DOI: 10.1111/j.1365-263X.2010.01081.x

A controlled study of dental erosion in 2- to 4-year-old twins

SUE S. TAJI[1], W. KIM SEOW[1], GRANT C. TOWNSEND[2] & TREVOR HOLCOMBE[3]

[1]School of Dentistry, The University of Queensland, Brisbane, Qld, Australia, [2]School of Dentistry, The University of Adelaide, Adelaide, SA, Australia, and [3]Kingston Oral Health (Logan-Beaudesert Division), Metro South Health Service District, Queensland Health, Qld, Australia

International Journal of Paediatric Dentistry 2010; 20: 400–409

Background. Dental erosion (DE) in children is a significant oral health issue and has become a focus for research in clinical paediatric dentistry.
Aim. This study investigated DE in the primary dentition of 2- to 4-year-old twin and singleton children with regard to the genetic, medical and dietary factors associated with the condition.
Design. The 128 subjects consisted of 88 twin children (31 monozygous, 50 dizygous, 7 unknown zygosity) and singletons (n = 40) aged 2–4 years. Medical, dental, and dietary histories were obtained. The children were examined for DE using a modified index.
Results. The prevalence of DE by subject affected was 77% in monozygotic twins (MZ), 74% in dizygotic twins (DZ), and 75% in singleton controls ($P > 0.1$). Of the teeth scored, 12% had mild, 10% moderate, and 1% severe lesions, and DE was more severe in the older age group ($P < 0.05$). Concordance rates for erosion lesions in MZ and DZ co-twins were not statistically significant.
Conclusions. The prevalence of DE and the concordance of erosion lesions were similar between MZ and DZ twins and singleton children, suggesting that the contribution of genetic factors to DE is negligible.

Introduction

Dental erosion (DE), defined as the progressive, irreversible loss of dental hard tissues by a chemical process without bacterial involvement[1], has become an increasingly recognizable oral health issue among the paediatric population. Numerous clinical problems have been linked to erosion and include dental hypersensitivity, altered occlusion, eating difficulties, poor aesthetics, pulp exposure, and abscesses[2,3]. Primary teeth have a thinner enamel layer, larger pulps, reduced microhardness, and reduced mineralization of enamel compared with permanent teeth[4,5]. Such structural difference may contribute to the primary dentition being more susceptible to development and progression of DE lesions. This is further supported with *in vitro* erosion progression having been reported to be 1.5 times more rapid in human primary than permanent teeth[6]. The clinical manifestations of DE vary from mild-to-moderate to severe and can include loss of surface anatomy, increased incisal translucency, absence of enamel, and chipping of the incisal edges[7]. As erosion progresses, rounding of the cusps, grooves, and incisal edges will take place[8], progressing towards loss of occlusal morphology, dentinal involvement, and severe loss of tooth structure.

Prevalence studies on DE in the paediatric population have shown a wide variation in results obtained[9]. A limited number of reported prevalences in the primary dentition over the last decade is available from a number of different countries, including China (5.7% prevalence[3]), UK (53% prevalence[10], 65% prevalence[11]), Germany (70.6% prevalence[12], 32% prevalence[13]), Ireland (47% prevalence)[14], Saudi Arabia (31% prevalence[15], 82% prevalence[16]), and Brazil (12.3% prevalence)[17]. The first study on the prevalence of DE in the primary dentition of Australian children reported a rate of 78%[18].

Within the literature, there are conflicting data on the relative contribution of different

Correspondence to:
Dr W. Kim Seow, Centre for Paediatric Dentistry, School of Dentistry, The University of Queensland, 200 Turbot Street, Brisbane, Qld 4000, Australia.
E-mail: k.seow@uq.edu.au

intrinsic and extrinsic factors to the development of DE[9]. Intrinsic factors associated with DE include gastro-oesophageal reflux disease, eating disorders, chronic vomiting, persistent regurgitation, and rumination[19–21]. The extrinsic factors involved in development of DE may include the consumption of acidic drinks[3,5,14,16,22], use of acidic medications[23,24], level of socioeconomic status[3], and enamel hypoplasia[18]. The purposes of the present study were to establish the prevalence and site distribution of DE in 2- to 4-year-old twin and singleton Australian children and to assess the relative genetic, medical, and dietary factors that are related to DE.

