The Prevalence of Malocclusal Traits and their Correlations in Mixed Dentition Children: Results from the Italian OHSAR Survey

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Purpose: To know the prevalence of malocclusal traits and their correlation in Italian mixed dentition children.

Materials and Methods: A sample of 1,198 children 7 to 11 years old, who had never undergone orthodontic treatment, were included in the Italian Oral Health of Schoolchildren of the Abruzzo Region (OHSAR) Survey. Canine and molar classes, overbite, overjet, dental crowding, maxillary midline diastema, crossbite and scissorbite were recorded. The canine and molar classes were considered as dependent variables, and their separate correlations with all of the other occlusal traits were analysed by multivariate methods.

Results: Over 90% of the children showed at least one malocclusal trait; the mean ± SD of malocclusal traits was 3.5 ± 1.8. Gender did not affect the prevalence of any malocclusal traits. Dental class II was correlated with increased overbite and overjet, and negatively correlated with the maxillary midline diastema; dental class III was correlated with decreased overbite and overjet, and crossbite. Asymmetrical dental class was correlated with increased overjet and crossbite. Dental crowding showed very little correlation.

Conclusions: The prevalence of malocclusal traits in Italian children is very high, and more effort is needed to implement early interventions, including close monitoring and modifications of lifestyle.

Key words: children, correlation, epidemiology, Italy, malocclusion/malocclusal trait, mixed dentition, OHSAR survey

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Collecting epidemiological data concerning the dental health and morbidity among communities is of primary importance, as has been recommended and stressed by the World Health Organization (WHO) (Aggerryd, 1983). While in Europe epidemiological evaluations of the prevalence of malocclusion began many years ago (Helm, 1968; Myrberg and Thilander, 1973; Foster and Day, 1974; Ingervall and Hedegaard, 1975) along with the planning of oral health services (Helm, 1982), in Italy there is still a substantial lack of data. This applies particularly to the mixed dentition status, knowledge of which is essential to plan preventive and interceptive measures to minimise the severity of lesions (Helm, 1977). Moreover, many of the epidemiological surveys have been focused mainly on permanent dentition. Knowledge of the prevalence of malocclusal traits in mixed dentition would be helpful to plan early interventions for which the effectiveness, although still controversial (Johnston, 2006), has been shown for specific malocclusal traits, such as unilateral crossbite (Thilander et al, 1984; Sonnesen et al, 2001). Previous studies have provided evidence of

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benefits, i.e. a reduced need for extraction and more stable results from early treatment (Inglesson-Dahlstrom and Hangberg, 1994). Moreover, in the only previous Italian study (Ciuffolo et al, 2005), no information regarding the prevalence of canine or molar classes was reported.

These malocclusal traits are usually present in combination (Brunelle et al, 1996; Keski-Nisula et al, 2003; Ciuffolo et al, 2005). As a consequence, studies of correlations among these malocclusal traits for carrying out main malocclusal profiles are of evident relevance, as for instance in the training of future orthodontists. However, while information is available from studies that have evaluated the changes in single occlusal traits over time (Bishara et al, 1988; Inglesson-Dahlstrom and Hangberg, 1994), only a few studies have evaluated these correlations, and conclusions have mainly been derived from either indirect observation (Carvalho et al, 1998; Lauc, 2003) or bivariate analyses (correlation between two traits) (Howe et al, 1983; Sampson and Richards, 1985; Kerosuo et al, 1988; Brunelle et al, 1996; Thilander et al, 2001; Lauc, 2003).

The present study was thus designed as a comprehensive evaluation of the prevalence of malocclusal traits and their correlations in a large sample of mixed dentition children. The data presented here are from the fourth year of an eight-year survey organised through the Regional Council of Abruzzo (a Region of Central Italy), the 'SS Annunziata' Local Public Health Agency of Chieti, and the 'G. D'Annunzio' University of Chieti, and the survey itself is known as the Italian Oral Health of Schoolchildren of the Abruzzo Region (OHSAR) Survey, as also detailed elsewhere (Perinetti et al, 2005, 2006).

MATERIALS AND METHODS

Population and examiners

This study included an urban sample of 7- to 11-year-old children attending five primary public schools situated in 15 municipalities in the Region of Abruzzo. For each school, all of the schoolchildren attending in each municipality were invited to participate in the study.

Parents of the children were notified about the study by the schools, and invited to participate by the signing of an informed consent form. The clinical examinations took place during the period from March 2003 to June 2003. The study was conducted by a group of six expert examiners who had previously been trained with the collaboration of an experienced assessor (author PE). The kappa statistics for each examiner with the main assessor (author GP) were also produced (WHO, 1997; Mugonzibwa et al, 2004), yielding values in the range of 0.61–0.96 across the different traits. The parents/guardians of the children were asked to fill in a structured questionnaire that sought the following information on the children: date of birth, gender, socioeconomic level (Perinetti et al, 2005) (results not shown), oral habits (results not shown), and previous or current orthodontic treatment.

