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ORIGINAL ARTICLE

F. Stahl · R. Grabowski

Malocclusion and caries prevalence: is there a connection in the primary and mixed dentitions?

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Abstract The purpose of this epidemiological cross-sectional study was to determine the prevalence of malocclusion and caries in children and to investigate whether a relationship exists between prevalence of caries and studied malocclusion. The study consisted of 8,864 preschool and schoolchildren with primary dentitions (mean age 4.5 years) and mixed dentitions (mean age 8.9 years). 1997 WHO dental caries criteria were applied to both groups. The existence of an increased caries risk was deducted from the dmft and DMFT indices related to age. Malocclusion in primary and mixed dentitions was classified into seven types. Fifty-seven percent of all children had some form of malocclusion. Prevalence of malocclusion increased and was significantly greater in the mixed dentition sample ($p<0.001$) than in the primary dentition sample. Seventy-four percent of children with primary dentitions and 23% of children with mixed dentitions had zero dmft and DMFT scores. Mean dmft indices in subjects with primary and mixed dentitions were 1.02 and 1.53, respectively. No positive correlation between prevalence of caries and malocclusion could be established in the sub sample with primary teeth only. However, statistically significant parallelism in prevalence of malocclusion and caries were found for posterior cross-bite ($p=0.050$) and mandibular overjet ($p=0.013$) in children with mixed dentitions.

Keywords Dental caries · Caries experience · Malocclusion · Cross-sectional study · Epidemiology

F. Stahl (✉) · R. Grabowski
Department of Orthodontics, School of Dentistry,
University of Rostock,
Strempelstraße 13, 18055 Rostock, Germany
e-mail: Franka.Stahl@medizin.uni-rostock.de
Tel.: +49-3814946655
Fax: +49-3814946651

Introduction

Many epidemiological studies on prevalence of caries and malocclusion in children have been presented in the literature. However, only a few have simultaneously evaluated dental and orthodontic findings in an adequate sample and even fewer have analysed possible interactions between them. It has been assumed by several authors that dental caries and premature loss of primary teeth are predisposing factors for occlusal and space anomalies in mixed and permanent dentitions [9, 11, 13]. However, a causal relationship between malocclusion and dental caries has not been convincingly demonstrated [8]. Previous attempts to investigate a possible association of malocclusion and dental caries have shown conflicting or inconclusive results [1, 2, 5]. This may be attributed to differences in caries experience of the study sample, small sample sizes, or in unsuitable criteria used for defining 'caries-free' and 'carious' dentitions. The aim of the present investigation was to analyse the data for a possible relationship between prevalence of caries and malocclusion in a representative sample of children. The study aimed to answer the following questions:

1. Does prevalence of malocclusion differ significantly between caries-free and carious dentitions, whether primary or mixed?
2. In which types of malocclusion with mixed and primary dentitions is caries found significantly more often than in dentitions with normal occlusion?
3. Is there a connection between high caries rates and malocclusion in children?

Subjects and methods

Study population

An epidemiological survey of 8,864 children (4,306 females and 4,558 males) was performed in the city of Rostock, Germany, which has low-fluoride drinking water containing 0.11 ppm F [15]. Out of all 20,028 children and adolescents who were examined as

Table 1 Definition of individual caries risk in children according to the DAJ guidelines

(1)	Up to 3 years:	Not caries-free: dmft>0
(2)	Up to 4 years	dmft>2
(3)	Up to 5 years	dmft>4
(4)	Up to 6–7 years	dmft, DMFT>5 or D/T>0
(5)	Up to 8–9 years	dmft, DMFT>7 or D/T>2
(6)	Up to 10–12 years	DMFS>0