Materials and methods

Ethical approval for the research project was obtained from the relevant institutions. Signed informed consent was obtained from the parents or guardians prior to the dental examination.

Subjects

Twins. The present investigation is part of a longitudinal national twin study, which has been ongoing since 2005.[25–27] The children had been recruited since birth, and all parents of twin children aged 2–4 years residing in one of the states in the country were sent a letter of invitation to participate in the proposed study. Parents who were interested to come for a dental examination were provided with a dental appointment. A total of 88 twin children (including two sets of triplets) responded out of 96 twin children. The consent rate for participation was therefore 91%. All participants received oral hygiene instruction, a free toothbrush and toothpaste, and reimbursement of travel costs for the study.

Singleton control children. Age-matched singleton children were recruited from childcare centres. The directors of selected childcare centres were approached to obtain consent for conduct of the study at their facilities. A letter of purpose and invitation was forwarded to all parents/carers of children aged 2–4 years at the centres. A total of 40 control children aged 2–4 years of age, matched for socioeconomic status and age, were recruited.

Sociodemography and medical history

Information regarding the main aetiological factors of DE was obtained from a simple questionnaire that was provided to the parents of the participating subjects. The questionnaire included social demographical data of the child and parents, such as parent's highest level of education and parental occupation. Medical histories including neonatal history, gestational age and birth weight, history of frequent vomiting, medications for reflux, surgical diagnosis or treatment for reflux, gastro-oesophageal reflux disease, asthma, and any current medications were obtained.

Dental examination

At the appointment for the dental examination, medical and dental histories were obtained by interview and the information given in the questionnaire was confirmed. The children were examined by one dentist. Each child was examined, using a disposable hand mirror in the dental clinic. The teeth were dried with gauze and all visible surfaces of the teeth were examined. The surfaces of all teeth present were scored, utilizing a modified clinical index[28], with DE being scored using the following grading system:

Grade 0 No erosion and no loss of tooth surface anatomy
Grade 1 Loss of surface enamel giving a smooth glazed shiny appearance, rounding of the cusps or incisal edges
Grade 2 Dentine exposure
Grade 3 Widespread dentine exposure
Grade X No assessment could be made due to extensive caries, large restoration, or missing tooth

Three sites per tooth, namely, the buccal/labial, lingual/palatal, and occlusal/incisal surfaces, were recorded. All data were recorded on standardized forms. The highest score per tooth was utilized for analysis. An erosion index was subsequently calculated for each subject. The erosion index was derived by dividing the total of erosion scores for the individual by the total number of teeth scored.

Genetic analysis

Comparisons of concordance rates within monozygotic (MZ) twin pairs with dizygotic (DZ) twin pairs were carried out for the presence of DE on the lower right- and left-first primary molars. These sites were selected as they were found to be most prevalent among the subjects studied. Each twin pair was assigned to one of two possible classes. The first included pairs in which both members of the twin pair had DE (concordance), whereas the second class consisted of twin pairs in which only one member had DE or no erosion was observed (nonconcordance). The theoretical maximum expected concordance values are 100% for MZ twins and 50% for DZ twins[29].

Intra-examiner consistency

Prior to the study, the examiner received training in the clinical scoring of DE lesions using coloured photographs, which demonstrated the range of DE criteria. To determine intra-examiner consistency, examinations were carried out, 1 week apart, on five children between the ages of 2 and 4. The kappa value for intra-examiner consistency was obtained based on the statistical model recommended by Fleiss *et al.*[30] The unweighted kappa value was found to be 0.83.

