ORIGINAL ARTICLE

Spacing and crowding among African and Caucasian children

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Structured Abstract

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Objective – To determine spacing and crowding according to ethnic group, gender and dental emergence stage among Tanzanian African and Caucasian children.

Design – Cross-sectional epidemiological clinical study.

Setting – A total of 869 African (428 boys, 441 girls) and 706 Caucasian (319 boys, 387 girls) school children, aged 3½–16 years.

Main Outcome Measures – Comparison of spacing and crowding between African and Caucasian children according to gender and dental emergence stage.

Results – Spacing was more often found in the maxilla, while crowding was more common in the mandible. Only during the transition of the maxillary permanent front teeth was there significantly more spacing in Caucasians. No gender differences were found. In both samples spacing decreased during later emergence stages. Crowding was more often found in Caucasian children than in African children. In Caucasian children the frequency of crowding increased with advanced emergence stages, while for Africans the trend was not consistent.

Conclusion – When planning resources for orthodontic treatment for different populations as well as planning treatment for individuals, ethnic background and emergence stage of the dentition need to be considered.

Key words: crowding; dental development; epidemiology; orthodontics; spacing

Introduction

Racial variations in space anomalies have interested descriptive and comparative anatomists, anthropologists, biologists, dentists and other scientists. Several studies have shown variations in space conditions between and within different racial groups. Prevalence of spacing has been reported to range from 6% to 50% and crowding from 5% to 80% in different populations (1–12). In North American Africans and Caucasians crowded malaligned teeth are the most common single contributors to malocclusion (13). Differences in extraction rate of deciduous teeth and differences in classification and age of the subjects studied could partly explain the observed variation in the prevalence of space anomalies. Apart from racial differences, other factors associated with variability in space anomalies prevalence are gender (14–16), heredity and environment

(17–21) and location, i.e. maxillary or mandibular arch (15, 22–26). Although gender differences in spacing and crowding have been described in some studies (14, 27), other researchers have reported no significant differences (1, 28). In a Finnish study, it was reported that young men had more lateral spacing in the maxilla, less incisal spacing in the mandible and slightly bigger teeth than women had (27).

Comparative studies between children of African and Caucasian origin (Table 1) on space conditions used different methods for data collection (14, 15, 29–32). Hence, the findings in the Tanzanian studies and others are difficult to compare essentially because of the different types of samples and methods of sampling, different criteria for determination of spacing and crowding of the dental arches, different processing and presentation of data and use of chronological age instead of eruption stage of the dentition for comparison of study subjects. Studies on emergence of permanent teeth have shown earlier emergence of permanent teeth in African children than in their Caucasian counterparts (33, 34). Therefore, comparing variation of space traits between the two groups using chronological age may be obscure.

While the prevalence of spacing has been found to be lower in Caucasian children than in African children (32), the prevalence of crowding has been found to be higher in Caucasians (31, 32). In both ethnic groups spacing and crowding were more frequent in the maxilla than in the mandible. However, the reported Tanzanian studies used chronological age to compare the subgroups and the sample was of mixed ethnic and racial background (31, 32, 35).

The purpose of the present study was to determine the variation in spacing and crowding of the dentition according to ethnic group, gender and emergence stages of the dentition among African Bantu and Caucasian children from Tanzania and Finland respectively.

Table 1. **Prevalence of spacing and crowding in some comparative epidemiological studies of African, American African and Caucasian children**

Reference	Year	n	Age (years)	Spacing	Crowding	Population, country
Lavelle (14)	1970			Maxilla		
		266	?	75%	?	British Caucasians
		218	?	74%	?	West Africans
				Mandible		
		266		25%	?	
		218		26%	?	
Kelly et al. (29)	1973		6–11	?	25.7%	American Africans, USA
				?	33.5%	American Caucasians, USA
Lavelle (15)	1976	1000	15–20	Maxilla	Maxilla	British Caucasians
				5–8.2%	18.8–27%	
				Mandible	Mandible	
				3–5.2%	29.2–2.6%	
		100	15–20	Maxilla	Maxilla	West African natives
				16%	2%	
				Mandible	Mandible	
				11%	5%	
Kelly and Harvey (30)	1977	?	12–17	?	1.6%	American Africans, USA
				?	2.8%	American Caucasians, USA
Kerosuo (31)	1990	482	3–8	?	5–21%	African children, Tanzania
		575	3–7	?	5–26%	Caucasian children, Finland
Kerosuo et al. (32)	1991	641	5–18	?	6–9%	African children, Tanzania
		458	5–18	?	23–40%	Caucasian children, Finland

?: not reported.