part of their yearly dental check-up by the Department of Public Health, 8,864 children were randomly selected for study by the Department of Orthodontics at the University of Rostock. The clinical examinations were performed in public kindergartens and primary schools. The children were chosen by chance and regardless of their social status, so the present study sample represents the whole range of different social classes. No preselection of kindergarten attendants and schoolchildren was made. All those who fulfilled the required inclusion criteria and who were present at the day of examination and in good health were included. The inclusion criteria were primary or early mixed dentitions without orthodontic treatment prior to examination. Children with craniofacial syndromes were excluded from the study. The mean ages of the children with primary dentitions (n=1,225) and mixed dentitions (n=7,639) were 4.5 years and 8.9 years, respectively. Age, gender, dental and orthodontic findings of all subjects were documented on two different examination sheets, one for children with primary dentitions and one for those with mixed dentitions. Both sheets were developed at the Department of Orthodontics at the University of Rostock prior to the survey. Socio-economic status of the children was not recorded. Clinical examinations were performed by experienced clinicians, two dentists and one orthodontist. The examiners received training and were calibrated against each other prior to this study. Criteria for recording dental caries experience were established according to WHO guidelines [20]. No radiographs were taken. Premature loss of primary teeth due to caries was considered when primary teeth were missing 2 years before their normal exfoliation. Prevalence of caries was judged by evaluating the dmft and DMFT values in primary and mixed dentitions. An increased caries risk was assessed by using guidelines of the German working group for youth tooth care [3]. These guidelines define the individual caries risk for a child by relating the dmft and DMFT indices to the age of the child (Table 1). Using these guidelines, criteria 1–4 appeared for children with primary dentitions, whereas criteria 4–5 appeared for those with mixed dentitions.

Orthodontic assessment was recorded by visual inspection. All irregularities in the anteroposterior, transverse and vertical planes as well as oral habits or dysfunctions were documented. The criteria used to designate malocclusion are listed below:

1. *Inter-arch relationship:* the relationship of the primary canines was considered to be Class I or normal if the tip of the upper primary canine was in the same vertical plane as the distal surface of the lower canine in habitual occlusion. When Class II or III were recorded, the tip of the upper primary canine tooth was located either mesially or distally to the distal surface of the mandibular primary canine. Class II division 1 was noted when the maxillary overjet was increased and the upper incisors were normally proclined. Class II division 2 was noted when there were retroclined maxillary incisors with a minimal or increased overjet. The inter-arch relationships were analysed bilaterally in all subjects.
2. *Overjet* (in millimetres): normal overjet was defined as the horizontal overlap of the incisors in occlusion with the maxillary incisors labially in contact with the mandibular incisors. Any deviations from normal overjet were measured from the palatal surface of the most protruded, fully erupted maxillary incisor to the labial surface of the corresponding mandibular incisor and defined as increased maxillary overjet. Mandibular overjet was recorded when one or more maxillary incisors occluded lingually to the mandibular incisors.
3. *Overbite:* normal overbite was defined as covering the middle third of the mandibular incisors by the maxillary incisors. An increased overbite was registered when more than two thirds of the lower incisors were covered by the upper incisors. A negative overlap in the vertical plane was recorded as an anterior open bite.
4. *Posterior cross-bite:* occlusion of maxillary primary canines or molars lingually to the buccal cusps of the opposing mandibular teeth was recorded as a posterior cross-bite.
5. *Crowding:* crowding was defined as any tooth rotated or out of line for which space would have to be created to allow correction of malalignment. In mixed dentitions, crowding was divided according to its location in the anterior, posterior or canine region.
6. *Spacing:* spacing in mixed dentitions was recorded as a remarkable mismatch of tooth and jaw sizes resulting in multiple spaces between the teeth.

As one aim of the present study was to determine prevalence of malocclusion, malocclusion was classified according to its main symptom, as proposed by Klink-Heckmann and Bredy [6]. Considering its importance and prognosis for orthodontic treatment, malocclusion was grouped into: crowding; Angle Class II division 1 malocclusion (increased maxillary overjet); Angle Class II division 2 malocclusion; posterior cross-bite; mandibular overjet; frontal open bite; and increased overbite with Class I inter-arch relationship. Spacing was defined as malocclusion only in mixed dentitions.

Habits such as any kind of sucking habits, nail biting, lip or tongue biting were registered. Functional disorders of the tongue such as tongue thrust swallowing, speech disorders and incomplete mouth closure were also recorded.