Statistical analysis

Data from the examination and questionnaire were entered into an electronic database. Statistical analyses, including linear regression and chi-square tests, were performed utilizing GraphPad InStat® computer software (GraphPad, San Diego, CA, USA). Statistical significance was accepted at the 95% confidence level at $P < 0.05$.

Results

Demography and medical status

Table 1 shows the demography and medical history of the 88 twins (49 males, 39 females) and 40 singletons (22 males, 18 females) in the study. The mean age at examination was 2.9(±0.6) years for twins and 3.0(±0.8) years for singleton children (range 2–4 years). A significant difference ($P < 0.001$) in birth weight was observed between twin (2.3 ± 0.5 kg) and singleton subjects (3.4 ± 0.8 kg). There was a significant difference in mean gestational age between all twins (35.3 ± 2.6 years) and singleton subjects (38.3 ± 2.6 years) ($P < 0.001$). However, no significant difference was observed in birth weight between MZ and DZ twins. Within the twin subjects, 13% currently took medications, 19% had asthma, 10% suffered from gastro-oesophageal reflux disease, 1% had surgical diagnosis/treatment for reflux, and 5% reported frequent vomiting. Within the singleton children, 5% currently took medications, 23% had asthma, 8% suffered from gastro-oesophageal reflux disease, 5% had surgical diagnosis/treatment for reflux, and 3% reported frequent vomiting. Medications consumed for treatment of reflux were found to be consumed in significantly higher levels in twin children (8%) compared with singletons (0%) ($P = 0.042$). Prevalence of asthma occurred at significantly higher levels in DZ twins (26%) compared with MZ twins (6%) ($P = 0.028$), but no significant difference was noted when all twin children were compared with the singleton subjects. There were no significant differences between twin and singleton subjects in relation to their current medication intakes, gastro-oesophageal reflux disease, surgical diagnosis/treatment for reflux and frequency of vomiting and occupation of mother.

Distribution of DE

A total of 7311 surfaces were scored for the presence of DE. Table 2 shows the prevalence of DE among all groups based on the presence of erosion on at least one tooth. The

Table 1. Demography and medical history of twins and singleton controls.

	Monozygous	Dizygous	*P*-value	Unknown	All twins	Controls	*P*-value (*t*-value, d.f.)
Gender							
Boys	18 (58)	29 (58)		2 (29)	49 (56)	22 (55)	
Girls	13 (42)	21 (42)		5 (71)	39 (44)	18 (45)	
Total subjects	31 (100)	50 (100)		7 (100)	88 (100)	40 (100)	
Mean age at examination (years)	2.77 ± 0.57	3.11 ± 0.62		2.43 ± 0.22	2.93 ± 0.61	3.02 ± 0.82	< 0.001 (9.25, 119)
Mean birth weight (g)	2332 ± 526	2369 ± 537	0.76	2361 ± 389	2354 ± 515	3452 ± 769	
Mean gestational age (weeks)	35.11 ± 2.1	35.3 ± 2.97	0.81	36.5 ± 1.91	35.3 ± 2.61	38.3 ± 2.59	< 0.001 (5.27, 118)
Mother's highest level of education							
Primary	0 (0)	0 (0)		0 (0)	0 (0)	1 (3)	< 0.005
High	9 (29)	12 (24)		3 (43)	24 (27)	22 (55)	
Tertiary	22 (71)	38 (76)		4 (58)	64 (73)	16 (40)	
No answer	0 (0)	0 (0)		0 (0)	0 (0)	1 (3)	
Occupation of mother							
Professional	4 (8)	4 (13)		0 (0)	8 (9)	2 (3)	NS
Semi-professional	40 (80)	26 (84)		7 (100)	73 (83)	67 (84)	
Unskilled	4 (8)	1 (3)		0 (0)	5 (6)	9 (11)	
No answer	2 (4)	0 (0)		0 (0)	2 (22)	2 (3)	
Currently taking medications							
Yes	2 (6)	8 (16)		0 (0)	10 (13)	2 (5)	NS
No	29 (94)	42 (84)		7 (100)	78 (87)	38 (95)	
No answer	0 (0)	0 (0)		0 (0)	0 (0)	0 (0)	
Asthma							
Yes	2 (6)	13 (26)	0.028	2 (29)	17 (19)	9 (23)	NS
No	29 (94)	37 (74)		5 (71)	71 (81)	31 (77)	
No answer	0 (0)	0 (0)		0 (0)	0 (0)	0 (0)	
Gastro-oesophageal reflux							
Yes	3 (10)	6 (12)		0 (0)	9 (10)	3 (8)	NS
No	28 (90)	44 (88)		7 (100)	79 (90)	37 (92)	
No answer	0 (0)	0 (0)		0 (0)	0 (0)	0 (0)	
Surgical diagnosis or treatment for reflux							
Yes	0 (0)	1 (2)		0 (0)	1 (1)	2 (5)	NS
No	21 (68)	42 (84)		7 (100)	70 (80)	34 (85)	
No answer	10 (32)	7 (14)		0 (0)	17 (19)	4 (10)	
Medications for reflux							
Yes	2 (6)	5 (10)		0 (0)	7 (8)	0 (0)	0.042
No	18 (58)	32 (64)		7 (100)	57 (65)	35 (87)	
No answer	11 (36)	13 (26)		0 (0)	24 (27)	5 (13)	
Frequent vomiting history							
Yes	0 (0)	4 (8)		0 (0)	4 (5)	1 (3)	NS
No	31 (100)	45 (90)		7 (100)	83 (94)	39 (97)	
No answer	0 (0)	1 (2)		0 (0)	1 (1)	0 (0)	

