Caries Experience and Gingivitis Levels of Permanent First Molars in Relation to Timing of Emergence

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Abstract
Aims: The present study examined the prevalence of dental caries in and gingivitis around permanent first molars (PFM) in relation to their timing of emergence. ***Methods:*** In a group of 1609 “early emergers” (all PFM present at baseline) and a group of 336 “late emergers” (no PFM present at baseline), caries experience, the presence of plaque, and gingival health were evaluated annually during five follow-up examinations. ***Results:*** Even though all children were born in the same year, mean DMFS scores for PFM remained higher in the early emergers throughout the study; mean buccal plaque and gingivitis scores were comparable in both subgroups. Early emergers had a significantly increased risk of caries experience in the occlusal surface of the PFM for two to four years. No consistent association was observed between timing of emergence and gingivitis levels. ***Conclusions:*** It is recommended that dental age as well as chronological age should be taken into account when caries prevalence data in young children are compared.

Key Words: Tooth Emergence, Dental Caries, Gingivitis, Permanent First Molars

Introduction

Several studies have indicated that the majority of caries experience in the permanent dentition of children is attributed to the permanent first molars, more specifically the occlusal surfaces [1,2]. Structural irregularities hamper efficient plaque removal in these sites, promote microbial colonisation, and interfere with salivary protection.

Clinical experience and scientific research show a high incidence of caries lesions in permanent first molars during and shortly after the eruption process [3]. Earlier studies suggested that caries susceptibility of erupting teeth is related to pre- and post-eruptive maturation of enamel [4]. Carvalho *et al.* (1989) [5] pointed out that permanent first molars are more likely to develop dental caries during the eruption process, due to favourable conditions for plaque accumulation.

Reports on the oral health of a Canadian Inuit community revealed a higher susceptibility for caries development in these children compared to age-matched southern Canadian children. The authors ascribed this finding to the fact that the teeth of the Inuit emerge in the oral cavity earlier: emergence at younger age results in a longer exposure time at the moment of assessment and consequent higher caries experience scores [6]. Other researchers observed no evidence for a possible impact of early or late emergence on caries development at a young age [7,8].

Several epidemiological studies indicated that the prevalence and severity of gingivitis in children increased with age, beginning in the deciduous dentition and reaching a peak at puberty [9]. Research on the impact of tooth emergence on gingivitis levels is scarce. Hugoson *et al.* (1981) [9] observed a higher prevalence of gingivitis in regions with erupting teeth.

Aims

The present study examined the occurrence of dental caries in and the presence of gingivitis around permanent first molars in relation to their timing of emergence.

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Methods

Data were obtained in the Signal-Tandmobiel® project, a prospective (1996-2001) oral health screening project in Flanders, Belgium. In this project, 2315 boys and 2153 girls were randomly selected through cluster (i.e. school) sampling, stratified by province and educational system. They represented 7% of Flemish children born in 1989; at the first examination the mean age of the children was 7.1 years (SD=0.4). Ethical approval was obtained at the Medical Ethics Committee from the Catholic University Leuven, Belgium.

For this study, analyses were based on data obtained in two extreme subgroups. One subgroup consisted of 336 children (=113 girls and 223 boys; i.e. 7.5% of the original sample) who had no permanent first molars present at the baseline examination; they will be referred to as "late emergers". A second subgroup consisted of 1609 children (=872 girls and 737 boys; i.e. 36% of the original sample) who had all four permanent first molars present at the first examination, representing the subgroup "early emergers". A tooth was recorded as emerged when at least one cusp was visible.

Each survey year, the children were examined by a trained dentist-examiner in a mobile dental clinic on school premises. The birth date of the child, obtained through school records, and the examination date were recorded. Teeth were examined using a World Health Organization/ Community Periodontal Index of Treatment Needs (WHO/CPITN) type E probe. Caries was recorded at the level of cavitation and scored according to the guidelines published by the British Association for the Study of Community Dentistry (BASCD) [10]. The examination methods and examiners were calibrated on a yearly basis. The obtained level of agreement for scoring caries between the 16 examiners and the benchmark examiner was good to excellent (ranged between 0.72-0.91) [11]. Because the examinations were not carried out in connection with routine check-ups or dental treatment appointments, no radiographs were available. The restorative index was defined as the ratio of the number of filled teeth (f) to the number of decayed (d) and filled teeth (f/d+f).

Plaque accumulation and gingival health status were assessed on the buccal surfaces of Ramfjord teeth—16(55), 21(61), 24(64), 36(75), 41(81), 44(84); if present, permanent teeth were preferred. The presence of plaque on the buccal surfaces of reference teeth was scored using the Index of Silness and Löe (1964) [12]. The presence of plaque on the occlusal surfaces of first permanent molars was assessed using a simplified version of the index described by Carvalho *et al.* (1989) [5]:

Code 0: No visible plaque (Carvalho *et al.,* 1989: Code 0).

Code 1: Detectable plaque restricted to fossae and grooves (Carvalho *et al.,* 1989: Codes 1 and 2).

