Community Dental Health (2003) **20**, 165–170
Received 21 October 2002; Accepted 24 February 2003

Dental erosion in 5-year-old Irish school children and associated factors: A pilot study

M.A. Harding[1,2], H. Whelton[1], D.M. O'Mullane[1] and M. Cronin[1]

[1]*Oral Health Services Research Centre, University Dental School and Hospital, Wilton, Cork, Ireland;* [2]*North Lee Community Services, Southern Health Board, Cork, Ireland.*

Objective To determine the prevalence of dental erosion in a stratified sample of 5-year-old children and to investigate whether demographic and dietary factors were associated. ***Design*** Cross sectional study in Cork City and County. ***Methods*** A sample of 202 5-year-old children stratified on fluoridation status was selected. Measurement of erosion used a scoring system and criteria based on those used in the UK. Wear on the palatal and labial surfaces of primary maxillary teeth considered to be predominantly erosive was assessed. Demographic and dietary details were collected via a parental questionnaire. Statistical analysis was stepwise logistic regression. ***Results*** In lifetime residents of fluoridated areas (n=114) 47% had evidence of erosion; in 21% erosion had progressed to the dentine or pulp. The corresponding figures in non-fluoridated areas (n=76) were 43% and 21% respectively. The variables significantly associated with erosion to dentine or pulp were low socio-economic status, measured by low family income and the frequency of fruit squash and carbonated drink consumption. ***Conclusion*** The prevalence of dental erosion overall was 47%, in 21% erosion affected the dentine or pulp. Levels in fluoridated and non-fluoridated areas were similar. Low socio-economic status and frequency of fruit squash and carbonated drink consumption were associated with erosion extending to dentine or pulp.

Key words: Carbonated drinks/fruit squash, dental erosion, fluoridated water supply, socio-economic status, tooth wear

Introduction

Tooth wear, particularly dental erosion in children and adolescents, is receiving increasing interest, emphasis being placed on establishing the prevalence and possible risk factors in populations. Tooth wear is the loss of mineralised tooth substance from the tooth surface as a result of physical and/or chemical attack (Walls, 1999). It is an all-embracing term used to describe the combined processes of abrasion, attrition and erosion. The first two are mechanical but erosion is the irreversible loss of dental hard tissue by a chemical process not involving bacteria (Pindborg, 1970). Although it is extremely difficult to separate out the three types of wear and undoubtedly the three co-exist, erosion is cited as the predominant cause of concern in children and adolescents (Millward *et al.*, 1994a; Milosevic *et al.*, 1994; O'Brien, 1994; Hinds and Gregory 1995; Jones and Nunn, 1995; Bartlett *et al.*, 1998; Milosevic, 1998a; Al-Dlaigan *et al.*, 2001a; Al-Malik *et al.*, 2001b).

Measurement of tooth wear is difficult in that some wear is normal throughout life, and no single index has been universally accepted. Smith and Knight (1984) introduced the tooth wear index (TWI), which attempted to provide a solution to some of the problems of measuring wear at the individual level and within the community. The TWI or modifications to it have been used in a large number of studies (Asher and Read, 1987; Millward *et al.*, 1994a; Millward *et al.*, 1994b; Milosevic *et al.*, 1994; O'Brien, 1994; Hinds and Gregory, 1995; Jones and Nunn, 1995; Smith and Robb, 1996; Bartlett *et al.*, 1998; Shaw *et al.*, 1999; Williams *et al.*, 1999; Al-Malik, 2000; Shaw *et al.*, 2000; Al-Dlaigan *et al.*, 2001a, 2001b), which would suggest widespread acceptance of the index, although it was described as flawed when used in an ageing population (Donachie and Walls, 1996). Prevalence studies of tooth wear, which have been conducted in the primary dentition, are set out in Table 1. Direct comparisons can not be made due to differences in the indices and age of participants.