Values represent *n* (%), unless specified.
NS, nonsignificant.

Table 2. Prevalence by subjects affected by dental erosion in monozygotic and dizygotic twins and singleton controls, *n* (%).

Erosion	Monozygous	Dizygous	Unknown	All twins	Controls
Affected*	24 (77)	37 (74)	5 (71)	66 (75)	30 (75)
Unaffected	7 (23)	13 (26)	2 (29)	22 (25)	10 (25)
Total	31 (100)	50 (100)	7 (100)	88 (100)	40 (100)

*The numbers of subjects showing at least one erosion lesion were not significantly different among the groups ($P > 0.1$, nonsignificant).

prevalence of DE by subject affected was 77% in MZ twins, 74% in DZ twins, and 75% in singleton controls. No significant differences in prevalence were observed between MZ and DZ twins or when all twins were compared with singletons ($P > 0.1$).

Table 3 shows the distribution of erosion lesions based on the extent of the lesion (mild, moderate, or severe). Within the whole dentition, 12% of all teeth showed mild DE, 10% had moderate DE, and 1% had severe

Table 3. Erosion lesion distribution by severity of lesion and teeth affected in maxillary and mandibular arches.

Arch	Tooth	Mild (E1)	Moderate (E2)	Severe (E3)	No erosion (E0)	*P*-value
Maxillary	Central incisor	63 (25)	12 (5)	4 (2)	175 (68)	< 0.001*
	Lateral incisor	62 (24)	23 (9)	0 (0)	171 (67)	
	Canine	42 (16)	51 (20)	0 (0)	163 (64)	
	First molar	51 (20)	59 (23)	0 (0)	146 (57)	
	Second molar	33 (13)	26 (10)	2 (1)	134 (52)	
	Total maxillary	251 (20)	171 (13)	6 (1)	789 (61)	
Mandibular	Central incisor	5 (2)	4 (2)	0 (0)	246 (96)	< 0.05†
	Lateral incisor	6 (2)	3 (1)	0 (0)	245 (96)	
	Canine	6 (2)	8 (3)	0 (0)	240 (94)	
	First molar	24 (9)	61 (24)	2 (1)	169 (66)	
	Second molar	20 (8)	20 (8)	4 (2)	157 (61)	
	Total mandibular	61 (5)	96 (7)	6 (1)	1057 (82)	
	P-value	< 0.001‡	< 0.001§	NS		
Combined	Central incisor	68 (13)	16 (3)	4 (1)	421 (82)	< 0.001¶
	Lateral incisor	68 (13)	26 (6)	0 (0)	416 (81)	
	Canine	48 (9)	59 (12)	0 (0)	403 (79)	
	First molar	75 (15)	120 (23)	2 (1)	315 (61)	
	Second molar	53 (10)	46 (9)	6 (1)	291 (57)	
	Total	312 (12)	267 (10)	12 (1)	1846 (72)	

