IN BRIEF

- This is the first study to show that water fluoridation protects from dental erosion/toothwear in 14-year-old children.
- The benefits of water fluoridation as a public health measure is strengthened.
- This particular study shows that dental erosion/toothwear is a 'disorder of affluence'.

VERIFIABLE CPD PAPER

Epidemiological studies of tooth wear and dental erosion in 14-year-old children in North West England. Part 1: The relationship with water fluoridation and social deprivation

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Objective The effect of water fluoridation upon dental erosion/tooth wear in the UK has not been investigated. This study aimed to compare the prevalence of tooth wear in 14–year-old schoolchildren in non-fluoridated and fluoridated districts of North West (NW) England. The influence of deprivation and tooth brushing was also investigated.

Design A random sample of 10% of the 14-year-old population in NW England was selected and stratified according to fluoridation status as determined from water authority postcode listings.

Methods Tooth wear was scored on the labial, incisal and palatal/lingual surfaces of the 12 anterior teeth and the occlusal surfaces of the first molars. Enamel wear was scored 0, dentine was scored 1 or 2, dependent on whether less than or more than a third of the surface had exposed dentine. Secondary dentine or pulpal exposure scored 3. Townsend deprivation scores were gained from residential post codes.

Results A total of 2,351 children were examined, of which 637 (27%) lived in the one fluoridated district of South Cheshire and 1,714 (73%) lived in 11 non-fluoridated districts. Fifty-three per cent of the children had exposed dentine with significantly more males affected than females ($p<0.001$). In the fluoridated district, significantly fewer children had exposed dentine on labial and palatal smooth surfaces ($p<0.001$) but no differences were found for incisal and occlusal surfaces. The interaction of fluoridation and tooth brushing twice per day resulted in a significant (30%) reduction in erosion. Smooth surface wear was more prevalent in children resident in affluent areas.

Conclusion Children in non-fluoridated districts are 1.5 times more likely to have smooth surface wear compared with children in fluoridated districts. Fluoridation and use of fluoridated toothpaste twice a day provide added protection from dental erosion. The risk of tooth wear is greater with increasing affluence.

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INTRODUCTION

Tooth wear of multifactorial aetiology (erosion, attrition and abrasion) is a well-recognised problem in dentistry. Its increase in prevalence and severity is a major concern for the dental profession. Epidemiological studies have been published but the results are not easily comparable because of the wide range of indices used to measure and record tooth wear or erosion and the inevitable variation in diagnostic criteria. Further difficulty arises in distinguishing between wear caused primarily by acid erosion as opposed to that caused mainly by abrasion and/or attrition. Presentation of data on smooth surface wear and exclusion of incisal and occlusal surfaces attempts to overcome this problem.

The 1993 UK National Survey of Children's Dental Health looked at erosion for the first time and reported 37% of 14-year-olds had erosion of palatal enamel without affecting the dentine.[1] Among 9–12-year-olds, 1% had erosion into dentine, rising to 2% of 13–15-year-olds . The upper four incisors, however, were the only teeth examined in the National Survey. When all teeth were examined in 14-year-olds, dentinal exposure on smooth surfaces was reported to be 8% and 9%.[2,3]

Fluoridation has been shown to reduce caries, but to date, the theoretical protection against erosion has scarcely been investigated. Teo *et al.* reported that fluoride exposure during the first 12 years of life in an Australian sample conferred a degree of resistance to acid erosion in adulthood, although the results must be interpreted with caution because of the small sample size of 49 subjects.[4] The influence of topical fluoride on the degree of abrasion of acid eroded enamel has been investigated.[5,6] Enamel blocks cycled between 5 min acid immersion and linear tooth brushing resulted in significantly less wear with the fluoride toothpaste compared with an otherwise identical non-fluoride formulation.[5] Brushing eroded bovine enamel with acidulated fluoride gels with a pH of 4.5 and 7.0 were compared with unfluoridated gels with the same pHs. Abrasion depth *in vitro* was significantly greater with the non-fluoridated gels and the fluoridated acidic gel produced less abrasive wear than its neutral counterpart.[6]

The literature on the relationship between tooth wear and social class is conflicting. Children from low socio-economic groups had statistically less erosion than those from higher groups in a prevalence study of four- and five-year-olds attending schools in opti-

mally fluoridated areas.[7] However, more wear was observed in teenagers from lower socio-economic groups as assessed by two different indices of social deprivation.[2,3] This study aimed to assess the relationship between fluoridation and dental erosion/tooth wear in 14-year-old schoolchildren, from mixed socio-economic backgrounds, resident in the North West of England. Local Research Ethics committee approval was obtained prior to commencing the study.