Code 2: Surface partially or totally covered with heavy plaque accumulation (Carvalho *et al.,* 1989: Code 3).

The Sulcus Bleeding Index (SBI) described by Mühlemann and Son (1971) [13] was used to assess the level of gingivitis. As oral hygiene and gingival health were scored at maxillary right permanent first molars (tooth 16) and mandibular left permanent first molars (tooth 36), this manuscript focuses on the results obtained for these two teeth.

Data on oral hygiene habits and dietary habits were obtained in every survey year through structured questionnaires, completed by the parents. For the present analyses only data obtained at baseline were used. A more elaborate description of the study sample and the applied methodology of the project has been published elsewhere [14].

Clinical and questionnaire data were entered directly in a database using the Dental Survey Plus® Programme, version 4.50 b (Providence Software, Cary, NC, U.S.A.) and converted into SAS® files for statistical analyses. The Fédération Dentaire Internationale (FDI) nomenclature was used to designate the teeth.

Baseline characteristics *(Table 1)* of the two subgroups were evaluated using chi-square tests (categorical variables) and *t*-tests (continuous variables). Although the distribution of the responses was skewed, parametric *t*-tests were performed because the sample sizes were large (central limit theorem); results were verified with non-parametric Wilcoxon tests. For a more convenient presentation of results, it was opted to present the results of the parametric tests (i.e. means, SEM and 95% confidence intervals).

Analysis of characteristics at follow-up was performed separately for boys and girls, to avoid confounding by gender. Because baseline mean age, mean dmfs score and reported brushing frequency differed significantly between the two subgroups, a possible confounding effect was tested. Only brushing frequency turned out to have a significant effect on some of the dependent variables. For consistency reasons, all statistical analyses were corrected for brushing frequency.

Table 1. *Sample Characteristics at Baseline Examination*

Variables	**Late emergers**	**Early emergers**	**P-value**
Demographic characteristics			
Gender			<0.001
Number of girls (%)	113 (34)	872 (54)	
Number of boys (%)	223 (66)	737 (46)	
Mean age	6.76	7.18	<0.001
(95% CI)	(6.72-6.79)	(7.16-7.20)	
Dental variables			
Mean number of primary teeth present	18.7	13.8	<0.001
(95% CI)	(18.5-18.9)	(13.7-13.9)	
Mean number of permanent teeth present	1.0	9.2	<0.001
(95% CI)	(0.9-1.1)	(9.1-9.3)	
Caries experience			
Mean dmfs	3.2	5.3	<0.001
(95% CI)	(2.5-3.8)	(4.9-5.7)	
Mean restorative index-deciduous teeth	37.4	41.8	0.190
(95% CI)	(30.9-43.9)	(39.0-44.5)	
Dietary habits			
Mean number of between-meals snacks	2.1	2.1	0.946
(95% CI)	(2.0-2.2)	(2.0-2.2)	
% children taking sweets to school daily	4.87	4.07	0.526
% children taking biscuits to school daily	58.03	57.70	0.914
Oral hygiene habits			
Mean age at start brushing in yrs	2.7	2.6	0.364
(95% CI)	(2.5-2.8)	(2.5-2.7)	
Frequency of brushing (%)			0.004
less than daily	19.68	13.47	
daily	52.26	50.94	
more than once a day	28.06	35.59	
% children never receiving help with brushing	11.84	10.33	0.333

Late emergers: no permanent first molars present at baseline; Early emergers: all permanent first molars present at baseline; %: percentage; CI: confidence interval; dmfs: decayed, missing or filled surfaces of primary teeth; yrs: years.

The effect of emergence status (i.e. early vs. late) and examination time (i.e. follow-up year 1 to 5) on plaque, caries experience, and gingivitis were evaluated by generalized estimating equations (GEE) models [15]. Significance of differences between the two subgroups was verified using the van Elteren test. This non-parametric test enables correction for a possible confounding factor.

Analyses were performed for each tooth separately. A difference was considered statistically significant if the *P*-value was <0.05.

Results

Table 1 presents the sample characteristics of the two subgroups. The late-emergers subgroup was younger and comprised more boys. These children had fewer permanent teeth and more primary teeth present; still, their mean dmfs score was lower than in the early-emergers group. The late emergers reported brushing significantly less frequently than the early emergers. No other statistically significant differences in reported oral hygiene habits or dietary habits were observed at baseline, nor in the subsequent years.