Dental visits

The dental visits were performed under natural light according to the WHO oral health survey recommendations (WHO, 1997), and the data were recorded on a dedicated dental form. Briefly, the examiners performed all of the recordings at the schools, and the instrumentation used included a plane dental mirror and a probe. Final year students helped the examiners and checked the finished records for completeness and accuracy of both the questionnaire and the dental forms at the moment of the visit.

Children who had never undergone orthodontic treatment, and with at least one permanent and one primary tooth visible in the oral cavity were included in the study. Canine and molar classes, overbite, overjet, dental crowding, maxillary midline diastema and crossbite were recorded as detailed below. Every time a parameter could not be classified due to the absence of or incomplete eruption of the teeth (depending on the emergence stage), or extensive caries or trauma, a 'not classified' score was assigned. All the relationships between the dental arches were recorded with the child in the centric occlusion. The numbers of primary and permanent teeth were also recorded, considering a tooth present when any part of it was visible in the oral cavity; no radiographs were taken.

The Angle classification was used for the canine and molar relationships. Canine classes as I, II and III were recorded either for primary or permanent canines according to the emergence stage of the child. In particular, a one-quarter-cusp displacement of less than normal was considered as class I (see also Katz, 1992). Molar classes I, II and III were recorded using the permanent first molars as reference teeth in all of the children. In the case of a half-cusp displacement of less than normal, this was considered as class I (Wheeler et al, 1994). Finally, when different canine or molar classes were found between the right and left sides, an 'asymmetrical class' was assigned.

The overbite was considered normal if the maxillary central incisors overlapped the incisal third of the crown of the mandibular central incisors. The overbite was classified as excessive if the overlap exceeded the middle third of the crown of the mandibular central incisors and reduced if it was less than the incisal third of the crown, including an edge-to-edge or open bite relationship (Onyeaso, 2004). The overjet was defined as the horizontal distance between the labial surface of the anterior upper maxillary and the anterior mandibular central incisors, parallel to the occlusal plane. Overjet values of between 2 and 3 mm were considered normal, greater than 3 mm were considered increased, and less than 2 mm were considered decreased (Onyeaso, 2004). For both the overjet and the overbite, incisors on the right side were used (Keski-Nisula et al, 2003; Mugonzibwa et al, 2004). If the right central incisors were missing, fractured or extensively decayed, then the left central incisors were considered (Brunelle et al, 1996).

Dental crowding was considered to be present in a segment when the teeth overlapped or if there was insufficient space for unerupted teeth to erupt without overlapping (Onyeaso, 2004). This shows the relationship between tooth size and arch size (Onyeaso, 2004). Maxillary midline diastema was recorded as present when there was a space of at least 1 mm between the central incisors (Lauc, 2003; Onyeaso, 2004).

Anterior crossbite was recorded when any primary/permanent incisors occluded lingually or in an edge-to-edge position with the antagonistic mandibular teeth (Lauc, 2003). Only in the cases in which all four of the incisors did not allow recording of the anterior crossbite, the not classified score was assigned. Posterior crossbite was recorded when the buccal cusps of any of the maxillary primary molars or maxillary permanent canines/premolars and molars totally occluded lingually or in an edge-to-edge position to the buccal cusps of the antagonistic mandibular teeth (Ben-Bassat et al, 1997; Mugonzibwa et al, 2004). A lateral scissors bite was recorded as present when any of the maxillary primary molars/permanent premolars and molars totally occluded the buccal surface of the antagonistic mandibular teeth (Mugonzibwa et al, 2004).

Both the questionnaire and the dental forms were printed on optical marker reader (OMR) modules and subsequently scanned by an OMR (Axiome 995, Axiome, Corcelles, Switzerland), and the data were stored on a computer in a dedicated database.

Data treatment

For the whole sample, descriptive statistics, as percentages and counts, are reported for the following occlusal variables (categories): canine and molar classes (I, II, III, asymmetrical, and not classified [including also not classifiable cases on 1 side only]); overbite and overjet (normal, decreased, increased and not classified); dental crowding (none, maxillary, mandibular, maxillary and mandibular); maxillary midline diastema (no, yes, not classified); and crossbite (none, anterior, posterior [including also cases with not classified anterior crossbite], anterior and posterior).