Subjects and methods

Subjects

The study was carried out in schools in the Ilala district, Dar es Salaam (Tanzania), and in Juuka (Northern Finland). A detailed description of the sampling procedure in both countries is given elsewhere (36, 37). In Tanzania, ethical permission was obtained from the Ministry of Health, the Ministry of Education of Tanzania, and the City Commission of Dar es Salaam as well as the school authorities who gave permission to conduct the study in the selected schools. Parents and subjects were informed verbally, and participation was voluntary. In Finland, ethical permission was obtained from the ethical committee, University of Kuopio. Registration of malocclusions, including crowding and spacing of the dentition was performed during annual dental check-ups of the dental clinics at schools. The Tanzanian sample included 869 Bantu children aged 3½–5, 6½–8, 9½–11 and 15–16 years. The Bantu ethnic group is the majority in the Tanzanian population. The Finnish sample consisted of all 706 five- to11-year-old children in Juuka, a municipality of about 7500 inhabitants. The Tanzanian sample consisted of 428 boys and 441 girls. The Finnish sample included 319 boys and 387 girls.

In order to compare children with similar occlusal development, five emergence stages of the dentition were defined as presented in Table 2. Table 3 shows the distribution of the Tanzanian African and Finnish Caucasian subjects according to gender and emergence stages of the dentition. Caucasian children with complete permanent dentition (ES4) could have received orthodontic treatment; therefore, they were excluded from the analyses. Consequently, the ethnic effect could only be analysed for the emergence stages ES0–ES3. Data on African children in ES4 are presented without comparison with Caucasians.

Methods

Spacing and crowding of the dentition were determined clinically according to the criteria described by Björk et al. (38) and modified by Laine (27). One dentist in Tanzania (E.A.M.) and four dentists in Finland collected the clinical data. The examiners in Tanzania and Finland were calibrated prior to the field study.

Table 2. **Definitions of emergence stages (ES0–ES4)**

Emergence stage	Definition
Emergence stage 0 (ES0)	Complete primary dentition only
Emergence stage 1 (ES1)	Incomplete first phase of the mixed dentition
Emergence stage 2 (ES2)	Complete first phase of the mixed dentition: first permanent molars and incisors fully erupted
Emergence stage 3 (ES3)	Incomplete second phase of the mixed dentition
Emergence stage 4 (ES4)	Complete permanent dentition: all permanent teeth fully erupted except third molars

Table 3. **Number of subjects according to ethnic group, gender and emergence stages of the dentition (ES0–ES4)***

	Africans			Caucasians		
Emergence stage	Boys	Girls	Total	Boys	Girls	Total
ES0	111	86	197	16	33	49
ES1	90	112	202	117	148	265
ES2	22	38	60	54	56	110
ES3	98	100	198	132	150	282
ES4	107	105	212	–	–	–
Total	428	441	869	319	387	706

*For coding ES0–ES4, see Table 2.

The incisal and lateral segments of the maxilla and mandible were considered separately (six segments). Spacing between two adjacent teeth was measured in millimetres using a periodontal probe as measuring device with a scale in millimetres. Total spacing of at least 2 mm in a segment was considered as the presence of spacing. Space resulting from extractions was not considered as spacing. Crowding was measured in millimetres as contact point displacement when two adjacent teeth are overlapping. Crowding was considered to be present when the total of the contact point displacements was at least 2 mm in a segment.

To calculate the inter-examiner consistency between Tanzanian and Finnish examiners double determinations were performed on 20 patients within an interval of 2 weeks.

The overall effects of ethnic group, emergence stage and gender were tested by means of logistic regression in which emergence stage was treated as a categorical variable (0.3). Chi-square test with continuity correction was applied to compare both ethnic groups within each stage. If the number of expected value was less than 5, then Fisher's exact test was applied.

Results

The inter-examiner consistency between Tanzanian and Finnish examiners was acceptable. Kappa values ranged from 0.52 to 0.76 for spacing and 0.27 to 0.76 for crowding.

Table 4 shows the percentage of subjects with spacing in the maxilla, mandible and both arches according to ethnic group and emergence stage of the dentition. Only slight differences were found between boys and girls and therefore, the data were pooled. Spacing of at least 2 mm was found in 9.1–55.8% of the African and 7.1–59.2% of the Caucasian children during different emergence stages of the dentition. In both ethnic groups, spacing tended to occur slightly more frequently in the maxilla than in the mandible. Overall, when both arches are taken together, Caucasians showed more spacing than Africans. But when the jaws are considered separately, only one significant difference between both ethnic groups was found (maxillary incisal region during ES1). For the mandibular incisal segment and entire mandible no differences were found. Regarding the effect of emergence stage, spacing was marked at the earlier stages of emergence and levelled off at the later ones in both ethnic groups.