Table 2 presents the percentage of late and early emergers with a caries-free permanent dentition in the five consecutive follow-up years. The proportion of children with caries-free permanent teeth was always higher in the late-emerging group compared to the early emergers; this difference was statistically significant for most survey years. For those children with caries experience (either decayed, filled, or extracted because of caries) in the permanent dentition, 73-100% had caries exclusively in (at least one of) the permanent first molars *(Figure 1).*

Table 2. *Proportion Late and Early Emergers With Caries-Free Permanent Dentition*

BOYS							
Year	**Late**			**Early**			**DIFF**
	n	**DMFT=0**	**%**	**n**	**DMFT=0**	**%**	***P*-value**
BL	223	222	**100**	737	641	**87**	**<0.001**
1	197	186	**94**	642	506	**79**	**<0.001**
2	180	155	**86**	608	449	**74**	**0.001**
3	162	124	**77**	587	387	**66**	**0.024**
4	155	112	**72**	573	362	**63**	**0.025**
5	152	100	66	547	331	61	0.242
GIRLS							
Year	**Late**			**Early**			**DIFF**
	n	**DMFT=0**	**%**	**n**	**DMFT=0**	**%**	**P-value**
BL	113	113	**100**	872	727	**83**	**<0.001**
1	97	93	**96**	785	589	**75**	**<0.001**
2	96	80	**83**	748	496	**66**	**0.003**
3	95	72	**76**	715	435	**61**	**0.003**
4	92	60	65	702	414	59	0.283
5	90	63	**70**	680	385	**57**	**0.041**

Statistically significant results are designated in bold. Year: survey year; BL: baseline; DMFT: decayed, missing or filled permanent teeth; n: number of children; DIFF: difference between late and early emergers. *P*-values are obtained from analyses with correction for reported brushing frequency.

DMFS scores increased gradually over time *(Figure 2).* There was no significant interaction between emergence status and time (i.e. the effect of emergence status—early vs. late—on DMFS scores was not statistically significantly different over the years), hence the effect of both could be interpreted. The effect of time as well as the effect of emergence status on DMFS scores was statistically significant. Mean DMFS remained higher in the early emergers compared to the late emergers,

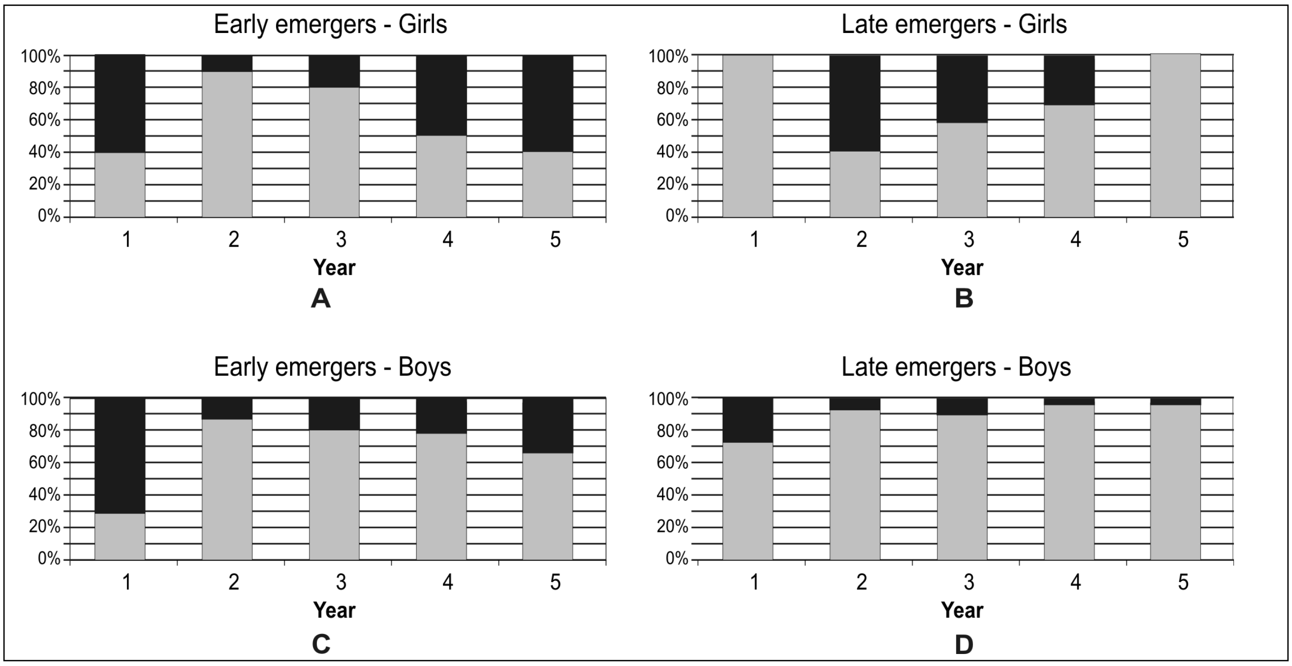

Figure 1. *Proportions of "late emergers" and "early emergers" with caries experience. Caries experience exclusively on at least one of the permanent first molars (grey) and in other teeth (black).*