Factors that have been implicated in dental erosion are; dict lifestyle and tooth and host factors. The type of drink (Holloway *et al.*, 1958; Imfeld, 1977; West *et al.*, 1998; Hunter *et al.*, 2000;) and the frequency with which the drink is consumed (Linkosalo and Markkonam, 1985; Jarvinen, 1991; Shaw and O'Sullivan, 2000) have been implicated. Cross-sectional studies suggest a high prevalence in the community (Millward *et al.*, 1994a; O'Brien, 1994; Jones and Nunn, 1995), and an association with soft drink consumption (Al-Dlaigan *et al.*, 2001b; Al-Malik *et al.*, 2001b). Research has indicated that lower socio-economic groups have poorer general health and dental health than higher socio-economic groups (Locker, 1993; Moynihan and Holt, 1996). A positive association between tooth wear and social deprivation has been recorded (Milosevic *et al.*, 1994; Jones and Nunn, 1995; Al-Dlaigan *et al.*, 2001a). Millward *et al* (1994a) however recorded the converse. A measure of low socio-economic

Correspondence to: Dr. M.A. Harding, Oral Health Services Research Centre, University Dental School and Hospital, Wilton, Cork, Ireland

Table 1. Studies of the prevalence of tooth wear in the primary dentition

	Age in years	*Any erosion* %	*Erosion to dentine or pulp* %
O'Brien (1994)	5	52%	24%
Millward *et al.* (1994a)	4	30% of upper palatal surfaces showed visible dentine	
Hinds and Gregory (1995)	3.5–4.5	29%	13%
Jones and Nunn (1995)	3	28.9% the most prevalent type involving enamel & dentine	
Al-Malik (2000)	2–5	31%	12.5%

Table 2. Criteria used for the measurement of wear.

Score	*Criteria*	*Description*
0	Normal, no evidence of wear	No loss of surface features, no loss of contour.
1	Tooth wear into enamel	Loss of enamel giving a smooth glazed shiny appearance. Relatively wide shallow concavities on enamel, dentine is not involved. Increased translucency of the tooth due to loss of enamel thickness. Evidence of "rimming" around the cervical margins.
2	Tooth wear to dentine	Extensive loss of enamel with dentine involvement. Exposure of dentine and/or secondary dentine. Distinct evidence of "rimming" around the cervical margins.
3	Tooth wear to pulp	Extensive loss of enamel and dentine with pulp exposure.
9	Could not be assessed	Extensive caries, large restoration, fractured tooth, missing tooth.

status used in Ireland is medical card ownership, which is means tested (O'Mullane and Whelton, 1992; Eastern Health Board, 1994).

With regard to fluoride the beneficial effect on the progression of dental caries is well established, consuming fluoridated water conferring a benefit over and above that of fluoridated toothpaste alone (O'Mullane, 1994). However, its effect on the progression of dental erosion is less clearly understood. Fluoride is nevertheless recommended in the management of dental erosion in the belief that it reduces demineralisation during erosion and promotes remineralisation (Milosevic, 1998b). *In vitro* experiments have demonstrated a positive effect (Spencer and Ellis, 1950; Holloway *et al.*, 1958; Davis and Winter, 1977; Rytomaa *et al.*, 1988; Bartlett *et al.*, 1994; Meurman and ten Cate, 1996). Teo *et al.* (1997) reported that residence in an optimally fluoridated region in childhood resulted in significantly less palatal erosion. Approximately 73% of the Irish population receive an optimally fluoridated water supply.

There is no information on the prevalence of tooth wear/dental erosion in 5-year-old children in Ireland. The aim of this study was therefore to measure the prevalence of dental erosion in a stratified-sample of, five-year-old children in Cork City and County. A secondary aim of the study was to investigate, whether an association existed between residence in a fluoridated area, socio-economic status, dietary factors, reported oral health practices, gender and the prevalence of dental erosion.