All of the following analyses were performed on the children who were fully classified for each occlusal trait (fully classified sample). The number of malocclusal traits was calculated considering each of the maxillary and mandibular dental crowding, and the anterior and posterior crossbite, as single traits. The differences in the mean numbers of malocclusal traits (as a continuous variable) across the age groups were also tested by a one-way analysis of variance (ANOVA). Two binomial logistic regressions were run to examine the correlations between gender (considered as dependent variable) and all of the other occlusal traits, but including either the canine or molar class.

With the aim of examining the correlations among malocclusal traits, overbite, overjet, dental crowding, maxillary midline diastema and crossbite (explanatory variables) were cross-tabulated with either the canine or the molar classes (dependent variables). The chi-squared test was used to assess the significance of the differences in the distributions of the categories within each explanatory variable among those of the canine and molar classes. Subsequently, the same explanatory variables were run in two multinomial logistic regressions to estimate the adjusted correlations with the canine or molar class, separately. The normal condition for every occlusal trait has been considered as the reference category and these models also included age and gender as continuous and dummy covariates, respectively. Finally, the explanatory variable 'crossbite' was recorded as 'no' and 'yes' to avoid major errors in the odds ratio (OR) estimations. The SPSS software (SPSS®, Chicago, IL, USA) was used to perform the bivariate analyses and binomial logistic regressions; the SAS software (SAS, Cary, NC, USA) was used to perform the multinomial logistic regressions. A P value < 0.05 was considered as being statistically significant.

Table 1 Distribution of children as %(count) according to age and gender in the whole sample

Age (years)	Boys	Girls	Total
7	17.8 (110)	22.5 (131)	20.1 (241)
8	22.9 (141)	19.1 (111)	21.0 (252)
9	22.4 (138)	20.1 (117)	21.3 (255)
10	18.8 (116)	17.9 (104)	18.4 (220)
11	18.2 (112)	20.3 (118)	19.2 (230)
Total	51.5 (617)	48.5 (581)	100 (1,198)

RESULTS

In total, 1,360 children were in mixed dentition at the moment of the visit. Among these, 1,198 had never received any orthodontic treatment and were thus considered as the whole sample for which the descriptive statistics for age and gender are shown in Table 1. The mean ± SD number of primary teeth from the 7- to the 11-year-old children ranged between 15.6 ± 2.6 and 5.5 ± 4.9; that of the permanent teeth ranged between 7.5 ± 3.0 and 19.0 ± 5.2.

The prevalence of each occlusal trait in the whole sample is shown in Table 2. Canine class I was the most frequent, at 41.4% of the sample. The corresponding class II was half as frequent as class I, and finally class III was the least frequent. Of note, there was 22.7% prevalence of the asymmetrical cases between the right and left sides. Similar results were seen for the molar class. Over 10% of the sample had a not classified canine or molar class. For both the canine and molar classes, the same frequencies were seen between the two sides (not shown). About one-third of the sample had a normal overbite, while one-fifth had a decreased overbite. The ratio of increased/decreased overbite was about 2:1. Similarly, a normal overjet was recorded in one-third of the sample, and the prevalence of increased overjet was seen to be higher than that of the normal condition. Decreased overjet was found in only 12.8% of the children and the ratio of increased/decreased overjet was about 3:1. For the overbite and overjet, 10.4% of the children could not be classified. About half of the sample showed dental crowding, and this was present in the mandibular arch alone in 23.2%, or in combination with the maxillary arch in 17.2%. In 4.0% of the sample, dental crowding was limited to the maxillary arch. About one-third of the sample showed maxillary midline diastema. Among the children analysed, 8.2% showed an anterior crossbite. In 1.6% of the whole sample, this was bilateral, and when unilateral, the same prevalence was found between the two sides (not shown). For anterior crossbite, 6.7% of the children could not be classified. In the whole sample, 14.3% showed a posterior crossbite. In 3.4% of the whole sample, this was bilateral, and when unilateral, the same prevalence was seen between the two sides

Table 2 Prevalence of occlusal traits as %(count) in the whole sample (n = 1,198)

Trait		Prevalence
Canine class		
	I	41.4 (496)
	II	19.9 (239)
	III	5.7 (68)
	Asymmetrical	22.7 (272)
	Not classified	10.3 (123)
Molar class		
	I	46.8 (561)
	II	16.8 (201)
	III	6.3 (76)
	Asymmetrical	17.4 (208)
	Not classified	12.7 (152)
Overbite		
	Normal	32.7 (392)
	Decreased	18.7 (224)
	Increased	38.1 (457)
	Not classified	10.4 (125)
Overjet		
	Normal	31.8 (381)
	Decreased	12.8 (153)
	Increased	45.0 (539)
	Not classified	10.4 (125)
Dental crowding		
	No	55.6 (666)
	Maxillary	4.0 (48)
	Mandibular	23.2 (278)
	Maxillary and mandibular	17.2 (206)
Maxillary midline diastema		
	No	60.8 (728)
	Yes	28.8 (345)
	Not classified	10.4 (125)
Anterior crossbite		
	No	85.1 (1,020)
	Monolateral	6.6 (79)
	Bilateral	1.6 (19)
	Not classified	6.7 (80)
Posterior crossbite		
	No	85.7 (1,027)
	Monolateral	10.9 (130)
	Bilateral	3.4 (41)