Values represent *n* (%), unless specified.
NS, not significant.
*The distribution of mild, moderate, and severe erosion in the maxillary arch was significantly different among teeth.
†The distribution of mild, moderate, and severe erosion in the mandibular arch was significantly different among teeth.
‡The total number of mild lesions was significantly different between the maxillary and mandibular arches.
§The total number of moderate lesions was significantly different between the maxillary and mandibular arches.
¶The distribution of mild, moderate, and severe erosion in both arches combined was significantly different among teeth.

Table 4. Sites of dental erosion in the maxillary and mandibular arches.

Arch	Surface	Central incisor	Lateral incisor	Canine	1st Molar	2nd Molar	Total
Maxillary	Occlusal/incisal	26 (10)	27 (10)	39 (15)	109 (42)	60 (23)	261
	Buccal	0 (0)	0 (0)	0 (0)	0 (0)	1 (100)	1
	Palatal/lingual	53 (32)	58 (35)	54 (32)	1 (1)	0 (0)	166
	Total maxillary	79 (18)	85 (20)	93 (22)	110 (26)	61 (14)	428
Mandibular	Occlusal/incisal	5 (3)	5 (3)	4 (3)	86 (60)	44 (31)	144
	Buccal	0 (0)	0 (0)	0 (0)	1 (100)	0 (0)	1
	Palatal/lingual	4 (22)	4 (22)	10 (56)	0 (0)	0 (0)	18
	Total Mandibular	9 (6)	9 (6)	14 (8)	87 (53)	44 (27)	163
P-value	< 0.0001*						< 0.001†
Combined	Occlusal/incisal	31 (8)	32 (8)	43 (10)	195 (48)	104 (26)	405
	Buccal	0 (0)	0 (0)	0 (0)	1 (50)	1 (50)	2
	Palatal/lingual	57 (31)	62 (34)	64 (35)	1 (0)	0 (0)	184
	Total	88 (15)	94 (16)	107 (18)	197 (33)	105 (18)	591

Values represent *n* (%), unless specified.
*The differences in site distribution of dental erosion lesions in the maxillary *versus* mandibular arch were found to be significant.
†The differences in location of dental erosion lesions based on occlusal/incisal, buccal, and palatal/lingual positions in the maxillary and mandibular arches compared were found to be significant.

DE ($P < 0.001$). In terms of severity, the prevalence of mild DE lesions was found to be 20% in the maxillary teeth, compared with 5% in the mandibular teeth ($P < 0.001$). A total of 13% of the teeth in the maxillary dental arch had moderate DE lesions compared with 7% in the lower dental arch ($P < 0.001$), whereas the prevalence of severe DE lesions was approximately 1% in both dental arches (N.S).

In Table 4, the site specificities affected by DE were evaluated across the whole dentition and within each of the dental arches. The prevalence of erosion on the buccal surfaces was negligible as only one tooth was shown to be affected in each arch. In the anterior dentition, significantly more erosion lesions were found on the palatal/lingual surfaces (31% in central incisors, 34% in lateral incisors, 35% in canines) compared with incisal surfaces (8% in central incisors, 8% in lateral incisors, 11% in canines). Within the posterior dentition, the majority of erosion lesions were found on the occlusal/incisal surfaces (48% in first primary molars, 26% in second primary molars). Lesions on palatal/lingual surfaces were rarely observed (1% in first primary molars, 0% in second primary molars). Furthermore, as shown in Table 4, DE was observed most frequently in primary first molars (33%), followed by second molars (18%) and canines (18%), lateral incisors (16%), and central incisors (15%). No significant difference was observed between the distribution of DE or between the severity of the lesions occurring in either the maxillary or mandibular dental arches (NS).