Methods

Ethical approval was granted by The Clinical Research Ethics Committee of the Cork Teaching Hospitals, University College Cork. Data were available for 202, 5-year-old children. The sample for this pilot study was calculated based upon figures reported in the 1993 national children's dental health survey in the United Kingdom (O'Brien, 1994). Children were selected on age and whether they attended a school with a fluoridated or non-fluoridated water supply. A total of 18 schools were included, 11 fluoridated and 7 non-fluoridated, the greater number in the fluoridated area explained by the fact that some were single sex schools while all in the non-fluoridated area were co-educational. To provide a socio-economic spread low socio-economic areas were identified and schools from those areas included in the study.

The index used was that described by Al-Malik (2000, 2001a), which is similar to that used in the children's dental health survey in the United Kingdom 1993 (O'Brien, 1994). Dr. R. Holt who was experienced in the use of the index trained and calibrated the examiner (MH) (Kappa 0.80). In the main study 5% (n=12) of subjects were re-examined, (intra-examiner Kappa 0.90). A questionnaire was designed for the study. Children for whom written positive consent was obtained were examined. Children where an existing medical condition may have put them at risk from the examination were excluded, as were children on long term oral or inhaled corticosteroids.

Prior to examination the primary teeth were dried using cotton wool rolls. The palatal and labial surfaces of the maxillary incisor teeth were assessed by visual examination. The descriptive criteria set out in Table 2 were followed. If there was any doubt a lower score was assigned or left out. Although tooth wear in the primary dentition, particularly the upper maxillary incisors may be mainly due to erosion, there is always a component of abrasion or attrition (Millward *et al.*, 1994a). Considering wear on the palatal and labial surfaces as erosion was in keeping with previous surveys of erosion in primary teeth (O'Brien, 1994; Hinds and Gregory, 1995; Jones and Nunn, 1995; Al-Malik *et al.*, 2001b). Wear confined to incisal surfaces was considered to be due to attrition and was excluded.

The parents of each participating child completed

Table 3. Erosion on maxillary incisors by fluoridation status.

	No. examined	*Any erosion*		*Erosion to dentine or pulp*	
		(n)	*%*	*(n)*	*%*
Fluoridated	114	(54)	47	(24)	21
Non-fluoridated	76	(33)	43	(13)	17
Total	190				

Table 4. Erosion on maxillary incisors by income level.

	(n)	*Any erosion*		*Erosion to dentine or pulp*	
		(n)	*%*	*(n)*	*%*
Medical card (low income)	55	(24)	44	(15)	27
No medical card	145	(70)	48	(26)	18
Total	200				

questionnaires at home. The child's oral hygiene practices, dietary practices, whether the child had frequent gastric upset or vomiting and whether the family had a medical card were recorded. Medical cards are provided for those who are on low income or unemployed and were used as a surrogate measure of socio-economic status of the child's family. Information was also sought on the child's current home water supply, duration of residency at that address and previous addresses if any. This information was then cross-checked with information provided by water authorities.

Data from the examination records and questionnaire were entered first in a Microsoft Excel spreadsheet and read into a SAS (version 8.01) database. A double data entry system was used to identify and minimise errors. A child was identified as having dental erosion when they had one or more lesions present on the palatal or labial surfaces of the maxillary incisors. The statistical analyses were conducted using SAS. Descriptive statistics, cross tabulations and logistic regression analysis were performed. Odds-ratios and 95% confidence intervals were calculated for significant factors, the level of statistical significance was 5%.

Results

Data were available for a total of 202 children for whom the mean age was 5.49 (± 0.28) years. The proportion of males was 52% and female 48%. Results are given for the prevalence of any erosion; i.e. erosion to enamel, dentine or pulp combined, and erosion to dentine or pulp (scores 2 and 3). Scores 2 and 3 were combined as the proportion of children with erosion extending to the pulp was low; 4.4% on the maxillary central incisors and 1% on the maxillary lateral incisors.

