper incisors and occlusal surfaces on all first permanent molars were included in the examination. Dental erosive wear was scored according to the Visual Erosion Dental Examination (VEDE) system with the following criteria: grade 0 = no erosion; grade 1 = initial loss of enamel, no dentine exposed; grade 2 = pronounced loss of enamel, no dentine exposed; grade 3 = dentine exposed, $< 1/3$ of the surface involved; grade

4 = dentine exposed, $1/3 - 2/3$ of the surface involved; grade 5 = dentine exposed, $> 2/3$ of the surface involved [Mulic et al., 2010]. The reliability of this scoring system has been tested and found to be sufficient [Mulic et al., 2010].

Calibration

Three experienced dentists examined the clinical images from Fit Futures and scored the dental erosive wear according to VEDE. Prior to the study, the observers were calibrated using 74 intra-oral photographs. Both the calibration and the subsequent scoring of dental erosions were carried out in the same room, using the same LCD screen and identical lighting. In order to calculate the intra-observer agreement, the same calibration material was scored a second time after 21 days.

Ethical approval

The study was approved by the Norwegian Social Science Data Services (NSD) (2009/1282), the Regional Committees for Medical and Health Research Ethics (REK) (2011/1702/REK nord) and Biobank. Written informed consent was obtained from all the participants, which the participants signed at the study site.

Statistical analyses

The statistical analyses were performed using SPSS version 19 (Statistical Package for the Social Sciences; SPSS Inc., Chicago, IL, USA), using descriptive statistics with frequency distribution. The significance level was set to $\alpha = 0.05$. Inter- and intra-observer agreement was expressed by the weighted kappa, κ_w [Landis and Koch, 1977] and calculated using Microsoft Excel.

Results

Calibration

The average inter-observer agreement expressed by weighted kappa (κ_w) on the photographs was calculated to be 0.84 for the three dentists, and the intra-observer agreement was 0.71 (observer 1), 0.73 (observer 2) and 0.89 (observer 3), which indicated good agreement [Landis and Koch, 1977].

Exclusion of surfaces

Out of 4704 surfaces of 392 participants, 240 (5.1%) were found to be illegible and excluded: 220 surfaces due to orthodontic treatment (brackets) and 20 surfaces because of fillings, which covered most of the surface, or comprehensive deformities in the enamel.

Prevalence and severity of dental erosive wear

Of the 392 adolescents studied, 148 (38%) exhibited dental erosive wear and 244 (62%) showed no erosive lesions. Looking at the severity of the erosions,

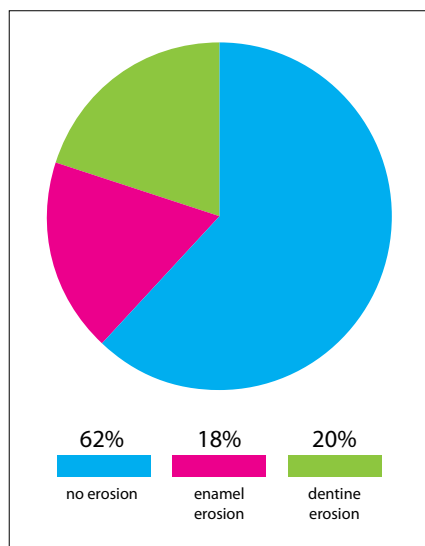


FIG. 1 Prevalence of dental erosions in the examined population (n=392), divided into individuals without erosions, with only enamel- or dentine erosions.

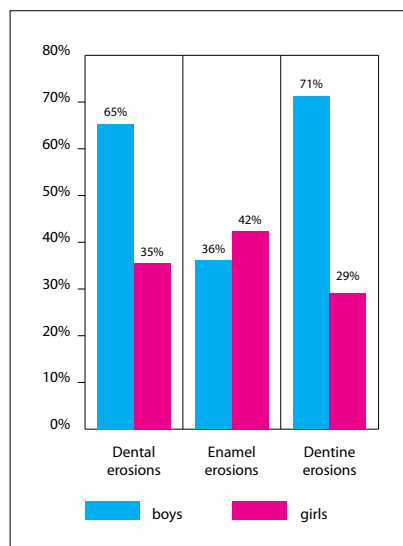


FIG. 2 Portion (%) of females and males with dental erosive wear limited only to the enamel or extending into the dentine (n=392).

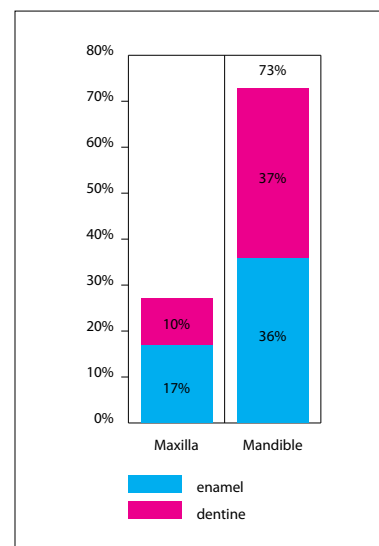


FIG. 3 Localisation of "cuppings" on the first permanent molars. Percentage calculated from the sum of "cuppings" in the upper and lower jaw.