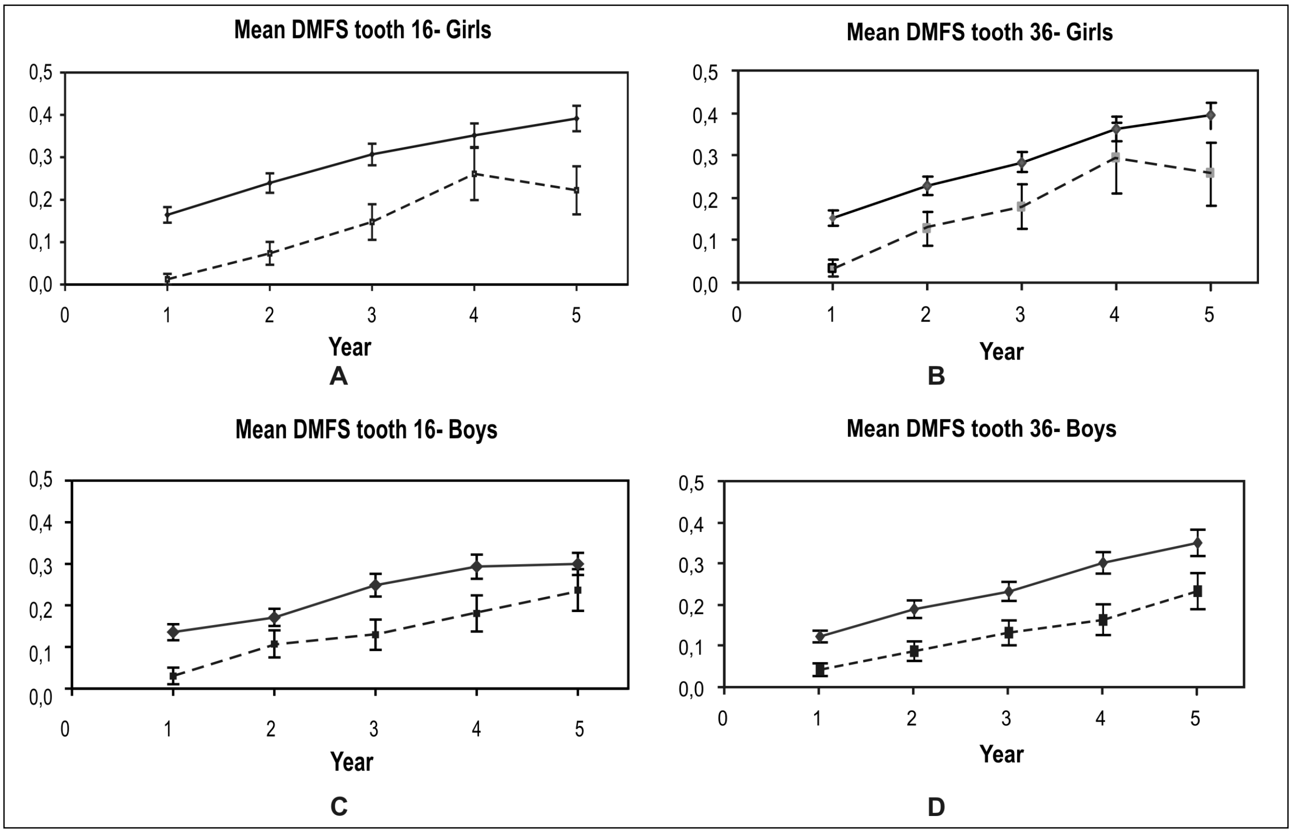

Figure 2. *Mean (SEM) DMFS scores for teeth 16 and 36 in the "early emergers" (black line) and "late emergers" (broken line).*

