

Is tooth wear in the primary dentition predictive of tooth wear in the permanent dentition? Report from a longitudinal study.

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Objectives: To determine the prevalence of tooth wear in the permanent dentition of a sample of 12-year-old school children and establish whether an association exists between tooth wear recorded now and tooth wear recorded in their primary dentition at age five.

Design: A prospective cohort study. **Methods:** At follow-up to a previous study complete data were available for 123 children; fieldwork was conducted in the child's primary school. Measurement of tooth wear used a scoring system modified from the Smith and Knight Tooth Wear Index (TWI). Tooth wear which had progressed to dentine was assessed on the occlusal surfaces of the four first permanent molars, the labial, lingual/palatal and incisal surfaces of the six upper and six lower anterior teeth; a total of 40 scoreable surfaces. Demographic data were collected from the parents, and a questionnaire on oral hygiene habits, diet and behaviours was completed by each child.

Results: In total 38% (n=47) of subjects had tooth wear, if incisor teeth only were included, 33% (n=40) had tooth wear and similarly if the occlusal surfaces of molar teeth only were included 10% (n=12) had signs of tooth wear. Gender was significantly associated with tooth wear: males had more tooth wear. The presence of tooth wear with dentine exposed in the primary dentition was significantly associated with tooth wear on the occlusal surfaces of the first permanent molars. **Conclusion:** Males had more tooth wear than females. An association existed between tooth wear recorded at age 5 and molar tooth wear recorded at age 12. Tooth wear is a lifelong cumulative process and should be recorded in both the primary and permanent dentitions.

Keywords: Behaviours, diet, longitudinal study, oral hygiene, tooth wear.

Introduction

Tooth wear is an all encompassing term used to describe the non-carious loss of tooth tissue, which may have occurred due to the dissolution of teeth by acids (erosion), the wear of tooth against tooth (attrition), the wear of teeth from other factors (abrasion) and open to debate the non-carious loss of cervical tooth tissue, possibly associated with occlusal loading (abfraction) (Smith, 1989; Bartlett and Shah, 2006).

Greater importance is attaching to tooth wear in younger populations as diets increase in acidity, and snacking frequency on both acidic and sugary foods continues to increase. Early identification of tooth wear is necessary due to these changing practices, coupled with increased longevity and the individuals desire to retain their own teeth throughout life. A growing concern for tooth wear in children and adolescents can be appreciated from the volume of research emerging over the past two decades (Bartlett *et al*, 1998; Al-Dlaigan *et al*, 2001; Al-Malik *et al*, 2002; Dugmore and Rock 2004; Bardsley *et al*, 2004; Wiegand *et al*, 2006) with tooth wear also recorded in both the UK and Irish national surveys (Kelly *et al*, 2000; ONS, 2004; Whelton *et al*, 2006; Whelton *et al*, 2007). Despite the greater importance attaching to tooth wear, dental caries is still the most common childhood disease and one of the most preventable (CDC, 2008). Currently, dental caries in the primary dentition is one of the predictors of dental caries in the permanent dentition (Zero *et al*, 2001).

If tooth wear in the primary dentition were a predictor of tooth wear in the permanent dentition, then early identification would be of long-term benefit. When the subjects in this study were first examined at age 5-years the findings were that 47% of subjects had erosive tooth wear and for 21% erosive tooth wear had progressed into dentine or pulp (Harding *et al*, 2003). At the time of the original study, tooth wear on the labial and palatal surfaces of the upper central and lateral incisors was reported and assumed to have an erosive aetiology. Tooth wear on the incisal surfaces was excluded as this was considered to be principally attrition, and at age five in primary incisors it was accepted as physiological or normal wear. In the time since the original paper was published there has been a greater appreciation of the difficulty of separating out the different types of tooth wear in a cross sectional epidemiological study and for that reason in the absence of an established aetiology and diagnosis, all types of tooth wear are reported collectively.

Objectives

To determine the prevalence of tooth wear in the permanent dentition of the 12-year-old Irish school children originally examined at age five (Harding *et al*, 2003). To determine whether an association exists between tooth wear at age five and tooth wear in the permanent teeth at age 12. To investigate whether an association existed between tooth wear and particular oral hygiene, dietary, behavioural or general health habits.