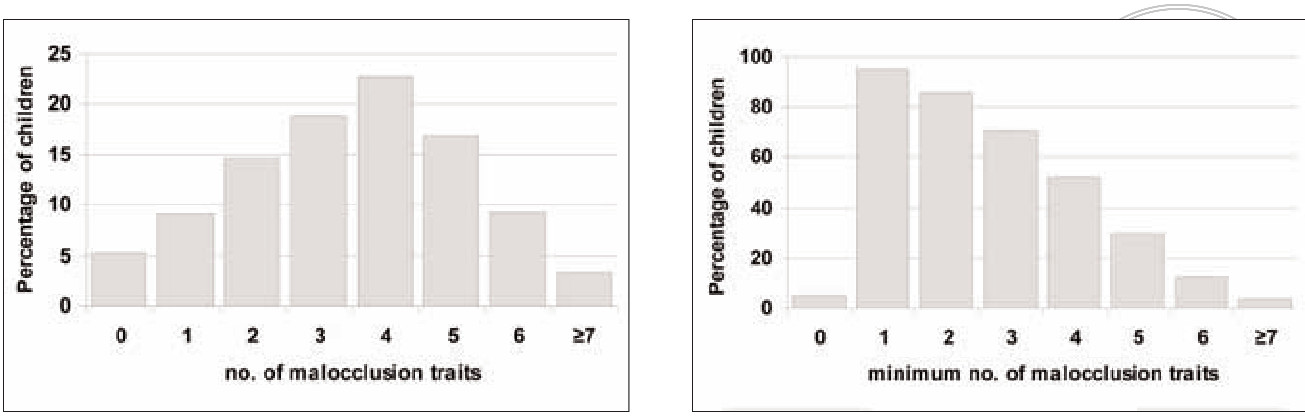

Fig 1 Frequencies according to the total number (left) and minimum number (right) of malocclusal traits present, of the fully classified sample (n = 858).

(not shown). All of the cases included in the present analysis could be classified. Finally, only 9 children (out of 1,360) were found to have a scissorbite, but they were excluded from the analysis since they had already undergone orthodontic treatment.

Within the whole sample, 858 children constituted the fully classified sample and were thus included in the analyses of the correlations of the occlusal traits with either the canine or molar classes. The frequency of children according to the total number, or to the minimum number, of malocclusal traits in the fully classified sample is shown in Fig 1. The overall mean ± SD of the number of malocclusal traits was 3.5 ± 1.8, with no significant differences among the age groups (one-way ANOVA, not shown). No significant correlations were seen at the binomial logistic regressions between gender and other occlusal traits (with either the canine or molar class) (not shown).

Results of the bivariate analyses (chi-squared tests) of the correlations between occlusal traits and either the canine or molar classes are shown in Table 3. The overbite, overjet, and crossbite showed statistically significant different distributions across both the canine and the molar classes. On the contrary, dental crowding and maxillary midline diastema did not show any differential distributions across either dental class.

Results of the multinomial logistic regressions for the correlations between occlusal traits and both the canine and molar classes are shown in Table 4. For the significant correlations with the canine classes: i) age was positively correlated with the third and asymmetrical classes, while gender did not show any significant correlations; ii) decreased and increased overbite had positive correlations with classes III and II, respectively; iii) decreased overjet was positively associated with class III, while increased overjet was positively correlated with both the second and asymmetrical classes; iv) dental mandibular crowding did not show any significant correlations with any of the canine classes, while the maxillary midline diastema was negatively correlated with class II only; v) crossbite (any) was positively correlated to the third and asymmetrical classes.

Regarding the significant correlations with the molar classes: i) age and gender did not show any significant correlations; ii) decreased overbite was negatively correlated with class II, and increased overbite had a positive correlation with the same class; iii) decreased overjet was positively correlated with class III, while increased overjet was positively correlated with both the second and asymmetrical classes; iv) dental mandibular crowding was positively correlated with the asymmetrical class, while the maxillary midline diastema was negatively correlated with class II; v) crossbite (any) was positively correlated with the asymmetrical class.