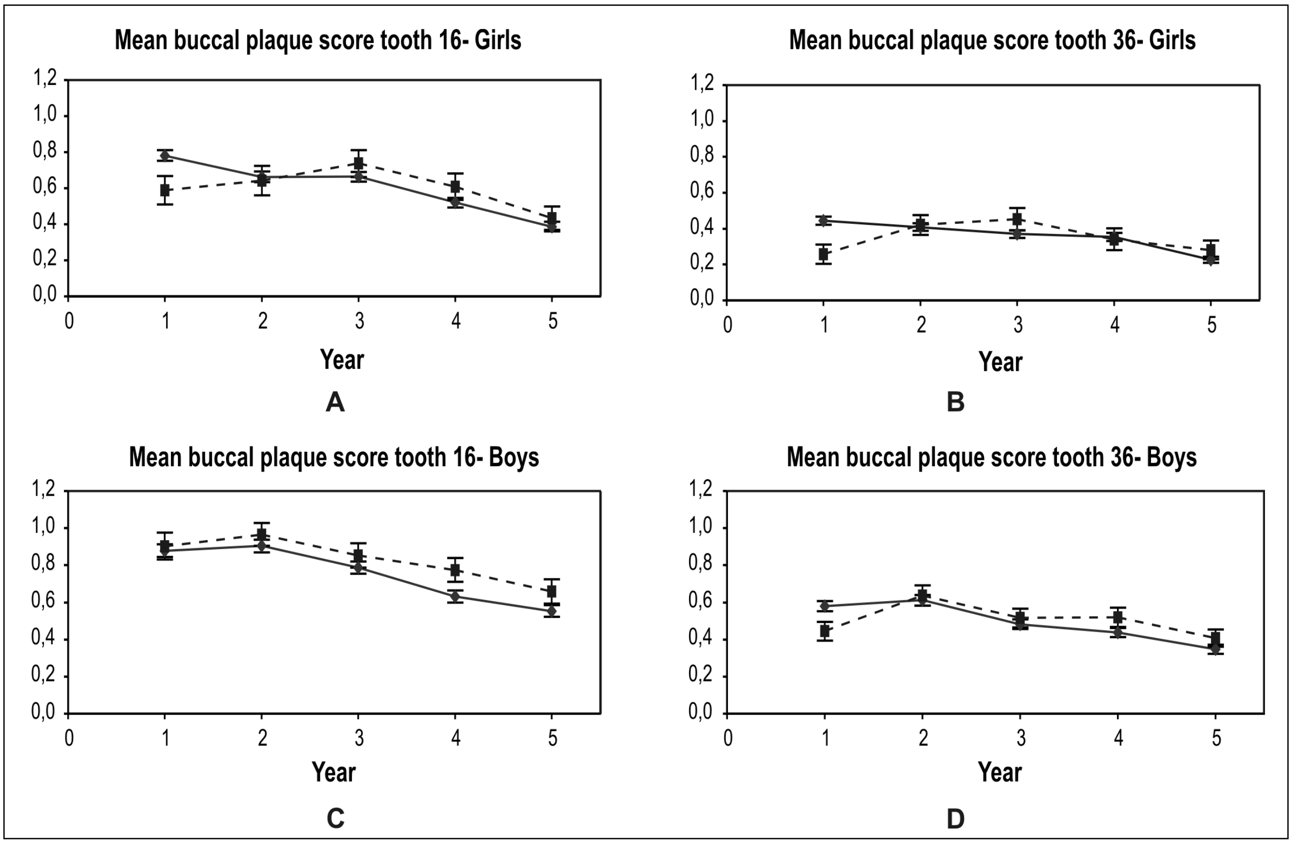

Figure 3. *Mean (SEM) buccal plaque scores for teeth 16 and 36 in the "early emergers" (black line) and "late emergers" (broken line).*

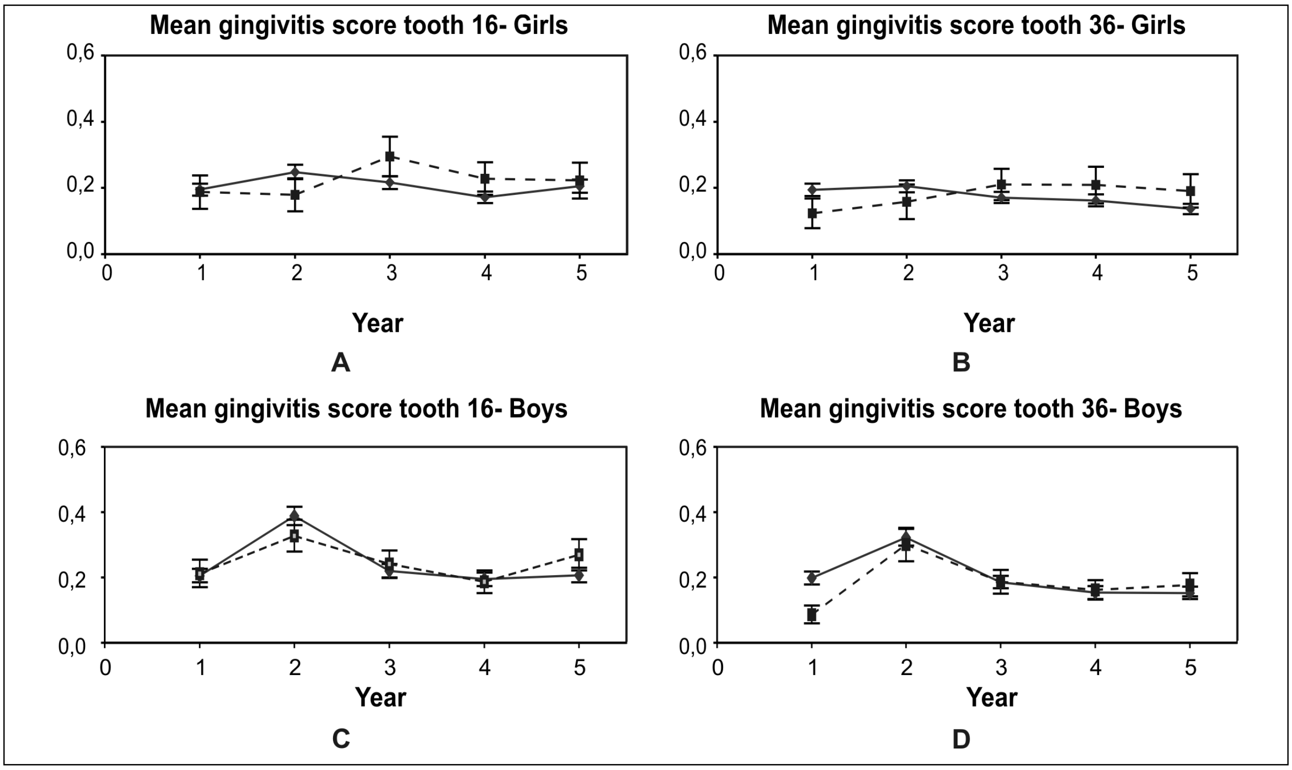

Figure 4. *Mean (SEM) gingivitis scores for teeth 16 and 36 in the "early emergers" (black line) and "late emergers" (broken line).*