Methods

In 2000, with ethical approval from the Clinical Research Ethics Committee of the Cork Teaching Hospitals University College Cork, five-year-old children in both fluoridated and non-fluoridated areas in the Cork city and county region were examined. In May 2007, ethical approval was provided for a follow-up study. In the follow-up study, children examined were those, who participated in the original study, provided that they could be contacted, the inclusion and exclusion criteria were met and written positive consent and assent were provided.

Teeth were examined dry, if there was doubt over a particular score as to whether the condition was present, or its severity, then it was either scored 0 or the lower score was applied. No attempt was made to distinguish between the different types of wear. The examinations were conducted at the child's school. A Daray lamp was used as the light source and the children were reclined on a portable dental chair.

The method used to record tooth wear was that described by Bardsley *et al* (2004), a modification of the original Smith and Knight Tooth Wear Index (1984): the six upper anterior teeth, the six lower anterior teeth and the four first permanent molars were examined. A condition score was given to the labial, lingual / palatal and the incisal surface of each anterior tooth and the occlusal surface of each first permanent molar. A maximum total of 40 surfaces could be scored.

- 0 - Loss of enamel surface characteristics can be present but no dentine visible
- 1 - Dentine is visible < 1/3rd, cupping on molar cusp tips. Change in colour
- 2 - >1/3rd dentine exposed
- 3 - Pulp or secondary dentine exposed
- R - Missing/restored/could not be assessed (If 1/4 of a surface was covered by a restoration it was scored R: could not be assessed).

Tooth wear needed to have progressed to dentine before a positive score was assigned. The examiner for the study (MH) was trained and calibrated in the use of the index (Kappa 0.7).

Each child completed a questionnaire on oral hygiene habits, dietary habits, and general health. Parents provided information on any relevant medical history and place of residence. The questionnaire completed by the children was the same as that which their parents had completed for them when they were five-years-old.

Data from the dental examinations were entered directly into a specially designed software programme. The demographic data, and questionnaire replies provided, were entered into an Excel spreadsheet and analysed in SAS (Statistical Analysis Software [version 9.1]).

The statistical methods used were stepwise logistic regression and multivariate analyses, with at 5% level of significance.

Results

When the children were examined at age five, data were available for 202 children of mean age 5.49 (± 0.28)

years, made up of 52% male and 48% female. Of these children, 168 consented to being contacted at a later date. In the current study, complete data are available for 123 children: nine refused to participate, nine were excluded due to incomplete information, five were excluded due to absence on day of the examination and 22 had left their school, providing a response rate of 82%. The mean age of the children was 12.01 (± 0.32) years and comprised 50% male and female (n=62 and n=61) respectively. At the time of the examination, no attempt was made to distinguish between the different types of tooth wear, the index is descriptive. An individual was deemed to have tooth wear when they had at least one positive score. The majority of scores were 'score 1' with a small proportion of 'score 2', and the scores were predominantly for the incisal surface of the incisor teeth.

The overall prevalence of tooth wear was 38% (n=47), where 50% of males (n=31) and 26% of females (n=16) had tooth wear. In the case of the incisor teeth, 40% (n=25) of males and 25% (n=15) of females exhibited incisor tooth wear, with an overall prevalence of 33% (n=40) for tooth wear on incisor teeth. On the molar teeth, 16% (n=10) of males and 3% (n=2) of females had signs of tooth wear, while the overall prevalence of tooth wear on the molar teeth was 10% (n=12) (Table 1).

A stepwise logistic regression model was used to determine whether associations existed between the outcome variables and the explanatory variables; gender, previous tooth wear, oral hygiene, dietary, behavioural or general health habits (Table 2). The outcome variables of interest were the presence of tooth wear, the presence of tooth wear on the incisor teeth and the presence of tooth wear on the occlusal surfaces of first permanent molar teeth.