The percentage distribution of subjects with crowding in the maxilla, mandible and both arches according to ethnic group and emergence stage are shown in Table 5. Crowding of at least 2 mm was found in 0–13.3% of the African Bantu children and in 6.1–38.7% of the Caucasian children. Generally, crowding was more common in the mandible than in the maxilla. The prevalence of crowding was significantly lower among Africans compared with Caucasians. The frequency of crowding increased with emergence stage of the dentition among the Caucasian children, while for the Africans the trend was not consistent. However, the prevalence of crowding among Africans had a tendency to decrease in the late mixed dentition.

Discussion

In the present study, both spacing and crowding of the dentition were determined. None of the African children had received any kind of orthodontic treatment. For the Caucasian sample, the older children in ES4 were not included in the analyses, as it could not be ruled out that some children had received orthodontic treatment, which could influence our comparison. Emergence stages of the dentition instead of chronological age were used to compare the subjects as differences in timing and pattern of eruption have been reported even within a population of the same ethnic origin (36, 39). As earlier Tanzanian studies (31, 32, 35) used chronological age to compare subgroups while the samples were also of mixed ethnic and racial background, the results of those studies have to be interpreted carefully.

Spacing was most prevalent in the primary dentition. In the later emergence stages of the dentition, it was found more frequently in the maxilla than in the mandible in both ethnic groups, being in agreement with earlier reports (14, 22, 26). Generally the prevalence of spacing was almost equally distributed among the two ethnic groups except at ES1 in the maxillary incisal segment and both arches where Caucasian children had more spacing than Africans. These findings are contrary to an earlier study comparing children of the same ethnic origin, which reported Africans to have a more spacious maxillary arch than Caucasians (15). This might be attributed to the use of emergence

Table 4. **Percentage of subjects with spacing according to ethnic group and emergence stages (ES0–ES4) of the dentition in the maxilla, mandible and both arches. The *p*-values are given for each stage and the overall effect across strata***

	Africans			Caucasians			Ethnic differences	Overall effect of
Emergence stage	n	%	95% CI	n	%	95% CI	per stage (*p*-value)	stage (*p*-value)
Maxillary front								
ES0	197	37.6	(32–45)	49	38.9	(26–54)	1.00	<0.0001
ES1	202	39.1	(33–46)	265	52.1	(46–58)	0.007	
ES2	60	30.0	(19–43)	110	45.5	(36–55)	0.07	
ES3	198	27.8	(22,34)	282	28.7	(24–34)	0.90	
ES4	212	17.5	(13–23)	–	–	–		
Maxilla (entire)								
ES0	197	44.2	(37–52)	49	44.9	(32,60)	1.00	<0.0001
ES1	202	43.1	(36–50)	265	52.8	(47–59)	0.46	
ES2	60	30.0	(19–43)	110	46.4	(37–56)	0.06	
ES3	198	29.8	(24–37)	282	32.6	(27–38)	0.58	
ES4	212	18.4	(13–24)	–	–	–		
Mandibular front								
ES0	197	44.2	(37,52)	49	44.9	(32–60)	1.00	<0.0001
ES1	202	18.3	(13,24)	265	17.4	(13–22)	0.89	
ES2	60	13.3	(5,23)	110	14.5	(8–22)	1.00	
ES3	198	9.1	(5,13)	282	7.1	(4–10)	0.53	
ES4	212	10.4	(6,15)	–	–	–		
Mandible (entire)								
ES0	197	46.7	(40–54)	49	46.9	(34–62)	1.00	<0.0001
ES1	202	20.8	(15–27)	265	18.5	(14–23)	0.61	
ES2	60	16.7	(8–27)	110	16.4	(10–24)	1.00	
ES3	198	15.2	(10–21)	282	15.2	(11–20)	1.00	
ES4	212	14.2	(10–19)	–	–	–		
Both arches								
ES0	197	55.8	(49–63)	49	59.2	(44–72)	0.79	<0.0001
ES1	202	46.0	(39–53)	265	56.2	(50–62)	0.04	
ES2	60	31.7	(21–45)	110	49.1	(40–59)	0.04	
ES3	198	30.8	(25–38)	282	39.4	(34–45)	0.07	
ES4	212	23.6	(18–30)	–	–	–		

*For coding ES0–ES4, see Table 2; CI = 95% confidence interval.

stages in the present study, which compared subjects according to the emergence of teeth in the oral cavity regardless of their chronological age. Among Caucasians, prevalence of spacing was well in agreement with earlier Scandinavian reports (16, 27, 28), using similar criteria.