METHODS

The Community Dental Services in the North West of England undertake dental surveys of 14-year-old school children every four years, as part of the British Association for the Study of Community Dentistry (BASCD) continuing national caries epidemiology programme. A prevalence study of tooth wear was carried out in tandem on a sample of these children, between January and July 1999. Lists of districts and schools were provided by the North West Dental Public Health Resource Centre based in Preston. The survey population were all those children attending maintained schools who had reached the age of 14 years but had not attained their 15th birthday on the date of examination. The sample of children were randomly selected using a two-stage sampling frame, first by random selection of the districts from a total of 30 districts followed by the selection of schools; urban, semi-rural, rural, fluoridated and non-fluoridated areas were represented. Fluoridation status was determined from each child's home postcode, cross-referenced to the NW Water Authority fluoridation listing. The desired sample size was determined by the power calculation for a 4:1 control case ratio with 100 cases.[8] An approximate prevalence of 10% with dentine exposure in this age group therefore required a minimum of 1,000 children to gain 100 cases. The protection afforded by fluoridation was postulated to be a 50% reduction of dentine exposure by erosion/wear although there was no previous work to support this figure. A further power calculation on the population of children in the fluoridated Crewe district in South Cheshire indicated that all 600 children would have to be included for a statistically significant difference to be detected. A 25% safety margin was deemed desirable and so the sample size was set at 2,000 children.

Examinations were carried out by a single calibrated examiner (PB) at the schools under standardised conditions. Examinations were conducted with the aid of a dental mirror and Daray® angle poise extra-oral light source (Daray Lighting Ltd, Leighton Buzzard, Bedfordshire, UK). Teeth were dried during the examination using cotton wool rolls. Cross-infection control measures were followed as prescribed by the Mersey Regional Health Authority protocol for Dental Epidemiological Studies. Tooth wear was scored on the labial, incisal and palatal/lingual surfaces of the six upper and lower anterior teeth and on the occlusal surfaces of all four first molars (total surfaces = 40). Surfaces were scored in accordance with a modified version of the Tooth Wear Index.[9] Orthodontically banded, carious or heavily restored surfaces were not scored. 'Cupping' of molar cusps was given a score of 1. In effect, tooth wear was dichotomised as the presence or absence of dentinal exposure, as shown in Table 1.

Table 1. Simplified scoring criteria for tooth wear

SCORE	
0	no wear into dentine
1	dentine just visible (including cupping) or dentine exposed for less than a third of the surface
2	dentine exposure greater than a third of the surface
3	exposure of pulp or secondary dentine

Training and calibration exercises were undertaken before commencement and during the study. Study casts were initially used for training purposes, followed by examination and calibration of clinical cases for assessment of inter-examiner reproducibility. Progression to large scale calibration exercises on classes of 14-year-olds prior to commencing the study as well as during the study facilitated a check on intra-examiner reproducibility.

In addition to tooth wear scores, other demographic details were recorded including the school name and full name of the child, with date of birth and residential postcode (when known), allowing determination of Townsend scores. The length of time that the child had been resident in that district was also recorded. Any child who had not attained their 14th birthday or who had achieved their 15th birthday on the day of examination was excluded. Prior to the examination, consent to participate in the study was obtained from the parents and pupils.

A statistical data analysis package, SPSS 10.0, was used to capture and analyse the data. Categorical data, such as gender difference and fluoridation status were analysed by Chi-square.

RESULTS

A total of 2,385 children were examined for tooth wear; of these 1,139 (48%) were male and 1,246 (52%) were female. A total of 1,276 children (53% of the total sample) had at least one tooth surface with exposed dentine, with gender distribution as in Table 2. The mean number of surfaces with exposed dentine per child was two. Significantly more males (n=677) had dentine exposed than females (n=599) (χ^2 =30.9, p <0.001).