When the presence of tooth wear was the outcome variable of interest, males had more tooth wear than females, odds ratio 3.67, (95% C.I. = 1.49 – 7.63, p=0.0036) (Table 3). Those that stopped using a baby bottle aged 18 months and older (56%) were more likely to have tooth wear, odds ratio 3.09, (95% C.I. = 1.32 – 7.22, p=0.0091). Similarly children who ate crisps once a day

Table 1. Distribution of children according to the presence of tooth wear by gender in all teeth, on incisors and occlusal surfaces of molar teeth

<i>Presence of Tooth Wear</i>	<i>Male</i>		<i>Female</i>		<i>Total</i>	
	<i>n</i>	<i>%</i>	<i>n</i>	<i>%</i>	<i>n</i>	<i>%</i>
No	31	50	45	74	76	62
Yes	31	50	16	26	47	38
<i>Presence of Incisor Tooth Wear</i>						
No	37	60	46	75	83	67
Yes	25	40	15	25	40	33
<i>Presence of Tooth Wear On occlusal surfaces of first molar teeth</i>						
No	52	84	59	97	111	90
Yes	10	16	2	3	12	10

Table 2. Explanatory variables used in the logistic regression model

Gender	Male / Female
Previous tooth wear	No tooth wear at age 5 / Tooth wear at age 5 No tooth wear in enamel age 5 / Tooth wear in enamel at age 5 No tooth wear to dentine or pulp at age 5 / Tooth wear to dentine or pulp at age 5
Frequency of tooth brushing	Brushes once a day and less / Brushes twice a day and more
Method of rinsing after brushing	Using a tooth brush Other method (cup, from hands, tap)
Types of drinks consumed	Extensive questionnaire data; carbonated, juices and squashes
Frequency of consumption of acidic drinks	Less than once a day / Once a day and more
Usual method of drinking	Cup/ glass Can Bottle Through a straw
Frequency of consumption of citrus and fresh fruits	Less than once a day / Once a day and more
Age at which use of a baby bottle stopped	Never used Less than 12 months Less than 18 months 18 to 24 months 24 months or more
Frequency of consumption of sweets	Less than once a day / Once a day and more

Table 3. Results of multivariate analysis – identification of statistically significant variables
All other variables were not statistically significant ($p > 0.05$)

<i>Outcome</i>	<i>Variable</i>	<i>p-value</i>	<i>Odds Ratio</i>	<i>95% C.I.</i>
Tooth Wear	Gender (male)	0.0036	3.67	1.49 - 7.63
	*Baby Bottle	0.0091	3.09	1.32 - 7.22
	*Eating Crisps	0.0449	2.56	1.02 - 6.67
Molar Wear	Erosion to dentine or pulp in primary teeth	0.0179	5.06	1.32 - 19.39
	<i>Pure Fruit Juice (less wear)</i>	0.0283	6.21	1.22 - 31.73
	<i>Brushing twice a day and more (less wear)</i>	0.0160	3.45	1.25 - 9.09
Incisor Wear	Drink from Bottle	0.0061	4.27	1.51 - 12.02
	*Baby Bottle	0.0105	3.91	1.38 - 11.12
	*Eating Yoghurt	0.0397	3.02	1.05 - 8.65
	<i>*Eating Sweets infrequently (less wear)</i>	0.0055	8.33	1.89 - 33.33

* These are responses provided when the child was five-years-old.
Italics indicate association with less tooth wear.

and more, as recorded on the questionnaire at age five, were more likely to have tooth wear than those who ate crisps less than once a day, odds ratio 2.56, (95% C.I. = 1.02 - 6.67, $p=0.0449$).

When tooth wear on the occlusal surfaces of the first permanent molar teeth was the outcome variable, the children with erosive tooth wear, which had progressed to dentine in the primary teeth (21%), were more likely to have tooth wear on the molar occlusal surfaces, odds ratio 5.06, (95% C.I. = 1.32 - 19.39, $p=0.018$). The children who reported that they consumed pure fruit juice less than once each day (49%) were more likely to have tooth wear than those consuming it frequently, odds ratio 6.21, (95% C.I. = 1.22 - 31.73, $p=0.0283$).