For the analysis by fluoridation status, children were divided into two groups; those who were lifetime residents of a fluoridated community (n=114) and those who were lifetime residents of a non-fluoridated community (n=76). The 12 children with a partial fluoride history were excluded from this analysis. The proportion of children with any erosion, and erosion to dentine or pulp by fluoridation status are presented in Table 3. In the fluoridated group the proportion of children with any erosion; was 47%, where 21% had erosion to dentine or pulp. In the non-fluoridated group the proportion with any erosion was 43%, where 17% had erosion extending to dentine or pulp.

In children where the family possessed a medical card (low income or unemployed) 44% of the 5-year-olds had erosion on their maxillary incisors where 27% had erosion to dentine or pulp. In the 5-year-old children where the families did not have a medical card (low income or unemployed) the percentage with erosion on their maxillary incisors was 48% with 18% having erosion to dentine or pulp (Table 4). Medical card status was not determined for two children.

In the questionnaire parents indicated the soft drinks consumed by their 5-year-old child; whether fruit juices, fruit squash, or carbonated drinks. They also indicated the frequency with which they were consumed and the method of consumption. The proportion with erosion and erosion extending to dentine or pulp with respect to soft drinks consumed are shown in Table 5. Each parent may not have answered every question, therefore the total may not always sum to 202.

In the data analyses the dependent variables (i) any erosion and (ii) erosion to dentine or pulp were investigated using a multivariate logistic regression. The outcome variables used are indicated in Table 6. When soft drink consumption was examined the frequency of consumption was collapsed into two groups; whether the drinks were consumed less than once a day (labelled A in Table 5) or once a day and more often (labelled B in Table 5).

A stepwise procedure was used to determine the best-fit logistic regression model. In the analysis when the dependent variable any erosion was examined none of the factors were significant. When erosion extending to dentine or pulp was the dependant variable, children where the family had a medical card were at a significantly higher risk of dental erosion to dentine or pulp, odds ratio 2.6, (95% C.I. 1.1, 6.1, p=0.029). This indicated where a family had a medical card the 5-year-olds were 2.6 times more likely to have erosion to dentine or pulp. In the study 40% of the children consumed carbonated drinks once a day or more and had significantly more dental erosion to dentine or pulp (29%) than those that consumed carbonated drinks less than once a day (17%), odds ratio 2.3, (95% C.I. 1.0, 5.0, p=0.043). Similarly 49% of the children consumed fruit squash once a day and more and had significantly more dental erosion to dentine

Table 5. Erosion on maxillary incisors by soft drink consumption.

		Carbonated drinks			*Fruit Squash*			*Fruit Juices*		
		(n)	*Any erosion (%)*	*Erosion to dentine or pulp (%)*	*(n)*	*Any erosion (%)*	*Erosion to dentine or pulp (%)*	*(n)*	*Any erosion (%)*	*Erosion to dentine or pulp (%)*
A	Once a month and less	41	39	12	49	51	16	32	34	19
	Once/Twice a week	72	47	19	40	30	13	62	55	23
B	Once a day	39	49	31	35	49	23	61	44	18
	Twice a day	25	48	24	30	43	30	24	63	38
	Three times a day or more	11	45	36	18	83	56	11	27	0
Totals		188			172			190		

Table 6. Variables used in the multivariate logistic regression.

Dependent variables: (i) Any erosion (ii) Erosion extending to dentine or pulp	
Fluoridated	Full/ None
Medical card	Yes/ No
Carbonated drinks	Less than once a day/ Once a day and more
Fruit squash	Less than once a day/ Once a day and more
Fruit juice	Less than once a day/ Once a day and more
Toothbrushing frequency	Once a day and less/ Twice a day and more
Dental visits	Never/ Once/ Twice or more
Gender	Male/ Female

Table 7. Results of multivariate logistic regression (Erosion to dentine or pulp).