Table 2 The distribution of exposed dentine on any tooth surface according to gender

	Dentine exposed	Dentine not exposed	Total
Male	677 (28%)	462 (20%)	1,139 (48%)
Female	599 (25%)	647 (27%)	1,246 (52%)
Total	1,276 (53%)	1,109 (47%)	2,385 (100%)

Incisal or occlusal wear into dentine was seen most frequently on central incisors and lower first molars, as shown in Figure 1. 1,198 children (50%) had dentine exposed on the occlusal and/or incisal surfaces, of whom 915 (38% of sample) exhibited incisal wear through to dentine and 575 (24% of sample) exhibited wear into dentine on one or more molar occlusal surfaces. Only two children scored 2 or 3 (ie more than 1/3 dentine exposed) on all four occlusal surfaces. The prevalence of lower lingual wear into dentine was low (0.3%) compared with upper anterior palatal wear, with 201 (8%) children exhibiting palatally exposed dentine. Altogether, 686 (29%) children had tooth wear into dentine on occlusal and/or palatal surfaces.

Fluoridation status was known by postcode for 2,351 children. Thirty-four children (1%) did not know their postcode, or gave it incorrectly. Their residential fluoridation status could not be determined and therefore they were excluded from further analysis. 1,714 (73%) did not live in the fluoridated district (812 (35%) males: 902 (38%) females). A total of 637 (27%) lived in the one fluoridated district of South Cheshire (312 (13%) males and 325 (14%) females). When all surfaces were examined, 1,261 children (54%) exhibited dentinal exposure on at least one surface. Of these 873 lived in the non-fluoridated districts and 388 in the fluoridated district (Table 3). There were significantly more cases of tooth wear in the fluoridated group when all examined surfaces were considered (χ^2=18.6, p<0.001). However, when dentinal exposure on labial and palatal surfaces was analysed, there was significantly less wear on smooth surfaces in the fluoridated group of children (χ^2=4.17, p<0.05; 95% C.I. 0.1% to 5.2%) (Table 4).

A total of 1,344 children had been resident at the same address for all of their life; 626 (47%) were male and 718 (53%) female. The fluoridation status could be determined for 1,331 of these children, with 383 (29%) of the 14-year-olds benefiting from fluoridated water since birth. Life long exposure to fluoride in the water sup-

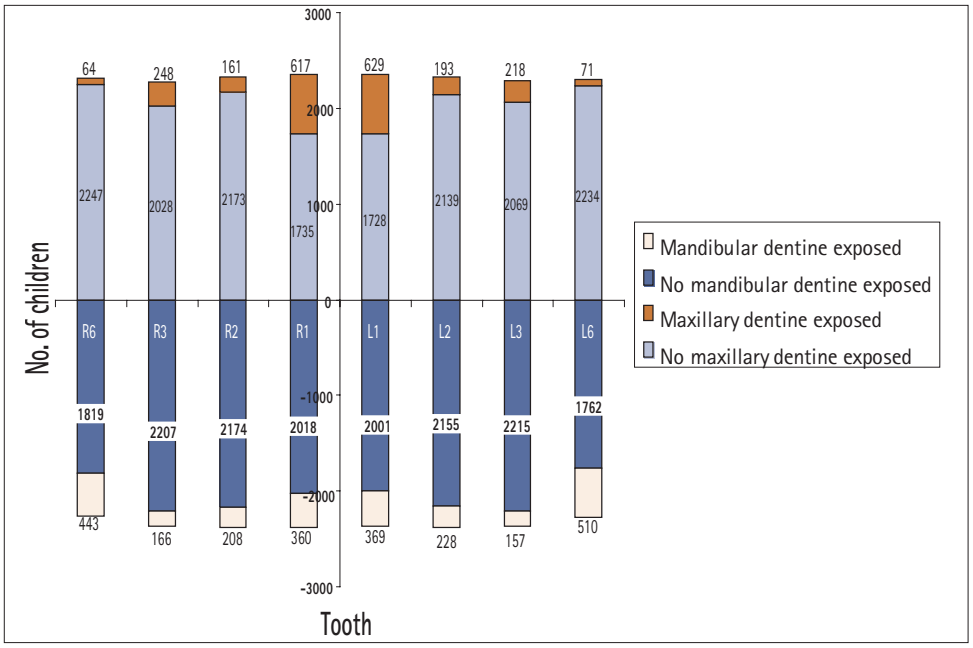

Fig. 1 Intra-oral distribution of incisal and occlusal wear

ply did not result in a statistically significant reduction in the number of surfaces with tooth wear.

The relationship of affluence/deprivation upon smooth surface tooth wear using the Townsend index was also considered. The boundaries between categories were determined by the quartiles obtained from the data. After controlling for fluoridation, the proportion of children (95% confidence limits) with smooth surface wear is shown in Figure 2. The positive Townsend scores indicate social deprivation whilst negative scores represent affluence. The trend is for a greater prevalence of smooth surface wear in the children from non-fluoridated districts. Amongst more affluent children (Townsend score ≤–3) a greater protective effect from fluoridation can be seen. There was no indication of any gender difference as regards tooth wear on labial/palatal surfaces.