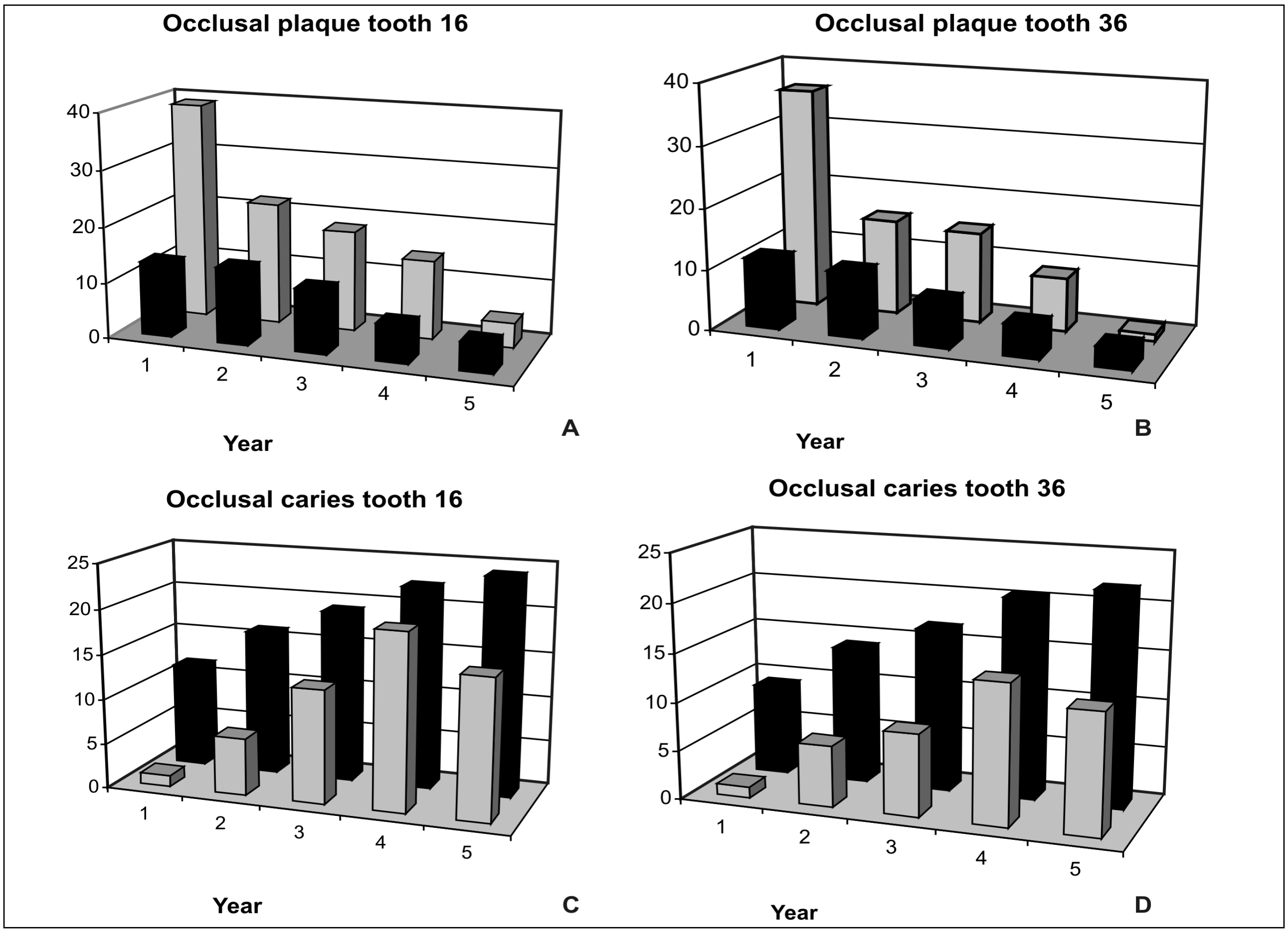

Figure 5. *Proportion "early emerger" (black) and "late emerger" (grey) girls with occlusal plaque (A-B) and occlusal caries (C-D) on teeth 16 and 36.*

Table 3. *Odds Ratios (OR) for Developing Occlusal Caries in and Gingivitis at Teeth 16 and 36*