Variable	*p-Value*	*Odds Ratio*	*95% C.I.*
Medical card (low income)	0.029	2.6	1.1,6.1
Carbonated drinks	0.043	2.3	1.0,5.0
Fruit squash	0.002	3.5	1.6,7.9

or pulp (32%) than those who had it less frequently (15%), odds ratio 3.5, (95% C.I. 1.6, 7.9, p=0.002) (Table 7).

Discussion and conclusion

This pilot study consisted of a sample of healthy school going 5-year-old children from fluoridated and non-fluoridated areas in Cork with schools in areas of known low socio-economic status included.

The prevalence reported of 'any' maxillary erosion was 47% overall (fluoridated and non-fluoridated combined) with progression to dentine or pulp in 21% of the sample. In fluoridated areas it was 47%, and in 21% erosion had extended to dentine or pulp. In non-fluoridated areas the proportion with 'any' erosion was 43% in which 17% had erosion extending to dentine or pulp. No statistical difference existed between the fluoridated and non-fluoridated groups. One would have expected less erosion in the fluoridated group, this outcome may be due to the sample selected, or the existence of the 'halo' effect with the absence of a true non-fluoridated group (Newbrun, 1989). The thin layer of enamel in the primary dentition may also be an issue. The existence of modifying factors such as salivary buffering capacity should be considered (Scheutzel, 1996).

The prevalence reported in this study is higher than that reported by Al-Malik (2000) using the same index but children aged 2 to 5-years. The higher prevalence in this study may be due to the fact that dental erosion increases with age (Hinds and Gregory, 1995).

Dietary elements such as citrus fruits and apples (Jarvinen *et al.*, 1991) have been implicated in dental erosion as have yoghurts and pickles. Toothbrushing frequency (Jaeggi, 1999; Lussi and Schaffner, 2000) and dental attendance have also been implicated in the permanent dentition. These were examined with respect to dental erosion in this study but the results were not significant, suggesting a complex inter-relationship between tooth and host factors. There was an association with low socio-economic status which was also reported by Jones and Nunn (1995). In the study daily fruit squash and carbonated drink consumption and erosion extending to dentine or pulp was identified in the primary dentition; Al-Malik *et al.* (2001b) also identified an association with carbonated drink consumption. No association with gastric upset and erosion was shown in this study, this factor may be more important in older populations or where there are particular illnesses, such as gastro-aesphageal reflux or cerebral palsy (Bartlett *et al.*, 1998; Shaw *et al.*, 1999).

Questionnaires used in cross sectional studies have limitations and the possibility of some self-reporting bias occurring cannot be discounted. Despite this, questionnaires completed by parents at home have been used in large studies (O'Mullane *et al.*, 1986; O'Brien, 1994). At the time of examination the examiner was blind to the answers provided in the questionnaire.

To overcome some of the difficulty of distinguishing

erosion from abrasion and attrition, measurement was confined to the palatal and labial surfaces, as in previous studies measuring erosive wear (Millward *et al.*, 1994a; O'Brien, 1994; Hinds and Gregory, 1995; Jones and Nunn, 1995; Al-Malik *et al.*, 2001b). It must be remembered that the three types of wear will sometimes co-exist and that erosion could theoretically affect any tooth or tooth surface. Further work should be undertaken and research must continue into the development of an index that is universally acceptable and which permits comparison between studies.

Acknowledgements

The authors wish to acknowledge financial assistance from GlaxoSmithKline. The cooperation of the children, their parents and teachers is also acknowledged.

References

Al-Dlaigan, Y.H., Shaw, L. and Smith, A. (2001a): Dental erosion in a group of British 14-year-old, school children. Part I: Prevalence and influence of differing socioeconomic backgrounds. *British Dental Journal* **190**, 145–149.

Al-Dlaigan, Y.H., Shaw, L. and Smith, A. (2001b): Dental erosion in a group of British 14-year-old, school children. Part II: Influence of dietary intake. *British Dental Journal* **190**, 258–261.

Al-Malik, M. (2000): Development of an epidemiological index for primary anterior teeth affected by erosion and prevalence of dental erosion in pre-school Saudi children. *PhD thesis*. University of London.

