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Occlusal status and prevalence of occlusal malocclusion traits among 9-year-old schoolchildren

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SUMMARY The aim of this study was to provide detailed information concerning clinically relevant occlusal traits and the prevalence of occlusal anomalies in an orthodontically relevant period of dental development. Four hundred and ninety-four German schoolchildren (237 males and 257 females), median age 9 years, were orthodontically examined. Overjet and overbite were measured to the nearest 0.5 mm, and sagittal molar relationships were registered clinically to the nearest quarter unit. In addition, crossbites, scissor bites, and midline displacements were evaluated. Descriptive statistics was complemented by testing gender differences and differences between groups with Class I and Class II anomalies (Mann–Whitney *U*-test) as well as a statistical evaluation of differences between the three dental stages (Kruskal–Wallis test).

Overjet exhibited an extreme range between –2 and 12 mm (median values 3–3.5 mm). An increased overjet was more prevalent than a reduced or reverse overjet, and a severely increased overjet greater than 6 mm was a common finding affecting around 5–10 per cent of the children. Similarly, overbite showed considerable variations of between –1 and 9 mm (medians 3–3.5 mm) and males exhibited a significantly larger overbite than females. In Class II malocclusion subjects, overbite was significantly enlarged (on average between 0.5 and 1 mm) when compared with those with a Class I malocclusion. Traumatic contact of the gingiva affected every 14th child. A Class II molar relationship of three-quarter units or more was a frequent finding affecting more than one child in five. In addition, at 9 years of age, 3 per cent of the children exhibited a Class III molar relationship of at least a half unit. The wide range of orthodontically relevant occlusal traits found in the present study underlines the need for orthodontic screening at 9 years of age (or earlier).

Introduction

Orthodontic treatment need has been addressed in a number of cross-sectional studies. Among German schoolchildren Bäßler-Zeltmann *et al.* (1998) and among adults Jonsson *et al.* (2007) determined that two groups of malocclusion traits were characterized by a particular high prevalence that subsequently require orthodontic attention. These are space anomalies, in particular anterior crowding (Bäßler-Zeltmann *et al.*, 1998), and occlusal anomalies, such as distal molar relationship and increased overjet. Thilander and Myrberg (1973) and Thilander *et al.* (2001) reported that among schoolchildren, at least half of all anomalies were occlusal, one-third space anomalies, and the remainder dental anomalies. Tausche *et al.* (2004) showed that an increased overbite and overjet were the most frequent malocclusions in the early mixed dentition period. However, in most studies clinically important parameters such as overjet, overbite, and sagittal occlusal relationship have only been approximately evaluated on the basis of some borderline values, for example increased maxillary overjet beyond 6 or 9 mm (Ingervall and Ratschiller, 1987, Bäßler-Zeltmann *et al.*, 1998, Souames *et al.*, 2006). Although this facilitates epidemiological registration and is appropriate to categorize orthodontic treatment need, for example based on the Index of Orthodontic Treatment Need (IOTN), it provides only limited insight into the inherent occlusal situation in a school population. Therefore, the aim of this study was to provide more detailed information concerning the physiological (normal) as well as malocclusion status based on clinically relevant traits of occlusion in an orthodontically relevant period of dental development.

Subjects and method

The present investigation was based on the examination of 494 schoolchildren (237 males and 257 females) between 8 years 6 months and 9 years 6 months (median age 9.0 years for both males and females). After approval from the local ethics committee (University of Heidelberg, reference number 161/2001), orthodontic examinations were carried out in the schools along with a dental examination focussing on caries. In cooperation with the local community dental service, schoolchildren in the south-western part of Germany were investigated. An epidemiological description of the sample used has been reported previously (Lux *et al.*, 2008) which addressed the prevalence of space anomalies.

Intraoral measurements

Overjet and overbite were measured with a metal ruler (Münchner Modell, No. 044-731-00, Dentaurum, Ispringen, Germany) to the nearest 0.5 mm. Overjet was registered at the most protruded central incisor (Björk *et al.*, 1964) between the labial surfaces of the upper and lower incisors. Sagittal molar relationships were registered bilaterally to the nearest quarter unit. Crossbites and scissor bites of the permanent teeth were registered according to the definitions of Björk *et al.* (1964). A centreline displacement was recorded if the midline of the mandibular arch was displaced at least 2 mm in relation to the midline of the upper arch (Björk *et al.*, 1964).