DISCUSSION

This study is part of the Italian OHSAR Survey, which was designed to comprehensively report the prevalence of caries and malocclusal traits in an Italian sample of children of mixed dentition (Perinetti et al, 2005, 2006).

The validity of professional experience in assessing malocclusion is the most realistic approach to epidemiological surveys (Helm, 1977; Steigman et al. 1983). Moreover, although the use of an index of treatment need is more effective in planning any oral health policy, this would require a great investment, while qualitative methods of assessing malocclusion have proven to be no less valid or reproducible than quanti-

Table 3 Prevalence (percentage) of canine and molar classes among the explanatory variables of the fully classified sample (n = 858)

Explanatory variable	Canine Class I (382)	Canine Class II (196)	Canine Class III (54)	Canine Class Asym. (266)	Diff.	Molar Class I (457)	Molar Class II (173)	Molar Class III (57)	Molar Class Asym. (171)	Diff.
Overbite										
Normal (310)	53.5	13.9	1.9	30.6		61.3	13.9	4.5	20.3	
Decreased (173)	38.7	8.7	22.0	30.6	***	52.6	5.2	19.1	23.1	***
Increased (375)	39.7	36.8	2.7	20.8		46.9	32.3	2.7	18.1	
Overjet										
Normal (294)	66.3	5.4	4.1	24.1		74.5	5.4	4.8	15.3	
Decreased (112)	36.6	4.5	28.6	30.4	***	51.8	5.4	26.8	16.1	***
Increased (452)	32.3	38.7	2.2	26.8		39.8	33.4	2.9	23.9	
Dental crowding										
None (471)	44.4	22.9	7.6	25.1		55.2	21.0	6.8	17.0	
Maxillary (35)	42.9	28.6	2.9	25.7	NS	54.3	28.6	2.9	14.3	NS
Mandibular (184)	45.7	20.7	3.3	30.4		50.0	16.8	6.5	26.6	
Maxillary and mandibular (168)	44.0	23.8	6.5	25.6		51.2	19.6	7.1	22.0	
Maxillary midline diastema										
No (559)	43.5	24.3	5.5	26.7	NS	53.0	21.3	5.7	20.0	NS
Yes (299)	46.5	20.1	7.7	25.8		53.8	18.1	8.4	19.7	
Crossbite										
None (715)	48.0	25.5	4.8	21.8		57.5	22.7	5.5	14.4	
Anterior (48)	29.2	6.3	22.9	41.7	***	50.0	12.5	20.8	16.7	***
Posterior (70)	34.3	15.7	7.1	42.9		24.3	5.7	7.1	62.9	
Anterior and posterior (25)	4.0	0	16.0	80.0		20.0	4.0	12.0	64.0	

Numbers in parentheses indicate the number of children in each category of the variables.
Asym., asymmetrical dental class.
Levels of significance (chi-squared test): ****P* < 0.001. NS, not significant.

tative methods (Helm, 1977; Myrberg and Thilander, 1973). Assessing single malocclusal traits also makes the results from surveys more comparable. In contrast, the degree of dentofacial anomaly, and hence the treatment need, is strongly related to socioeconomic and ethnic differences among populations (WHO, 1997), making comparisons less reliable. Nevertheless, more effort will have to be made to assess the treatment need in the Italian population. Finally, the malocclusal traits included herein are related to key aesthetic and functional considerations.

Whole sample analysis

The present study shows a very high prevalence of malocclusal traits (93.0% of children presenting at least one malocclusal trait; see also Fig 1 for the fully classified sample). This prevalence is, however, comparable with that reported for samples of European (Keski-Nisula et al, 2003; Lauc, 2003) and Latino-American (Thilander et al, 2001; Silva and Kang, 2001) children, but extremely different to that found in other Asiatic countries (Esa et al, 2001). Indeed, western populations show a higher prevalence of malocclusal traits (along with high degrees of variability for each) compared with other populations from less modernised countries, suggesting an epidemiological transition in dental occlusion (Corruccini, 1984).

As expected, in the present study, the overall prevalence of canine and molar classes was generally the same. For the molar classes I and III, the present findings show agreement with others (Lauc, 2003). The prevalence of molar class II and III in a group of Argentinean children were 5% and 10% (Muniz, 1986), with the latter in good agreement with the present results. At the same time, the frequencies of molar class II and III in Colombian 5- to 17-year-old children were 20.8% and 3.7% (Thilander et al, 2001). Finally, the

Table 4 Results of the multinomial logistic regressions for estimates of correlation of canine and molar classes with each explanatory variable of the fully classified sample (n = 858)