approximately equal numbers of participants with enamel and dentine erosions were found. Figure 1 shows the distribution of healthy surfaces (grade 0), surfaces with enamel lesions (grade 1-2) and surfaces with lesions extending into the dentine (grade 3-5). In the group of participants with dentine erosions (20%), half showed only dentine erosions and half exhibited both enamel and dentine erosions. Of the group with dental erosive wear localised to the enamel (18%), 76% had ≤ 2 affected surfaces while the rest (24%) had 3 or more. The gender distribution of the participants studied was almost equal, 199 (51%) were male and 193 (49%) were female. A significantly higher share of males (65%) exhibited dental erosive wear ($p < 0.001$), and lesions extending into the dentine were also more common in male adolescents ($p < 0.001$) (Fig. 2). When assessing the severity of the dental erosions based on the type of tooth, more erosive wear was found on molars (18%) compared to both the central incisors (11%) and lateral incisors (10%) (Table 1). On the upper central incisors erosive wear limited to the enamel was most common, while about the same amounts of enamel and dentine lesions were found on the molars. When comparing the level of dental erosion on the first permanent molars significantly more erosive lesions were found in the lower jaw, 8% in the upper and 29% in the lower jaw, respectively. In general, a larger number of surfaces affected with dentine erosions compared to enamel erosions were found in the lower jaw, while erosions into the enamel were most common in the upper jaw. "Cupping" on the molars was found in 136 of the 148 participants with dental erosive wear. They were equally distributed between individuals with enamel erosions only (48%) and those with both enamel and dentine erosions (52%). Of the participants with

erosions limited to the enamel, 62% had 1 "cupping" and 12% had 3 or more. In the group of participants with dentine erosions only 18% had 1 "cupping", while 45% had 3 or more (Table 2). In total, 309 "cuppings" on the first permanent molars were registered, 85 (27%) in the upper jaw and 224 (73%) in the lower jaw. In the upper jaw the "cuppings" were localised in the enamel, while in the lower jaw they were equally common in the enamel and dentine. The mesiobuccal cusp was most often affected (75%, $n = 231$).

Discussion

This study showed that 38% of 16-year-olds in Troms exhibited dental erosion, which corresponds well with the study on 18-year-old adolescents in Oslo [Mulic et al., 2012b], but is slightly lower than the prevalence

	Erosions % (n)	Enamel lesions % (n)	Dentine lesions % (n)
LJ central incisors (B og P surfaces)	11 (180)	96 (64)	4 (4)
UJ lateral incisors (B og P surfaces)	10 (151)	100 (43)	0 (0)
1st permanent molars in total (O surfaces)	18 (287)	52 (139)	48 (128)
UJ 1st permanent molars (O surfaces)	8 (60)	74 (40)	26 (14)
OJ 1st permanent molars (O surfaces)	29 (227)	46 (99)	54 (114)

UJ: upper jaw; LJ: lower jaw; B: buccal surfaces; P: palatal surfaces; O: occlusal surfaces

TABLE 1 Prevalence of erosions on different teeth surfaces.

Lesion	Individuals %(n)	Individuals w cupping %(n)	1 cupping %(n)	2 cuppings %(n)	≥3 cuppings %(n)
Enamel	48 (71)	48 (65)	62 (40)	26 (17)	12 (8)
Dentine	52 (77)	52 (71)	18 (13)	37 (26)	45 (32)
Total	100 (148)	100 (136)			

TABLE 2
Prevalence
and severity of
"cupping."

in Rogaland County [Søvik et al., 2014]. Studies from the other Nordic countries [Arnadottir et al., 2010; Hasselkvist et al., 2010; Isaksson et al., 2014] have reported varying prevalence of dental erosive wear in adolescents. The differences in the prevalence may be explained by several factors. One reason might be that both mixed dentition and permanent teeth are included. Some studies score dental erosions on the full dentition ("full mouth recording"), while others use selected index teeth and surfaces. Studies from different countries with differing dietary habits and lifestyles will also influence the results.

The 16-year-old study group was selected for several reasons. At this age, the selected index teeth, first and second molars and anterior teeth have been present and exposed to erosive challenges for several years. In young people there is a higher probability of finding erosive lesions only, as attrition and abrasion are less present compared with older individuals [Ganss, 2008; Van't Spijker et al., 2009]. Furthermore, the adolescents in this age group are more likely to cooperate during the examination, compared with younger participants.

The registration of the dental erosive wear was performed on index teeth and surfaces. The selection of the surface was based on earlier "full mouth recording" studies among adolescents, demonstrating highest prevalence of dental erosion on occlusal surfaces of molars and labial and palatal surfaces of maxillary anterior teeth. In addition, a full mouth scoring is time consuming and it may decrease the accuracy of the scoring system and diagnosis of dental erosive wear [Young et al., 2008]. Furthermore, in the present study, it was considered important to distinguish between erosive wear and wear assumed to be pure attrition/abrasion. Surfaces and teeth, such as mandibular front-teeth, supposed to be influenced by attrition/abrasion were thus excluded.