Extent of the erosive lesions by age category

Table 5 shows the average number of teeth affected by different severities of erosion according to age category. The twins and the singleton children were divided into two groups [aged 2 to <3 years of age (n = 59) and aged 3–4 years of age (n = 69)]. Significantly higher scores for the erosion index were obtained within the 3- to 4-year-old age group compared with that of the 2- to 3-year-old age group. When all twin subjects in the 2- to 3-year group were considered, an average erosion index score of 0.27 was obtained, compared with 0.41 in the 3- to 4-year-old group ($P < 0.005$). In 2- to 3-year-old singletons, the average erosion index score was 0.2 compared with 0.51 in the 3- to 4-year-old group ($P < 0.032$). Overall, when all subjects, including twins and singletons were considered, the average erosion index score was 0.25 in the 2- to 3-year-old group and 0.45 in the 3- to 4-year-old group ($P < 0.001$).

Range of DE present in the subjects

Arbitrary cut-offs were employed based on ranges of the erosion index score to diagnose the erosion as mild, moderate, or severe (Table 6). Based on this approach, 24% of subjects were found to have a dentition described as having mild DE, 46% were found to have moderate erosion, and 5% had severe erosion.

Concordance testing in MZ and DZ twins

Concordance for sites of DE on the surfaces of lower right and left primary molars were evaluated for the MZ co-twins and compared with those for the DZ co-twins. The concor-

Table 5. Average number of teeth affected by different severity of erosion by age category.

Age group	All twins	Controls	Total
2 to <3 years			
Mean age at examination (years)	2.43 ± 0.25	2.24 ± 0.24	2.38 ± 0.26
Number of subjects	44	15	59
Nil erosion recorded (E0)	14.18 ± 3.77	16.00 ± 2.85	14.64 ± 3.62
Mild (E1)	2.45 ± 3.02	1.80 ± 2.54	2.29 ± 2.90
Moderate (E2)	1.16 ± 1.75	1.00 ± 1.56	1.12 ± 1.69
Severe (E3)	0.09 ± 0.60	0.00 ± 0.00	0.07 ± 0.52
Erosion index score	0.27	0.20	0.25
3 to 4 years			
Mean age at examination	3.44 ± 0.41	3.72 ± 0.45	3.54 ± 0.45
Number of subjects	44	25	69
Nil erosion recorded (E0)	14.48 ± 3.57	13.80 ± 4.08	14.23 ± 3.75
Mild (E1)	2.80 ± 2.44	2.16 ± 2.40	2.57 ± 2.43
Moderate (E2)	2.50 ± 2.26	3.64 ± 2.68	2.91 ± 2.46
Severe (E3)	0.11 ± 0.44	0.12 ± 0.44	0.12 ± 0.44
Erosion index score	0.41	0.51	0.45
Total number of teeth scored	1662	775	2437
P-value comparing 2 to <3 and ≥3 to 4 years groups	0.005	0.032	0.001

Values represent n ± SD, unless specified.

Table 6. Prevalence of erosion based on erosion index score.

Erosion	Erosion index score	Monozygous	Dizygous	Unknown zygosity	All twins	Controls	All subjects
Nil	0	8 (26)	13 (26)	2 (29)	23 (26)	9 (23)	32 (25)
Mild	< 0.30	9 (29)	11 (22)	2 (29)	22 (25)	9 (23)	31 (24)
Moderate	0.30–1.0	14 (44)	24 (48)	2 (29)	40 (45)	19 (47)	59 (46)
Severe	> 1.0	0 (0)	2 (4)	1 (13)	3 (4)	3 (7)	6 (5)
Total		31 (100)	50 (100)	7 (100)	88 (100)	40 (100)	128 (100)
P-value			NS			NS	

Values represent *n* (%), unless specified.
NS, not significant.

dance levels for the MZ co-twins were found to be 13% on the mandibular right-first primary molar as well as the mandibular left-first primary molar. In DZ co-twins, concordance values of 20% and 16% were found for the lower right- and left-first primary molar teeth, respectively. No statistically significant differences in concordance were noted when the two groups were compared (Table 7).