Explanatory variable	Canine class: I	II		III		Asym.	
	OR	OR	95% CI	OR	95% CI	OR	95% CI
Age	1	1.07	0.91–1.26	1.38**	1.08–1.77	1.42***	1.23–1.64
Gender							
Boys	1	1		1		1	
Girls	1	0.94	0.63–1.38	1.58	0.83–3.02	1.39	0.97–1.97
Overbite							
Normal	1	1		1		1	
Decreased	1	0.60	0.29–1.25	9.17***	3.19–26.4	1.06	0.61–1.83
Increased	1	1.81*	1.14–2.88	2.27	0.77–6.72	0.78	0.51–1.19
Overjet							
Normal	1	1		1		1	
Decreased	1	1.88	0.61–5.78	3.31*	1.32–8.30	1.45	0.76–2.79
Increased	1	13.96***	7.79–25.01	0.75	0.30–1.90	2.80***	1.85–4.25
Dental crowding							
None	1	1		1		1	
Maxillary	1	1.54	0.59–4.00	0.25	0.03–2.18	1.06	0.42–2.69
Mandibular	1	0.89	0.54–1.48	0.57	0.22–1.49	1.41	0.91–2.19
Maxillary and mandibular	1	0.81	0.48–1.35	0.65	0.29–1.49	0.91	0.57–1.48
Maxillary midline diastema							
No	1	1		1		1	
Yes	1	0.59*	0.38–0.91	1.57	0.79–3.10	0.98	0.66–1.45
Crossbite (any)							
No	1	1		1		1	
Yes	1	1.56	0.76–3.22	2.14*	1.01–4.64	4.87***	2.99–7.96

Explanatory variable	Molar class: I	II		III		Asym.	
	OR	OR	95% CI	OR	95% CI	OR	95% CI
Age							
Gender							
Boys	1	1		1		1	
Girls	1	0.82		1.06	0.59–1.91	1.11	0.75–1.64
Overbite			0.55–1.21				
Normal	1	1		1		1	
Decreased	1	0.29**	0.12–0.67	2.10	0.90–4.90	0.85	0.46–1.56
Increased	1	1.60*	1.01–2.53	0.75	0.31–1.84	1.00	0.62–1.61
Overjet							
Normal	1	1		1		1	
Decreased	1	2.29	0.78–6.72	4.22**	1.74–10.19	0.69	0.32–1.52
Increased	1	11.54***	6.44–20.68	1.10	0.48–2.54	4.28***	2.63–6.96
Dental crowding							
None	1	1		1		1	
Maxillary	1	1.77	0.71–4.43	0.40	0.05–3.32	1.01	0.34–3.04
Mandibular	1	0.88	0.52–1.48	1.44	0.68–3.06	1.89**	1.17–3.04
Maxillary and mandibular	1	0.82	0.48–1.38	1.13	0.52–2.46	1.31	0.79–2.19
Maxillary midline diastema							
No	1	1		1		1	
Yes	1	0.64*	0.41 – 1.00	1.40	0.75–2.60	0.75	0.49–1.15
Crossbite (any)							
No	1	1		1		1	
Yes	1	1.79	0.81–3.95	1.60	0.76–3.38	11.20***	6.53–19.21

Asym., asymmetrical dental class.
OR, adjusted odds ration; 95% CI, 95% confidence interval of the OR.
Levels of significance (chi-squared test): *P < 0.05, **P < 0.01, ***P < 0.001.

overall incidence of the molar classes found herein is similar to that reported for Black Americans, but very different to that of Kenyans (Garner and Butt, 1985), supporting the concept that environmental factors have important roles in determining malocclusion (Corruccini, 1984; Garner and Butt, 1985). Moreover, the prevalence of asymmetrical canine and molar classes (22.7% and 17.4%, respectively; Table 1) can be accounted for by a premature loss or massive caries of deciduous teeth. Indeed, although the dft index in this Italian population is not particularly high, the percentage of untreated caries of the primary teeth is extremely high, at over 80% (Perinetti et al, 2005, 2006).

In the present study, almost two-thirds of the children showed an increased/decreased overbite or overjet (Table 1). The ratios of increased to decreased overbite and overjet were 2:1 and 3:1, respectively, which do not differ particularly from previous observations (Thilander et al, 2001). Data regarding overbite do not differ dramatically from those seen previously in 4- to 8-year-old Finnish (Keski-Nisula et al, 2003), 7- to 14-year-old Croatian (Lauc, 2003) and 6- to 8-year-old German children (Tausche et al, 2004). On the contrary, the prevalence of the increased/decreased overjet found herein is greater compared with that reported in these previous studies. Even though definitive threshold levels for overbite and overjet indicating the need for an early treatment are still missing, the frequency of only about 30% of the sample with normal overbite and overjet seen in the present study is of interest.