Reliability/validity of intraoral occlusal measurements

Interexaminer reliability was determined by two observers (CJL and BD) evaluating 30 children on the same day independently from each other. According to Bister *et al.* (2002), the mean of the differences (systematic bias), the 95 per cent confidence interval (CI) of the true bias, and the reproducibility coefficient with the corresponding 95 per cent limits of agreement were calculated for the metric data. In addition, the intraclass correlation coefficient (ICC) and its corresponding 95 per cent CI were determined. Table 1 shows the results for the occlusal measurements: overjet, overbite, and molar relationship. No relevant systematic bias at the 5 per cent level of significance was determined. In general, the measurement error for recording overjet was slightly better than for overbite. All measurements showed a high degree of interexaminer reproducibility (ICCs 0.91 or above, Table 1).

Statistical analysis

Statistical testing included gender differences, differences between groups with Class I and Class II anomalies (independent measurements), as well as differences between the left and right sides (compared with molar relationship, dependent measurement). For independent and dependent measurements, a Mann–Whitney *U*-test and a Wilcoxon matched-pairs signed-rank test were used, respectively. A significance level of $\alpha = 0.05$ was chosen for all statistical tests. In addition, the various parameters were analysed separately within the stages of dental development (dental stages = DS) developed by Björk *et al.* (1964), that is DS 1 = incisors erupting, DS 2 = incisors fully erupted, and DS 3 = canines and premolars erupting. A Kruskal–Wallis test was used to evaluate the differences between the three dental stages DS 1 to DS 3. Due to multiple testing and estimation, the *P* values and the confidence levels of intervals cannot be interpreted in a strong confirmatory sense.

Results

Overjet

Figure 1 shows the distribution of overjet among males and females. The most frequent finding was an overjet between >2 and ≤3 mm (24.7 per cent males and 29.1 per cent females), followed by an overjet between >3 and ≤4 mm (23.4 per cent males and 22.8 per cent females). In general, overjet showed an extreme range between −1.5 and +11.5 mm among the males and between −1 and +11 mm among the females. For both genders, an increased overjet occurred more frequently than a reduced overjet. An overjet larger than 6 up to 9 mm (corresponding to the IOTN grade 4) was found in 6.0 per cent of males and 4.7 per cent of females, and an overjet larger than 9 mm (IOTN grade 5) in 1.3 and 2.0 per cent, respectively (Figure 1). Descriptive statistics for overjet among the males and females are presented in Table 2. Although a slight gender difference emerged (median overjet among the boys 3.5 versus 3 mm among the females, $P = 0.046$), no significant gender differences were found when evaluated within the respective dental stages (DS 1 to DS 3).

Overbite

Figure 2 shows the relative frequency of overbite, separately for males and females. The most frequent finding was an overbite between >3 and ≤4 mm, both among males (21.7 per cent) and females (25.2 per cent). Concerning gender differences, a significantly larger overbite was found for males when compared with females (median 3.5 versus 3 mm, $P < 0.001$, Table 2). Gender differences were also statistically significant when tested within the dental stages: in DS 1 and DS 3, males exhibited a significantly larger

Table 1 Measurement error: mean of the differences (systematic error), the 95 per cent confidence interval (CI) for the bias, the reproducibility coefficient, and the intraclass correlation coefficient (ICC) with its 95 per cent CI.

Parameter	Mean of the differences (bias)	95% CI for the bias	Reproducibility coefficient	ICC	95% CI for ICC
Overjet (mm)	−0.15	−0.29/−0.01	0.78	0.96	0.94/0.99
Overbite (mm)	−0.17	−0.38/0.05	1.16	0.91	0.84/0.97
Molar relationship right (cusp width)	−0.02	−0.07/0.04	0.29	0.91	0.85/0.97
Molar relationship left (cusp width)	−0.03	−0.08/0.02	0.28	0.93	0.88/0.98