Al-Malik, M., Holt, R.D., Bedi, R. and Speight, P.M. (2001a): Investigation of an index to measure tooth wear in primary teeth. *Journal of Dentistry* **29**, 103–107.

Al-Malik, M.I., Holt, R.D. and Bedi, R. (2001b): The relationship between erosion, caries and rampant caries and dietary habits in pre-school children in Saudi Arabia. *International Journal of Paediatric Dentistry* **11**, 430–439.

Asher, C. and Read, M.J.F. (1987): Early enamel erosion in children associated with the excessive consumption of citric acid. *British Dental Journal* **162**, 384–387.

Bartlett, D.W., Coward, P.Y., Nikkah, C. and Wilson, R.F. (1998): The prevalence of tooth wear in a cluster sample of adolescent schoolchildren and its relationship with potential explanatory factors. *British Dental Journal* **184**, 125–129.

Bartlett, D.W., Smith, B.G.N. and Wilson RF (1994): Comparison of the effect of fluoride and non-fluoride toothpaste on tooth wear *in vitro* and the influence of enamel fluoride concentration and hardness of enamel. *British Dental Journal* **176**, 346–348.

Davis, W.B. and Winter, P.J. (1977): Dietary erosion of adult dentine and enamel protection with a fluoride toothpaste. *British Dental Journal*; **143**, 116–119.

Donachie, M.A. and Walls, A.W.G. (1996): The tooth wear index: a flawed epidemiological tool in an ageing population group. *Community Dentaistry and Oral Epidemiology* **24**, 152–158.

Eastern Health Board (1994): *Children's dental health in the Eastern Health Board Region 1993*. Dental dept., Eastern Health Board and University College Cork. Ireland.

Health (Fluoridation of Water Supplies) Act (1960): Dublin: Stationery Office.

Hinds, K. and Gregory, J.R. (1995): *National diet and nutrition survey: Children aged 1.5 to 4.5 years* Volume 2: Report of the dental survey. Her Majesty's Stationery Office.

Holloway, P.J., Mellanby, M. and Stewart R.J.C. (1958): Fruit drinks and tooth erosion. *British Dental Journal* **104**, 305–309.

Hunter, M.L., West, N.X., Hughes, J.A., Newcombe, R.G. and Addy, M. (2000): Erosion of deciduous and permanent dental hard tissue in the oral environment. *Journal of Dentistry* **28**, 257–263.

Imfeld, T.N.O. (1977): Evaluation of the cariogenecity of confectionery by inter oral wire telemetry. *Helvetica Odontologica Acta* **21**, 1–28.

Jaeggi, T. and Lussi, A. (1999): Toothbrush abrasion of erosively altered enamel after intra-oral exposure to saliva: an *in situ* study. *Caries Research* **33**, 455–461.

Jarvinen, V.K., Rytomaa, I.I. and Heinonen, O.P. (1991): Risk factors in dental erosion. *Journal of Dental Research* **70**, 942–947.

Jones, S.G. and Nunn, J.H. (1995): The dental health of 3-year-old children in East Cumbria 1993. *Community Dental Health* **12**, 161–166.

Linkosalo, E. and Markkonam, H. (1985): Dental erosion in relation to lactovegetarian diet. *Scandinavian Journal of Dental Research* **93**, 436 – 441.

Locker, D. (1993): Measuring social inequality in dental health services research: individual, household and area-based measures. *Community Dental Health* **10**, 139–150.

Lussi, A. and Schaffner, M. (2000): Progression of and risk factors for dental erosion and wedge-shaped defects over a 6-year period. *Caries Research* **34**, 182–187.

Meurman, J.H. and ten Cate J.M. (1996): Pathogenesis and modifying factors of dental erosion. *European Journal of Oral Science* **104**, 199–206.