Tooth wear on the incisor teeth was associated with oral hygiene habits, dietary habits and prolonged baby-bottle use. Children that were brushing at least twice a day (58%) had less incisor tooth wear than those brushing less than twice each day, odds ratio 3.45 (95% C.I. = 1.25- 9.09, $p=0.016$). When asked how did they usually take their drink the children who took it directly from a bottle (44%) had more incisor tooth wear than those who did not, odds ratio 4.27, (95% C.I. = 1.51 - 12.02, $p=0.0061$). Again the children who were using a baby bottle at 18 months and more had more incisor tooth wear than those that finished with it sooner, odds ratio 3.91, (95% C.I. = 1.38 - 11.12, $p=0.0105$). Both the variables eating yoghurt frequently and infrequent sweet eating as reported by the parents appeared to confer a benefit. Where it was recorded that yoghurt was eaten at least once a day and more, these children had less tooth wear than those that ate it infrequently, odds ratio 3.02, (95% C.I. = 1.05 - 8.65, $p=0.0397$). The children eating sweets less than once a day had less incisor tooth wear than those eating sweets more frequently, odds ratio 8.33 (95% C.I. 1.89 - 33.33, $p=0.0055$) (Table 3).

Discussion

Tooth wear in this sample of children first examined at age five and again at age 12 indicated that erosive tooth wear present in the primary teeth is predictive of tooth wear in the permanent dentition; children identified with erosive tooth wear extending to dentine or pulp at age five were five times as likely to have tooth wear on the occlusal surfaces of the first permanent molar teeth at age 12, Ganss *et al* (2001) using orthodontic study models reported a similar finding. Interestingly, tooth wear on the occlusal surfaces of the molar teeth is described as 'cupping', and is often considered to be partly or wholly associated with tooth wear with an erosive aetiology. At the time of the original study, the incisal surfaces of the upper primary incisors were excluded as it was thought the tooth wear present would be principally attrition and was discounted as acceptable or normal (Al-Malik, 2000). At age 12, all scoreable surfaces of the index teeth were included; the results would suggest the importance of recognising the co-existence of the different types of tooth wear and the potential of one to affect the other (Eisenburger *et al*, 2003). The prevalence in this study is less than that reported by Bardsley *et al* (2004) using the same index but children aged 14-years, which would be expected as tooth wear increases with age (Whelton

et al, 2006; Whelton *et al*, 2007), in both studies males had more tooth wear than females. In the current study, children brushing twice a day or more had less tooth wear on their incisors than those brushing less frequently. A similar finding was recorded with regard to dental caries at age 15 in the Irish national survey (Whelton *et al*, 2006). This positive finding indicates the importance of encouraging tooth brushing twice daily, and suggests further research into the timing of brushing. Since frequent tooth brushing was associated with less incisor wear, the benefits of local fluoride delivery should be emphasised and further research into delivery methods of fluoride undertaken. In the study a dietary association was identified between the presence of tooth wear and pure fruit juice consumption at age 12, where those consuming pure fruit juice less than once a day had more occlusal wear than those consuming it more frequently: this finding may be associated with a reduced power in the study to detect what the children were consuming if they were not drinking pure fruit juice. Drinking directly from a bottle was associated with more tooth wear than using other methods to drink further endorsing recommendations with regard to methods of consumption (Lussi *et al*, 2004).

An odds ratio of 5.05 for tooth wear in the permanent dentition if present in the primary dentition stresses the importance of examining the primary teeth, modifying dietary practices and the early initiation of preventive strategies. In this study many factors were examined for their association with tooth wear, at the time of the clinical examination the examiner (MH) did not have sight of the original records or responses to the questionnaire; incorporation of the questionnaire results collected at both age five and age 12 in the logistic regression model permitted investigation of factors over time. Frequent brushing, infrequent sweet eating and frequent yoghurt consumption were associated with less tooth wear and the prolonged use of a baby bottle and eating crisps were associated with more tooth wear. The effect of prolonged baby bottle use and crisp eating may not be directly associated with tooth wear but associated with early learned behaviours and dietary choices. The early introduction of preventive measures and the adoption of a common risk factor approach is thus crucial (Sheiham and Watt, 2000; Zero and Lussi, 2005).