A stepwise logistic regression analysis for smooth surface tooth wear gave a statistically significant effect for both fluoridation and the Townsend deprivation index (p<0.001). Those living in non-fluoridated districts are 1.5 times more likely to have tooth wear than those in the fluoridated districts. In terms of deprivation the chance of having tooth wear increases with increasing affluence. Those with an index of –3 are 1.5 times more likely to have tooth wear than those with an index of +3.

Table 3 The distribution of cases with dentinal exposure on any surface by fluoridation status

	Dentine exposed	Dentine not exposed	Total
Non-fluoridated	873 (37%)	841 (36%)	1,714 (73%)
Fluoridated	388 (16%)	249 (11%)	637 (27%)
Total	1,261 (53%)	1,090 (47%)	2,351 (100%)

Table 4 The distribution of labial and palatal smooth surface wear by fluoridation status

	Dentine exposed	Dentine not exposed	Total
Non fluoridated	180 (8%)	1,534 (65%)	1,714 (73%)
Fluoridated	49 (2%)	588 (25%)	637 (27%)
Total	229 (10%)	2,122 (90%)	2,351 (100%)

Table 5 Parameter estimates in logistic regression model for interaction effects of fluoridation, toothbrushing twice per day and Townsend Score

Term	Estimate	SE	Chi-square	P
Fluoridation *brushing twice per day	-1.053	0.412	6.157	0.013
Fluoridation *Score >0 Townsend	-0.616	0.341	3.263	0.05

The interaction of fluoridation and tooth brushing with fluoride toothpaste was also assessed in a logistic regression model. The interaction of fluoridation and brushing teeth twice per day resulted in a reduced risk of tooth wear in children resident in the fluoridated district (Table 5).

DISCUSSION

This study of a random sample of 14-year-olds considered the number of individuals, the number of teeth and the number of surfaces affected by tooth wear. Tooth wear was measured on a four point ordinal scale with the degree of dentine exposure as the defining criterion. Evidence from calibration exercises has revealed lack of uniformity when assessing enamel surface wear only, but dentinal exposure was considered a more reliable measure.[1]

Inter-examiner reliability between PB and AM resulted in a Kappa value of 0.7 whilst the intra-examiner values ranged from 0.6 (at the start) to 0.8 at the conclusion of the study. Differential diagnosis of attrition, erosion or abrasion from clinical examination alone can be difficult, and in many cases the aetiology is multifactorial. The interest in dental erosion and associated risk factors has led many authors to correlate various potential aetiologies with

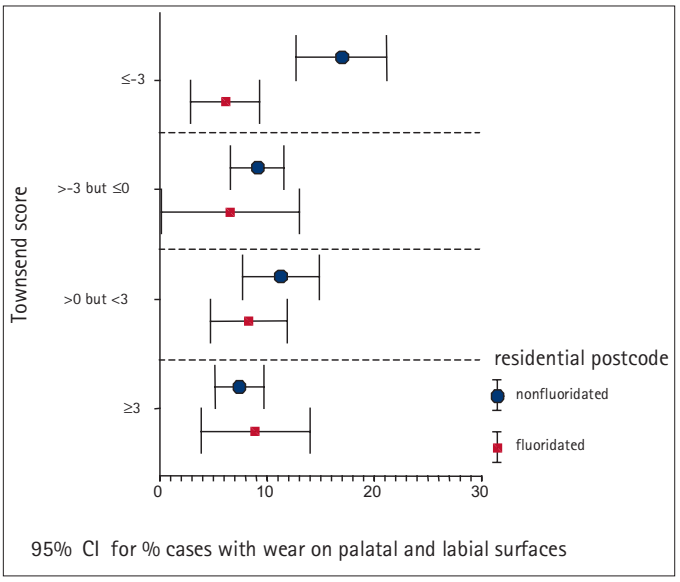

Fig. 2 Distribution of tooth wear by social class for fluoridated and non-fluoridated groups

dental erosion when in fact abrasion, attrition or a multi-factorial aetiology was present. Tooth wear can be described in terms of the area or depth of exposed dentine on any particular surface. Problems arise when this is labelled as erosion, abrasion or attrition. One attempt to overcome this problem, is to relate surface specificity with one mode of wear and discount the effect of other aetiologies. The smooth labial and palatal surfaces, therefore, are deemed to be more likely to have undergone erosion rather than attrition or abrasion. The results have been partly presented as such although this presumption overlooks the influence of abrasion labially and attrition palatally. In a normal class I incisal relationship, a complete overbite provides contact guidance of the lower incisal edge against the palatal incline (anterior/incisal guidance).