About half of the children from the present study showed dental crowding, mainly in the mandibular arch (Table 1). This prevalence is close to that reported for age-matched children living on an Adriatic island (Lauc, 2003) and in the USA (Brunelle et al, 1996). Even in 4- to 5-year-old Finnish children the prevalence of dental crowding is above 50% (Keski-Nisula et al, 2003). Of note, in 11- to 18-year-old Nigerian children, the prevalence of dental crowding was reported to be much lower (16%), compared with Caucasian children (Kerosuo et al, 1988). For the asymmetrical dental classes, a further explanation for high prevalence of dental crowding seen herein could be space reduction due to extensive caries of the primary teeth (see above). Although crowding in the lower front of the mandible has been reported as a natural phenomenon in the mixed dentition (Moorrees and Chadha, 1965), the high frequency of dental crowding during mixed dentition is of interest considering that it does not undergo a self-reduction over time, and hence, in most of cases it is an early sign of treatment need (Keski-Nisula et al, 2003), and early orthodontic treatment has been suggested (Gianelly, 2002).

Maxillary midline diastema has been recorded as both 1 mm (Lauc, 2003; Onyeaso, 2004) and 2 mm (Thilander et al, 2001) spacing between the central incisors, and therefore the results from the present study may well be comparable with some of the others. The prevalence of midline diastema, recorded as 1 mm of space, reported for a sample of 12- to 17-year-old Nigerian children (Onyeaso, 2004) was very similar to that found herein, while it was about half in the sample of 7- to 14-year-old Croatian children (Lauc, 2003).

Prevalence of the posterior crossbite seen in the present study (14.3%) is almost double that seen in the mixed-dentition Finnish children (Keski-Nisula et al, 2003) and slightly higher or similar to those reported for samples of 3- to 5-year-old Belgian (Carvalho et al, 1998), 6- to 13-year-old Israeli (Ben-Bassat et al, 1997) and 6- to 8-year-old German (Tausche et al, 2004) children. Sucking habits have been correlated with the development of a posterior crossbite (Larsson, 1986). Indeed, reduction in the use of pacifier sucking over the last decades has significantly reduced the prevalence of such a malocclusal trait in Finnish children (Keski-Nisula et al, 2003).

Moreover, considering that a unilateral crossbite requires early treatment, thus avoiding neuromuscular (Sonnesen et al, 2001) and mandibular growth (Thilander et al, 1984) imbalances, and that nearly 11% of the children included in the present study showed this malocclusal trait (Table 1), future oral health policies will have to address reduction of the sucking habit and implementation of early treatment where needed. The higher prevalence of anterior crossbite seen in the present study, compared with others (Heikinheimo et al, 1987; Keski-Nisula et al, 2003; Lauc, 2003; Mugonzibwa et al, 2004; Ciuffolo et al, 2005), may also be related to the recording that also included the incisors in edge-to-edge position. Indeed, a very similar prevalence of this trait was reported for 6- to 13-year-old Israeli children (Ben-Bassat et al, 1997) in which the same recording was made; however, Lauc (2003) reported only 0.9% 7- to 14-year-old children presenting anterior crossbite recorded in this manner. Anterior crossbite does not self-correct with age, and it is therefore an early sign of treatment need. In the present study, 18.9% of the children presented anterior and/or posterior crossbite.

Fully classified sample analysis

No significant differences in the numbers of malocclusal traits were seen across the age groups (see Results). Interestingly, a previous study showed that in many cases the number of malocclusal traits does not change over time, although they may change in type within the same subject (Heikinheimo et al, 1987). However, the severity of each trait cannot be accounted for in these analyses.

Similar results were obtained when analysing the effects of gender on the malocclusal traits when no significant interactions were seen with binomial logistic regressions (see Results). No or little gender differences have been reported by previous investigations (Kerosuo et al, 1988; El-Mangoury and Mostafa, 1990; Brunelle et al, 1996; Esa et al, 2001; Thilander et al, 2001; Keski-Nisula et al, 2003; Lauc, 2003; Mugonzibwa et al, 2004; Onyeaso, 2004). However, differences in the protocols used need to be taken into account when comparing all of these studies. A further explanation for these inconsistencies may also derive from the speculation that gender dimorphism has been associated more to different habit practising between boys and girls, than to genetics (Ben-Bassat et al, 1997).