In this study the data was collected from clinical intraoral photographs, which is advantageous, provided that the photographs are of high quality. The observer can spend an unlimited amount of time examining the photos and the scoring can easily be repeated. However, it is important to validate the method of scoring dental erosive lesions from photographs compared to the dental clinic. A study by Al-Malik [2001] where scoring of erosions in children in the clinic was compared with scoring of erosions from photographs concluded that both methods are valid. Photographs and a clinical examination were also used by Hove et al. [2013] for scoring of dental erosions and Boye et al. [2013] for caries, and both studies found no significant difference

between these methods.

Identical study methods, same sample size, use of the same grading system, calibrated clinicians, choice of the index teeth and the age of the participants allow for the comparison of prevalence of dental erosion in this study with the two other studies from Norway [Mulic et al., 2012b; Søvik et al., 2014].

The prevalence and severity of dental erosions was found to be significantly higher in males than females. This corresponds well with the previous studies [Hasselkvist et al., 2010; Mulic et al., 2012b; Søvik et al., 2014]. Several reasons for this observation have been suggested. Smith et al. [2006] showed that the enamel was significantly thicker in females than males, while Bardsley et al. [2004] suggested that the reason was differences in the strength of the chewing musculature and consumption of carbonated beverages. The latter is also in accordance with other studies [Hasselkvist et al., 2010; Isaksson et al., 2014; Mulic et al., 2012c].

The prevalence of dental erosive wear was most frequent on the occlusal surface of the first permanent molars in the lower jaw, and there was also more erosive damage on the palatal surfaces than the buccal surfaces in the upper jaw, which is supported by findings in several studies [Arnadottir et al., 2010; Mulic et al., 2012b]. Amaechi et al. [1999] suggested this to be due to a thinner pellicle on the palatal surfaces in the upper jaw as well as the abrasive effect of the tongue on acid-exposed enamel. Furthermore, the observed higher prevalence of erosions on the central incisors compared to the lateral incisors in this study may be explained by the later eruption of the lateral incisors.

Of all the occlusal surfaces in the lower jaw 29% were affected, while only 8% exhibited erosive lesions in the upper jaw. The higher prevalence of erosions on the first permanent molars in the lower jaw, also evident in other studies [Arnadottir et al., 2010; Isaksson et al., 2014; Mulic et al., 2012b], may be explained by several reasons. The first permanent molar erupts first and is therefore exposed to acid beverages and food longer than the other teeth in the dentition [El Aidi et al., 2010], the thickness of the enamel of the molars in the lower jaw has been shown to be thinner than in the upper jaw and the enamel of the first permanent molars is also thinner than the enamel of the second and third permanent molars [Smith et al., 2006].

"Cuppings" was found in a large portion of the 16-year-olds and 73% of these were found in the lower jaw. The mesiobuccal cusp was most frequently affected, in accordance with previous studies [Arnadottir et al., 2010; El Aidi et al., 2010; Mulic et al., 2012b].

Studies from Australia have shown that “cuppings” are most frequent and severe in young patients (< 27 years old) and the reason is thought to be higher intake of acidic beverages in children and adolescents [Khan et al., 2001]. Kono et al. [2002] have shown that the layer of enamel near the top of the cusps on the first permanent molars in the upper and lower jaw is relatively thin, and it is speculated whether “cuppings” can occur by exposure of the deeper layers of enamel of lower hardness. As this phenomenon may be a result of attrition/abrasion one might criticise the claim that this is a clear criterion for initial or progressive erosive wear. Attrition/abrasion is not very common in adolescents in industrialised countries, and hence it is more likely that the reason for “cupping” is exposure to acidic beverages and foodstuff than abrasion [Ganss, 2008]. Today, it is more commonly accepted that “cupping” on the first permanent molars is an early sign of erosion.

In 2012, Mulic et al. [2012a] carried out a study in the Public Dental Health Service (PDHS) in Norway investigating clinicians’ knowledge and experience of dental erosion. It was revealed that most clinicians are relatively updated on the field and are able to assess the cause and implement the necessary treatment. Although clinicians today feel confident in the treatment of dental erosion, the prevalence and severity of the condition in general is likely to increase and there are no strategies for the prevention of dental erosion in place. Dental erosive wear have a multifactorial background, where lifestyle factors play the most important role. Changes in lifestyle are very challenging to accomplish, and today helping people choosing a healthier lifestyle imposes a cost on society. New and better strategies for achieving this are most welcome. Recently, research has focused on methods like cognitive behavioural therapy and motivating interview techniques as new tools. In a study from Sweden investigating the prevention of periodontal diseases, these novel methods were found to be more advantageous than the more traditional approach and more patients were able to change their lifestyle [Jonsson et al., 2012]. Perhaps these methods can be applied to prevention of dental erosion as well.

The adolescents who present dental erosive wear today are likely to require further treatment and comprehensive restorations later in life. Dental erosion will therefore also be a challenge in the future. This will be costly for both the individual and society; in addition to the subjective discomforts eroded teeth can lead to. More research into the cause and progression of dental erosions is required, as well as implementation of effective prevention measures against dental erosive wear, at both the individual and population level.

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