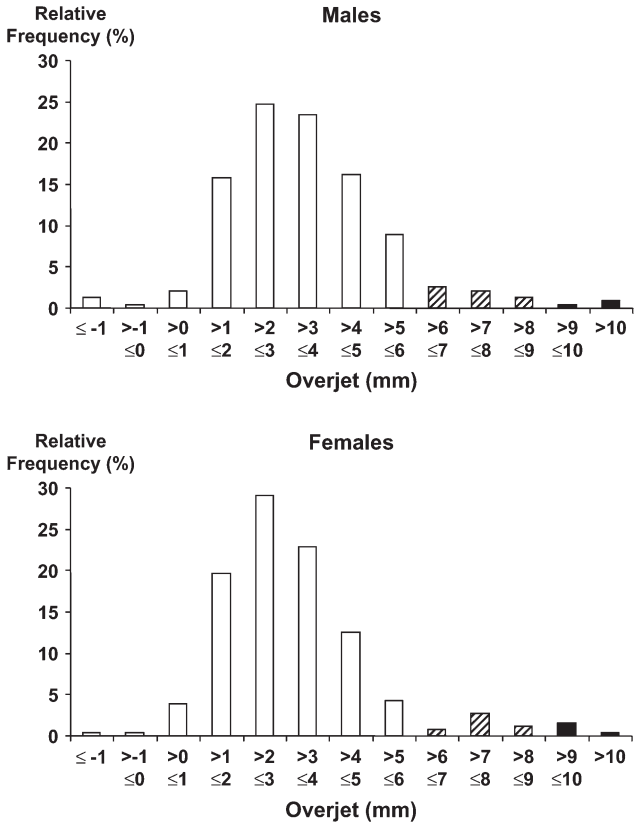

Figure 1 Distribution of overjet (relative frequency in per cent) among males (n = 235) and females (n = 254). Subjects with an overjet between 6 and 9 mm (>6 and ≤9 mm) are hatched [Index of Orthodontic Treatment Need (IOTN) grade 4], and those with an overjet larger than 9 mm (IOTN grade 5) are marked in black.

overbite than females (P = 0.010 in DS 1 and P = 0.008 in DS 3, Table 2).

The prevalence of a deep or an open bite is shown in Table 3. In general, males exhibited a higher prevalence of deep bites than females. A deep bite larger than 5 mm was found in 13.6 per cent of males and 5.1 in per cent of females. In addition, the proportion of traumatic gingival contact increased along with the degree of deep bite (Figure 2) and traumatic contact affected 8.1 per cent of males and 5.9 per cent of females. Finally, whether Class II subjects' distal molar relationship of half or more units exhibited a different degree of overbite when compared with Class I children was evaluated. In both genders, overbite was significantly larger among the Class II children (median for males 4 mm, females 3.5 mm) when compared with the Class I subjects (median for males and females 3 mm).

Molar relationship

Class I was the most frequently found molar relationship (Figure 3). In addition, a Class II molar relationship of up to a half unit, which may be normal during dental development,

Table 2 Descriptive statistics for overjet and overbite, separately for males and females. P values show differences between males and females. In addition, the medians within each dental stage (DS 1, 2, and 3) given. No significant group differences between the three dental stages were found (P < 0.05, Kruskal–Wallis test).

	Males (n = 235)	Females (n = 254)	P value
Overjet			
Median	3.5	3	0.046
Medians DS 1–3	3.5/3.5/3	3/3/3	
Minimum	−1.5	−1	
Maximum	11.5	11	
Mean	3.72	3.48	
SD	1.89	1.82	
Overbite			
Median	3.5	3	<0.001
Medians DS 1–3	3.5/3.5/4	3/3.5/3	
Minimum	0	−1	
Maximum	9	7.5	
Mean	3.56	3.03	
SD	1.70	1.58	

Table 3 Prevalence (relative frequency in per cent, males and females = 100 per cent, respectively) of increased and reduced overbite.

Prevalence overbite (mm)	Males (n = 235)	Females (n = 254)
>4 to ≤5	20.9	16.5
>5 to ≤6	10.6	3.1
>6 to ≤7	0.9	0.8
>7	2.1	1.2
≤0	3.0	4.3

was a common finding. However, a distal molar relationship of three-quarter units or more, which will presumably necessitate orthodontic treatment, was also a frequent finding (Table 4): 16.5 per cent of the boys exhibited a three-quarter unit Class II relationship and 11.4 per cent a full unit Class II molar relationship or more, that is 27.8 per cent of the males showed a uni- or bilateral molar relationship of at least three-quarter units. Lower prevalences were found among the females: 16.7 per cent were affected by a Class II molar relationship of three-quarter units or more. Table 4 also shows the results when prevalences were calculated only for patients with no or minimal posterior crowding (≤1 mm). In these children, the prevalence of a Class II relationship was only slightly less, suggesting that the majority of Class II molar relationships (three-quarter units and more) did not result from molar migration as indicated by the absence of posterior crowding. The prevalence of at least a half unit Class III molar relationship (Table 4) was considerably less (approximately 3 per cent of