Discussion

This study considered DE in twin and singleton children aged between 2 and 4 years and, for the purposes of our analysis, visible surfaces across the primary dentition were evaluated. Prevalence was initially assessed purely on the presence of at least one affected tooth in an individual. Based on this approach, 25% of the sample were found to be unaffected by DE whereas 75% had one or more teeth affected by DE. The prevalence reported in our study falls within the reported prevalence rates observed in other research cohorts[9] and is similar to the only other Australian data available on the prevalence of DE in the primary dentition, with a prevalence of 78% in the primary dentition of the study subjects[18]. However, for DE to be clinically relevant, various teeth should be affected, and conceptually basing prevalence on the presence of one or a few teeth with DE may artificially inflate the prevalence levels. Hence, in the present study, in-depth analysis was undertaken to consider the varying degrees of DE present in the dentitions of subjects utilizing arbitrary cut-off points (Table 6). This allowed the sample to be split on the basis of mild, moderate, and severe erosion across their dentitions.

The reported prevalence of DE in the primary dentition within the scientific literature varies considerably, suggesting difficulties in finding a unified tooth wear index among researchers for measuring and detecting erosion lesions[14]. Other difficulties that may be encountered during the diagnostic process and thus with the reporting of its prevalence include the lack of standardized classifications, utilization of different indices, different examination techniques, the teeth selected for examination, epidemiological factors, and method of reporting the findings. Other limiting factors in diagnosis can include, difference in age of participants, the sample population, differences in consumption of acidic beverages, presence of plaque (masking the defects), and the parents not providing a precise dental/medical history that may otherwise aid diagnosis. Most epidemiological studies have analysed erosion on specific teeth and do not provide information about the distribution and severity of the erosive lesions across the whole dentition[3,14,16,22,31–33]. Furthermore, there is no unifying acceptance with regard to pathological as opposed to physiological DE.

Table 7. Concordance of dental erosion lesions in the mandibular first primary molar in monozygous and dizygous twins.

	Concordance, *n* (%)		
Trait	Monozygous	Dizygous	Overall
Presence of dental erosion on the mandibular right-first primary molar	3 (20)	5 (20)	8 (20)
Presence of dental erosion on the mandibular left-first primary molar	3 (20)	4 (16)	7 (18)
Total	6	9	15

n represents the number of twin pairs.

Our results showed an increase in the extent of DE with increasing age as noted by an increase in the DE score. These results are consistent with those found by Wiegand *et al.*[13] and Al-Malik *et al.*[15] These results are suggestive of time being a major determining factor in the progression and severity of DE observed within the primary dentition. DE should be viewed as a cumulative multifactorial process, which is not static.

Site-specific analysis of lesions of DE across the sample indicated significant differences in the location of the lesions between segments of the anterior and posterior dentition. In the posterior dentition, the occlusal surfaces were found to be affected far more frequently compared with the anterior dentition where the majority of the lesions were observed on the palatal/lingual surfaces. The location of the maxillary anterior dentition together with their earlier eruption time subjects these teeth to the influences of intrinsic and extrinsic acids for longer periods of time. The occlusal surfaces of the posterior dentition would be more prone to the effect of extrinsic dietary acids. The mandibular anterior teeth were significantly less affected by erosion compared with the maxillary anterior dentition. This may be due to the protective effects of the saliva produced from the submandibular and sublingual glands in the mandibular anterior region.