Year	BOYS				GIRLS			
	Occlusal caries				**Occlusal caries**			
	tooth 16		tooth 36		tooth 16		tooth 36	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
1	**4.76**	[1.47, 15.39]	**5.92**	[1.36, 25.69]	**10.00**	[1.36, 73.59]	**8.62**	[1.22, 60.88]
2	**2.03**	[1.01, 4.07]	**4.08**	[1.44, 11.53]	**2.59**	[1.11, 6.05]	2.21	[0.94, 5.22]
3	1.68	[0.94, 3.00]	1.84	[0.95, 3.57]	1.61	[0.86, 3.03]	**2.22**	[1.05, 4.69]
4	**1.64**	[0.97, 2.79]	**2.38**	[1.27, 4.44]	1.24	[0.71, 2.17]	1.24	[0.71, 2.17]
5	1.53	[0.91, 2.55]	1.21	[0.72, 2.04]	1.71	[0.93, 3.12]	1.91	[0.98, 3.71]
Year	**Gingivitis**				**Gingivitis**			
	tooth 16		tooth 36		tooth 16		tooth 36	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
1	0.96	[0.59, 1.56]	**2.32**	[1.24, 4.34]	0.95	[0.50, 1.82]	1.86	[0.84, 4.13]
2	1.15	[0.77, 1.72]	1.28	[0.83, 1.95]	1.32	[0.69, 2.52]	1.79	[0.86, 3.69]
3	0.86	[0.55, 1.33]	1.05	[0.64, 1.71]	0.70	[0.42, 1.18]	0.70	[0.40, 1.22]
4	0.93	[0.57, 1.55]	0.65	[0.39, 1.07]	**0.56**	[0.32, 0.98]	0.72	[0.39, 1.31]
5	0.74	[0.47, 1.17]	0.78	[0.46, 1.31]	0.93	[0.52, 1.69]	0.79	[0.42, 1.49]

Statistically significant odds ratios are designated in bold. CI: confidence interval. For occlusal caries as well as gingivitis, early emergence was considered exposed in order to obtain odds ratios ≥1 (i.e. early/late). Results are obtained from analyses with correction for reported brushing frequency.

the difference being statistically significant up to the third survey year in girls and up to the fourth year in boys *(Figure 2).*

Mean buccal plaque scores decreased gradually from year 3 to year 6 in both subgroups *(Figure 3).* For all molars (except tooth 16 in boys), the effect of emergence changed significantly over time (i.e. the interaction between emergence and time was significant).

Mean gingivitis scores increased between year 1 and year 2 and decreased from then on *(Figure 4).* The trend was comparable in both subgroups. A significantly higher score was obtained in the early boys for the mandibular first molar in the first survey year. In boys, the interaction between emergence and time proved to be significant for the mandibular molar. In girls, no significant effect of time or emergence status on gingivitis scores could be detected.

Figure 5 illustrates the proportion of early- and late-emerging girls with occlusal plaque (A-B) and occlusal caries (C-D) on teeth 16 and 36. A comparable trend was observed in boys. The percentage of first molars with occlusal plaque decreased with increasing age; the late group displayed significantly higher values for two to three years.

The proportion of first molars with caries experience in the occlusal surface increased with time *(Figure 5* C-D); the effect of emergence status did not change significantly over time. More early than late emergers had caries in the occlusal surface of the permanent first molars; the effect of emergence status as well as time was significant.

Odds ratios were calculated to quantify the association between emergence status (early vs. late) and the experience of occlusal caries in and gingivitis at the permanent first molars *(Table 3).* Early emergers had a significantly increased risk of having caries (i.e. DMFS>0); odds ratios reached statistical significance during two to three follow-up years. No consistent association was observed between the timing of emergence and gingivitis scores.

Discussion

When tooth emergence is examined, it is impossible to assess the exact moment of emergence of a single tooth in a single child. The phenomenon may have taken place before the first examination, in-between two consecutive examinations, or after the last examination; such data are called interval-censored data [16]. In the present sample, 81-88% of the permanent first molars had already emerged at the first examination. In order to examine the association between tooth emergence and the occurrence of dental caries, plaque and gingivitis, two extreme subgroups were composed: the early emergers had all four permanent first molars present at the baseline examination whereas the late emergers had no permanent first molars present at the first examination.

For this study, separate analyses were performed for girls and boys, because it was demonstrated in the same sample [17] and in other studies on permanent tooth emergence that girls are ahead of boys [18,19,20,21]. Reports on the impact of gender on caries attack show conflicting results: a study performed in the same population found no significant gender effect [22] whereas Virtanen *et al.* (1993) [23] indicated that girls have a lower risk for caries when analyses are based on dental age. Earlier work in periodontal research indicated that mean gingivitis scores reached comparable peak levels in both sexes but that the peak occurred earlier in girls than in boys [24,25]. Consequently, in order to prevent any possible confounding by gender, all analyses were performed separately for girls and boys.