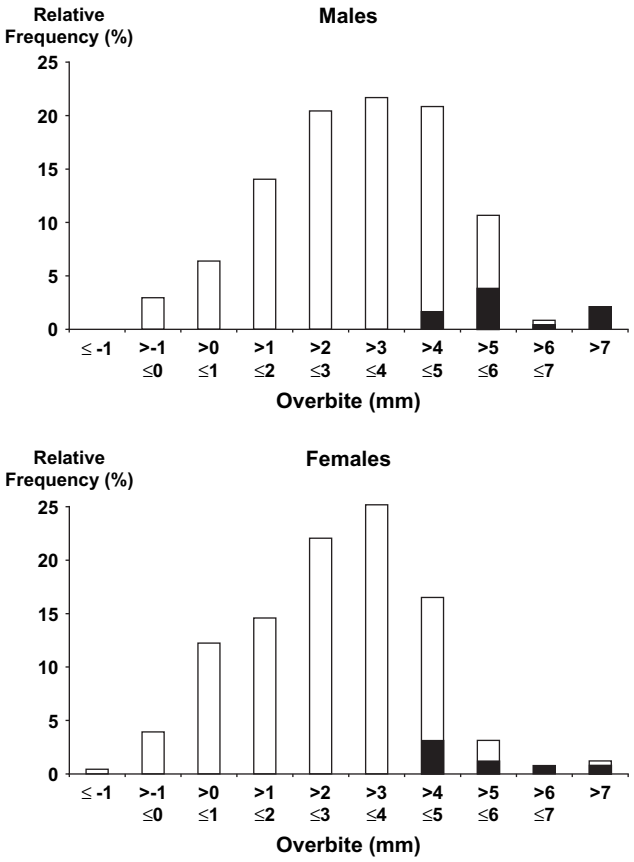

Figure 2 Distribution of overbite (relative frequency in per cent) among males (n = 235) and females (n = 254). The columns marked in black depict the respective proportion of children with traumatic gingival contact.

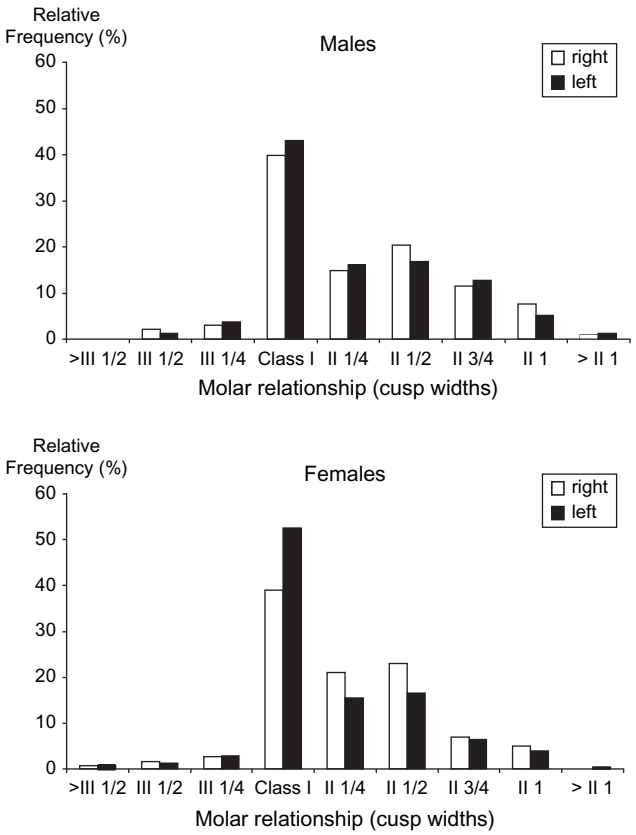

Figure 3 Distribution (relative frequency in per cent) of the molar relationship on the right and left sides (=100 per cent, respectively), separately for males and females (males: n = 236 right, n = 237 left; females: n = 257 right, n = 253 left).

the children; Table 4). No significant gender differences were found for molar relationship when tested within each dental stage. In both genders, the median molar relationship was a quarter unit Class II in DS 1 and a Class I in DS 3.