In the present study, in most cases different malocclusal traits are present in the same children, with 71.1% of the fully classified sample showing at least three malocclusal traits (Fig 1). This result is in agreement with other investigations (Brunelle et al, 1996; Thilander et al, 2001; Keski-Nisula et al, 2003, 2006; Lauc, 2003), making the study of the correlations among these malocclusal traits of interest. However, the study of such correlations may be complex, and therefore, herein all of the malocclusal traits were related to either the canine or molar class, which were thus considered as dependent variables. Subsequently, to avoid mathematical coupling, the bivariate and multivariate analyses were run for the canine and molar classes separately (Tu et al, 2006). Finally, these models were also adjusted for age and gender. Generally, the results in terms of correlations with the canine and molar classes are similar.

An increase in prevalence of molar class III together with a decrease in molar class II with age has been reported previously (Thilander et al, 2001). On the contrary, a longitudinal study showed an increased severity of class II malocclusion in 7- to 14-year-old children (Inglesson-Dahlstrom and Hangberg, 1994). In the present study, the prevalence of the third and asymmetrical canine (but not molar) classes positively correlated with age. It can be speculated that such an increase in prevalence of malocclusal canine classes in older children is a consequence of transition from primary to permanent dentition. Moreover, different growth end points of the mandible and the maxilla must be considered in the interpretation of this result. The cross-sectional nature of the present study does not allow an individual analysis of such changes, while a stratification by dental age, rather than chronological age, has been reported to be better in detecting variations in malocclusion (Thilander et al, 2001).

In the present study, generally increased overbite and overjet were positively associated with dental class II, while decreased overbite and overjet were associated with dental class III (Table 4). Interestingly, although not analysed specifically, Lauc (2003) reported a high prevalence of molar class II with deep bite in mixed dentition children, and a correlation between class III malocclusion and decreased overbite and overjet in deciduous dentition has also been reported previously (Chang et al, 1992). Of note, a combination of deep overbite and notably increased overjet, such as in the dental class II children reported herein, has been suggested to be an indication for early treatment to prevent tooth fracture and to normalise lip function (Tausche et al, 2004).

Increased overjet was positively associated with both the canine and molar asymmetrical classes (adjusted ORs, 2.80 and 4.28, respectively; Table 4). Asymmetry in each dental arch (including dental class asymmetry) has been reported to be associated with increased overjet (Kula et al, 1998), supporting the hypothesis that dentoalveolar compensation helps to modify asymmetries in dental arches (Kula et al, 1998). Although the present study did not include specific measurements of dental arch asymmetries, its results fit with this previous hypothesis.

The dental crowding did not show significant correlations with either the canine or molar class with the bivariate and multivariate analyses. The only exception was for the dental mandibular crowding, which was significantly associated with the asymmetrical molar (but not canine) class (Table 4). In the present study, both mandibular dental crowding and crossbite (see below) were associated with an asymmetrical molar class and, interestingly, a severe anterior teeth misalignment has previously been described to be associated with posterior crossbite (Brunelle et al, 1996).

Generally, the same results have been obtained for maxillary midline diastema. In particular, this was only negatively associated with the canine and molar class II (Table 4). The reason and the clinical significance of such a correlation warrants further studies. However, in the present study, 55.8% of children having maxillary midline diastema also showed a hypertrophic maxillary frenulum (not shown).

A positive correlation between any crossbite with canine class III and the asymmetrical dental classes is seen (Table 4). In the present study, the crossbite and decreased overbite (see above) are both positively associated with canine class III. Interestingly, 40% of a sample of Belgian children showing posterior crossbite also showed an open bite (Carvalho et al, 1998). In the present study, among the children showing posterior crossbite only, 32.9% also had decreased overbite (not shown). Moreover, the adjusted ORs for the presence of any crossbite with asymmetrical canine and molar classes were very high (4.88 and 11.20, respectively; Table 4). It is worth mentioning that 62.9% of the children with posterior crossbite only also had an asymmetrical molar class, and the same was seen for the canine class (Table 3). The knowledge of this strong correlation might be useful in treatment planning, while longitudinal studies may focus on possible causal relationships.

The comparisons of the present results with others suggest a high prevalence of malocclusal traits in children living in developed countries, although the prevalence of each trait and their correlations may differ among communities. Therefore, epidemiological surveys are useful to decide treatment priorities among those demanding orthodontic treatment at public expense. Further studies are also warranted to elucidate the role of environmental factors in determining malocclusions, while national dental surveys are strongly recommended in Italy.

CONCLUSIONS

- The prevalence of malocclusal traits is very high in mixed dentition Italian children.
- No differences between genders were seen in the prevalence of any malocclusal traits.
- Dental class II was generally correlated with increased overbite and overjet. On the contrary, maxillary midline diastema was negatively correlated with the same dental class.
- Dental class III was generally correlated with decreased overbite and overjet, and crossbite.
- Asymmetrical dental class was mainly correlated with increased overjet and crossbite.
- Dental crowding showed very little correlation.

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