Statistical methods

Data were processed and statistical analysis was performed using SPSS (version 10.0). Descriptive data analysis comprised calculation of mean values and standard deviations (SD) of dmft and DMFT scores. Prevalence of malocclusion in carious (dt>0, DT>0) and caries-free (dt=0, DT=0) dentitions were compared using chi-square tests. The differences between prevalence of caries in the primary and in the mixed dentitions with normal occlusion on the one and malocclusion on the other side were examined using the Kruskal-Wallis test. Mann-Whitney U tests were performed to compare mean dmft and DMFT scores in dentitions with normal occlusion and different types of malocclusion. All tests were performed at the 95% confidence level.

Results

Prevalence of caries and malocclusion

Seventy-four percent of children with primary dentitions and 23% of children with mixed dentitions had dmft and DMFT scores of zero. Thus, caries-free dentitions (dt=0, DT=0) were more common in children with primary dentitions compared with those with mixed dentitions (80 vs. 65%). The mean dmft values in subjects with primary and mixed dentitions were 1.02 and 1.53, respectively (Table 2). The difference between means was statistically significant ($p<0.001$). With regard to gender, the only significant difference in the prevalence of caries was found in mixed dentitions, with males exhibiting significantly higher dmft scores than females ($p<0.001$). An

Table 2 Dental caries indices of primary and mixed dentitions in Rostock's children (Germany)

Primary dentition				Mixed dentition			
dmft	d/t (%)	m/t (%)	f/t (%)	dmft	d/t (%)	m/t (%)	f/t (%)
1.02 (SD=2.3)	69.6	2.0	28.4	1.53 (SD=2.2)	31.5	1.2	67.3

Table 3 Distribution of specific types of malocclusion in caries-free and caries-affected primary dentitions

Malocclusion Primary dentition	Caries-free		Carious		*p*-value
	n	%	n	%	
Crowding	25	2.6	5	2.0	0.819
Maxillary overjet	171	17.6	35	13.9	0.186
Mandibular overjet	11	1.1	2	0.8	1.000
Frontal open bite	67	6.9	15	6.0	0.673
Angle Class II/2	25	2.6	6	2.4	1.000
Increased overbite	60	6.2	12	4.8	0.455
Posterior cross-bite	40	4.1	8	3.2	0.588

Table 4 Distribution of specific types of malocclusion in caries-free and caries-affected mixed dentitions

Malocclusion Mixed dentition	Caries-free		Carious		*p*-value
	n	%	n	%	
Crowding	974	19.6	548	20.5	0.337
Maxillary overjet	707	14.2	344	12.9	0.109
Mandibular overjet	42	0.8	51	1.9	<0.001
Frontal open bite	133	2.7	80	3.0	0.423
Angle Class II/2	316	6.4	156	5.8	0.397
Increased overbite	242	4.9	198	7.4	<0.001
Posterior cross-bite	141	2.8	94	3.5	0.110
Spacing	59	1.2	34	1.3	0.744

increased caries risk was found in children with primary and mixed dentitions at levels of 11 and 12%, respectively (p=0.532). Between males and females who were categorised as children with an individual caries risk, no significant differences were found in the primary (p=0.626) or in the mixed dentition sample (p=0.580).

Children with mixed dentitions were found to have significantly more malocclusion (p<0.001) compared with children with primary dentitions (57 vs. 42%). Increased maxillary overjets and frontal open bites were most prevalent in primary dentitions: 41% of all children with malocclusion had maxillary overjets and open bites were observed in 16% of all subjects. Crowding in the anterior region was the most prevalent malocclusion in mixed dentitions, occurring in 33% of all children having any form of malocclusion. This was followed by maxillary overjet with 23%. The percentage distribution of other kinds of malocclusion in mixed dentitions ranged from 2 to 13%.