Generally, the prevalence of crowding was low in both ethnic groups compared to other publications. This may be explained by the use of strict criteria to determine crowding in this study where a mild space deficiency of less than 2 mm in each segment was not registered as crowding. The prevalence of crowding was significantly lower among Africans in both arches. Other studies have been reported in which the prevalence of crowding in the permanent dentition was also found to be higher in Caucasian than in African children (14, 15, 29–32). The difference in the prevalence of crowding between African and Caucasian children may be associated with polygenetic factors which have been indicated to contribute to the variations in space

Table 5. **Percentage of subjects with crowding according to ethnic group and emergence stages (ES0–ES4) of the dentition in the maxilla, mandible and both arches. The *p*-values are given for each stage and the overall effect across strata***

	Africans			Caucasians			Ethnic differences	Overall effect
Emergence stage	n	%	95% CI	n	%	95% CI	per stage (*p*-value)	of stage (*p*-value)
Maxillary front								
ES0	197	0	(0–2)	49	6.1	(1–17)	0.006	<0.001
ES1	202	4.5	(2–8)	265	8.7	(5–12)	0.11	
ES2	60	10.0	(3–19)	109	18.2	(11–26)	0.23	
ES3	198	2.0	(0–4)	205	14.5	(11–19)	0.0001	
ES4	212	2.4	(1–5)	–	–	–		
Maxilla (entire)								
ES0	197	0	(0–2)	49	6.1	(1–17)	0.006	<0.0001
ES1	202	4.5	(2–8)	265	9.1	(6–13)	0.08	
ES2	60	10.0	(3–19)	110	19.1	(12–27)	0.18	
ES3	198	3.5	(1–6)	282	20.2	(16–25)	0.0001	
ES4	212	5.2	(2–8)	–	–	–	–	
Mandibular front								
ES0	197	1.0	(0–4)	49	8.2	(1–17)	0.02	<0.01
ES1	202	6.4	(3–10)	265	25.7	(21–31)	0.0001	
ES2	60	3.3	(0–12)	110	24.5	(17–33)	0.001	
ES3	198	3.0	(1–6)	282	25.5	(21–31)	0.0001	
ES4	212	3.3	(1–6)	–	–	–	–	
Mandible (entire)								
ES0	197	1.5	(0–4)	49	8.2	(1–17)	0.04	<0.005
ES1	202	7.4	(4–11)	265	26.4	(21–32)	0.0001	
ES2	60	5.0	(1–14)	110	27.3	(19–36)	0.001	
ES3	198	4.0	(2–7)	282	30.1	(25–36)	0.0001	
ES4	212	7.5	(4–11)	–	–	–	–	
Both arches								
ES0	197	1.5	(0–4)	49	8.2	(1–17)	0.04	<0.0001
ES1	202	10.9	(7–16)	265	29.4	(24–35)	0.0001	
ES2	60	13.3	(5–23)	110	30.9	(23–40)	0.02	
ES3	198	7.1	(4–11)	282	38.7	(33–45)	0.0001	
ES4	212	9.0	(5–13)	–	–	–	–	

CI, 95% confidence interval.
*For coding ES0–ES4, see Table 2; CI = 95% confidence interval.

anomalies among dizygotic twins and between families (17, 19, 20). Correspondingly, genetic factors may influence variation in space anomalies among different ethnic groups. However, some studies on family and twin data have suggested that occlusal similarities within families may be related to common environmental, rather than hereditary, effects (18, 40). Therefore, when comparing different ethnic groups both environmental factors and genetic ones have to be considered, although environmental factors may be singled out as more important especially with reference to crowding (18).

The total prevalence of crowding among Finns was slightly higher than in a previous report on young Finnish adults (27) in which a lower prevalence of crowding in the maxilla and a slightly higher prevalence in the mandibular incisor region were reported, but these differences may be due to the difference in

age distribution of the study subjects. In Caucasians the prevalence of crowding had a tendency to increase when permanent teeth emerged in the oral cavity, while the pattern in Africans was inconsistent. This agrees with previous reports indicating that crowding is rare in the primary dentition, but increases as dental development proceeds (1, 22, 31). The finding contradicts a previous Tanzanian report (35) according to which crowding was more common in the younger age groups than in the oldest ones.

With respect to gender, no difference was found for spacing being in agreement with earlier studies (3, 5–7, 14), but in contradiction to other studies on comparable populations where boys had more often spacing in the maxillary and mandibular incisal region than girls had (8, 16, 28). Although in our study no gender difference was found for crowding, being in agreement with other reports (6, 7, 35, 41), in some studies it has been reported to occur more frequently in females than in males (1, 8, 22, 28).

This study shows that spacing was more often found in the maxilla, while crowding was more common in the mandible. No gender differences were found. In both samples spacing decreased during the later emergence stages. Crowding was more often found in Caucasian children than in African children. The frequency of crowding increased with emergence stage of the dentition among the Caucasian children, while for the Africans the trend was not consistent. Therefore, when planning resources for orthodontic treatment for different population groups as well as planning treatment for individual patients, ethnic background and emergence stage of the dentition need to be considered.

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