Other occlusal anomalies

An anterior crossbite was found in 3.4 per cent of males and 5.1 per cent of females (Table 5). In particular, the lateral incisors were affected by frontal crossbite, and frontal crossibite affected one to three upper front teeth. A lateral crossbite of the permanent teeth was found in 6.3 (males) and 5.4 (females) per cent, predominantly affecting the first molars unilaterally (Table 5). A scissor bite of the permanent teeth was found only in one child. Midline deviations (≥2 mm) were common and found in 21.9 per cent of the males and 20.2 per cent of the females.

Table 4 Prevalence (relative frequency in per cent; right and left sides and children with at least one affected side = 100 per cent, respectively) of distal and mesial molar relationship: prevalences if sides with posterior crowding more than 1 mm in upper and/or lower jaw are excluded are shown in parentheses (posterior crowding as indicator for mesial migration of molars).

Prevalence (%) molar relation	Gender	Right side	Left side	Children with at least one affected side
Three-quarter unit Class II	Males	11.4 (11.2)	12.7 (12.0)	16.5 (15.9)
	Females	7.0 (6.3)	6.3 (6.0)	8.9 (8.4)
≥Full unit Class II	Males	8.5 (7.0)	6.3 (5.5)	11.4 (9.7)
	Females	5.1 (5.1)	4.3 (4.3)	7.8 (7.2)
Quarter unit Class III	Males	3.0 (2.3)	3.8 (3.2)	4.2 (3.5)
	Females	2.7 (3.0)	2.8 (2.6)	3.9 (3.6)
≥Half unit Class III	Males	2.1 (2.3)	1.3 (1.4)	3.0 (3.1)
	Females	2.3 (2.5)	2.0 (2.1)	2.7 (2.8)

Discussion

Recent epidemiological reports have estimated orthodontic treatment need on the basis of a variety of indices such as the IOTN (Tausche *et al.*, 2004, Souames *et al.*, 2006) or the index of the Swedish National Board of Welfare and Health (Bäßler-Zeltmann *et al.*, 1998). The present study, however, did not focus on the complex relationship between treatment need and malocclusion (Jonsson *et al.*, 2007), but aimed to

Table 5 Prevalence of lateral and anterior crossbites (permanent teeth), separately for males and females (=100 per cent, respectively). *P* values indicate possible gender differences.

Prevalence (in %)	Males (n = 237)	Females (n = 257)	P value
Lateral crossbite			
Unilateral	5.5	5.1	0.82
Bilateral	0.8	0.4	
Total	6.3	5.4	
Anterior crossbite			
One tooth	1.3	3.1	0.37
More than one tooth	2.1	1.9	
Total	3.4	5.1	

provide a detailed insight into the distribution of clinically relevant occlusal traits underlying common indices of treatment need. The orthodontic significance of the occlusal status for the assessment of treatment need clearly emerges in the IOTN. In this index, a hierarchical scale using the acronym 'MOCDO' (Missing teeth–Overjets–Crossbites–Displacements of contact points–Overbites) reveals the clinical relevance of occlusal malocclusion traits, in particular sagittal and vertical incisor relationships, with regard to orthodontic treatment priority (Richmond *et al.*, 1992).

With respect to overjet, Proffit *et al.* (1998) reported that between 8 and 11 years of age, 29.6 per cent had an ideal overjet and 45.2 per cent a mildly increased overjet (3–4 mm). This is supported by the findings of the present study: a majority of children either exhibited an ideal overjet (>1 to 3 mm) or a moderately increased overjet (>3 to 5 mm). The prevalence of an increased overjet was much higher than a decreased or reverse overjet. Bäßler-Zeltmann *et al.* (1998) found an increased overjet between 6 and 9 mm in 10.2 per cent of children and an overjet larger than 9 mm in 3.8 per cent. The respective values in the investigation by Ingervall and Ratschiller (1987) were 13 and 2.7 per cent. In the present study, an overjet between 6 and 9 mm (>6; ≤9 mm: IOTN grade 4) was found in 6.0 per cent of males and 4.7 per cent of females, and an overjet larger than 9 mm (IOTN grade 5) in 1.3 and 2.0 per cent, respectively. If, in the present study, the same intervals as described by Bäßler-Zeltmann *et al.* (1998) were used, the respective prevalences for an overjet between 6 and 9 mm would be 10.6 per cent (males) and 6.3 per cent (females). This is close to the values described by Bäßler-Zeltmann *et al.* (1998) but smaller than the prevalences reported by Ingervall and Ratschiller (1987).