Relationship between prevalence of caries and malocclusion

Significantly more malocclusion was found in caries-free children when compared with carious primary dentitions (p=0.005). The mean dmft value calculated for children with primary dentitions and normal occlusion (dmft=1.15) was higher when compared with the dmft value of children exhibiting specific malocclusion in primary dentitions. However, this difference in dmft was not statistically significant in the primary dentition group (p=0.319). Maxillary overjets and frontal open bites occurred most often in both caries-free and carious primary dentitions. Crowding was found in only 3% of children with either caries-free or carious primary dentitions. No significant differences were found between prevalence of different kinds of malocclusion in caries-free and carious primary dentitions (Table 3).

In contrast to the primary dentition sample, no significant difference was observed between the prevalence of malocclusion in caries-free and carious mixed dentitions (p=0.574). Crowding in the anterior region and maxillary overjet were found most often in caries-free and carious mixed dentitions and of equal frequencies in caries-free and in carious mixed dentitions (Table 4). Only mandibular overjet and increased overbite were found significantly more often in carious mixed dentitions (Table 4).

Loss of space due to premature loss of primary teeth in the posterior teeth was observed in 273 children with mixed dentitions. This means that only 18% of all crowding conditions in the mixed dentition sample were combined with premature loss of primary teeth in the posterior arches.

Subjects with crowding in the posterior segments, spacing, posterior cross-bite and mandibular overjet had significantly higher mean dmft scores when compared with children with normal occlusion in mixed dentitions (Fig. 1).

Relationship between increased caries risk and malocclusion

When differentiating between caries risk children with and without malocclusion, malocclusion was identified in 54% among those who were categorised as children with an increased caries risk. The percentage of children with an increased caries risk also having malocclusion rose significantly from primary to mixed dentition (35 vs. 62%). Although high percentages of children with an increased caries risk were recorded to have crowding (17%) and open bite (12%) in primary dentitions, no positive correlation could be established. Only mandibular overjet and posterior cross-bite were significantly

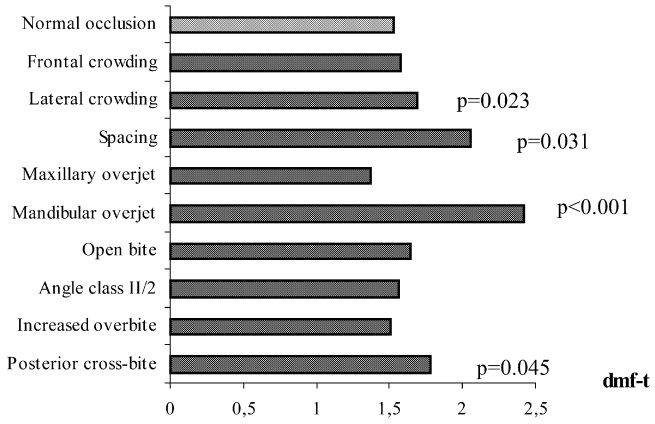

Fig. 1 dmft indices in mixed dentitions with normal occlusion and malocclusion

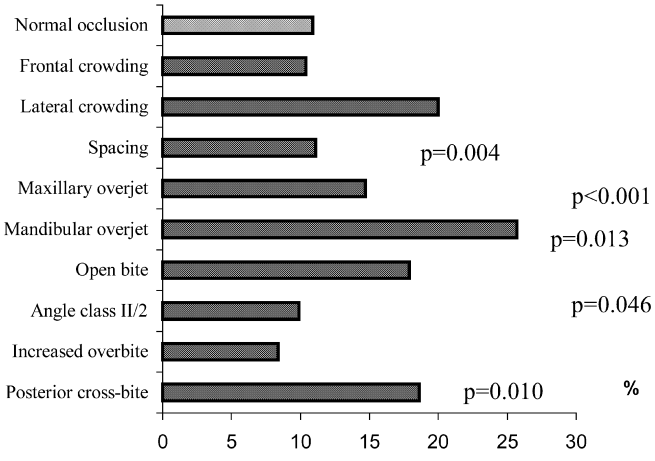

Fig. 2 Prevalence proportion rates (%) of normal occlusion and malocclusion in children with increased caries risk

correlated with an increased caries risk in mixed dentitions (Fig. 2).