Because the division into subgroups was based on dental age, it was anticipated that late emergers were younger and presented at baseline with more deciduous teeth and fewer permanent teeth *(Table 1).* Because the early group had fewer deciduous teeth present at baseline, one would expect them to have a lower dmfs score. However, the majority of caries experience in the primary dentition of this population was observed in the primary molars [26], teeth that were still present at baseline in both groups. The higher dmfs score in the early group is most likely attributable to the longer period at risk, because these children were older. In a previous study, in the same sample it was observed that the emergence of the premolar is accelerated by 2-8 months when its predecessor had been decayed, restored, or extracted because of caries [26]. Additional analyses, however, revealed that the emergence of the permanent first molars is not significantly affected by the caries experience status of the primary molars.

The results of this study are based on data collected in a larger sample of 4468 boys and girls, representative of the Flemish children born in 1989 (Signal-Tandmobiel® project). Every survey year, 10-32% of children selected for both subgroups were not present at the day of the examination; the non-participation rate increased with time and was slightly higher in the late group. The difference in non-participation rate between late and early emergers reached statistical significance in the first follow-up year in girls and the third and the fourth year in boys. Yet, the major reasons for non-participation were illness or absence on the day of the examination or change of school, reasons unrelated to the study purpose.

Although no significant effect of emergence status on buccal plaque accumulation and gingivitis scores could be found *(Figures 3* and *4),* mean buccal plaque and gingivitis scores decreased in both subgroups from year 3 on. The decrease in gingivitis scores with increasing age did not conform with earlier work [9,27]; however, differences in sampling, index teeth, or study set-up may explain the apparently conflicting results. Further analyses in the larger sample and on all index teeth are indicated to fully explore the effect of chronological age on gingivitis.

Referring to the work by Carvalho *et al.* (1989) [5], who demonstrated in a clinical study that in the absence of oral hygiene for 48 hours fully erupted permanent first molars accumulated less plaque on the occlusal surfaces, it was expected that the proportion of early emergers with plaque on the occlusal surfaces of the first permanent molars would be lower *(Figure 5).* However, it was surprising that the differences between early and late emergers (boys) maintained statistical significance up to the third survey year in the maxilla and up to the second year in the mandible. It is questionable that the eruption process itself is responsible for the higher occlusal plaque scores observed in the late group for so many years. However, in the follow-up years, no statistically significant differences in reported brushing habits (brushing frequency, received help, and quantity of toothpaste) could be detected between the two subgroups. On the other hand, Cumming and Löe (1973) [28] noted that brushing frequency does not necessarily reflect thoroughness. The proportion of occlusal surfaces with visible plaque decreased over time, which was also observed by Carvalho *et al.* (1992) [3].

The essential role of undisturbed plaque accumulation for caries initiation and progression is well established [29,30,31,32]. However, in the present study it was illustrated that although occlusal plaque scores decreased with increasing age, occlusal caries scores increased. Moreover, although late emergers accumulated more plaque on the occlusal surface, they experienced less caries than the early emergers. These seemingly contradictory results conform with earlier work indicating that individual oral hygiene is poorly related to caries experience [33,34]. Plaque levels depict oral hygiene at a given moment, whereas DMFT(dmft) scores represent the result of oral hygiene and exposure to fluorides, dietary habits and so on, over a longer period of time.

The bulk of dental caries was observed in permanent first molars and mainly at the occlusal surfaces, a finding that confirms earlier studies [35,36]. Although caries prevalence has decreased substantially since the publication of the first above-cited articles, McDonald and Sheiham (1992) [37] pointed out that as caries prevalence decreases, the number of least susceptible sites decreases most, whereas the number of most susceptible (occlusal) sites decreases least.

The present study indicated that early emergence of permanent first molars is a significant risk factor for occlusal caries development. The statistically significantly increased risk was observed during a follow-up period of 1-2 years in girls and even for four years in boys *(Table 3* and *Figure 5),* confirming the results of the studies by Mayhall (1977) [6] and Boesen *et al.* (1978) [38]. In a Scandinavian study [8], where caries susceptibility was measured by the placement rate of the first restoration, no consistent effect of early or late emergence of permanent teeth was observed. Earlier work by Miller *et al.* (1968) [7] also failed to find evidence of an impact of timing of emergence on the onset of caries in permanent first molars. Differences in research methods (sampling methods, caries prevalence, statistical analysis, definition of early vs. late emergence) may explain the observed differences between the above-cited studies.

Conclusions

In conclusion, the results of this study indicate that early emergence is an important risk factor for occlusal caries development in permanent first molars for a period of 2-4 years after emergence, when comparing children of the same year of birth. In the present study, all children were born in the same year, yet significant differences in caries experience between the late and early emergers were observed. Especially the first years following emergence, differences in caries prevalence between population groups may be attributed rather to differences in emergence ages than true differences in caries experience between the examined groups. Consequently, it can be recommended when data on caries prevalence in young children are evaluated, to make comparisons based on dental age rather than on chronological age.

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