Concerning overbite, Bäßler-Zeltmann *et al.* (1998) found a deep bite (≥5 mm) in 33.7 per cent of the examined children. In the present study, the prevalence of a deep bite (>5 mm) was less and ranged between 13.6 per cent (males) and 5.1 per cent (females). On the basis of the deep bite definition used by Bäßler-Zeltmann *et al.* (1998), that is including children with a 5 mm overbite into the deep bite group, the respective prevalences would be 25.1 and 12.2 per cent, respectively. This is very close to the values reported by Ingervall and Ratschiller (1987) who found a deep bite (≥5 mm) in 22 per cent of males and 16 per cent of females. Helm (1970), as well as Thilander and Myrberg (1973), found in Danish schoolchildren that a deep bite was more prevalent among males than females, a finding which is supported by the results of the present study. This also applies when gender differences were evaluated within the respective dental stages as suggested by Helm (1970). Nevertheless, this sexual dimorphism may be related to differences in skeletal maturity. In general, 9-year-old girls are closer to their respective skeletal growth spurt than males, a fact which may influence the prevalence of a deep bite (Helm, 1970) because overbite is related to the growth of the jaws (Ngan *et al.*, 1999, Tausche *et al.*, 2004).

In the present study, a considerable number of children exhibited a distal molar occlusion of three-quarter units or more, which is outside the physiological pattern of dental development. Mesial molar relationships were far more uncommon. During the transition from DS 2 to 3, however, Helm (1970) found a decreasing frequency of distal and an increasing frequency of mesial occlusion. In addition, the effect of the more pronounced prepubertal and pubertal mandibular growth as well as the physiological changes during exfoliation, that is replacement of the primary molars by the somewhat smaller permanent premolars, will additionally alter molar occlusion after 9 years of age. Helm (1970) found that a mandibular overjet, defined as an anterior crossbite of all four upper incisors, was extremely uncommon, a finding which is supported by the results of the present study. Moreover the prevalence of a lateral crossbite was 6.3 per cent for males and 5.4 per cent for females. Bäßler-Zeltmann *et al.* (1998) and Ingervall and Ratschiller (1987) found higher prevalences for lateral crossbite. In this context, it must be borne in mind that at the time of the investigation orthodontic treatment has already been initiated in a small percentage of children with removable appliances. Hence, it is likely that the prevalence of anomalies in which early interception is recommended in Germany (Schopf, 2003), for example anterior and lateral crossbites or extreme overjet (>10 mm), may be slightly underestimated in the present study.

Conclusions

1. Among 9-year-old schoolchildren, overjet exhibited an extreme range between −2 and 12 mm with median values between 3 and 3.5 mm. An increased overjet was more prevalent than a reduced or reverse overjet, and a severely increased overjet greater than 6 mm was a common finding affecting around 5–10 per cent of the children.
2. Similarly, overbite showed considerable variation between −1 and 9 mm (median 3–3.5 mm) and males exhibited a significantly larger overbite than females. Among males, an overbite between 1 and 6 mm was the

most frequent finding, and among females, values between 0 and 5 mm. In Class II malocclusion subjects, overbite was significantly increased (around 0.5–1 mm) when compared with subjects with a Class I malocclusion. Traumatic contact of the gingiva affected one in 14 children (a prevalence of approximately 7 per cent).

3. Concerning molar relationship, a Class II relationship of a three-quarter unit or more affected more than every fifth child, which supports the significance of Class II malocclusions. In addition, at 9 years of age, 3 per cent of the children exhibited a Class III molar relationship of at least a half unit. This group of children in particular require orthodontic attention.
4. The wide range of orthodontically relevant traits encountered in the present study underlines the need for orthodontic screening at 9 years of age (or earlier).

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