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References

- Al-Dlaigan YH, Shaw L, Smith A (2001): Dental erosion in a group of British 14-year-old, school children. Part 1: Prevalence and influence of differing socioeconomic backgrounds. *Br Dent J*; **190**, 145-149.
- 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 MI, Holt RD, Bedi R (2002): Erosion, caries and rampant caries in preschool children in Jeddah, Saudi Arabia. *Community Dent Oral Epidemiol*; **30**, 16-23
- Bardsley PF, Taylor S, Milosevic A (2004): 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. *Br Dent J*; **197**, 413-416.
- Bartlett DW, Coward PY, Nikkah C, Wilson RF (1998): The prevalence of tooth wear in a cluster sample of adolescent schoolchildren and its relationship with potential explanatory factors. *Br Dent J*; **184**, 125-9.
- Bartlett DW and Shah P (2006): A Critical Review of Non-carious Cervical (Wear) Lesions and the Role of Abfraction, Erosion and Abrasion. *J Dent Res*; **85**, 306-312.
- Centre for Disease Control and Prevention (2008): Preventing Chronic Diseases: Investing Wisely in Health p1. www.cdc.gov/nccdphp/publications/factsheets/Prevention/pdf/oh.pdf, [accessed 24th October 2009].
- Dugmore CR and Rock WP (2004): The prevalence of tooth erosion in 12-year-old children. *Br Dent J*; **196**, 279-282;
- Eisenburger M, Shellis RP, Addy M (2003): comparative study of wear of enamel induced by alternating and simultaneous combinations of abrasion and erosion *in vitro*. *Caries Res*; **37**, 450-456.
- Ganss C, Klimek J, Giese K (2001): Dental erosion in children and adolescents – a cross-sectional and longitudinal investigation using study models. *Community Dent and Oral Epidemiol* **29**, 264–271.
- Harding MA, Whelton H, O’Mullane DM, Cronin M (2003): Dental erosion in 5-year-old Irish school children and associated factors: a pilot study. *Community Dent Health*; **20**, 165-170.
- Kelly M, Steele J, Nuttall N, Bradnock G, Morris J, Nunn J, Pine C, Pitts N, Treasure E, White D (2000). Adult Dental Health Survey. Oral Health in the United Kingdom in 1998. London: The Stationary Office.
- Lussi A, Jaeggi T, Zero D (2004): The role of diet in the aetiology of dental erosion. *Caries Res*; **38**, 34-44.
- Office for National Statistics (2004). <http://www.statistics.gov.uk/children/dentalhealth/>, [accessed 24th October 2009].
- Sheiham A and Watt RG (2000) ‘The common risk factor approach: a rational basis for promoting oral health’, *Community Dent and Oral Epidemiol*; **28**, 399-406.
- Smith BGN and Knight JK (1984): An index for measuring the wear of teeth. *Br Dent J*; **156**, 435-438.
- Smith BG (1989): Toothwear: aetiology and diagnosis. *Dental Update*; **16**, 204-12.
- Whelton H, Crowley E, O’Mullane D, Harding M, Guiney H, Cronin M, Flannery E, and Kelleher V (2006). North South Survey of Children’s Oral Health in Ireland 2002. Dublin, Department of Health and Children. http://www.dohc.ie/publications/pdf/oral_health_report.pdf , [accessed 24th October 2009].
- Whelton H, Crowley E, O’Mullane D, Cronin M, Kelleher V, Byrtek, M (2007). Oral Health of Irish Adults 2002. Dublin, Department of Health and Children. http://www.dohc.ie/publications/pdf/oral_health02.pdf , [accessed 24th October 2009].
- Wiegand A, Müller J, Werner C, Attin T (2006). Prevalence of erosive tooth wear and associated risk factors in 2-7-year-old German kindergarten children. *Oral Dis*; **12**, 117-124.
- Zero D, Fontana M, Lennon AM (2001). Clinical applications and outcomes of using indicators of risk in caries management. *J Dent Educ*; **65**, 1126-32.
- Zero DT and Lussi A (2005). Erosion - chemical and biological factors of importance to the dental practitioner. *Int Dent J*; **55**, 285-290.