Millward, A., Shaw, L. and Smith, A.J. (1994a): Dental erosion in four-year-old children from differing socio-economic backgrounds. *Journal of Dentistry for Children* **61**, 263–266.

Millward, A., Shaw, L., Smith, A.J., Rippin, J.W. and Harrington E. (1994b): The distribution and severity of tooth wear and the relationship between erosion and dietary constituents in a group of children. *International Journal of Paediatric Dentistry* **4**, 151–157.

Milosevic, A. (1998a): Toothwear: aetiology and presentation. *Dental Update* **25**, 6–11.

Milosevic, A. (1998b): Toothwear: Management. *Dental Update* **25**, 50–55.

Milosevic, A., Young, P.J. and Lennon, M.A. (1994): The prevalence of tooth wear in 14-year-old children in Liverpool. *Community Dental Health* **11**, 83–86.

Moynihan, P.J. and Holt, R.D. (1996): The national diet and nutrition survey of 1.5 to 4.5-year-old children: summary of the findings of the dental survey. *British Dental Journal* **181**, 328–332.

Newbrun, E. (1989): Effectiveness of water fluoridation. *Journal of Public Health Dentistry* **49**, 279–289.

O'Brien, M. (1994): *Children's dental health in the United Kingdom 1993*. Office of Population Censuses and Surveys. London: Her Majesty's Stationery Office.

O'Mullane, D. (1994): Introduction and rationale for the use of fluoride for caries prevention. *International Dental Journal* **44**, 257–261.

O'Mullane, D. and Whelton, H. (1992): *Oral Health of Irish Adults 1989–1990*. Dublin: Government Publications.

Pindborg, J.J. (1970): *Pathology of the dental hard tissues*. pp 312–321. Copenhagen. Munskgaard.

Rytomaa, I., Meurman, J.H., Koskinen, J., Laakso, T., Gharazi, L. and Turunen, R. (1988): *In vitro* erosion of bovine

enamel caused by acidic drinks and other foodstuffs. *Scandinavian Journal of Dental Research* **96**, 324–333.

Scheutzel, P. (1996): Etiology of dental erosion – intrinsic factors. *European Journal of Oral Science* **104**, 178–190.

Shaw, L. and Smith, A.J. (1999): Dental erosion – the problem and some practical solutions. *British Dental Journal* **186**, 115–118.

Shaw, L., Weatherill, E.D.T. and Smith, A.J. (1999): Tooth wear in children: An investigation of etiological factors in children with cerebral palsy and gastro-oesphageal reflux. *Journal of Dentistry for Children* **65**, 484–486.

Smith, B.G.N. and Knight, J.K. (1984): An index for measuring the wear of teeth. *British Dental Journal* **156**, 435–438.

Smith, B.G.N. and Robb, N.D. (1996): The prevalence of tooth wear in 1007 dental patients. *Journal of Oral Rehabilitation* **23**, 232–239.

Spencer, I.J. and Ellis, L.N. (1950): The effect of fluoride and grapefruit juice on the etching of teeth. *Journal of Nutrition* **42**, 107–115.

Teo, C., Young, W.G., Daley, T. and Sauer, H. (1997): Prior fluoridation in childhood affects dental caries and tooth wear in a South East Queensland population. *Australian Dental Journal* **42**, 92–102.

Walls, A.W.G. (1999): Prevention in the ageing dentition. In: *Prevention of oral disease.* 3rd Edition; ed. Murray, J.J. pp 173–188. New York: Oxford University Press.

West, N.X., Maxwell, A., Hughes, J.A., Parker, D.M., Newcombe, R.G. and Addy, M. (1998): A method to measure clinical erosion: the effect of orange juice consumption on erosion of enamel. *Journal of Dentistry* **26**, 329–335.

Williams, D., Croucher, R., Marcenes, W. and O'Farrell, M. (1999): The prevalence of dental erosion in the maxillary incisors of 14-year old school children living in Tower Hamlets and Hackney, London, UK. *International Dental Journal* **49**, 211–216.