Discussion

Previous attempts to investigate the association between dental health and malocclusion have preponderantly produced equivocal conclusions. The aim of the present study was to compare the prevalence of caries in primary and mixed dentitions with normal occlusion and malocclusion. The relationship between different kinds of malocclusion and high caries rates had to be analysed.

The high percentages of caries-free primary and mixed dentitions and the low caries experience which were observed in the present sample confirm the remarkable improvement in dental health among young European children as stated by other authors [10, 16, 17, 18]. The low number of prematurely lost primary teeth also appears to reflect this.

However, when comparing low caries experience with high prevalence rates of malocclusion of 42 and 57% in the primary and mixed dentition, it is evident that caries-preventive measures do not have a significant effect on prevention of malocclusion. The transfer of malocclusion from primary to mixed dentition and the development of new malocclusion in mixed dentition explain the remarkable increase in malocclusion prevalence from primary to mixed dentition. The long-term effects of unfavourable functional influences and the influence of inherited factors on developing dentition become evident at later developmental stages.

It was the purpose of the present study to determine prevalence of malocclusion in general; therefore, conclusions about the need for orthodontic treatment cannot be drawn from the present data. Nevertheless, the high prevalence of children exhibiting malocclusion in both groups points to the lack of preventive orthodontic programs in Germany when compared with the well-organised caries-preventive program in Germany.

Increased maxillary overjet and frontal open bite dominated in the primary dentition sample. Their etiology is known to be related to oral habits such as finger, thumb or pacifier sucking, or myofascial dysfunctions of the craniomandibular muscles [4, 7, 14, 19]. Previous and present oral habits or myofascial dysfunctions were difficult to determine in the present study. The absence of parents, psychological strain and presence of classmates were the reasons for difficulties in communication. An individual examination in the presence of the parents and with more time available would be preferred in order to determine oral habits or dysfunctions. The prevalence of oral habits or dysfunctions in the sample could only partially be detected and, thus, these results were not included in this paper.

From the present data it is evident that caries experience is not an important factor in formation of the most prevalent types of malocclusion in primary and early mixed dentitions. It is not surprising, therefore, that prevalence of malocclusion in primary dentitions was found significantly more often in caries-free dentitions when compared with carious dentitions. There was no significant difference between the dmft index in primary dentitions with or without malocclusion.

Crowding in the anterior region was the most prevalent malocclusion in the mixed dentition sample. However, only 18% of all crowding conditions in mixed dentitions were combined with early loss of primary teeth and the resulting loss of space. The fact that crowding was found equally often in caries-free and in caries-affected mixed dentitions indicates that non-caries-related factors might have induced formation of crowding. However, the general increase in the prevalence of crowding cannot be explained by human evolutionary development and inherited characteristics alone. Functional factors such as mouth breathing might conceivably contribute to crowding [12].

This is also supported by the fact that there was no major difference between prevalence of caries in mixed

dentitions with or without malocclusion. However, significantly increased dmf-t indices were found with some specific types of malocclusion in mixed dentitions when compared with prevalence of caries in mixed dentition without malocclusion. Mandibular overjet and posterior cross-bite were even significantly correlated with an increased caries risk. As there appears to be no causal relationship between caries experience and malocclusion in the present sample, another explanation must be looked for. The answer might be that there are conditions which lead to dental caries and malocclusion independently in the same individual. For instance, myofascial dysfunctions such as mouth breathing resulting in incomplete mouth closure or dysfunction of the tongue could contribute to both the formation of caries and malocclusion, as in posterior cross-bite and mandibular overjet.

Conclusion

From the data presented on the prevalence of dental caries and malocclusion, it is evident that caries-reducing measures are not likely to have a significant influence on formation of malocclusion in primary and early mixed dentition. No conclusion can be drawn about the relationship between prevalence of caries and malocclusion in general. With some specific types of malocclusion, however, there is a significant parallelism of high dental caries experience and malocclusion, but this does not mean that there is a causal relationship between caries and malocclusion.

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