Correlation of DE lesions with the frequency of acidic intake, socio-economic status, and medical factors such as gastro-oesophageal reflux disease and acidic medications were evaluated but did not reveal any significant correlation. Our results are thus in agreement with other reports, which have only been able to show very weak to no associations between these factors and DE or tooth wear[13,34–36]. It is important to emphasize that DE is a multifactorial process and other factors such as salivary factors including pH, buffering capacity, constituents, and flow, which were not evaluated as part of our study could also have influenced our results. Also self-reporting and recall bias and the relatively low numbers of subjects in this study may have affected the results.

Application of the twin model allows assessment of the relative contribution of genes and the environment to variation of a particular trait[37]. If a trait shows high concordance between monozygous co-twins (i.e., identical twins sharing all their genes), but a lesser degree of concordance is noted in dizygous co-twins (i.e., fraternal twins who, like siblings, on average share half their genes[37]), it can be concluded that a genetic contribution to variation exists in that particular trait[38].

It is well recognized that DE has complex aetiologies and that environmental and host factors may interact to contribute to its pathogenesis. Immunological and behavioural factors may be influenced by underlying genetic factors[37]. There have been reports that the pattern of host inheritance can contribute to either an increased susceptibility or resistance to dental caries[39]. Genetically regulated processes identified as possible contributing factors include tooth eruption and development, altered enamel biomineralization, salivary flow and salivary composition, dental morphology that includes surface topography, fissure depth, and wall inclination[40]. Also the innate characteristics of the host dentine and the genetic susceptibility in dentinal degradation cannot be excluded from affecting disease progression[39,40]. All of these factors could possibly also affect DE.

It has been suggested that, at an early age, the genetic contribution to susceptibility for a given trait (such as dental caries and/or erosion) may be significant, but as individuals age, environmental factors become more dominant and reduce the relative contribution of heritable factors[37]. Thus, as most studies that aim at providing detailed results of genetic influences on traits often attempt to limit the age range of the subjects, we limited the analysis of our data to the 2- to 4-year age group.

Currently, studies that examine genetic influences regarding susceptibility towards DE are very limited. Dooland *et al.*[41] investigated tooth grinding in 116 monozygous and 124 dizygous twins in the primary and early mixed dentition stages. Although the study was aimed at tooth-grinding habits, the authors also recorded erosion and reported a prevalence of 91% in the maxillary arch only, and found no statistically significant difference in DE between MZ and DZ twins.

In the present study, we did not detect greater concordances in site specificity of DE on the mandibular right- and left-first primary molars in the MZ co-twins compared with the DZ co-twins. Furthermore, the concordance values found between MZ co-twins was only 20%. The closer the concordance values between MZ co-twins to 100%, the higher the genetic influence is likely to be for variation in the trait under consideration. Conversely, the greater the deviation from 100% concordance observed in MZ co-twins, the more likely environmental factors are the main influence on variation of the trait. Our results suggest that environmental factors are much greater contributors to variability in the expression of DE than genetic factors. However, our findings may be affected by limitations of the twin analysis, including relatively low numbers of twin pairs, difficulty with ascertaining equality of environmental factors between the twin pairs, and unknown gene–gene and environmental–gene interactions that may affect the phenotypes[42]. Future studies utilizing a larger sample of twins may offer a more definitive analysis of the role that genetic factors play in the formation of these lesions compared with environmental factors.

In conclusion, the results of the present study show that twin children are not at an increased susceptibility to developing DE compared with singleton children.

What this paper adds

- This study of dental erosion in the primary dentition of monozygotic and dizygotic twins compared with singleton children demonstrates that environmental factors have a greater role than genetic factors in the formation of erosion lesions.

Why this paper is important to paediatric dentists

- A better understanding of the pathogenesis of dental erosion in the primary dentition would help the paediatric dentist make an early diagnosis and implement interventive measures to prevent damage to the permanent dentition.

Acknowledgements

The authors thank all the children and parents who took part in this study as well as the staff of Logan-Beaudesert Division, Metro South Health Service District, Queensland Health, Australia, for their assistance. This study was supported in part by The Commonwealth Bank of Australia, Dental Board of Queensland, Australian Dental Research Foundation, and the National Health and Medical Research Council of Australia.

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