The prevalence of exposed dentine was 53% (1,276 children), a similar figure to the 52% of 418 children sampled in Birmingham[3] but more than the 30% previously reported in Liverpool.[2] Only 1-2% of 12-year-olds in London exhibited dentine exposure.[10] Although, a higher prevalence in older cohorts is to be expected, several years have elapsed since the earlier Liverpool study was carried out and this may indicate evidence of an increase in prevalence (of exposed dentine) in the14-year-old cohort.

Dentinal exposure was commonest on the incisal edges and occlusal surfaces of the lower first molars, which corroborates previous work by Milosevic *et al.* However, the 29% prevalence of children with exposed dentine on the palatal/occlusal surfaces in this study is greater than the 8% of children with palatal/occlusal wear previously reported in Liverpool.[2] The 38% of children with dentine exposed on the incisal edges is similar to that reported by Egermark-Eriksson *et al.*,[11] in 15-year-olds and slightly less than Al-Dlaigan *et al.* reported in the Birmingham study.[3] It may be that the frequency of exposed dentine on incisal edges has remained stable but it has increased on occlusal and palatal surfaces reflecting the importance of an acid cause. This concurs with previous observations that the prevalence of tooth wear in adolescents is increasing.[12-14] Palatally exposed dentine occurred in 8% of this sample compared with the low prevalence in London of only 2% of 12-year-olds[10] and 1% of 14-year-olds.[15] This is harder to explain although regional differences could exist. Significantly more wear amongst males than females supports previous results.[2,3,14] This can be attributed to stronger masticatory musculature and greater biting force in males and it has been reported that boys drink more fizzy drinks than girls.[16]

Prior to this study there have been no investigations to see what (if any) protective influence fluoridation has on tooth wear (particularly erosion) in the UK. Fluoride exposure during the first 12 years of life provided protection from tooth wear in 49 adults from South East Queensland.[4] Wear was attributed to erosion from dietary or intrinsic acid, but diagnostic criteria were not stated. Local council records of water fluoridation and recollection of taking supplements ascertained fluoride experience during the first 12 years of life for each participant, although the reliability of recall was not considered.

In this study the fluoridation status at the time of examination was recorded for 2,351 children by matching residential postcodes to NW Water Authority records. When analysing all examined surfaces the frequency of tooth wear in non-fluoridated districts was not significantly different to fluoridated South Cheshire. However, significantly fewer children had exposed dentine on labial and palatal smooth surfaces in South Cheshire than the non-fluoridated areas. This is in agreement with Teo *et al.*[4] who reported a significantly higher prevalence of 'erosional lesions' on the palatal aspects of teeth in subjects not exposed to fluoridation. These smooth surfaces are more prone to erosion, and fluoridation has a greater protective effect on smooth surfaces. The results presented here indicate that water fluoridation decreases the risk of smooth surface tooth wear by a factor of 1.5. This has not been previously published and reinforces the protective role of this important public health measure.

A number of indices of socio-economic deprivation have been adopted for use by the health services. Using 1991 census data, matched by postcode, the Townsend index adheres closely to the concept of material disadvantage, considering the variables of unemployment, overcrowding, owner-occupancy and car ownership.[17] Affluent areas are given negative values and positive values reflect deprivation. In this study, children from the low socio-economic groups in both the non-fluoridated and fluoridated districts had less tooth wear than those from more affluent areas. This agrees with the results found in the primary dentition of four-year-olds but conflicts with the findings of Al-Dlaigan *et al.*[3] and previous results in Liverpool.[2] Whether dental erosion is a disorder of affluence remains unclear. The eating and drinking habits of teenagers and young adults may well differ from those of young children who are under greater parental control. This could explain differences in tooth wear between primary and permanent dentition. For all categories of Townsend score, the trend was for more tooth wear amongst the children not exposed to fluoridation of their residential water supply, further supporting a protective role.

Possibly of most interest is the significant interaction between fluoridation of the water supply and regular tooth brushing with fluoridated tooth paste. The children who brushed twice per day and received fluoridated water are approximately one-third (0.37) less likely to have dental erosion as those who do not receive fluoridated water and brush less than twice per day.

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